PhD in Computer Science

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1 Admission requirements to the PhD program

1.1 Minimum requirements

Applicants for admission to the PhD program must possess an MSc degree in Computer Science from a reputable university, college or institute. At least a 75% average (or a GPA of 3/4.0) in the MSc program as determined by the Department is required. However, meeting the minimum requirements does not guarantee admission.

Since we receive so many applicants who meet our minimum requirements, each year we must turn away many well-qualified students. For the most part, it is unrealistic to expect that you will be admitted with an average less than 78% (based on the grades of the last two academic years). Please note that in the past few years, most of the accepted MSc students have had over 82% average and most of the accepted PhD students have had over 85% average.

1.2 Entry into PhD Program for applicants with non-CS MSc degrees

An applicant to the PhD program, who does not hold a MSc degree in Computer Science from a reputable university, must have the equivalent of the following:

R1 A 4-year Honor's-level Bachelor's degree with very high standing from a reputable university, college, or institute. As admission to our graduate program is highly competitive, only very strong students interested in pursuing interdisciplinary research will be considered.

R2 Computer Science 3331 (Foundations of Computer Science I)

R3 Computer Science 3340 (Analysis of Algorithms I)

R4 at least one course among the following List I:

1. Computer Science 3307 (Object Oriented Design and Analysis)
2. Computer Science 3342 (Organization of Programming Languages)

R5 at least two courses among the following List II:

1. Computer Science 3305 (Operating Systems)
2. Computer Science 3350 (Computer Architecture)

If an applicant to the PhD program, who does not hold a MSc degree in Computer Science from a reputable university, and who does meet the above requirements R2, R3, R4 and R5, may still be considered for admission:

- if admitted to the PhD program, this student would be required to take undergraduate courses in order to satisfy requirements R2, R3, R4 and R5;
- moreover, those undergraduate courses would be specified in the offer letter of the applicant;

- taking those undergraduate courses would be in addition to the graduate breadth requirements, as defined in Section 2.2.2.

1.3 Direct Entry into PhD from BSc

Students with an undergraduate degree in Computer Science may apply for admission directly to the PhD program. Successful applicants will have an outstanding academic record, breadth of knowledge in computer science, and strong letters of recommendation.

For those who have a BSc in Computer Science with a very high average and wish to be admitted to the PhD program without having a MSc degree, they can apply to a CS thesis MSc and if they academically prove themselves within the first three terms, they can be offered to transfer to a CS PhD program without completing their MSc degree. If this request is approved by their supervisor and the Graduate Executive Committee, all credits collected during the MSc program will be automatically transferred toward the PhD degree.

1.4 English requirements

If your mother tongue is not English and you have not attended a university or college in a country whose official language is English, then you must take TOEFL and achieve a score of at least 92 with a minimum score of 20 in each section. The TOEFL test date must be within two years of the first term of registration at The University of Western Ontario. We also accept the results of the following tests as proof of proficiency in English.

The International English Language Testing System (IELTS) of the British Council; (the minimum acceptable score is 6.5 out of 9 – with a minimum score of 6 in each section.) The Michigan English Language Assessment Battery (MELAB) of the University of Michigan; (students must have at least 80 on each of the sections and an overall score of at least 85). The Canadian Academic English Language (CAEL) Assessment; (the minimum acceptable score is 60 out of 100)

You should arrange for the testing agency to send us an original copy of your score. Western‘s TOEFL identifier is 0984. Permanent residents may be required to submit proof of proficiency in English.

2 Degree requirements

On enrolment in the PhD program, the student and their supervisor will determine an appropriate course of study. If necessary, and in order to complete the undergraduate breadth requirement, the student will be required to take a number of undergraduate courses, as Specified in Section 1.2; those courses must be completed during your first two years in the program.

2.1 PhD advisory committee

The Advisory Committee should be appointed as soon as possible within a maximum of one year after registration and must consist of a minimum of three members including the supervisor. The student should be consulted on the composition of the Committee. The student's supervisor acts as Chairperson of the Committee. All members of the Advisory Committee must be members of the School of Graduate and Postdoctoral Studies and must be approved by the Graduate Chair. Changes to the Advisory Committee require approval by the Graduate Chair.

The Advisory Committee reviews the student's progress until graduation and should be available for research/thesis advice.

2.2 Breadth requirement

Breadth requirement refers to a body of knowledge about a broad range of topics that are usually taught

- at an undergraduate level in a Computer Science program, and
- at a graduate level in the form of courses introducing students to a research/technology area.

There are several goals in having a breadth requirement for a PhD student. These include the following:

(a) Ensure that the student is adequately prepared to take graduate courses on advanced topics in Computer Science.
(b) Ensure that the student has basic knowledge that is likely to be useful for their PhD research or post-PhD research.
(c) Ensure that the students can communicate with other computer scientists using a common vocabulary.
(d) Ensure that the student can teach a broad range of courses if and when they become a faculty member in a computer science department.
(e) Ensure that the student's training reflects well on the Computer Science department at the University of Western Ontario.
(f) Ensure that the student has a basic knowledge of computer science that is inherently good to have, and/or is a requirement for being able to call oneself a computer scientist.

With regard to (b), we recognize that a student might not use all the breadth requirements in their PhD research. However, we also recognize that it is unpredictable what aspects of the breadth requirement they will need. The goal is to choose a set of topics that is likely to include topics that they need to know about for their research and future career . The proposed breadth requirement consists of two components, one undergraduate, see Section 2.2.1 and one graduate, see Section, see Section 2.2.2.

2.2.1 Undergraduate breadth requirement

1. Knowledge equivalent to CS 3331, i.e. discrete mathematics and automata theory. Topics include sets, functions, relations, proof techniques, finite automata, regular languages, context-free grammars, Turing machines, undecidability.
2. Knowledge equivalent to CS 3340, i.e., algorithm analysis and complexity theory. Topics include big O notation, recurrence relations, algorithm design techniques, searching and sorting, trees, string matching and NP-completeness.
3. Knowledge equivalent to EITHER:
   (a) CS 3307, i.e., object-oriented analysis and design;
   (b) CS 3342, i.e., programming languages.
   Topics in these courses include programming in OO programming languages, development of large software systems, the Unified Modelling Language, type systems for programming languages, paradigms of programming and principles of compilers and interpreters.
4. Knowledge equivalent to EITHER:
   (a) CS 3305, i.e. operating systems
   (b) CS 3350, i.e. computer architecture
   Topics in these courses include process scheduling, mutual exclusion, synchronization and concurrency, virtual memory, memory addresses, deadlock, file systems, Boolean functions, combinational circuits, caching, multicore CPUs, I/O handling, assemblers, stacks.

2.2.2 Graduate breadth requirement

A student meets the graduate breadth requirement by taking a number of advanced courses in a broad range of categories and areas. The courses used must all have a minimum mark of 70% (or equivalent). A student must have

- at least one course in four of the twelve areas,
- including at least one area from each category.

Categories and areas for breadth requirement: The graduate breadth requirement divides the subject matters of computer science into three broad categories:

1. Mathematics of Computing,
2. Computing Technology,
3. Applications.

To specify our three categories, we use the terminology of the ACM Computing Classification System. Our first category includes both ACM branches of *Theory of Computation* and *Mathematics of Computing*. Our second category includes the ACM branches of *Computing Methodologies*, *Hardware*, *Computer System Organization*, *Networks*, *Software and its engineering*, *Information Systems* and *Security and Privacy*. We note that in the ACM classification, *Artificial Intelligence* is under Computing Methodologies. Our third category includes the ACM branches of *Human-Centered Computing*.

Applied Computing, and *Social and Professional topics*. Each category is subdivided into areas that represent a range of fields of computer science. The table below shows the areas covered by the graduate courses offered in the academic years 2019-2020 and 2020-2021. The following principles should be followed in updating this table.

1. On a yearly basis, before the beginning of the Fall Term, the Graduate Executive Committee should update and approve that table, based on the graduate course offering in the commencing academic year.
2. This table should be discussed every year by the Faculty members of the Computer Science Department during the Summer Term.
3. While we do not specify any formulas here, it is intended that every academic year, each of the three categories is represented by several areas and several courses.
4. Each graduate course may be listed in one or two areas, possibly in different categories.
5. Graduate courses, from other departments, in areas that are related to Computer Science, may be listed in one area.

Category	Area	Courses
Mathematics of Computing	Algorithms and Complexity	Internet Algorithmics (CS 9668/4438) Analysis of Algorithms II (CS9554)
	Data science	Intro to Data Science (CS 9637/4414) Analysis of High Dimensional Noisy Data (CS9878) Theoretical Machine Learning (CS 9875) Unstructured Data (CS 9647/4417)
	Scientific Computing	Algorithmic Properties of Polynomial Rings (CS 9867)
Computing Technology	Software Engineering	Software Design and Architecture (CS 9549/4471) Software Engineering for Big Data Applications and Ana Software Eng Topics in Cyber-Physical Systems (CS983
	Hardware and Software Systems	Computer Networks II (CS 9657/4457) Distributed and Parallel Systems (CS9635/4402A)
	Artificial Intelligence	Machine Learning (CS 9860) AI Ethics (CS 9147) Artificial Intelligence II (CS 9542/4442) Brain Inspired Artifical Intelligence (CS9873)
Applications	Gaming	Game Design (CS 9541/4483) Game Engine Development (CS 9511/4482)
	HCI	Human Computer Interaction Information Visualization (CS 9639)
	Graphics and vision	Intro. To Computer Vision Techniques (9645) Image compression (CS4481/9628)
	Databases	Databases II (cs 9538/4411)
	Bioinformatics	Topics in BioInformatics (CS 9832) Research Topics in Genomics and Proteomics (CS9877/4
	Health informatics	Topics in Health Informatics (CS 9855)

2.3 In-depth study

2.3.1 Overview

A PhD Research Topics Survey/Proposal (which we will refer to as TSP for short) is proposed to evaluate a student's proficiency in understanding important research. The intention is that this evaluation be done at a relatively early point in their degree.

Each student must pass the TSP. The purpose of the TSP is to test the student's ability to master a particular research area as well as to demonstrate the ability to provide critical analysis of research papers and to generate new ideas. The student must produce a paper that consists of two parts:

- **Literature review:** The paper shall demonstrate a deep understanding of the relevant literature for a research topic through an organization of existing concepts.
- **Research proposal:** The paper shall identify one or more research directions and/or suggest new approaches to solving problems that could potentially result in significant research contributions.

Objectives: There are several objectives to be achieved:

1. To allow the Advisory Committee to guide the research with helpful suggestions;
2. To ensure that the student has considered important background material;
3. To ensure that the student understands and is able to present a description of a problem based on their understanding of the state-of-the art and its significance.

2.3.2 Tme-line of the TSP

The paper shall be submitted before the last day of the term (as stated in the Academic Calendar) corresponding to student's fourth term of enrolment as a PhD student. The examination shall occur no later than the sixth week of the student's fifth term of enrolment as a PhD student. Extensions can be given due to extenuating circumstances. If the student fails to successfully defend the proposal by the end of the sixth term and has NOT BEEN GRANTED an extension by GEC then the candidate will be asked to withdraw from the PhD program. If the candidate was fast tracked from the MSc program into the PhD program, then the paper should be submitted before the last day of the term corresponding to the student's second term of enrolment and the candidate must successfully defend the proposal by the end of the fourth term.

Once the TSP is submitted, the candidate or his/her supervisor will send to the graduate chair the names of two internal examiners. These examiners will evaluate the TSP and examine the candidate. They may also suggest possible research directions. In most of the cases, it is expected that these examiners will serve on the PhD Thesis Examination Board as well. The examination shall occur no later than the sixth week of the student's fifth term of enrolment as a PhD student.

2.3.3 Consequence in case of non-compliance with the time-line

The following describes actions taken by the Graduate Executive Committee or the Graduate Chair when the student does not comply to the rules stated in Section 2.3.2.

1. At the beginning of the fourth term a reminder will be sent to those candidates, and their supervisors, who have not yet submitted their TSP to advise them that the TSP should be submitted during that term.
2. If a candidate does not submit his/her TSP by the end of the fourth term, a strong warning letter from the graduate chair will be sent to the candidate with a copy to the supervisor at the beginning of term number 5. The candidate will be notified that if he/she does not submit the TSP by the end of term number 5, he/she might be asked to withdraw from the program.
3. If the candidate fails to submit the proposal by the end of term number 5, he/she will not be able to register in term number 6, until he/she meets with the graduate chair and the supervisor. In this meeting, a strict plan should be put in place to have the candidate finish the TSP by the end of term number 6. Also in this meeting, the candidate will be officially informed that he/she will not receive any funds from the department after the end of his/her funding period. The only potential funding, if any, is from the supervisor(s).
4. If the candidate fails to follow the plan and consequently fails to submit the TSP by the end of term number 6, the case will be forwarded to the GEC. If the student IS NOT GRANTED an extension by GEC then the candidate will be asked to withdraw from the PhD program.

2.3.4 Evaluation procedure of the TSP

Submission. The written TSP should normally be made available to the examiners at least three weeks before the examination. Each examiner must independently and without consultation decide whether the TSP meets the Department's scholarly standards in form and content. This evaluation is recorded on the "Evaluation of PhD Research Topics Survey/Proposal" form. The completed "Evaluation of PhD Research Topics Survey/Proposal" forms are confidential to the Graduate Chair. The Graduate Program must receive the completed forms from all the Examiners at least two working days before the date scheduled for the candidate's TSP Examination.

If the TSP submission is judged acceptable. Both examiners must judge that both the TSP content and form are acceptable to allow the oral examination to proceed. An examiner's preliminary judgment of acceptability is provisional. It does not preclude the examiner from changing his/her judgment to finding the TSP unacceptable at the TSP examination.

If the TSP submission is judged unacceptable. If at least one examiner judges the TSP to be unacceptable in both content and form, the Graduate Chair will review the case and decides whether or not to allow the candidate to prepare a revised version of the TSP and, if so, the time limit for doing so. The Graduate Chair provides the supervisor(s) and student written notification of the decision and the changes suggested by the examiners. Normally the same examiners assess the re-submitted

TSP. If the resubmitted TSP is judged unacceptable the case will be forwarded to the GEC, with a recommendation from the supervisor to decide the fate of the candidate.

Examination. The examination consists of a public presentation of approximately 30-minutes by the candidate, that is then followed by an in camera oral examination of the candidate's proposal and of the proposed research area where the examiners:

- Appraise the TSP's content, including its underlying assumptions, methodology, potential findings, and significance of the potential findings.
- Appraise the TSP's form, including its organization, presentation of graphs, tables, and illustrative materials, and its use of accepted conventions for addressing the scholarly literature.
- Evaluate the candidate's skill and knowledge in presenting an overview of their research field and research proposal, responding to questions and defending the research proposal.
- Ensure authenticity of authorship.

Determination of the outcome. A TSP, that would require only minor revisions in order to meet the Department's scholarly standards in form and content, would be judged acceptable. Minor revisions would include typographical or grammatical errors, errors in calculations, labels for tables, nomenclature, and bibliographic form, and the need for minor clarifications of content. Implementing those minor revisions would not be required. A TSP that requires major revisions in form and or content before it can meet requisite scholarly standards must be judged unacceptable. Major revisions include, for example, faulty conceptualization, inappropriate or faulty use of research methodology, misinterpretation or misuse of data, neglect of relevant material, illogical argument, unfounded conclusions, seriously flawed writing and presentation, and failure to engage the scholarly context. The need for the rewriting of substantial portions of the TSP to make it acceptable cannot be construed as minor. As a rule of thumb, revisions requiring more than two weeks to complete cannot be construed as minor.

Outcome. If both examiners find that the TSP and the oral defence are acceptable, the candidate passes the TSP examination. The examiners might make such suggestions to the candidate such as that the candidate needs to take some particular courses to improve their background on a specific field of relevance for the candidate's research work. If at least one examiner rejects the TSP, a written report will be prepared by both examiners to highlight the concerns and to suggest directions to make the TSP acceptable. While the candidate will not be informed of which examiner rejected the TSP, he/she will be given a copy of the examiners' report. After revising the TSP, the candidate will be given another chance to re-take the exam. In this second chance, the two examiners must accept the TSP. If not, the case will be forwarded to the GEC, with a recommendation from the supervisor to decide the fate of the candidate. These new rules will be applied to all PhD candidates. However, exceptions will be made to those who started their PhD program before September 2021. Exceptions to these rules must be decided by the Graduate Executive Committee.

2.4 Yearly Seminar (692)

Each PhD candidate must present at least TWO publicly announced seminars, at least one in the third year and at least one in the fourth year of their program. Presenting a paper in a conference can be counted as a seminar Presentation in a course, proposal presentation, and PhD defence presentation, will not be counted toward the yearly seminar requirement.

2.5 PhD Thesis

Thesis preparation and format, public lecture requirements and the procedure for examining the candidate and the thesis are covered in the School of Graduate and Postdoctoral Studies Thesis Regulation Guide.