UNIVERSITY OF ONTARIO INSTITUTE OF TECHNOLOGY

**Faculty of Science**

# CSCI 4060U: Massively Parallel Programming

Course outline for Winter 2019

## 1. Course Details & Important Dates*

| Term | Course Type | Day | Time | Location |
|---|---|---|---|---|
| Winter | Lecture | Tuesdays | 2:10pm-3:30pm | UB2050 |
| Winter | Lecture | Fridays | 2:10pm-3:30pm | UB2050 |
| Winter | Lab #1 | Tuesdays | 9:40am-11:00am | UA2460 |
| Winter | Lab #2 | Thursdays | 9:40am-11:00am | UA2460 |

* for other important dates go to: www.uoit.ca >Current Students >Important Dates and Deadlines

## 2. Instructor Contact Information

| Instructor Name | Office | Email |
|---|---|---|
| Jeremy Bradbury | UA4016 | jeremy.bradbury@uoit.ca |
| Office Hours: Tuesdays 1:00pm-2:00pm, Fridays 11:00am-12:00pm or by appointment. | | |

| Laboratory/Teaching Assistant Name | Email |
|---|---|
| Taylor Smith | taylor.smith@uoit.ca |
| Office Hours: during laboratories, or by appointment. | |

## 3. Course Description

**CSCI 4060U: Massively Parallel Programming.** An advanced undergraduate course on programming for multicore and many-core systems. Programming approaches for systems with multiple central processing units (CPUs) will include programming with preprocessor directives (e.g., OpenMP), threads and actors. Programming approaches for systems with many graphical processing units (GPUs) will include programming with task and data parallelism (e.g., OpenCL, CUDA). This course will also discuss challenges in parallel programming including optimization and debugging. 3cr, 3 lec, 1.5 lab. Prerequisite: CSCI 3070U.

## 4. Learning Outcomes

On the successful completion of the course, students will be able to:

1. Understand of the challenges of programming with multicore, many-core and massively parallel computer systems.
2. Develop applied knowledge of multicore programming approaches, strategies and design patterns.
3. Develop applied knowledge of many-core programming approaches, strategies and design patterns.
4. Understand how to debug multicore and many-core source code.

## 5. Course Design

This course will consist of two weekly lectures and a weekly laboratory. Students will be required to complete three tests during the semester, which will cover material from the lectures, laboratories and course readings. Students will be expected to attend all the lectures and complete required readings. In addition to the tests and laboratories, students must complete a final project demonstrating knowledge of parallel programming.

## 6. Outline of Topics in the Course

Introduction (1 week)

- Overview of shared memory vs. distributed memory processing
- Overview of CPU & GPU hardware
- Overview of the challenges of parallel computation
- Approaches to parallel programming – preprocessor directives, threads, actors

OpenMP Programming (3 weeks)

- Introduction to preprocessor directives and OpenMP (in C++)
- OpenMP Memory Model
- Sharing work between threads (e.g., loop, sections and workshare constructs)
- Controlling work-sharing constructs (e.g., shared and private clauses)
- Synchronization (e.g., atomic construct, locks)

Thread Programming (3 weeks)

- Explicit vs implicit threading
- Introduction to programming with threads (C++ POSIX threads)
- Managing threads (e.g., creation)
- Mutex variables (locking, unlocking)
- Conditional variables
- Debugging

OpenCL Programming (3 weeks)

- Introduction to task and data parallelism in OpenCL
- OpenCL Programming Model
- The anatomy of an OpenCL program (kernel, host)
- Working with data in OpenCL – dividing up your data, sending data to and getting results from the kernel
- Debugging

Heterogeneous Computing (1 week)

- Looking at the future of multicore and many-core programming and exploring how we can leverage both the CPU and GPU together.

## 7. Required Texts/Readings

Online Resources.

- Online articles and websites will be used. Links to all online resources will be posted on the course website.

*Additional readings may be assigned or recommended during the course.*

## 8. Evaluation Method

- Tests (3) – 40%
- Laboratories – 40%
- Final Project – 20%

*Final course grades may be adjusted to conform to program or Faculty grade distribution profiles. Further information on grading can be found in Section 5 of the UOIT Academic Calendar.*

## 9. Assignments and Tests

The schedule for tests is as follows:

- Test #1 – late January 2019
- Test #2 – early March 2019
- Test #3 – April 2019

The policy for missed tests and assignments is available at http://www.science.uoit.ca/undergraduate/current-students/academic-policies.php.

## 10. Students with Disabilities

Accommodating students with disabilities at UOIT is a responsibility shared among various partners: the students themselves, SAS staff and faculty members. To ensure that disability-related concerns are properly addressed during this course, students with documented disabilities and who may require assistance to participate in this class are encouraged to speak with me as soon as possible. **Students who suspect they have a disability that may affect their participation in this course are advised to go to Student Accessibility Services (SAS) as soon as possible.** Maintaining communication and working collaboratively with SAS and faculty members will ensure you have the greatest chance of academic success.

Students taking courses on the North Campus Location can visit Student Accessibility Services in the U5 Building located in the Student Life Suite. Students taking courses on the Downtown Oshawa Campus Location can visit Student Accessibility Services in the 61 Charles St. Building, 2nd Floor, Room DTA 225 in the Student Life Suite.

Disability-related support and accommodation support is available for students with mental health, physical, mobility, sensory, medical, cognitive, learning challenges, as well as students with temporary disabilities (concussion, broken arm/hand/fingers, etc.). Office hours are 8:30am-4:30pm, Mon-Fri. For more information on services provided, you can visit the SAS website at http://uoit.ca/studentaccessibility

Students may contact Student Accessibility Services by calling 905-721-3266, or email studentaccessibility@uoit.ca

Students who require the use of the Test Centre to write tests, midterms, or quizzes MUST register online using the SAS test/exam sign-up module, found here www.uoit.ca/SASexams. Students must sign up for tests, midterms or quizzes AT LEAST seven (7) days before the date of the test.
Students must register for final exams by the registration deadline, which is typically 3 weeks prior to the start of the final examination period. SAS will notify students of the registration deadline date.

## 11. Professional Conduct (if applicable)

Not applicable.

## 12. Academic Integrity

Students and faculty at UOIT share an important responsibility to maintain the integrity of the teaching and learning relationship. This relationship is characterized by honesty, fairness and mutual respect for the aim and principles of the pursuit of education. Academic misconduct impedes the activities of the university community and is punishable by appropriate disciplinary action.

Students are expected to be familiar with and abide by UOIT's regulations on Academic Conduct (Section 5.15 of the Academic Calendar) which sets out the kinds of actions that constitute academic misconduct, including plagiarism, copying or allowing one's own work to copied, use of unauthorized aids in examinations and tests, submitting work prepared in collaboration with another student when such collaboration has not been authorized, among other academic offences. The regulations also describe the procedures for dealing with allegations, and the sanctions for any finding of academic misconduct, which can range from a resubmission of work to a failing grade to permanent expulsion from the university. A lack of familiarity with UOIT's regulations on academic conduct does not constitute a defense against its application.

Further information about academic misconduct can be found in the Academic Integrity link on your laptop. Extra support services are available to all UOIT students in academic development, study skills, counseling, and peer mentorship. More information on student support services can be found in the Academic Calendar (Section 8).

## 13. Turnitin (if applicable)

UOIT and faculty members reserve the right to use electronic means to detect and help prevent plagiarism. Students agree that by taking this course all assignments are subject to submission for textual similarity review by Turnitin.com. Assignments submitted to Turnitin.com will be included as source documents in Turnitin.com's restricted access database solely for the purpose of detecting plagiarism in such documents for five academic years. The instructor may require students to submit their assignments electronically to Turnitin.com or the instructor may submit questionable text on behalf of a student. The terms that apply to UOIT's use of the Turnitin.com service are described on the Turnitin.com website.

Students who do not wish to have their work submitted to Turnitin.com must provide with their assignment at the time of submission to the instructor a signed Turnitin.com Assignment Cover sheet:
http://www.uoit.ca/assets/Academic~Integrity~Site/Forms/Assignment%20Cover%20sheet.pdf

Further information about Turnitin can be found on the Academic Integrity link on your laptop.

## 14. Final Examinations (if applicable)

Final examinations are held during the final examination period at the end of the semester and may take place in a different room and on a different day from the regularly scheduled class. Check the published Examination Schedule for a complete list of days and times.

Students are advised to obtain their Student ID Card well in advance of the examination period as they will not be able to write their examinations without it. Student ID cards can be obtained at the Campus ID Services, in G1004 in the Campus Recreation and Wellness Centre.

Students who are unable to write a final examination when scheduled due to religious publications may make arrangements to write a deferred examination. These students are required to submit a Request for Accommodation for Religious Obligations to the Faculty concerned as soon as possible and no later than three week prior to the first day of the final examination period.

Further information on final examinations can be found in Section 5.24 of the Academic Calendar.

## 15. Freedom of Information and Protection of Privacy Act

The following is an important notice regarding the process for submitting course assignments, quizzes and other evaluative material in your courses in the Faculty of Science.

As you may know, UOIT is governed by the *Freedom of Information and Protection of Privacy Act* ("FIPPA"). In addition to providing a mechanism for requesting records held by the university, this legislation also requires that UOIT not disclose the personal information of its students without their consent.

FIPPA's definition of "personal information" includes, among other things, documents that contain both your name and your Banner ID. For example, this could include graded test papers or assignments. To ensure that your rights to privacy are protected, the Faculty of [Insert Faculty name] encourages you to use only your Banner ID on assignments or test papers being submitted for grading. This policy is intended to prevent the inadvertent disclosure of your information where graded papers are returned to groups of students at the same time. If you still wish to write both your name and your Banner ID on your tests and assignments, please be advised that UOIT will interpret this as an implied consent to the disclosure of your personal information in the normal course of returning graded materials to students.

If you have any questions or concerns relating to the new policy or the issue of implied consent addressed above, please contact accessandprivacy@uoit.ca

## 16. Course Evaluations

Student evaluation of teaching is a highly valued and helpful mechanism for monitoring the quality of UOIT's programs and instructional effectiveness. To that end, course evaluations are administered by an external company in an online, anonymous process during the last few weeks of classes. Students are encouraged to participate actively in this process and will be notified of the dates. Notifications about course evaluations will be sent via e-mail, and posted on Blackboard, Weekly News and signage around the campus.