Department of Computer Science
176 Thorvaldson Building
110 Science Place, Saskatoon, SK, S7N 5C9, Canada
Telephone: (306) 966-4886, Facsimile: (306) 966-4884

CMPT 851-01
Winter 2020–2021

UNIVERSITY OF SASKATCHEWAN

COURSE SYLLABUS
CMPT 851: PARALLEL PROGRAMMING FOR SCIENTIFIC COMPUTING

Catalogue Description

Parallel programming paradigms and algorithms for shared and distributed memory computer architectures; performance analysis; use of shared infrastructure; applications in scientific computing (e.g., linear systems, differential equations, optimization, quadrature).

Prerequisite(s):	Instructor permission (numerical analysis background desirable)
Class Time and Location:	Tue / Thu 1:00 p.m. – 2:20 p.m., via WebEx
Website:	Canvas on PAWS

Instructor Information

Instructor	Raymond J. Spiteri
Contact:	Email: mailto:spiteri@cs.usask.ca
	Office Phone: (306)-966-2909
Office Hours:	Location: virtual
	Times: by appointment

Course Objectives

Despite the extraordinary advances in computing technology, we continue to need ever greater computing power to address important fundamental scientific questions. Because individual compute processors have essentially reached their performance limits, the need for greater computing power can only be met through the use of parallel computers. This course is intended for students who are interested in learning how to take advantage of high-performance computing with the focus of writing parallel code for processor-intensive applications to be run on local clusters, the cloud, or shared infrastructure such as that provided by Compute Canada. Extensive use of pertinent and practical examples from scientific computing will be made throughout. The course material will be mainly presented in C/C++, but students are free to use other programming languages including Julia, Matlab, Maple, sage, python, and Fortran. Various paradigms of parallel computing will be covered via the MPI, OpenMP, and CUDA/OpenCL libraries.

Learning Outcomes

By the end of the course, students will be expected to be able to correctly solve non-trivial problems involving parallel programming as well as appreciate the issues involved in solving such problems.

Student Evaluation

Intangibles may be considered in the determination of your grade.

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Grading Scheme

Item	Description	Weighting
Class Contribution		10%
Assignments	4, every 2–3 weeks; 5% each	20%
Course Project		50%
Midterm Examination	(Thu Apr 01, 2021; in class)	20%
	Total	100%

Criteria That Must Be Met To Pass Course

Attendence Expectation

Students are expected to attend class at the scheduled meeting times. The class contribution grade assigned is necessarily linked to attendance.

The "Class Contribution" portion of your grade will be calculated according to the following guidelines:

- excellent (mid-80s–100): Contributed frequently and insightfully; demonstrated critical understanding of readings/videos; showed awareness of how readings/videos relate to each other and to overarching themes; interacted with other students and built on their comments.

- good (70–low 80s): Contributed regularly; grasped main points of readings/videos; showed awareness of interrelationships between readings/videos and themes or interacted with other students.

- adequate (50s–69): Contributed occasionally; demonstrated partial understanding of readings/videos; some comments unconnected to main subject or restatements of those offered by other students.

- substandard (0–49): Remained silent or contributed minimally; demonstrated little or no understanding of readings/videos; made irrelevant or erroneous comments; absent without excuse.

Course Project

An important part of the course is a project on a topic of your choice that is closely related to the course material. Examples of eligible projects include review papers, tutorials, and software. Projects are required to have final written reports of at least 20 pages. Use of LaTeX is required.

Grading Scheme for Course Project

Interim presentation (Tue Mar 23, 2021)	5%
Interim progress report (Tue Mar 30, 2021)	5%
Final presentation (Tue Apr 06, 2021)	10%
Final report (Tue Apr 20, 2021)	30%
Total	50%

Note: All students must be properly registered in order to attend lectures and receive credit for this course.

Textbook Information

Required Text

- D.L. Chopp, Introduction to High Performance Scientific Computing, Society for Industrial and Applied Mathematics, 2019.

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Lecture Schedule

Topic	Subtopics
Tools of the Trade (2 weeks)	• editors, compilers, makefiles, shell scripts • debuggers, profilers • version control
Elementary programming (2 weeks)	• programming patterns, containers, and data types • input/output, flow control • functions, libraries • projects
High-performance hardware (1 week)	• current and near-future high-performance computing hardware • abstractions of computing environments
Distributed Programming (2 weeks)	• preliminaries, passing messages • groups and communicators, measuring efficiency, checkpointing • MPI libraries • projects
Shared Memory Programming (3 weeks)	• introduction, threads, subdividing for loops • serial tasks inside parallel regions, distinct tasks in parallel • critical and atomic code, OpenMP libraries • GPU Programming and CUDA/OpenCL • GPU memory, command queues, work-groups • CUDA/OpenCL libraries • projects
High-performance input/output (1 week)	• portable, hierarchical binary file types
Applications, use of numerical libraries (1 week)	• stochastic differential equations • finite difference methods • iterative solution of elliptic equations • pseudospectral methods

Course Policies

Recording of Lectures

All lectures will be recorded and made available to those officially registered in the course.

Copyright

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Late Assignments

Late assignments are subject to a penalty of 10% of the maximum mark for up to 24 hours late and 20% of the maximum mark for up to 48 hours late.
Assignments that are more than 48 hours late are not accepted without valid justification.

Missed Assignments

Missed assignments will be given the mark of 0 unless there is valid justification.

Grading Concerns

Please contact the marker regarding any assignment marking concerns, with a cc to the instructor. Should you continue to have concerns, please escalate to the instructor. Please note that should your concern be a comparison with another's work, both must be submitted for regrading: we reserve the right to re-grade your work and the other's work. Furthermore, the instructor will re-grade the entire work, not just selected portions.

Other Policies

Missed Examinations

1. *Midterm exams.* Students who have missed a midterm exam must contact their instructor as soon as possible. Arrangements to make up the exam may be arranged with the instructor. Missed midterm exams throughout the year are left up to the discretion of the instructor if a student may make up the exam or write at a different time. If a student knows prior to the midterm exam that she/he will not be able to attend, they should let the instructor know before the midterm exam.

2. *Final exams.* Final examinations may be scheduled at any time during the examination period; students should therefore avoid making prior travel, employment, or other commitments for this period. A student who is absent from a final examination through no fault of his or her own, for medical or other valid reasons, may apply to the College of Arts and Science Dean's office. The application must be made within three days of the missed examination along with supporting documentary evidence. Deferred exams are written during the February mid-term break for Term 1 courses and in early June for Term 2 and full year courses. http://students.usask.ca/academics/exams.php

Incomplete Course Work and Final Grades

beginquote *When a student has not completed the required course work, which includes any assignment or examination including the final examination, by the time of submission of the final grades, they may be granted an extension to permit completion of an assignment, or granted a deferred examination in the case of absence from a final examination.*

Extensions past the final examination date for the completion of assignments must be approved by the Department Head, or Dean in non-departmentalized Colleges, and may exceed thirty days only in unusual circumstances. The student must apply to the instructor for such an extension and furnish satisfactory reasons for the deficiency. Deferred final examinations are granted as per College policy.

In the interim, the instructor will submit a computed percentile grade for the class which factors in the incomplete coursework as a zero, along with a grade comment of INF (Incomplete Failure) if a failing grade.

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In the case where the student has a passing percentile grade but the instructor has indicated in the course outline that failure to complete the required coursework will result in failure in the course, a final grade of 49% will be submitted along with a grade comment of INF (Incomplete Failure).

If an extension is granted and the required assignment is submitted within the allotted time, or if a deferred examination is granted and written in the case of absence from the final examination, the instructor will submit a revised assigned final percentage grade. The grade change will replace the previous grade and any grade comment of INF (Incomplete Failure) will be removed.

A student can pass a course on the basis of work completed in the course provided that any incomplete course work has not been deemed mandatory by the instructor in the course outline and/or by College regulations for achieving a passing grade. http://policies.usask.ca/policies/academic-affairs/academic-courses.php

For policies governing examinations and grading, students are referred to the **Assessment of Students** section of the University policy *Academic courses: class delivery, examinations, and assessment of student learning*, http://policies.usask.ca/policies/academic-affairs/academic-courses.php.

Academic Integrity

The University of Saskatchewan is committed to the highest standards of academic integrity and honesty. Students are expected to be familiar with these standards regarding academic honesty and to uphold the policies of the University in this respect. Students are particularly urged to familiarize themselves with the provisions of the **Student Conduct & Appeals** section of the University Secretary Website and avoid any behaviour that could potentially result in suspicions of cheating, plagiarism, misrepresentation of facts and/or participation in an offence. Academic dishonesty is a serious offence and can result in suspension or expulsion from the University.

All students should read and be familiar with the *Regulations on Academic Student Misconduct*, http://www.usask.ca/secretariat/student-conduct-appeals/StudentAcademicMisconduct.pdf, as well as the *Standard of Student Conduct in Non-Academic Matters and Procedures for Resolution of Complaints and Appeals*, http://www.usask.ca/secretariat/student-conduct-appeals/StudentNon-AcademicMisconduct.pdf.

For more information on what academic integrity means for students see the **Student Conduct & Appeals** section of the University Secretary Website at: http://www.usask.ca/university_secretary/pdf/dishonesty_info_sheet.pdf

You are encouraged to complete the Academic Integrity Tutorial to understand the fundamental values of academic integrity and how to be a responsible scholar and member of the USask community: https://library.usask.ca/academic-integrity.php#AcademicIntegrityTutorial.

Collaboration Policy

You may neither possess work from other students (including those not enrolled in this course) nor share your work (rough drafts, finished answers, or graded assignments) with another student at any time during the course. Study groups and group discussion are encouraged, but if you plan to employ these then you must adhere to a *no-recording* policy:

> Collaboratively, you may discuss and sketch on a non-permanent surface (e.g. white board), but no written-on-paper and no typed-into-computer activities are allowed. Every student must leave the discussion without a record (no written notes or document, no computer file, no photograph, and no audio/video recording) and must reproduce the result from their own memory. The impermanent surface must be erased.

Offering another's work as your own is academic misconduct, as above. But, one student's possession of other students' work (even after the due date) is also *prima facia* evidence of academic misconduct on the part of both students, even if one is not registered in this class.

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System Outages

System (canvas, labs, network) outages of 6 hours or longer, in the 24 hours before a deadline, automatically grant a 24-hour extension. Shorter outages, even if they overlap with a deadline, do not. Most systems allow resubmission, students are counselled to submit early, and submit regularly as progress is made.

Examinations with Access and Equity Services (aes)

Students who have disabilities (learning, medical, physical, or mental health) are strongly encouraged to register with Access and Equity Services (aes) if they have not already done so. Students who suspect they may have disabilities should contact aes for advice and referrals at any time. Those students who are registered with aes with mental health disabilities and who anticipate that they may have responses to certain course materials or topics, should discuss course content with their instructors prior to course add / drop dates. In order to access aes programs and supports, students must follow aes policy and procedures. For more information or advice, visit https://students.usask.ca/health/centres/access-equity-services.php, or contact aes at 306-966-7273 or mailto:aes@usask.ca.

Students registered with aes may request alternative arrangements for mid-term and final examinations. Students must arrange such accommodations through aes by the stated deadlines. Instructors shall provide the examinations for students who are being accommodated by the deadlines established by aes.

Student Supports

Student Learning Services (sls) offers assistance to U of S undergrad and graduate students. For information on specific services, please see the sls web site https://library.usask.ca/studentlearning/.

Teaching, Learning, and Student Experience

The Teaching, Learning and Student Experience unit (tlse) focuses on providing developmental and support services and programs to students and the university community. For more information, see the sesd web site https://students.usask.ca.

Financial Support

Any student who faces challenges securing their food or housing and believes this may affect their performance in the course is urged to contact Student Central (https://students.usask.ca/student-central.php).

Aboriginal Students' Centre

The Aboriginal Students' Centre (asc) is dedicated to supporting Aboriginal student academic and personal success. The centre offers personal, social, cultural and some academic supports to Métis, First Nations, and Inuit students. The centre is also dedicated to intercultural education, bringing Aboriginal and non-Aboriginal students together to learn from, with, and about one another in a respectful, inclusive, and safe environment. Students are encouraged to visit the asc Facebook page to learn more: https://www.facebook.com/aboriginalstudentscentre/

International Student and Study Abroad Centre

The International Student and Study Abroad Centre (issac) supports student success in their international education experiences at the U of S and abroad. Issac is here to assist all international undergraduate, graduate, exchange and English as a Second Language students and their families in their transition to the U of S and Saskatoon. Issac offers advising and support on all matters that affect international students and their families and on all matters related to studying abroad. Please visit https://students.usask.ca for more information.

Treaty Acknowledgement

We acknowledge we are on Treaty Six Territory and the Homeland of the Métis. We pay our respect to the First Nation and Métis ancestors of this place and reaffirm our relationship with one another.