COURSE SYLLABUS
CMPT 332: OPERATING SYSTEMS CONCEPTS

Catalogue Description
An introduction to the principles of modern operating systems. The synchronization and communication of cooperating processes. Process Scheduling. Virtual Memory. File System design and organization. Introduction to distributed systems.

Prerequisites: CMPT 280, and CMPT 215 or CME 331.

Note: Students with credit for CMPT 422 may not take this course for credit.

Delivery Mode: In person

Class Time & Location:
Section 01: M W F, 9:30-10:20, Arts 133
Section 03: M W F, 12:30-13:20, Thorv 105

Tutorials:
M, 10:30-11:20, Spinks 320
M, 16:00-16:50, Spinks 320
T, 10:00-10:50, Spinks 320
W, 10:30-11:20, Spinks 320
Th, 11:30-12:20, Spinks 320
Th, 16:00-16:50, Spinks 320

You are free to participate in any tutorial session(s) you wish, regardless of which tutorial section you are registered in. Tutorials will begin the week of September 13th.

Website: Moodle

Instructor Information
Instructor: Derek Eager
Contact: Email: eager@cs.usask.ca
Feel free to email me at any time. I am usually able to respond to emails received during the day (9:00 am to 5:00 pm) on weekdays (Monday to Friday) within a few hours, depending on other commitments. Emails received during the evening may not be responded to until the following morning.

Course Overview and Objectives
The purpose of this course is to provide an understanding of operating system concepts. Although examples will be drawn from various systems, it is not the purpose of this course to provide training in any particular operating system. Students will be expected to read the (free, online) text, and other provided references, and to come to lectures prepared to participate in discussions. The tutorials will cover information not covered in the lectures that is needed for completing the assignments. Assignments will involve C programming, use of Pthreads, and the xv6 teaching operating system. Assignments will be done in self-selected groups of at most two students.

After completing this course, students should be able to:
- Demonstrate and illustrate how application software accesses computer hardware through the abstractions provided by the operating system and how the operating system shares hardware resources.
- Utilize system library functions robustly in the implementation of applications that access operating system facilities.
• Design, implement and document system-level software in a small-team environment.
• Explain the operation of basic operating system resource management mechanisms and policies.
• Describe the use of locks, condition variables, semaphores, and monitors, and how these can be implemented.
• Design algorithms to provide concurrent access to shared resources and implement these algorithms using the C programming language and Pthreads.
• Compare and evaluate options for filesystem implementation.
• Explain time, space and complexity tradeoffs in operating system implementation issues, demonstrating their application with approximate solutions for various resource sharing problems.
• Modify existing system-level source code to add new functionality.

Student Evaluation

There will be 4 equally weighted assignments (likely approximate due dates – beginning of October, mid/late October, third week November, and early December), to be done in self-selected groups of at most two students. Due dates for the assignments are strict – if an extension is required for some special reason (e.g. medical), the instructor must be contacted as soon as feasible. An in-person, in-class midterm exam will be held for each Section during its regularly scheduled lecture time on Friday October 29th. A three-hour in-person final exam will be held during a time slot that will be assigned in the University final exam schedule. The midterm exam and the final exam will be closed book, with no electronic devices permitted.

Grading Scheme

<table>
<thead>
<tr>
<th>Assignment</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assignments (4)</td>
<td>35%</td>
</tr>
<tr>
<td>Midterm Exam</td>
<td>20%</td>
</tr>
<tr>
<td>Final Exam</td>
<td>45%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
</tr>
</tbody>
</table>

Final Exam Scheduling:

The Registrar schedules all final examinations, including deferred and supplemental examinations. Students are advised not to make travel arrangements for the exam period until the official exam schedule has been posted.

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

Textbook Information

Required Text (free online)


Software

A portion of the assignment work for this course will use the teaching operating system xv6. Documentation for xv6 includes a draft text available via: git clone git://github.com/mit-pdos/xv6-riscv-book.git

Lecture Schedule (all timings approximate; indicated readings based on text as of August 2021)

1. Introduction
   What is an operating system, operating system abstractions.
   Readings: Operating Systems: Three Easy Pieces, Chapter 2
2. Processes and CPU Scheduling (2 weeks)  
   Process API, process implementation, CPU scheduling policies.  
   
   Readings: Operating Systems: Three Easy Pieces, Chapter 3-11

3. Address Spaces and Memory Management (2 weeks)  
   Virtual memory systems, memory API, address translation, management policies.  
   
   Readings: Operating Systems: Three Easy Pieces, Chapters 12-24

4. Threads and Concurrency (3 weeks)  
   Thread API, use and implementation of synchronization primitives (locks, condition variables, semaphores, monitors), common concurrency problems.  
   
   Readings: Operating Systems: Three Easy Pieces, Chapter 25-34, Appendix D

5. Communication in Distributed Systems (1 week)  
   Communication basics, introduction to UDP and TCP, sockets API, remote procedure call.  
   

6. I/O and File Systems (2.5 weeks)  
   Interacting with I/O devices, hard disk drives and RAID, disk I/O scheduling, file systems and their implementation, flash-based SSDs, NFS.  
   
   Readings: Operating Systems: Three Easy Pieces, Chapters 35-47, 49, 51

7. Other Topics (1 week, time permitting)  
   Virtual machines, security.  
   

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University of Saskatchewan Grading System (for undergraduate courses)

**Exceptional** (90-100) A superior performance with consistent evidence of  
- a comprehensive, incisive grasp of the subject matter;  
- an ability to make insightful critical evaluation of the material given;  
- an exceptional capacity for original, creative and/or logical thinking;  
- an excellent ability to organize, to analyze, to synthesize, to integrate ideas, and to express thoughts fluently.

**Excellent** (80-90) An excellent performance with strong evidence of  
- a comprehensive grasp of the subject matter;  
- an ability to make sound critical evaluation of the material given;  
- a very good capacity for original, creative and/or logical thinking;  
- an excellent ability to organize, to analyze, to synthesize, to integrate ideas, and to express thoughts fluently.

**Good** (70-79) A good performance with evidence of  
- a substantial knowledge of the subject matter;  
-
• a good understanding of the relevant issues and a good familiarity with the relevant literature and techniques;
• some capacity for original, creative and/or logical thinking;
• a good ability to organize, to analyze and to examine the subject material in a critical and constructive manner.

**Satisfactory** (60-69) A generally satisfactory and intellectually adequate performance with evidence of

• an acceptable basic grasp of the subject material;
• a fair understanding of the relevant issues;
• a general familiarity with the relevant literature and techniques;
• an ability to develop solutions to moderately difficult problems related to the subject material;
• a moderate ability to examine the material in a critical and analytical manner.

**Minimal Pass** (50-59) A barely acceptable performance with evidence of

• a familiarity with the subject material;
• some evidence that analytical skills have been developed;
• some understanding of relevant issues;
• some familiarity with the relevant literature and techniques;
• attempts to solve moderately difficult problems related to the subject material and to examine the material in a critical and analytical manner which are only partially successful.

**Failure** <50 An unacceptable performance

**Important guidelines for this transition term**

During this transition term it is important that we undertake in-person elements of this class safely. In order to do this the university has developed a set of expectations and safety protocols that all students must adhere to if they are to engage in in-person activity.

**Throughout the term:**

- **Protect the pack:** Right now, the impact of student choices and activities when not on campus cannot be separated from time spent on campus. In order to “protect the pack”, the university is asking all students who are doing in-person work to be mindful and do whatever possible to lower the risk that you will contract COVID-19 and bring it onto campus.

- **Know what is required and expected of you:** One of the critical lessons learned in dealing with COVID-19 is knowing that situations can change and we must be flexible and ready to adjust our safety protocols. The university has created a web page where all up-to-date information around returning to campus is listed. **You are responsible for regularly** checking the health and safety guidelines [https://covid19.usask.ca/about/safety.php#Expectations](https://covid19.usask.ca/about/safety.php#Expectations) and knowing what is expected of you throughout the fall term.

- **Follow all guidance:** Students are expected to follow all guidance provided by the University’s Pandemic Recovery/Response Team (PRT), College/Department, professors, lab instructors, TAs, and any other staff member involved in the in-person academic program activities (e.g., Protective Services, Safety Resources).
Key channels of communication: If there is a need for the class to pause meeting in-person for a period of time you will be notified. If this occurs, you will be provided with detailed information on the Moodle course home page on what you will need to do in place of the in-person class sessions.

Policies

Recording of Lectures
Students may record lectures if desired.

Late Assignments
Due dates for assignments are strict – if an extension is required for some special reason (e.g. medical) the instructor must be contacted as soon as possible.

Missed Assignments
Students who do not submit anything for an assignment by the due date (possibly as extended by the instructor) will receive a grade of zero for it.

Missed Examinations
1. Students who miss an exam should contact the instructor as soon as possible. If it is known in advance that an exam will be missed, the instructor should be contacted before the exam.

2. "If a student is absent from a final examination due to an extenuating circumstance, they may be eligible to apply for a deferred exam. Students in the College of Arts and Science must contact the Undergraduate Student Office within three business days of the missed exam to be considered." (http://artsandscience.usask.ca/undergraduate/advising/strategies.php)

Incomplete Course Work and Final Grades
"When a student has not completed the required class 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 percentage grade for the class which factors in the incomplete class work as a zero, along with a grade comment of INF (Incomplete Failure) if a failing grade.

In the case where the student has a passing percentage grade but the instructor has indicated in the class syllabus that failure to complete the required class work will result in failure in the class, 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 class on the basis of work completed in the class provided that any incomplete class work has not been deemed mandatory by the instructor in the class syllabus as per College regulations for achieving a passing grade." (https://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 Policy on Class Delivery, Examinations, and Assessment of Student Learning” (https://policies.usask.ca/policies/academic-affairs/academic-courses.php)

Copyright

Course materials are provided to you based on your registration in a class, and anything created by your professors and instructors is their intellectual property, unless materials are designated as open education resources. This includes exams, PowerPoint/PDF slides and other course notes. Additionally, other copyright-protected materials created by textbook publishers and authors may be provided to you based on license terms and educational exceptions in the Canadian Copyright Act (see http://laws-lois.justice.gc.ca/eng/acts/C-42/index.html).

Before you copy or distribute others’ copyright-protected materials, please ensure that your use of the materials is covered under the University’s Fair Dealing Copyright Guidelines available at https://library.usask.ca/copyright/general-information/fair-dealing-guidelines.php. For example, posting others' copyright-protected materials on the open web is not covered under the University’s Fair Dealing Copyright Guidelines, and doing so requires permission from the copyright holder.

For more information about copyright, please visit https://library.usask.ca/copyright/index.php where there is information for students available at https://library.usask.ca/copyright/students/rights.php, or contact the University's Copyright Coordinator atmailto:copyright.coordinator@usask.ca or 306-9668817.

Integrity

The University of Saskatchewan is committed to the highest standards of academic integrity (https://academic-integrity.usask.ca/). Academic misconduct is a serious matter and can result in grade penalties, suspension, and expulsion. Students are expected to act with academic integrity. Students 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 (tutorial link: https://libguides.usask.ca/AcademicIntegrityTutorial). Students can access campus resources that support development of study skills, time and stress management, and ethical writing practices important for maintaining academic integrity and avoiding academic misconduct.

Students are expected to be familiar with the academic misconduct regulations (https://governance.usask.ca/student-conduct-appeals/academic-misconduct.php#About).

• Definitions appear in Section II of the academic misconduct regulations.
• The academic misconduct regulations apply regardless of type of assessment or presence of supervision during assessment completion.
• Students are advised to ask for clarification as to the specific expectations and rules for assessments in all of their courses.
• Students are urged to avoid any behaviour that could result in suspicions of cheating, plagiarism, misrepresentation of facts. Students should note that posting copyrighted course materials (e.g., notes, questions, assignments or exams) to third party websites or services or other forum or media without permission is an academic or non-academic misconduct offense.

Non-academic offenses are dealt with under the Standard of Student Conduct in Non-Academic Matters and Procedures for Resolution of Complaints and Appeals.

Access and Equity Services (AES) for Students

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 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.

For information on AES services for Fall 2021 please visit:
https://students.usask.ca/health/centres/access-equity-services.php#Fall2021Information

Student Supports

Academic Help for Students

The University Library offers a range of learning and academic support to assist USask undergrad and graduate
students. For information on specific services, please see the Learning page on the Library web site

- Remote learning support information https://students.usask.ca/remote-learning/index.php
- Class and study tips https://students.usask.ca/remote-learning/class-and-study-tips.php
- Remote learning tutorial https://libguides.usask.ca/remote_learning
- Study skills materials for online learning https://libguides.usask.ca/studyskills
- A guide on netiquette, principles to guide respectful online learning interactions
  https://teaching.usask.ca/remote-teaching/netiquette.php

Teaching, Learning and Student Experience

The Teaching, Learning and Student Experience Unit (TLSE) provides developmental and support services and
programs to students and the university community. For more information, see 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).

College Supports

Students in Arts & Science are encouraged to contact the Undergraduate Student Office and/or the Trish
Monture Centre for Success with any questions on how to choose a major; understand program requirements;
choose courses; develop strategies to improve grades; understand university policies and procedures;
overcome personal barriers; initiate pre-career inquiries; and identify career planning resources. Contact
information is available at: (http://artsandscience.usask.ca/undergraduate/advising/)

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’s Facebook page
(https://www.facebook.com/aboriginalstudentscentre/) to learn more.
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.

Land Acknowledgement

As we engage in Remote Teaching and Learning, I would like to acknowledge that the Saskatoon campus of the University of Saskatchewan is 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. I would also like to recognize that some may be attending this course from other traditional Indigenous lands. I ask that you take a moment to make your own Land Acknowledgement to the peoples of those lands. In doing so, we are actively participating in reconciliation as we navigate our time in this course, learning and supporting each other.