Course Objectives

Operating systems exploit the hardware resources of one or more processors to provide a set of services to system users. The operating system also manages secondary memory and I/O devices on behalf of its users. There is a tremendous range and variety of computer systems for which operating systems are being designed: from embedded devices (e.g., the on-board computers for the space shuttle or a luxury sedan) and smartphones over PDAs and Laptops to PCs, workstations, and mainframes, to supercomputers. The variety is not just in the capacity and speed of machines, but in applications and system support requirements. Also, operating system research has been characterized by a rapid rate of change, and there is no indication that this will let up. Just think about such topics as the Java Virtual Machine, Android, or iOS.

In spite of this variety and pace of change, certain fundamental concepts apply consistently throughout. The intent of this course is to provide a thorough discussion of the fundamentals of operating system design, and to relate these to contemporary design issues and current directions in the development of operating systems. The objective is to provide you with a solid understanding of the key mechanisms of modern operating systems, the types of design tradeoffs and decisions involved in OS design, and the context within which the operating system functions (hardware, other system programs, application programs, interactive users).

Learning Outcomes

Understand history of Operating Systems and major milestones
Understand impact of hardware changes/development (RAID, multicore) on OS
Able to write C programs that exercise various aspects of an OS (process management, file system, etc)
Understand the concepts of processes and threads, and their difference
Apply synchronization primitives to solve synchronization problems
Appreciate the impact of different memory management schemes on degree of multiprogramming
Know the various OS tasks related to virtual memory management
Able to evaluate CPU scheduling policies based on a range of criteria and to compare it with popular policies
Understand how an OS manages I/O devices in general
Know various disk I/O scheduling policies and how to evaluate/compare them
Design a filesystem based on common examples (Windows, Unix)

Graduate Attributes

- Programming and Algorithms, Computer Systems, Programming and Algorithms, Computer Systems

Course Web Site

http://kunz-pc.sce.carleton.ca/sysc4001/

Textbook and References


Evaluation and Marking Scheme

There will be three programming assignments, collectively worth 15% of the final grade, lab assignments worth 10%, a midterm exam worth 25% and a final exam worth 50%. To pass the course (in addition to obtaining an appropriate overall mark), the final exam must be passed (i.e., obtain at least 50%). The final exam is for evaluation purposes only and will not be returned to students.

The midterm exam will be Wednesday, October 31, from 6 pm to 7:30 pm. Students who are unable to write the exam because of illness or other circumstances beyond their control must provide evidence. In the case of illness, this requires a medical certificate dated no later than one working day after the exam. The certificate must specify the date of the onset of the illness, the (expected) date of recovery, and the extent to which the student was/is incapacitated during the time of the examination. If this information is provided to the instructor no later than five working days after the exam, students will be given a deferred midterm exam.

The final exam will be scheduled during the university exam period, December. Students who miss the final exam may be granted permission to write a deferred examination (see the Undergraduate Calendar for regulations on deferred exams). These students have additional months to study and a less
crowded examination schedule compared to their colleagues who write the final exam in December. As such, it is only fair to expect substantially better performance from these students on the deferred examination than on the final exam. Note that the above formulation leaves it up to the instructor whether the supplemental or deferred examination will be harder or the marking scheme will be more rigorous.

There will be a number of assignments and labs. While the lectures will focus on general principles and algorithms, the labs and assignments will deal with some of the issues in the context of a real operating system, Linux. Assignment due dates will be clearly stated on the assignment handouts. Late assignments will not normally be accepted, and will receive a mark of 0; however, students who cannot submit an assignment by the due date for valid medical or compassionate reasons should contact the instructor immediately and prior to the due date to arrange for appropriate accommodations (e.g., an extension of the due date). Arrangements must be made in a timely manner, otherwise the assignment will be considered late and not accepted. For medical reasons, the same rules/requirements stated above for the midterm apply (see also General Regulation 2.6 about Deferred Term Work).

Students are encouraged to discuss design issues when working on assignments and labs; however, you are expected to write your own programs. There is a fine line between cooperating with your colleagues (discussing problems and ideas) and copying program code (plagiarism). Not only is plagiarism an instructional offense (see the current Undergraduate Calendar, Academic Regulations of the University, Section 12), but doing the assigned work by yourself is by far the best way to prepare for the exams. To facilitate discussion of assignment-related issues, cuLearn maintains a discussion topic for each assignment that will be monitored by the TAs and myself.

Both exams will be open textbook. Only proper hardcopies of the official course textbook will be accepted, no alternative textbooks, photocopies, ebooks, etc. However, I will allow older versions of the textbook.

Due Dates: Right now, I plan to schedule the assignments as indicated in the table below. No late deadlines will be given. If you foresee any problem with an assignment deadline, please come and talk to me early, in particular before the deadline is passed.

<table>
<thead>
<tr>
<th></th>
<th>Handed Out</th>
<th>Due</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assignment 1</td>
<td>September 20</td>
<td>October 10, noon</td>
<td>5 %</td>
</tr>
<tr>
<td>Assignment 2</td>
<td>October 11</td>
<td>November 7, noon</td>
<td>5 %</td>
</tr>
<tr>
<td>Assignment 3</td>
<td>November 8</td>
<td>November 28, noon</td>
<td>5 %</td>
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<tr>
<td>Labs</td>
<td>See table below</td>
<td></td>
<td>10%</td>
</tr>
<tr>
<td>Midterm Exam</td>
<td>October 31, 6-7:30 pm</td>
<td></td>
<td>25 %</td>
</tr>
<tr>
<td>Final Exam</td>
<td>December exam period</td>
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<td>50 %</td>
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</tbody>
</table>

Labs

The TA will be available during the scheduled lab times to help with both the lab assignments as well as the programming assignments. The list of labs is as follows:
There will be a total of 10 lab assignments, which you are expected to work on during the assignment lab periods. These labs will exercise various aspects of the Linux OS. Each lab assignment will ask you to submit something using cuLearn before the end of the lab. At the end of the term, we will check your submissions (to ensure you did complete the lab). Marks will be assigned based on the number of labs you completed (i.e., a student who completed 7 labs will get a mark of 7, etc.).

**Exams**

The final examination is for evaluation purposes only and will not be returned to students. You will be able to make arrangements with the instructor or with the department office to see your marked final examination after the final grades have been made available.

**General Regulations**

- **Copyright on Course Materials**: The materials created for this course (including course outline, slides, posted notes, labs, project, assignments, quizzes, exams and solutions) are intended for personal use and may not be reproduced or redistributed or posted on any web site without prior written permission from the author(s).
- **Attendance**: Students are expected to attend all lectures and lab periods. The University requires students to have a conflict-free timetable. For more information, see the current Undergraduate Calendar, Academic Regulations of the University, Section 1.2, Course Selection and Registration and Section 1.5, Deregistration. Requests to accommodate a missed midterm exam, lab periods, etc., because of conflicts with jobs or vacation plans will not be considered.
- **Health and Safety**: Every student should have a copy of our Health and Safety Manual. A PDF copy of this manual is available online: http://sce.carleton.ca/courses/health-and-safety.pdf.
- **Deferred Term Work**: Students who claim illness, injury or other extraordinary circumstances beyond their control as a reason for missed term work are held responsible for immediately informing the instructor concerned and for making alternate arrangements with the instructor and in all cases this must occur no later than three (3.0) working days after the term work was due. The alternate arrangement must be made before the last day of classes in the term as published in the academic schedule. For more information, see the Academic Regulations of the
University, Section 2.6, Deferred Term Work

- **Appeal of Grades**: The processes for dealing with questions or concerns regarding grades assigned during the term and final grades is described in the Academic Regulations of the University, Section 2.7, Informal Appeal of Grade and Section 2.8, Formal Appeal of Grade.

- **Academic Integrity**: Students should be aware of their obligations with regards to academic integrity. Please review the information about academic integrity at: https://carleton.ca/registrar/academic-integrity/. This site also contains a link to the complete Academic Integrity Policy that was approved by the University's Senate.

- **Academic Accommodations**: Requests for Academic Accommodation. You may need special arrangements to meet your academic obligations during the term. For an accommodation request, the processes are as follows:
  - **Pregnancy obligation**
    Please contact your instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details, visit the Equity Services website: carleton.ca/equity/wp-content/uploads/Student-Guide-to-Academic-Accommodation.pdf
  - **Religious obligation**
    Please contact your instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details, visit the Equity Services website: carleton.ca/equity/wp-content/uploads/Student-Guide-to-Academic-Accommodation.pdf
  - **Academic Accommodations for Students with Disabilities**
    If you have a documented disability requiring academic accommodations in this course, please contact the Paul Menton Centre for Students with Disabilities (PMC) at 613-520-6608 or pmc@carleton.ca for a formal evaluation or contact your PMC coordinator to send your instructor your Letter of Accommodation at the beginning of the term. You must also contact the PMC no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable). After requesting accommodation from PMC, meet with your instructor as soon as possible to ensure accommodation arrangements are made. carleton.ca/pmc
  - **Survivors of Sexual Violence**
    As a community, Carleton University is committed to maintaining a positive learning, working and living environment where sexual violence will not be tolerated, and is survivors are supported through academic accommodations as per Carleton's Sexual Violence Policy. For more information about the services available at the university and to obtain information about sexual violence and/or support, visit: carleton.ca/sexual-violence-support
  - **Accommodation for Student Activities**
    Carleton University recognizes the substantial benefits, both to the individual student and for the university, that result from a student participating in activities beyond the classroom experience. Reasonable accommodation must be provided to students who compete or perform at the national or international level. Please contact your instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. https://carleton.ca/senate/wp-content/uploads/Accommodation-for-Student-Activities-1.pdf

**Additional Information**

Plagiarism (copying and handing in for credit someone else's work as well as allowing someone else to copy your own work) is a serious instructional offense that will not be tolerated. Please refer to the
section on instructional offenses in the Undergraduate Calendar for additional information.

Tentative Week-By-Week Schedule

- **Weeks 1-2** – Introduction and Operating System Overview
- **Week 3** – Process Description and Control
- **Week 4** – Threads
- **Week 5** – Concurrency: Mutual Exclusion and Synchronization
- **Week 6** – Concurrency: Deadlock and Starvation
- **Week 7** – Memory Management
- **Week 8** – Virtual Memory
- **Week 9** – Uniprocessor Scheduling
- **Week 10** – Multiprocessor and Real-Time Scheduling
- **Week 11** – I/O Management and Disk Scheduling
- **Weeks 12-13** – File Management