CSC 351: Operating Systems

Davidson College
Fall 2018

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Office hours:

Mon	Tue	Wed	Thu	Fri
2:30 – 4:00pm	9:00 – 10:30am	2:30 – 4:00pm	9:00 – 10:30am	2:30 – 4:00pm

I am also available for office hours at other times via appointment. Feel free to stop by my office anytime to check for immediate availability.

Audience

Middle to upper-level CS Majors and those interested in the internals of computer systems.

Pre-requisites

Data Structures (CSC 221), Computer Organization (CSC 250), and the ability to program in C.

Class Meetings

Mondays, Wednesdays, and Fridays 11:30am-12:20pm, Watson 132

1 About the Course

Operating Systems are collections of software services that manage physical hardware resources, from small sensors to complex servers, and provide applications with a higher-level interface for

common tasks. Typical responsibilities of operating systems include task and memory management; input and output abstractions and services (which includes file systems and networking); and authentication / authorization. For workstations and servers, operating systems also commonly include the means to define and enforce security policies, to perform virtualization, and to manage energy consumption, among others.

The algorithms that compose an operating system represent a paragon of a well-developed, long-term research field that has been applied in practice in numerous devices, from cell phones to aircraft. These algorithms are not only relevant theoretically, but also historically. In addition, as computing devices become more available, especially those embedded in mobile applications, custom-designed operating systems to manage tasks, memory, files, energy, network I/O, security policies, etc, may represent the crucial advantage of one platform over another.

In our course, in line with the above rationale, we adopt a *hands-on approach*: students develop in practice the crucial parts of a modern operating system. Throughout the semester, we encourage peer learning and develop scientific writing and public presentation skills in an informal and rewarding class environment.

2 Learning Outcomes

This course provides strong conceptual and practical knowledge on the design and implementation of modern operating systems, and a clear perspective on the services that they should provide. By the end of the course, students will be able to:

- Identify the fundamental services provided by operating systems in workstations, servers, and embedded devices.
- Understand the thread abstraction, and the main problems and solutions related to concurrent data accesses.
- Evaluate different process scheduling algorithms and their implications.
- Identify the protection mechanisms implemented by a typical operating system, particularly the protection concerns related to memory management.
- Evaluate different algorithms and techniques for caching and virtual memory.
- Describe the overall architecture of differently virtualization techniques.
- Comprehend in detail the design and implementation of file systems.

3 Course Text and Other Resources

The textbook for the course is *Operating Systems: Principles and Practice, 2nd Edition*, by Thomas Anderson and Michael Dahlin. Recursive Books, 2014.

Course announcements, clarifications, readings, assignments, and solutions, will all be posted at the CSC 351 Moodle page. Please verify your access at:

`http://moodle.davidson.edu`

Additional reading:

- *Learning the UNIX Operating System*, by Grace Todino, Jerry D. Peek, and John Strang. O'Reilly Media, 1998. Available electronically in the College Library.
- *The Linux Programming Interface : A Linux and UNIX System Programming Handbook*, by Michael Kerrisk. No Starch Press, 2010. Available electronically in the College Library.
- *21st Century C: C Tips from the New School*, by Ben Klemens. O'Reilly Media, 2012.

4 Course Structure and Expectations

The final grade in the course is determined based on 4 homework assignments, a set of take-home quizzes, and a final exam. Homework assignments account for 50% of the grade, quizzes account for 25% of the grade, and the final exam accounts for 25% of the grade. Homework assignments are due 11:55pm on their due date unless otherwise noted in the handout.

4.1 Homework Assignments

All homework assignments have the same weight towards the final homework grade. They are released at least a week before their due dates, which are found in Sec. 7. Some homework assignments are individual, others are pair-programming assignments (please refer to Sec. 4.4).

4.2 Quizzes

Quizzes are short, and relatively informal in-class or take-home questionnaires, problems, or activities, administered at various moments during the semester. They are aimed to check the student's comprehension of the assigned readings and of the overall ideas covered in class. Each quiz will be worth a varying number of points, depending on its difficulty. Your quiz average will be computed as the total number of points you received over the term, divided by the total number of points possible. Some quizzes are individual, and others are group assignments (please refer to Sec. 4.4).

4.3 Final Exam

The final exam is a comprehensive, timed exam to be completed during the finals week. The exam evaluates the comprehension of the main concepts discussed throughout the semester, with particular focus on scheduling, memory management, and file system design.

4.4 Pair Programming

Pair programming is a software development technique in which two programmers work closely together *on a single computer* to develop a solution to a problem. Studies have shown that code produced by pairs of programmers have significantly fewer bugs and display more thoughtful design. More significantly, within the context of this course, having to communicate your ideas to a partner will also help you learn more. You may work in pairs on designated assignments in this class. Note that this does *not* mean that you adopt a divide-and-conquer strategy, where each team member works on only certain parts of the assignment – you will end up learning only half of what you are supposed to. Instead, *both* partners must work on the same computer, with one playing the role of the "pilot" (the one at the keyboard), and other playing the "navigator". The navigator's role is not passive – it is a chance to think big picture while the pilot is engaged in dealing with the nitty-gritty details, to double-check the pilot's thinking, to devise test cases etc. *You should switch roles often and aim for roughly equal time at the keyboard.* Both partners will receive the same score on a given assignment, and having a flaky partner does not excuse you from getting the assignment done on time. You are free to change partners between assignments, but may not switch partners part-way through an assignment. Note that the joint working requirement extends to office hours as well – if you are working with a partner on an assignment and want to meet with the professor, *both* of you need to be present.

Any student should work with the same partner at most twice during the semester, except when override permission is granted by the professor.

4.5 Homework Hand-In Policy

Each student has *three 24h extension allowances* for any assignment (homework or quiz). These extensions are used at the student's discretion, but the due date of a single assignment cannot be extended by more than 48h. On pair-programming assignments *two* extensions allowances must be used for a 24-hour extension. Those may belong to a single team member or to both of them. The use of each extension must be clearly noted in the assignment submission to be considered. Late assignment submissions with no considered extension are not given credit. Other extensions could be granted due to co-academic activities (such as seminars or competitions) or personal circumstances. Timely notification and professor's approval are required – the details are described in Sec. 4.7.

4.6 Grading

Grading is done on an absolute, but adjustable scale. The translation of percent grade **p** to the letter grade **l** is given below:

Percent grade **p**	93	90	87	83	80	77	73	70	65	60	0
Letter grade **l**	A	A-	B+	B	B-	C+	C	C-	D+	D	F

With the purpose of improving grading consistency across different course offerings, I may decrease (and *only* decrease) the percent grade **p** necessary to grant any letter grade **l**, applicable to the whole class. Please note the following additional policies regarding grading in Sec. 4.7.

On regrading. Please feel free and comfortable to request the regrading of any assignment. I am always willing to clarify any concern or fix any error.

4.7 Attendance and Extensions

Your participation in class is deeply valued, and impacts not only your learning, but also that of everyone else present. I expect you to attend at least 75% of the class meetings. Absences due to co-academic activities (such as seminars or competitions) or personal circumstances (including religious and health-related events) are excused if they are timely notified and approved by the instructor. Co-academic activities or personal circumstances can also grant extensions to homework assignments if the accommodation requests are likewise timely notified and approved. *Timely notification* is simply a one-week advance notice, or the earliest possible notification in case of unforeseen circumstances.

While the student is expected to learn the missed class material, I am *always* willing to help. Please note that missing 25% of class meetings without proper notification is a reason for receiving a failing grade in the course.

4.8 Getting Help

Your success in this class depends on many factors – regular attendance, keeping up with the readings, starting early on the homework assignments, etc. But importantly, you also need to work *smart*. This means recognizing when you need help and seeking it out. *I expect that all students will need help at some point in this course.* If you find yourself needing help, this is not a cause for embarrassment – it is completely expected.

There are a number of avenues for getting assistance. You are free to use the Internet and search engines to troubleshoot error messages, or to resolve syntactic issues (but *not* to resolve algorithmic problems). You may meet with the professor during my office hours, or schedule an appointment.

Additionally, the Math & Science Center (MSC) offers free assistance to students in all areas of math and science, with a focus on the introductory courses. Trained and highly qualified peers hold one-on-one and small-group tutoring sessions on a drop-in basis or by appointment, as well as timely recap sessions ahead of scheduled reviews. Emphasis is placed on thinking critically, understanding concepts, making connections, and communicating effectively, not just getting correct answers. In addition, students can start or join a study group and use the MSC as a group or individual study space. Located in the Center for Teaching & Learning (CTL) on the first floor of the College Library, drop-in hours are Sunday through Thursday, 8-11 PM, and Sunday, Tuesday, Thursday, 4-6 PM, beginning Sunday, August 27. Appointments are available at other times. For more information, visit

www.davidson.edu/offices/ctl/students/
math-science-and-economics-center

or contact Dr. Mark Barsoum (mabarsoum or ext. 2796).

5 Academic Integrity

All assignments in this course are pledged, and the Davidson College Honor Code applies:

www.davidson.edu/about/distinctly-davidson/honor-code

Students are encouraged to discuss the course material and assignments with the professor and colleagues. Please consider the following rules for collaboration: (i) you *are* allowed to point small errors in another student's code or line of reasoning, but not provide complete solutions to problems; (ii) in the final exam, collaboration is not allowed; (iii) all work submitted by a student or group has not been partially written by any other person or resource, including other students or groups (current or previous semesters), previous semester's solutions, and Internet resources; and (iv) group assignments are expected to reflect equal collaboration among all group members. *If you ever have questions about the bounds of acceptable collaboration, please contact me for clarification.*

6 Accessibility Statement

The college welcomes requests for accommodations related to disability and will grant those that are determined to be reasonable and maintain the integrity of a program or curriculum. To make such a request or to begin a conversation about a possible request, please contact the Office of Academic Access and Disability Resources, which is located in the Center for Teaching and Learning in the E.H. Little Library: Beth Bleil, Director, bebleil@davidson.edu, 704-894-2129; or Alysen Beaty, Assistant Director, albeaty@davidson.edu, 704-894-2939. It is best to submit accommodation requests within the drop/add period; however, requests can be made at any time in the semester. Please keep in mind that accommodations are not retroactive.

7 Course Calendar

The course schedule is described below. While topics and dates for lectures or assignments may change, due mainly to course pace and class interest, the general structure will be preserved. An updated schedule will always be available on Moodle. "Catch-up days" are meant to accommodate any dynamic adjustments to our course schedule during the semester.

Monday	Wednesday	Friday

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Aug 20th **1** History, Multiprogramming	22nd **2** UNIX Workshop I	24th **3** Protection and Virtual Memory Basics **Quiz #1 out**
27th **4** UNIX Workshop II	29th **5** C Workshop I	31st **6** System Calls **Quiz #2 out**
Sep 3rd **7** C Workshop II	5th **8** UNIX Signals	7th **9** Multithreading **HW #1 out**
10th **10** Locks, Condition Variables	12th **11** Producers/Consumers	14th **12** Atomics
17th **13** Mode Transfer Implementation	19th **14** Threads: Implementation I	21st **15** Threads: Implementation II, Deadlocks **HW #2 out**
24th **16** Scheduling I	26th **17** Scheduling II	28th **18** Catch-up Day
Oct 1st **19** OS351: Genesis	3rd **20** OS351: Terminal and Library	5th **21** OS351: 64bits and Interrupts
8th **Fall Break**	10th **22** Real-Time Considerations I Guest Lecturer Dr. Locke	12th **23** Real-Time Considerations II Guest Lecturer Dr. Locke
15th **24** Address Translation I: Introduction	17th **25** Address Translation II: The Intel Solution	19th **26** Address Translation III: Protection and Performance **Quiz #3 out**
22nd **27** Multiprocessor Scheduling I	24th **28** Multiprocessor Scheduling II	26th **29** Multiprocessor Scheduling III **HW #3 out**
29th **30** OS351: Multitasking	31st **31** OS351: Paging I	Nov 2nd **32** OS351: Paging II
5th **33** The Memory Hierarchy	7th **34** Cache Replacement Policies	9th **35** Cache Performance **Quiz #4 out**
12th **36** Storage Technologies	14th **37** File System Design I: Introduction	16th **38** File System Design II: FFS & Journalling

Monday	Wednesday	Friday
19th **39** File System Design III: ZFS/AFS	21st **Thanksgiving Break**	23rd **Thanksgiving Break**
26th **40** Virtualization I **HW #4 out**	28th **41** Virtualization II	30th **42** Review for Final
Dec 3rd **43** Review for Final (cont.) and Evaluations	5th **44**	7th **45**

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