Operating Systems, CS-UH 3010

Fall 2022

Instructor:	Azza Abouzied azza@nyu.edu	Lectures:	TuTh 9:55 AM – 11:10 AM @ C2-E050
TA:	Miro Mannino miro.mannino@nyu.edu	Labs: TBD	TBD

Course Description: The operating system is a computer's chief manager overseeing interactions between users, applications, shared software and hardware resources. This course covers the fundamentals of operating system design and implementation. Lectures present the central ideas and concepts such as synchronization, deadlock, process management, storage and memory management, file systems, security, protection, networking and virtualization. Assigned readings and programming assignments illustrate the manifestation of these concepts in real modern operating systems and future research ones.

Course Website: The course website is azzadev.github.io/osbook. The password is os2022.
This course website will contain links to any assigned readings.

Course textbook:

- Abraham Silberschatz, Peter Baer Galvin, and Greg Gagne. **Operating System Concepts**. 10th. Wiley, 2018.

  Both digital and print versions are available. Reach out to the bookstore for assistance

Reference textbooks:

- Robert Love. **Linux Kernel Development**. 3rd. Addison-Wesley Professional, 2010.

  An online version of the book is accessible from the online course website.

Getting help: Email any questions to the Slack class channel for the most immediate help from your peers or instructors.
Join the Slack channel here.
To book appointments with

- Azza: Use https://calendar.app.google/Zud7cR3xKKbdnsJ28; https://calendly.com/prof-azza.
- Miro: Use https://calendar.app.google/unzLQ7BZmBijF7b47

Learning Outcomes:

- Explain basic abstraction techniques employed by operating systems
- Explain trade-offs made by particular operating system designs
- Understand components of an OS by implementing different ones through a series of five, challenging and programming-intensive labs in Assembly and C
- Synthesize a set of design principles that are useful for building large systems
- Analyze, critique, and debate research articles on system design
- Study how one can break down fundamental assumptions about hardware, process behavior, trust, etc studied earlier in the course to construct novel and interesting operating systems

Teaching Methodologies:

- *Lectures*: In class lectures will cover fundamental OS design concepts. Most lectures have *in-class interactive exercises* and students are expected to participate. For practical demonstrations of an OS, we will focus on the Linux operating system.
- *Readings*: The course schedule lists sections of the course textbook as well as research papers that students should read prior to class. By keeping on top of the readings, you will make the best use of lecture time: you can clarify concepts you found difficult to understand and you can better participate in class discussions and exercises.
- *Collaborative work*: You will work with your peers to complete your programming-intensive labs and to understand and present an assigned research paper. Effective team work is crucial for developing large software systems.
- *Labs, Tutorials & Design Reviews*: You will complete a series of five to six programming-intensive group labs to build the following OS components: bootloader, a non-preemptive kernel, a preemptive kernel, inter-process communication, a virtual memory system and possibly a file system if time permits. By implementing the building blocks of a working kernel, you apply the concepts learned in class. Professor Kai Li at Princeton University has kindly shared these labs with us. A condition of using the Princeton code base is not to distribute/share the skeleton code or your solutions. All assignment resources are therefore distributed through NYU Drive. Solutions must be submitted securely and you should not publish your solutions online.

  For some labs, we will run tutorials a few days after release. Design reviews are 15 minute meetings that you will schedule with your instructors a week after lab release. Design reviews consist of lab milestones that you need to complete as well as open-ended design discussions. **Design reviews are graded.**
- *Class Presentations & Discussions*: **Paper Cuts** is a debate between two student groups on a single research paper. Each group gives a 10 minute intro on the paper and then each group takes a for/against position and the debate begins. Your stance will be chosen randomly. After your initial presentation, there will be one rebuttal round to respond to your opponent's main points. Each group should not only examine the paper but also examine secondary sources such as online commentary, preceding and follow-on work. You will also evaluate the paper's experimental methods. You will argue for or against the paper in a style similar to what a conference program committee does. Points will be awarded for dynamic presentations and convincing arguments. Imagine your fellow classmates and instructors are a star OS/systems development team and your goal is either to make us implement the system described in the paper or move away to something else.
- *Critiques*: For each of the assigned Paper Cuts research papers, students are expected to write a one to two page critique where they summarize the most important contributions of the paper and describe its strengths and weaknesses. By writing critiques, you will gain a more thorough understanding of research developments and appreciate the complexities and nuances of OS designs and trade-offs.

Grading Policy:

3-5 Programming Labs	50%
Midterm 1	15%
Midterm 2	15%
Paper Cuts	10%
Paper Critiques	10%
Bonus and Participation	≈5%

The exact grade breakdown may change. If this happens, the course instructor will notify students in a reasonable time.
In general, 90% or above is within the A range, 80%-90% is within the B range and 70%-80% is within the C range. Typically, marks are not curved.
You have **100 hours of lateness forgiveness** that you can use throughout the course for any problem set or lab submission deadline.

Course Schedule:

This is a tentative schedule. We may spend more or less time on a certain topic.

Week	Lectures, Readings, Case Studies, Assignments
1	**Overview**
	Assignment: 0 Preparation Lab
	The Boot Process
	Assignment: 1 The Bootloader (2 weeks)
2	**Communicating with the Kernel: System Calls, Interrupts & Exceptions**
	Tutorial: Lab 1
	Processes & Threads
	Assignment: Design Review for Lab 1
3	**Concurrency Control: Synchronization Primitives**
	Concurrency Control: Semaphores and More; Deadlocks
	Assignment: 2 The Non-Premeptive Kernel (3 weeks)
4	**Process Scheduling**
	Tutorial: Lab 2
	Assignment: Design Review A for Lab 2
5	**Preemption**
	Inter Process Communication (IPC)
	Tutorial: Lab 2
	Assignment: Design Review B for Lab 2
6	**Memory Management**
	Virtual Memory & Paging
	Assignment: 3 Kernel with Preemptive Scheduling (2 weeks)
7	**Paging & TLB**
	Midterm 1
	Assignment: Design Review for Lab 3
8	**Device Drivers**
	Block Devices
	Assignment: 4 Inter-process Communication (IPC) (2 weeks)
9	**File Systems - Interface**
	File Systems - Implementation
	Assignment: Design Review for Lab 4
10	**Caching, Journaling & Recovery**
	Log Structured File Systems
	Assignment: 5 Virtual Memory (3 weeks)
11	**Distributed Systems**
	Tutorial: Lab 5
	Assignment: Design Review A for Lab 5
12	**Virtualization**
	Assignment: Design Review B for Lab 5

13	**Paper Cuts:** Students choose research papers to debate
	Assignment: Written critiques for first paper cuts
	Paper Cuts: Students choose research papers to debate
	Assignment: Written critiques for second paper cuts
14	**Paper Cuts:** Students choose research papers to debate
	Assignment: Written critiques for third paper cuts
	Midterm 2

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