Overview

This course in Computer Operating Systems is a required 3-credit class for all ECE majors taking the Computer Engineering track. Those from a different major or track are welcome as long as they have the prerequisite course work or equivalent knowledge and skills. The course provides a deep technical understanding of how modern computer operating systems function.

Classroom rules

No "devices" are to be used by students or in view during class. The only thing on your desk should be paper and a writing implement. This rule may seem stringent -- after all this is a technology class -- but it is based on years of classroom experience and numerous studies from across academia. The use of electronic devices in class creates a climate of distraction which not only detracts from your own learning but also impacts the learning environment of others. This ban includes "smart watches" (there is a clock in the room). Keep all these devices out of sight such as in your bag and turned off or set so they don't make noise. Feel free to use your devices during breaks, before class begins and after class ends.

(The use of an electronic device for the sole purpose of taking notes for this class is permitted if requested by the student in advance. Please sit in the front row so the device is visible to me. However, this device will not be permitted under any circumstances during exams, so be prepared to print out your notes)

Likewise, I ask that you **refrain from side conversations** during class that are audible to others in the room, that you raise your hand prior to speaking, and generally follow rules of classroom etiquette. Since this is an evening class, I am very tolerant of food and non-alcoholic drink being consumed during class so long as it is not malodorous.

Regular **Attendance** of classes is required by Cooper Union academic policies. I believe that attending classes adds value to your learning experience and recommend that you attend all of your classes in their entirety. I am required by the administration to report students who are habitually absent from class. However, I realize that things do come up, therefore you do not need my advance permission, nor do you need to provide any kind of "excuse" to be absent from a regular class. You are responsible for any material which was covered in class during your absence. If you will be missing two or more classes in a row, please let me know in advance. Absences from quiz or exam days are not permitted!

Since our class is a 3-hour block, I elect to give one break, approximately at the mid-way point, not to exceed 20 minutes. Please return from break promptly. Avoiding delay in getting the class resumed after a break, or disturbance from students entering long after class has resumed, is a major factor in the success of the class.

Office Hours / Contact

I generally maintain office hours at 41CS, Rm 810 Mon/Tue/Wed 6PM until close. However, it is best to email me and make an appointment: `hak@cooper.edu` I will try to answer student email questions within 12 hours, including weekends. Lecture notes, problem sets and other material will be distributed via a course web site: `faculty.cooper.edu/hak/ece357`

Prerequisite Topics

The following academic topics and skills are assumed upon entry to the course and will be important for your success. If you are under-prepared entering the course, please take some time in the first week to refresh or enhance your knowledge of these topics:

ECE251 (Computer Architecture) : the basic instruction cycle. register and memory operands. memory addressing. I/O devices. interrupts.

ECE160 / CS102: The C language! structs and unions. local vs global variables. memory allocation with malloc. pointers and arrays. strings.

ECE264: Linked lists, trees, hashing.

UNIX environment

Much of this course will be conducted with reference to a "UNIX" programming and operating systems environment. You will need to gain familiarity with using the operating system from the "command line" including compiling and executing programs with gcc. We will be studying the Linux kernel as a reference kernel. Many of the homework assignments will work just as well on other flavors of UNIX such as Mac OSX but the assignments will be written with the assumption that you are using some Linux distribution. Note that using "CYGWIN" under Windows will generally not be sufficient since it is not a true and full emulation of the UNIX systems programming environment and since the underlying kernel is not a UNIX kernel. Students have successfully used WSL2, which is a full Virtual Machine running Ubuntu.

Since we aren't working with the GUI, your choice of "distro" is not that critical. One recommendation is to download a live bootable USB image so you can run UNIX on your computer without installing it permanently. "KNOPPIX" is one such distribution which works reasonably well and has most of the common tools that you'd need. There are certainly other usable choices such as Debian or Ubuntu live media. All of these "live" systems will allow you to "mount" your existing hard drive to store files there if you wish, or you can keep files on a "persistent" partition within the USB drive. Of course, I recommend that you back up your work.

You will be given an account on a virtual machine running Oracle Linux. The primary purpose is for homework submission but you may also use it for testing. Note that any work placed on the VM environment is not backed up and will be destroyed after the end of the semester.

Homework Assignments

Associated with most of the syllabus units in this course are "problem sets" which generally involve one or more of the following:

i) writing code that runs under the UNIX environment illustrating kernel interfaces.
ii) obtaining experimental results such as performance benchmarks.
iii) exercises and problems/questions to be filled out.

The problem sets are designed to reinforce the material presented in lecture and lecture notes and are mandatory. They form a crucial part of the pedagogy of this course. It is very important that

you do this work, and do so promptly.

Generally speaking, a problem set will be distributed at the conclusion of a lecture which concludes an academic unit, and will be due 2 weeks later. At each class meeting following distribution of a problem set, a period of time is set aside for discussing questions that students have which arise during the course of implementing the assignment. It is therefore very important that you begin work on a problem set within this initial 7 day period. If you wait until the last minute, you will not have the benefit of meaningful participation in the class discussion. Please pay close attention to the deadlines!

In some cases, problem sets will overlap and at other points, there may be no active problem sets. This will be dictated by class pace and schedule issues. If due dates change, you will be notified by email.

For many units, the problem sets are split into two parts. The first part contains exercises and short answers, will be due one week after it is released, and will be reviewed in class. The second part will be due in two weeks, and contains a programming or implementation assignment.

Please read each problem set carefully! It contains many details on the requirements of the solution as well as hints to common implementation problems. Although some of the problem sets may be similar to ones used in previous instantiations of this course, do not assume that they are identical!

Problem Set Submissions

You will be provided with an account on a Linux virtual machine which will be used for homework submission (unless otherwise noted). Within your *home directory* on this VM will be a subdirectory `hwsub`. Under that, multiple subdirectories will be automatically created such as `ps1p1` for problem set #1, part 1. To submit your homework, you will place it in the correct subdirectory prior to the stated deadline. At the deadline, I will run a script which takes a "snapshot" of your homework submission directory. Beyond the deadline, you will need to contact me via email to request that I manually grab your homework submission.

I will separately email you specific instructions for accessing the VM, uploading files, and accessing it via a VPN tunnel when off-campus.

Your homework submission must contain:

* All source code files necessary to build any program that your wrote, for example .c files, .h files, Makefiles (if applicable). If your code will not build or run on the provided VM, please leave a clear note to that effect.

* "Proof" that you ran the program and it gave correct results, including any specifc results or outputs that are requested in the problem set sheet. This could take the form of a session log in text format (some students have used `.md` files, which is OK), or a screenshot in JPEG, PDF or PNG format. If you choose the screenshot, make sure the resolution is sufficient to see the text! My preference is for a text-mode session log. You can capture this in a number of ways. For example, the `putty` program has a feature to log the session, or your can use the `screen` program.

* If a write-up (narrative) is requested, for example where you answer questions, or analyze

experimental results, this **must** be in PDF format, or a plain text file (or .md file) using only 7-bit ASCII. Do not send .docx, .pptx, .xlsx, or other application-specific formats.

Homework Grading, Lateness & Return

The due date of each homework assignment (or portion thereof) will be announced with the assignment. I will assess a penalty of up to one letter grade if the assignment is late beyond a reasonable period of time.

In some cases, we will be reviewing a homework assignment immediately via in-class discussion. I will select students randomly to present their answers to selected questions.

I will endeavor to return your graded homework assignments in 1-2 weeks after submission. The homework grading sheet will be sent to your individual Cooper Union email (I can not send to any non-Cooper personal email addresses) so please be sure to check that frequently.

Group Work

Partnered group work **is permitted** but not required for homework assignments. You may work in a group of two students (including yourself), or up to three students if special circumstances warrant this and if I give explicit permission. You may change your groupings in between homework assignments, but not within. E.g. if students A & B submit jointly for problem set 2, part 1, then A &B are also working together for problem set 2, part 2, but are free to regroup (or work individually) for problem set 3.

When you work in a group, all members of that group will receive the same grade for that entire homework assignment. I will only provide one grading sheet for the group and it will be sent to the designated group leader/submitter. When the group work is submitted, the entire complete assignment should be submitted by one student. Please don't place part of the assignment in one student's directory and another part with another student! Don't change who is the leader/submitter in the middle of a multi-part problem set. The submitting student must clearly indicate the additional member(s) of that group, and each group member will leave a brief note in their submission directory indicating the name of the submitting student.

In my experience, some students will prefer to work alone. Whether you work in a group or alone will not bias my grading decision in any way. Note that I will not be able to mediate any disputes which may arise within your group.

Accommodations

Please consult the following web site:

`https://cooper.edu/students/student-affairs/disability`

to learn more about Cooper Union's commitment to a classroom environment which is equitable for students with disabilities or diagnosed learning differences. If you have a letter of accommodation provided by the Office of Student Care, it is very important that we schedule a private one-on-one meeting as early as possible in the semester (or when the letter is provided, if mid-semester) to discuss how we can accommodate your needs consistent with the educational goals of the course. In general, granting extra time on homework assignments will not be possible. The pacing of the class requires that we have submission, review, and grading of

assignments within the scheduled times, otherwise the pedagogy of the entire course will suffer. Working with a partner is one way to address time constraints on homework assignments. We must have an agreed-upon plan for any accommodations in advance. Per school policy, accommodations are not retroactive.

Academic Honesty

All work submitted must be the original work of the individual student or group.

You are permitted to search the internet for solutions to your homework. I must caution you that a lot of the information that you will find this way is either misleading or just plain **wrong**. You may find similar work that other Cooper students, who took this class previously, have left online, either deliberately or accidentally. Again, just because this stuff is out there doesn't mean that it is correct!

I will have **zero tolerance** for any code that is copied entirely from another source. You are permitted to borrow concepts from other sources and to interpolate small passages of code. If you do so, you **must give proper attribution**. This means placing a comment in your source code identifying which sections of code were interpolated or derived, and clearly identifying the source where I can find the original material.

Although I can not enforce this, I suggest that when you do "cut and paste" code from other sources, that you re-type it rather than using your mouse. This may seem like a pointless waste of time. Trust me, having to type it in again forces you to think about the code that you are borrowing and how it works (or doesn't work) in your application.

I remind you that **Submitting code that you didn't write** and attempting to pass it off as your own work (i.e. without proper attribution) is **plagiarism** and per Cooper Union's academic honesty policies I am required to report such to the office of the Dean.

Generative AI with Large Language Models, such as ChatGPT, is increasingly being used by people in the industry to produce code. It is **strictly forbidden** in this class! Perhaps this seems mean-spirited? Please bear in mind that the purpose of doing the homework exercises is not actually to deliver a product for me! I already know the answers to the questions being asked and I already have done the projects that I am asking you to perform. Homework is going to the gym, for your intellect. When or if you go to a gym, the goal is not actually to lift a certain weight many times, but rather to strengthen your own physical condition. So if you instead built a robot to lift the weights, that might be much more productive in a commercial sense, but would totally defeat the purpose of the gym. Likewise, using a tool to do your homework does nothing to strengthen your mind. If you take this approach, you will find out the hard way when it comes to the exams.

I should also note that I have put some of my past assignments into ChatGPT and the result is about the same as what a very poor student in my class would produce.

Although in-class exams are designed to thwart "cheating," to be clear, it is a violation of academic honesty rules to obtain or attempt to obtain, during the exam, the answer to any test question from any other person or any source other than explicitly permitted sources, or to disseminate your answers to others by any means or in any form during the exam.

Exams

There will be one mid-term exam designed to be covered in a maximum of one hour, and one comprehensive final exam which is designed for the full three-hour session. The midterm will be reviewed immediately following a class break. The midterm is scheduled for Oct 22 and the final for Dec 17. If these dates need to change you'll be notified well in advance. Since the semester ends on Dec 19, we will not have a formal class meeting to review the test. I will schedule an optional TEAMS meeting in which to review the test.

All exams are open-notes and open-book. You may bring any **printed** material with you into the exam. All electronic devices are prohibited during the exam. This includes calculators, for which there will be no need in these exams. If you need to leave the exam room, e.g. for a bathroom break, you are not permitted to take any materials or devices with you.

Grading

Grading in the class will be on the following subjective basis:

"A" indicates good understanding of most of the major concepts in the course, good understanding of details, and good quality homework assignments.

"B" indicates fair understanding of the concepts, and/or homework of fair quality.

"C" indicates mediocre understanding of the major concepts, and/or numerous deficiencies in the homework assignments.

"D" indicates serious deficiencies in the major concepts of the course, and serious deficiencies in the homework assignments.

"F" indicates that the student did not demonstrate any understanding of the major concepts in the course and had serious deficiencies in homework assignments.

I have rarely needed to use the C, D or F grades. I will attempt to give each student feedback sufficiently early in the course so that a student who is performing poorly can either make a plan to improve performance, or decide to drop the class. The withdrawal deadline for Fall 2025 is Tuesday, October 28.

While grades are ultimately my subjective evaluation of your performance and understanding, as a point of reference, I weigh the various assessment metrics as follows:

35% homework average (normalized to a 100 scale)

20% midterm

35% final exam

10% other factors*

*Subjective factors such as quality of class participation, effort and improvement are also weighed.

Regarding homework assignments: Grades are given for each problem set on a 10-point basis. When I return an assignment, I will have a breakdown of things that you misunderstood or implemented incorrectly. This is not intended as an itemized tax return of how I arrived at your grade! Your homework grade is ultimately a *subjective* assessment of how I felt it demonstrated your understanding and mastery of the topic material involved, and the quality and effort on your part which I felt it demonstrated.

In some cases there will be extra-credit portions of an assignment. To receive full extra credit, you must do all the work that is specified as meeting the extra-credit criteria. The award of partial extra credit is entirely at my discretion.

Textbook / Lecture Notes

There is no required textbook for this class. However, the following reference book is considered a "bible" of UNIX systems and network programming and may be helpful for at least some of the assignments:

Stevens, W. Richard & Rago, Stephen A. *Advanced Programming in the UNIX Environment*. 3rd ed. Addison-Wesley, 2013.

I create "lecture notes" which function as a de-facto textbook, and distribute them at the end of each unit. I update these each year. You are encouraged to pre-read the notes for an upcoming unit. Sometimes I update the notes after a unit is completed, either because an error is found, or to provide additional information based on class discussion. I will notify you via email when this happens. Make sure you are referring to the correct revision when doing your homework assignments or studying for tests.

Students are academically responsible for studying material that I distribute in written (either printed or PDF) form, which includes the "lecture notes" and the problem sets.

The expectation is that you will read the lecture notes linearly, like a textbook. Topics are developed and introduced in a deliberate order. Trying to search and pick out just the items you need to answer a specific problem is not a good strategy.

Course Outline

Below is the intended list of topics and the class contact hours allotted to each. This is subject to change depending on how the class progresses and scheduling issues.

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Unit 1: Introduction to operating systems (3 hours)

Unit 2: Introduction to filesystem (6 hours)

Unit 3: Processes and I/O redirection (6 hours)

Unit 4: Signals and pipes (4.5 hours)

Midterm: will cover units 1-4  (2 hours incl. review)
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Unit 5: Virtual Memory (8 hours)

Unit 6: Concurrency and Synchronization (3.5 hours)

Unit 7: Introduction to the Kernel (4 hours)

Unit 8: Task switching in the Linux kernel, scheduling (5 hours)

Final Exam: cumulative (3 hours)

  (TOTAL 45 contact hours)
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Note 1: Likely no class meeting, Wed Oct 1

Note 2: Wednesday, November 26 is a Friday schedule. Our class will not meet this day.

Policies and other information

Please visit the following URL for school-wide information about Title IX:

`https://cooper.edu/sites/default/files/uploads/assets/site/files/2020/Cooper-Union-Policy-Upholding-Human-Rights-Title-IX-Protections.pdf`

Please visit the following URL for school-wide information about student care services and counseling
`https://cooper.edu/students/student-affairs/health/counseling`

Please visit the following URL for more information about the Engineering School's academic standards policies:

`https://cooper.edu/engineering/curriculum/academic-standards-regulations`