Introduction to Computer Architecture
Fall 2021
Course Information
Prof. Kaplan

Be sure to read **all** of this document!

1 The topics

For most users, a computer is a mysterious box of *hardware* on which they use mysterious *software*. For many purposes, these users need to know little about either. Indeed, well designed systems and programming languages allow the user to focus on doing their own work, solving their own problems, hiding the complexity of how any of that work or computation happens.

Of course, **someone** must understand how each of these components work, and how the group of them work together. This course focuses on the core elements of the computing hardware: the *processor* and the *memory*. Other courses focus (including, but not limited to, *COSC-171: Computer Systems*) the operating system, the programming languages and their compilers, and the networks.

Our goal is to understand how a physical device can be designed to remember and operate on data. We will see that computers are designed and constructed in *layers*. Each layer is the result of combining operations and capabilities from a simpler layer below, resulting in qualitatively different operations and capabilities. Somehow, by building one layer on top of another, we are able to build complete, complex systems. We will see that hardware systems, software systems, and networks are all the result of this type of layering, and that certain conceptual ideas and problems repeat themselves across layers and systems.[1]

Here is a brief list of **many** (but not all) of the topics that we will cover, in **roughly** the order that we will cover them:

- Boolean logic and Boolean algebra
- Combinational logic circuits (gates)
- Memory elements and addressable memories
- Sequential logic and functions
- Binary arithmetic
- Addition and multiplication circuits
- Arithmetic Logic Units (ALUs)

[1] Do you find all of this talk of *layers*, *operations*, *capabilities*, and *systems* all a bit vague and incomprehensible? Don't be surprised if you do. You might not have much of a sense of what they mean now, but by the end of the course, you will be able to re-read this paragraph and find that these terms have specific, significant meanings to you.

- Introductory assembly and machine coding
- Basic data path and control structures
- Pipelines
- Branch prediction and out-of-order execution
- Memory buses and caches
- Multiple processing cores and cache coherency

The nature of the labs and projects for this course will vary with the material throughout the semester. Early in the semester, we will work with *digital logic circuits*, building computational components with chips, wires, buttons, and blinking lights. As the circuit structures get more advanced, we will move our work onto a *circuit simulator*.

This course should be fun because there is a great deal of hands-on experience with the material. It is also a great demystifying course, as you will have a much better understanding of the operation of, and principles behind, the computers that surround us. Note, however, that it is a course with a great many details, as well as a course that is exceedingly cumulative. It will be critical that you stay on top of lectures, labs, and readings at all times.

2 Lectures, labs, and help

Lectures and labs: This class will meet for *lectures* on **MW** of each week, from **1:30 pm to 2:20 pm**, in **SCCE A131**. We will also meet for *labs* on **F** of each week, at either **12:00 pm to 12:50 pm (Section 1)** or **1:30 pm to 2:20 pm (Section 1)**, in **SCCE C107** (the digital lab).

You are expected to be present for **all of the lectures and labs**. I will not teach material twice, so if you miss a class meeting, then you're on your own for whatever material was covered that day. If you must miss lecture or lab due to an illness, a curricular conflict (e.g., a Geology field trip), or an emergency situation, contact me and I will arrange to handle the problem. **If you have a extra-curricular conflict** with a lecture or lab—for an athletic event, for a (non-curricular) musical or theatrical performance, to depart early for or arrive late from a vacation, or for any other non-emergency—then **the choice is yours to miss or to attend**. If you choose to miss the class meeting, I do **not** need to know **why** nor even **that** you will be absent. You have elected, voluntarily, not to attend, and you must be prepared to obtain and learn on your own the material that you missed. I recommend that you choose to attend the class meeting when these conflicts arise. Do not underestimate the willingness of those who run extra-curricular programs to support and to accommodate your academic priorities.

Individual meetings (a.k.a., *office hours*): If you seek assistance, reinforcement, review, or other opportunities to discuss the course material or assignments, you should see me. There is a link on the course web page for scheduling a time to meet. I encourage you to use these hours to delve deeping into the material and the projects; chatting with me outside of class is one of the reasons you came to a small college.

Slack channel: We will make regular use of Slack. You will be added to the `#cosc-171-F21` Slack channel, where you will be able to send questions directly to me, or for the whole class to see. It will also be the mechanism by which I distribute announcements quickly, send files/documents that may be immediately helpful, and try to keep a running sequence of questions and answers.

Email: Many questions simply do not need an in-person meeting, at least not initially. You should certainly feel free to send email to me with your questions or concerns. Be forewarned, however, that I do not typically respond to email quickly, so do not expect a quick turnaround. For a quicker response, Slack is likely to be better.

3 Texts and materials

There will be two texts for this course. For the earlier part of the course, there will be a my systems book, available as a free PDF through the college's Moodle site.

The textbook for the latter part of the course is, *Computer Organization and Design: The Hardware Software Interface, ARM Edition (1st edition)*, by Patterson and Hennessy.[2].

All other tools for this course—all of the software and documentation—will be provided online.

4 Assignments, deadlines, and extensions

There will be a number of implementation assignments. The deadline for each will be stated clearly on the assignment. **Late submissions may receive failing grades**. Submit what you have, and do so on time.

An extension for any assignment **must be requested, in writing** (email counts as *writing*), **at least 48 hours prior to the deadline**. The determination as to whether or not a particular situation merits an extension will be made on a case-by-case basis. Scheduled events are **not** sufficient reason to warrant an extension. Rather, extensions are intended for unusual circumstances that prevent you from planning your time well in order to meet the deadline. Note that a sudden onset of illness or other emergency situation that occurs less than 48 hours before a deadline will be treated as a special case.

5 Exams and grading

There will be a single, **comprehensive final exam** given during the final exam period at the semester's end. It will be 3-hours and self-scheduled.

Your final grade will be chosen by my evaluation of how well you have mastered the course material at the semester's end. All of the work that you submit, as well as your participation in class, contributes to my impression of that mastery.

[2]Paperback ISBN: 9780128017333; eBook ISBN: 9780128018354

6 Academic dishonesty

You will be expected to do your own work on all assignments and exams in this course. While I encourage you to interact with your classmates and discuss the material and assignments, there is a limit to the specificity of such discussions. I seek to make that limit clear here.

It is acceptable to discuss any assignment for the class with a classmate. You may even discuss your approach to a particular problem, or review relevant material for a problem with another person. However, you **may not show another student your work, nor see another student's work. If in doubt, *ask me*.** If you are unusure whether or not a particular kind of communication would rise to the level of academic dishonesty, then you should contact me immediately and find out.