Systems I: Computer Organization and Design
Fall 2025
Course Information

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

1 The topics

For most people, 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 and solving their own problems byhiding 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 components then fit together. This course focuses on the core elements of the computing hardware: the *processor* and the *memory*. Other courses focus on the operating system, programming languages and their compilers, and networks—the other components of general-purpose computing systems.

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, resulting in qualitatively different operations and capabilities. 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 and non-comprehensive list of the topics that we will cover, **roughly** in 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

[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.

- Binary arithmetic
- Addition and multiplication circuits
- Arithmetic Logic Units (ALUs)
- 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* and *field-programmable gate arrays (FPGAs)*, building computational components with both simulated and real circuits. As the structures get more advanced, we will move our work onto a *System Verilog*, a language for simulating complex circuit architectures.

This course should be fun because there is a great deal of hands-on experience with the material. It is also a great demystifying experience because 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 **9:00 am to 9:50 am**, in **SCCE A131**. We will also meet for *labs* on **F** of each week, at either **8:35 am to 9:50 am (Section 01L)** or **10:05 am to 11:20 am (Section 02L)**, in **SCCE C107**.

You are expected to be present for **all of the lectures and labs**. There are a few different circumstances for missing lectures and labs:

- **Unplanned & urgent:** If you are ill or injured, or some other emergency arises, contact me as soon as practicable. We will make a plan to address what you missed.

- **Planned & college-affiliated:** If some curricular event (e.g., field trip for a Geology class) or non-curricular-but-college-associated event (e.g., athletic contest, musical or theatrical performance) will conflict with class meetings, then contact me as far in advance as possible. We will make a plan to address what you are going to miss. Note that there are limits to this adjustment for non-curricular events; your curricular work is expected to take precedence, and I may not move deadlines or exams for non-curricular conflicts. In those cases, you should be working also with those running those conflicting events (e.g., coaches) to find alternative solutions.

- **Non-college related:** For all other reasons for missing lectures or labs, the choice is yours whether to miss those class meetings. If you choose to miss them, then you do not need to contact me, and any material or activities missed are entirely your responsibility. I will not accomodate such missed class meetings with adjusted deadlines or alternate plans. I strongly recommend that you choose to attend the class meeting when these conflicts arise.

Meeting with me: If you wish to discuss the course material or assignments with me, then I encourage you to contact me. Send me times that you are available, and I will prioritize meeting with you as soon as possible. Chatting with your professors outside of class is one of the reasons you came to a small college, so take advantage of the opportunity.

TA help sessions: There will be weekly help sessions with the course TA's where you can ask questions about the material and the assignments. Again, coming to a small college provides you the opportunity to work closely with your fellow students, so take advantage of this opportunity as well. The schedule for these weekly meetings will be posted early in the semester.

Slack channel: We will make regular use of Slack. You will be added to the `#cosc-175-2526f` 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: You should certainly feel freeto 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

The textbook for the latter part of the course is, *Digital Design and Computer Architecture, RISC-V Edition, Edition 1*, by Harris and Harris. It should be provided by the college's

textbook program.

All other tools for this course—all of the hardware, software, and documentation—will be provided in labs and the class web page.

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. Because the assignments are so cumulative, it is often more important to move forward, skipping temporarily over what was missed, than to slog through late assignments in the hope of catching up.

An extension for any assignment **must be requested in 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 a 3-hour scheduled exam.

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, your final exam, and your participation during classes and labs all contribute to my impression of that mastery.

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.

Regarding the use of AI's or other internet sources: Don't. The core experience of this course is to internalize the concepts, logic, and structures involved in designing and implementing a physical computer system. Engage fully with that project and you will understand much more clearly and deeply. Embrace the struggle to build a clear understanding of the concepts and their implementation. Share that struggle with your fellow students as they do the same. Don't ask an AI, because it was already trained on all of this background and doesn't need to learn it (and doesn't know how to struggle). Using AI steals from yourself the work that changes your brain. Don't do that. Change your brain.