# CS 4290: Advanced Computer Organization

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Office Hours: WF 12:30-1:30 p.m.
Office Hours Link: Teams

Web: Canvas, Piazza
Class Hours: MWF 09:30-10:45 a.m.
Class Room: Teams

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## Course Description

3 Credit Hours. This course covers topic concerning the hardware design of computer systems. We will cover advanced techniques in high-performance, pipelined central processing units, memory and I/O systems, and parallel processors including shared-memory multiprocessors and cluster computers. Credit is not allowed for CS 6290, ECE 4100, or ECE 6100.

## Prerequisites

1. Understanding of basic computer organization, equivalent of GT CS 2200
2. Competence with programming (including data structures)
3. Programming ability in C or C++, and some knowledge of an assembly language

## Book

**No book** – The lectures and course notes contain everything you need.

## Course Objectives

By the conclusion of this course, you will appreciate major topics in the field of Computer Architecture, and you will be able to read and understand current research papers in the field. More specifically, you will be able to

1. State the types of parallelism in a modern computer and explain the uses of each,
2. Use standard metrics to evaluate and compare processor designs,
3. Implement detailed simulations of architectural components, including caches and out-of-order pipelines.
4. Understand the major challenges in implementing multiprocessing systems including cache coherence, synchronization, and consistency, as well as solutions to these problems.

## Remarks

This course is very challenging because the topics are highly technical. So please stay on keep on top of the lecture material, start assignments early, and reach out sooner rather than later when you need help with a topic.

# Topics

We will cover the following topics in this course. The name of the associated notes file is in parentheses.

1. (n1_intro) Introduction, overview and history of general-purpose computers, current trends
2. (n2_perf) Measuring performance and cost
3. (n3_cache) Uniprocessor memory hierarchy design
4. (n4_pipe) Pipelined microarchitectures
5. (n5_ilp) Instruction level parallel microarchitectures: superscalar and VLIW
6. (n6_multiproc) Multiprocessors: shared memory vs. message passing, Cache-coherent shared memory: snooping and directory-based protocols, Memory consistency
7. (n7_sync) Synchronization
8. (n8_interconn) Interconnection networks and storage
9. Advanced topics (time permitting): phase analysis

# Policies

## Grading Policies

*Grade Calculation*

- **45%** - 3 Projects, 15% each
- **15%** - Homework (4 to 5)
- **10%** - Midterm Exam 1 - Friday, June 11
- **10%** - Midterm Exam 2 - Friday, July 9
- **20%** - Final Exam - Friday, July 30 at 8:00am - 10:50am.

*Grade Cutoffs*

A = $[100, 90]$, B = $(90, 80]$, C = $(80, 70]$, D = $(70, 60]$, F = $(60, 0]$.

## Class Policies

*Attendance*

Attendance is very important. I will be teaching by writing on the board (virtually), and I encourage interactive lectures. Additionally, students with good attendance tend to do better on exams and have higher final grades.

*Distractions*

Please avoid any distractions during lecture, such as social media, reading the news, or surfing the web. While you have to use a device to watch the lectures, you should still take notes by hand, which is linked to better course outcomes just like class attendance.

*Extra Credit*

There will be no extra credit.

*Projects*

There are three projects this semester, each involving writing some part of an architectural simulator. More details will be announced when they are assigned. The final project will be due during Final Instructional Class Days.

*Midterms and Final Exam*

There will be two midterm exams. These will consist of several short questions, be closed book, and closed notes. Midterms will take place during lecture time. The final will be the same format but will take place at the time dictated by Georgia Tech.

*Homework*

Homework assignments cover material from lecture. When they are assigned concurrent with active projects, they also will emphasize the concepts needed for the projects. There will be approximately four to five homework assignments in total, (not including the Honorlock practice quiz, which is counted as a homework assignment). The final homework will be due during Final Instructional Class Days.

*Course Notes*

After we finish a module, I will post the course notes on Canvas. These can be used to make sure you didn't miss anything from lecture.

*Late Work*

Work will not be accepted late. Students who believe they have a valid excuse should check that it complies with the Institute regulations on excused absences.

*Regrades*

Regrades requests should be submitted within 3 days of the return of the assignment. Assignments are only regraded if you answered something correctly but it was marked as incorrect. There are no re-grades for higher partial credit.

*Students with Disabilities*

Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with the Office of Disability Services.

*Everything Else*

Any issues not mentioned here will follow Institute policies and procedures.

## Coding Guidelines

- You must turn in ALL files specified in the "Deliverables" section of the assignment instructions. I reserve the right to impose a penalty on submissions that do not follow the given submission directions.
- You must provide a Makefile that compiles and links your code by default. If you are given a Makefile with the project, I expect your code to compile under the given Makefile.
- Your code must compile with gcc on Ubuntu 20.04 LTS or later. I will provide a virtual machine to use. If your code does not compile, you will receive a 0 for the assignment.
- You will be penalized if your code produces warnings when compiled with the given Makefile, or the following flags if no Makefile is provided: gcc -Wall -pedantic -O2
- Code should be well commented and use a clean, consistent (readable) style (i.e., proper indenting, etc.). We reserve the right to impose style requirements, and deduct for non-conforming solutions. This is not the obfuscated C code competition!
- Are you new to debugging C? Check out this tutorial on how to use gdb.

## Unauthorized Copying and Plagiarism (Cheating)

- As a Georgia Tech student, are assumed to have read and agreed to the Georgia Tech Honor Code.
- A student must submit an assignment or project as their own work (this is what is expected of the students).
- **Important**: collaboration is not permitted. No code or answers should be copied from others. Such copying is unauthorized and will be referred to the Office of Student Integrity. Simply put, the sharing of the answer is academic misconduct. If you are not sure about it, please ask.
- Suspected plagiarism will be reported to the Division of Student Life Office of Student Integrity.
- **Using code from GitHub, via Googling, from Stack Overflow, etc.**, is plagiarism and is not permitted. Also, **do not publish your assignments on public repositories or chats** (i.e., accessible to other students). This is also a punishable offense treated as plagiarism.

## Resources

These uncertain times can be difficult, and many students may need help in dealing with stress and mental health. The CARE Center and the Counseling Center, and Stamps Health Services will offer both in-person and virtual appointments. Face-to-face appointments will require wearing a face covering and social distancing, with exceptions for medical examinations. Student Center services and operations are available on the Student Center website. For more information on these and other student services, contact the Vice President and Dean of Students or the Division of Student Life.

## Honorlock

This course will use digital proctoring for all exams.

### Honorlock Technical Requirements

Check that you device meets these requirements by going to Honorlock support and scrolling to *Simple Single-Click Test*.

*Operating System*

- Windows 10
- MacOSX 10.13 and higher
- ChromeOS 79 and higher

*Browser*

- Google Chrome version 84 and higher

*Internet Speed*

- 1.5 Mbps down, 750 Kbps up

### Other Requirements

- Students must have **a webcam and a microphone**.
- Students must have **a secure private location to take an exam.**
- Students will be asked to **provide a picture ID and take a picture of themselves via a webcam** as part of the exam process.
- Honorlock requires the installation of Google Chrome and the Honorlock Chrome extension.

Note: Honorlock ***is not*** compatible with Linux OS, Virtual Machines, tablets, or smartphones.