

CS4290/6290 - ECE4100/6100 Syllabus, Fall 2021

High Performance Computer Architecture/Advanced Computer Organization, 3 Credits

Tuesday/Thursday, 9:30-10:45am, Howey L4

Instructor Information

Instructor

Prof. Alexandros (Alex) Daglis

Email

adaglis@gatech.edu

Office Hours & Location

TBA on Canvas

Teaching Assistant(s)

TBA

Email

Office Hours & Location

General Information

Description

This course covers modern computer architecture, including out-of-order instruction execution, branch prediction, multi-level caches and cache optimizations, memory, cache coherence, memory consistency, and multi-core processors.

Prerequisites

Undergraduate computer architecture course that covers basic computer organization: instruction sets, basic caching, pipelining, etc. (CS2200 or ECE3057). It may be beneficial to refresh your knowledge on these topics before taking this course.

The course has a significant project component that heavily relies on C/C++ programming. You need to be familiar with C/C++ and Linux.

Course Goals and Learning Outcomes

By the conclusion of this course, you will appreciate major topics in the field of Computer Architecture and understand the main principles of operation of modern general-purpose computer hardware.

Course Requirements & Grading

Your grade will be determined by your performance on homeworks, lab assignments and exams. You will receive these grades through Canvas. The grade breakdown is as follows:

- Labs: 35%
 - Lab 1: 5%
 - Lab 2: 10%
 - Lab 3: 10%
 - Lab 4: 10%
- Exams: 60%
 - Midterm 1: 20%
 - Midterm 2: 20%
 - Final Exam: 20%
- Homeworks: 4%
 - Homework 1: 2%
 - Homework 2: 2%
- In-class and/or Piazza participation: 1%

Description of Graded Components

All labs involve developing a computer architecture simulation component in C/C++.

- Lab 1 involves implementation of a program trace analysis tool that classifies types of instructions.
- Lab 2 involves the implementation and performance evaluation of a 5-stage in-order superscalar pipeline with instruction dependence tracking and branch prediction.
- Lab 3 involves the implementation and performance evaluation of an out-of-order pipeline.
- Lab 4 involves the implementation of a multi-level memory hierarchy, including a DRAM and multiple cache components.

Exams will assess acquired knowledge on the course's covered topics.

- Midterm 1 will cover module 1's topics: instruction-level parallelism, branch prediction, dependence tracking, out-of-order execution.
- Midterm 2 will cover module 2's topics: multithreading, vector processors and GPUs, caches, DRAM, virtual memory.
- The final exam will cover all three course modules. Module 3 includes multiprocessors, interconnects, cache coherence and memory consistency.

Homeworks correspond to their module's topics and their main objective is to be used as exam preparation material.

Notes:

- All graded assignments will be submitted on Canvas.
- No late assignments or exams will be accepted unless we are advised to do so by the Dean of Students. Please contact the office of the Dean of Students with emergencies. The Dean's office is equipped to verify these exceptions better than us and provides a level of uniformity across courses on how emergencies are handled.
- There will be no make-up assignments. The only way a lab assignment, homework, or exam score will change, is if a legitimate mistake in grading has been made. Re-grading can only be requested within 14 days of the graded item's score release. When requesting a re-grade, keep in mind that the entire item will be regraded, which may result in a net score reduction.

Extra Credit Opportunities

Some of the lab assignments will feature optional components for extra credit.

Grading Scale

Your final grade will be assigned as a letter grade according to the following scale:

A	90-100%
B	80-89%
C	70-79%
D	60-69%
F	0-59%

Course Materials

Course Text

There are no required readings.

Additional Materials/Resources

When appropriate, optional reading material will be made available to complement lecture content. Although there is no required textbook, you may find "Computer Architecture: A Quantitative Approach" by J. L. Hennessy and D. A. Patterson a useful reading source.

Course Website and Other Classroom Management Tools

Canvas will be used for all communication and course materials.

Course Expectations & Guidelines

Academic Integrity

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. For information on Georgia Tech's Academic Honor Code, please visit <http://www.catalog.gatech.edu/policies/honor-code/> or <http://www.catalog.gatech.edu/rules/18/>.

We take cheating very seriously. All Georgia Tech faculty are required to report any student suspected of cheating or plagiarizing on a quiz, exam, or assignment to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations.

Accommodations for Students with Disabilities

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services at (404)894-2563 or <http://disabilityservices.gatech.edu/>, as soon as possible, to make an appointment to discuss your special needs and to obtain an accommodations letter. Please also e-mail me as soon as possible in order to set up a time to discuss your learning needs.

Attendance and/or Participation

According to the Institute's current official policy, this course will be conducted in residential (in-person) mode. As the evolution of the pandemic is unpredictable, the Institute's policy may change, and the course's delivery mode will adapt accordingly.

Collaboration & Group Work

All homework and lab assignments should strictly be a product of individual effort. You are allowed to discuss assignments with your peers, but not to share code. We will be using tools for code similarity detection.

Student-Faculty Expectations Agreement

At Georgia Tech we believe that it is important to strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members and the student body. See <http://www.catalog.gatech.edu/rules/22/> for an articulation of some basic expectation that you can have of me and that I have of you. In the end, simple respect for knowledge, hard work, and cordial interactions will help build the environment we seek. Therefore, I encourage you to remain committed to the ideals of Georgia Tech while in this class.

Resources for Students

In your time at Georgia Tech, you may find yourself in need of support. Below you will find some resources to support you both as a student and as a person.

Academic support

- Center for Academic Success <http://success.gatech.edu>
 - 1-to-1 tutoring <http://success.gatech.edu/1-1-tutoring>
 - Peer-Led Undergraduate Study (PLUS) <http://success.gatech.edu/tutoring/plus>

- OMED: Educational Services (<http://omed.gatech.edu/programs/academic-support>)
 - Group study sessions and tutoring programs
- Communication Center (<http://www.communicationcenter.gatech.edu>)
 - Individualized help with writing and multimedia projects
- Advising and Transition (<https://advising.gatech.edu>)
 - Study Strategies Seminar course <https://advising.gatech.edu/gt2801-study-strategies-seminar>
 - Academic coaching <https://advising.gatech.edu/academic-coaching>
 - Advising in your major <http://advising.gatech.edu/>

Personal Support

Georgia Tech Resources

- The Office of the Dean of Students: <https://studentlife.gatech.edu/content/get-help-now>; **404-894-6367**; Smithgall Student Services Building 2nd floor
 - You also may request assistance at https://gatech-advocate.symplcity.com/care_report/index.php/pid383662?
- Center for Assessment, Referral and Education (CARE) **404-894-3498**; <https://care.gatech.edu/>
 - Smithgall Student Services Building 1st floor
 - Students seeking assistance from the Counseling Center or Stamps Psychiatry need to visit CARE first for a primary assessment and referral to on and off campus mental health and well-being resources.
 - *Students in crisis may walk in during business hours (8am-4pm, Monday through Friday) or contact the counselor on call after hours at 404-894-2575 or 404-894-3498. Other crisis resources: <https://counseling.gatech.edu/content/students-crisis>*
- Students' Temporary Assistance and Resources (STAR): <https://studentlife.gatech.edu/content/star-services>
 - Can assist with interview clothing, food, and housing needs.
- Stamps Health Services: <https://health.gatech.edu>; **404-894-1420**
 - Primary care, pharmacy, women's health, psychiatry, immunization and allergy, health promotion, and nutrition
- OMED: Educational Services: <http://www.omed.gatech.edu>
- **Women's Resource Center: <http://www.womenscenter.gatech.edu>; 404-385-0230**
- **LGBTQIA Resource Center: <http://lgbtqia.gatech.edu/>; 404-385-2679**
- **Veteran's Resource Center: <http://veterans.gatech.edu/>; 404-385-2067**
- **Georgia Tech Police: 404-894-2500; <http://www.police.gatech.edu>**

National Resources

- The [National Suicide Prevention Lifeline](#) | 1-800-273-8255
 - Free and confidential support 24/7 to those in suicidal or emotional distress
- The [Trevor Project](#)
 - Crisis intervention and suicide prevention support to members of the LGBTQ+ community and their friends
 - Telephone | **1-866-488-7386** | 24 hours a day, 7 days a week
 - [Online chat](#) | 24 hours a day, 7 days a week
 - Text message | Text "START" to **687687** | 24hrs day, 7 days a week

Statement of Intent for Inclusivity

As a member of the Georgia Tech community, I am committed to creating a learning environment in which all of my students feel safe and included. Because we are individuals with varying needs, I am reliant on your feedback to achieve this goal. To that end, I invite you to enter into dialogue with me about the things I can stop,

start, and continue doing to make my classroom an environment in which every student feels valued and can engage actively in our learning community.

Course Schedule (subject to minor changes)

	Date	Topic	Assignment	Due
Module 1	24-Aug	Intro	Lab 1, Homework 0	
	26-Aug	Performance evaluation		
	27-Aug			Lab 1
	31-Aug	Single-Cycle		
	2-Sep	Pipeline & Hazards	Lab 2	
	7-Sep	Branch Prediction		
	9-Sep	Branch Prediction & Superscalar		
	14-Sep	OOO: Hazards & Renaming		
	16-Sep	OOO: Tomasulo	Homework 1	
	17-Sep			Lab 2 - Part A
	21-Sep	OOO: ROB + Speculation		
	23-Sep	OoO: LSQ		
	24-Sep			Lab 2 - Part B
	26-Sep			Homework 1
	28-Sep	OoO: Practice Problem		
	30-Sep	Midterm 1	Lab 3	
Module 2	5-Oct	Multithreading + VLIW		
	7-Oct	Vector/GPU		
	14-Oct	Caches		
	15-Oct			Lab 3 - Part A
	19-Oct	Caches		
	21-Oct	Caches	Homework 2	
	26-Oct	DRAM		
	28-Oct	Virtual Memory		
	29-Oct			Lab 3 - Part BC
	31-Oct			Homework 2
	2-Nov	Virtual Memory		
	4-Nov	Midterm 2	Lab 4	
Module 3	9-Oct	Multiprocessors		
	11-Nov	Interconnects		
	16-Nov	Interconnects		

	18-Nov	Coherence		
	23-Nov	Coherence		Lab 4 - Part A
	30-Nov	Memory consistency		
	2-Dec	Memory consistency		
	3-Dec			Lab 4 - Part B
	7-Dec	Datacenters		
	3-Dec	Reading period		
	7-Dec	Final exam		