EEL 5764 Computer Architecture

Class Periods: MWF Period 3 (9:35 – 10:25 am)
Location: NEB 201
Academic Term: Fall 2022

Instructor:
Name: Dr. Herman Lam
Email Address: hlam@ufl.edu
Office, Phone Number: Benton Hall 313, 352-392-2689
Office Hours: TBA

Teaching Assistants

- Projjal Gupta, projjalgupta@ufl.edu, office hours: TBA
- Daniyal Tahsildar, daniyaltahsildar@ufl.edu, office hours: TBA

Catalog Course Description

Fundamentals in design and quantitative analysis of modern computer architecture and systems, including instruction set architecture, basic and advanced pipelining, superscalar and VLIW instruction-level parallelism, memory hierarchy, storage, and interconnects. (3 credits)

Course Pre-Requisites / Co-Requisites

Students are expected to have a background in computer organization and design, and in microprocessors. Additionally, students must have basic experience in a programming language such as C/C++, debugging, Linux operating system, and shell scripting.

Course Objectives

Upon completion of the course, students should have a good understanding of the following core components of computing architecture and computer architecture design:

- Technology impacts on computer architectures
- Various aspects of modern computer architecture design - memory hierarchy, instruction set design, pipelining, out-of-order execution, speculation, etc.
- Various parallelisms and their exploitations, e.g., instruction-level, data-level, and thread-level parallelism
- Quantitative evaluation of design tradeoffs in terms of different application and architectural parameters

Required Textbook

Computer Architecture: A Quantitative Approach (6th Edition), John L. Hennessy and David Patterson, Morgan Kaufmann Publishers, 2019, ISBN 978-0-12-811905-1.

Course notes will also be provided on the class website via Canvas.

Recommended Reference

Computer Organization and Design RISC-V Edition, (2nd Edition), David A. Patterson and John L. Hennessy, Morgan Kaufman Publishers, 2021, ISBN 978-0-12-820331-6.

Course Topics

Module 1: Overview of computer architectures

- Trends in computer technologies and factors for computer system performance
- Key principles and trends in computer architectures

Memory Hierarchy Design

Module 2: Fundamentals of memory hierarchy

- Memory technologies
- Memory hierarchy and cache hierarchy concepts

Module 3: Memory hierarchy and cache design

- Basic optimizations of cache performance
- Advanced optimizations of cache performance

Module 4: Virtual memory

- Virtual memory concepts
- Virtual memory design

Instruction Set Architecture (ISA) & Instruction-level Parallelism

Module 5: Instruction set architecture (ISA)

- Instruction set architecture (ISA) principles
- Overview of RISC-V ISA

Module 6: Instruction pipelining & performance evaluation

- Introduction to instruction pipelining
- Performance evaluation

Module 7: Pipeline hazards and optimizations

- Structural hazards
- Data hazards

Module 8: Control hazards and optimizations

- Branch prediction
- Static & dynamic scheduling

Current Trends in Computer Architecture

Module 9: Overview of current trends in computer architecture

- **Data-level parallelism:** Vector architectures, SIMD architectures, Graphics processing units (GPUs)
- **Thread-level parallelism:** shared-memory architectures, distributed shared-memory architectures
- **Large scale parallel computing architectures:** warehouse-scale computers, HPC computer architectures, domain-specific architectures

Lab Experiments: A series of laboratory experiments (spanning the first half of the semester) will be assigned in learn to use the gem5 simulator. The gem5 simulator is a modular platform for computer-system architecture research, encompassing system-level architecture as well as processor microarchitecture. gem5 is an open-source computer architecture simulator used in academia and in industry (www.gem5.org).

Project: Students will form teams of two to three students each and undertake a research project (on a proposed topic subject to instructor approval). For example, projects can involve exploring fundamental issues in computer architectures using the gem5 simulator platform, or experimentation with benchmark suits on systems, etc. The culmination of each project will be a clear and concise technical report (and a demonstration) discussing project concepts, development, experiments, results, and analyses. The most important outcome of each project and report will be the research results that are achieved, analyses rendered, and conclusions drawn with demonstrable insight.

Attendance Policy, Class Expectations, and Make-Up Policy

- Class attendance is not required. The classes will be recorded and will be available on Canvas.
- Missed or late labs and assignments will be penalized, as specified in the lab and assignment writeups.
- There are no scheduled makeup exams. Makeup exams are handled case-by-case, only for documented illness and emergencies. Excused absences for exams must be in compliance with university policies in the Graduate Catalog (https://catalog.ufl.edu/graduate/regulations/) and require appropriate documentation. Additional information can be found here: https://gradcatalog.ufl.edu/graduate/regulations/.
- As stated above, our class sessions will be audio visually recorded for students in the class to refer back and for enrolled students who are unable to attend live. Students who participate with their camera engaged or utilize a profile image are agreeing to have their video or image recorded. If you are unwilling to consent to have your profile or video image recorded, be sure to keep your camera off and do not use a profile image. Likewise, students who un-mute during class and participate orally are agreeing to have their voices recorded. If you are not willing to consent to have your voice recorded during class, you will need to keep your mute button activated and communicate exclusively using the "chat" feature, which allows students to type questions and comments live. The chat will not be recorded or shared.

Evaluation of Grades

Assignment	Total Points	Percentage of Final Grade
Labs	100 each	15%
Midterm Exam	100	25%
Final Exam	100	30%
Project	100	30%
		100%

Grading Policy

The following is the standard grading scale and serves as the basic guideline. Final grade assignments will be adjusted based on class performance (e.g., class averages on different class deliverables).

Percent	Grade	Grade Points
90.0 - 100.0	A	4.00
89.0 - 89.9	A-	3.67
85.0 - 88.9	B+	3.33
80.0 – 84.9	B	3.00
79.0 - 79.9	B-	2.67
75.0 - 78.9	C+	2.33
70.0 – 74.9	C	2.00
69.0 – 69.9	C-	1.67
65.0 - 68.9	D+	1.33
60.0 - 64.9	D	1.00
59.0 - 59.9	D-	0.67
0 - 58.9	E	0.00

More information on UF grading policy may be found at:

UF Graduate Catalog

Grades and Grading Policies

Students Requiring Accommodations

Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting https://disability.ufl.edu/students/get-started/. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

Course Evaluation

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at https://gatorevals.aa.ufl.edu/students/. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via https://ufl.bluera.com/ufl/. Summaries of course evaluation results are available to students at https://gatorevals.aa.ufl.edu/public-results/.

In-Class Recording

Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A "class lecture" is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To "publish" means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

University Honesty Policy

UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Honor Code (https://sccr.dso.ufl.edu/process/student-conduct-code/) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Commitment to a Safe and Inclusive Learning Environment

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- Jennifer Nappo, Director of Human Resources, 352-392-0904, jpennacc@ufl.edu
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

Software Use

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: https://registrar.ufl.edu/ferpa.html

Campus Resources:

Health and Wellness

U Matter, We Care:
Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center: https://counseling.ufl.edu, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Discrimination, Harassment, Assault, or Violence
If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the **Office of Title IX Compliance**, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu

Sexual Assault Recovery Services (SARS)
Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or http://www.police.ufl.edu/.

Academic Resources

E-learning technical suppor*t*, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. https://lss.at.ufl.edu/help.shtml.

Career Connections Center, Reitz Union, 392-1601. Career assistance and counseling; https://career.ufl.edu.

Library Support, http://cms.uflib.ufl.edu/ask. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring. https://teachingcenter.ufl.edu/.

Writing Studio, 302 Tigert Hall*,* 846-1138. Help brainstorming, formatting, and writing papers. https://writing.ufl.edu/writing-studio/.

Student Complaints Campus*:* https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/;https://care.dso.ufl.edu.

On-Line Students Complaints*: https://distance.ufl.edu/state-authorization-status/#student-complaint*