Fall 2025

ECE 451 - Advanced Computer Architecture

General information: 3 credit hours. T/R: 10:00 AM - 11:20 AM. ECEC 100

Instructor: Shaahin Angizi, ECE 325, (973)-596-3516, shaahin.angizi@njit.edu

Office Hours: T/R: 11:30 AM - 1:30 PM or by appointment.

Required Text: Lecture notes: primary references

References:

John L. Hennessy and David A. Patterson, *Computer Architecture: A Quantitative Approach*, ISBN: 012383872X.

Morris Mano, *Computer System Architecture*, ISBN: 0131755633

David A. Patterson and John L. Hennessy, *Computer Organization & Design, The Hardware/ Software interface*, ISBN: 0123747503

Catalog Description: This course focuses on advanced concepts in computer systems design, and the interaction between hardware and software components at various levels (i.e., hardware/software codesign). It introduces common performance measures and tradeoffs used by hardware and software designers to facilitate comparative analysis. The main topics are: Technology challenges, Pipelining, Multicore architecture, Advanced memory technologies, Introduction to parallel computing, Conventional architecture for AI acceleration, Analog neuromorphic computing architecture, and Digital in-memory computing.

Prerequisite: Computer Organization and Architecture (ECE 353)

Course Syllabus:

Lecture 0: Introduction

Lecture 1: Technology Challenges

- Power Wall
- Memory Wall

Lecture 2: Pipelining & Multi-core

- Von-Neumann Model
- Pipelining
- Virtual Memory
- Multi-Core

Lecture 3: Toward Advanced Memory Technologies

- Volatile Main Memory
- Main Memory in Multicore Systems
- Non-volatile Magnetic Memories

Lecture 4: Domain-Specific Architectures

- Neural Networks

- Acceleration in Von-Neumann Computing Architecture (ASIC, FPGA, GPU)
- Processing-in-non-Volatile Memory (Resistive Memory, e.g., spin-based memory)
- Processing-in-Volatile Memory (DRAM)

Grading Criteria:	HomeWorks and Critical Reviews:	30%
	Research Project:	30% (15% Report +15% Presentation)
	Exams:	40% (20% Midterm + 20% Final)

Grading Policy:

Grades	Significance	Approx. Points
A	Superior	94–100
B+	Excellent	87–93
B	Very Good	80–86
C+	Good	74–79
C	Acceptable	66–73
D	Minimum	60–65
F	Failing	Below 60

Course Learning Outcomes:
The student will be able to:
1. Understand the technology challenges and tradeoffs between device/circuit/architecture parameters and interaction between hardware and software components;
2. Understand and utilize the common performance measures used by hardware and software designers to facilitate comparative analysis;
3. Design a basic instruction pipeline and quantitatively evaluate and compare the multicore processor designs and memory hierarchy;
4. Understand volatile and non-volatile memory design techniques;
5. Understand the basics of AI/ML and performance measures used by AI accelerator architectures;
6. Understand how architecture-level simulators work, and choose and present one simulator at the class.

Collaboration: You are allowed to collaborate with your classmates by discussing the materials and ideas on how to solve the homework. Such discussions should be done in speaking only. No written materials or code should be shared. The work you submit should be of your own making.

Homework: Homework will be assigned in the format of problem-solving or assigned reading. All homework must be completed on time and uploaded to NJIT Canvas.

Submission / Late Submission / Make-up Policies / Use of AI assistants):

- All submissions must be uploaded to Canvas prior to the specified due date and time – no other form of submission can be accepted: please do not email your submissions.

- The use of Large Language Model (LLM)-based text generation tools (such as ChatGPT, Gemini, Claude, or similar AI assistants) is strictly prohibited in this course for all coding assignments, critical reviews, and written submissions. These tools generate text that does not reflect a student's own understanding, reasoning, or effort, and therefore undermine the purpose of the assignments, which is to develop your analytical, problem-solving, and communication skills. Students are expected to complete all work independently, demonstrating their authentic knowledge and skills.
- Late Work: useful to study but cannot be utilized for credit to be fair to all students.

Honor Code: The NJIT Honor Code will be upheld, and any violations will be referred to the Dean of Students for disciplinary action. "Academic Integrity is the cornerstone of higher education and is central to the ideals of this course and the university. Cheating is strictly prohibited and devalues the degree that you are working on. As a member of the NJIT community, it is your responsibility to protect your educational investment by knowing and following the academic code of integrity policy that is found at: http://www5.njit.edu/policies/sites/policies/files/academic-integrity-code.pdf.

Please note that it is my professional obligation and responsibility to report any academic misconduct to the Dean of Students Office. Any student found in violation of the code by cheating, plagiarizing or using any online software inappropriately will result in disciplinary action. This may include a failing grade of F, and/or suspension or dismissal from the university. If you have any questions about the code of Academic Integrity, please contact the Dean of Students Office at dos@njit.edu"

Course Schedule:

Topic	Weeks
Technology Challenges, Power & Memory Wall	1,2
Von-Neumann Model & Pipelining	3,4
Multicore Systems	5
Volatile Main Memory	6
Main Memory in Multicore Systems	7
Non-volatile Memories	8,9
Domain-Specific Architectures & Parallel Processing	10,11
In-Memory Computing	12,13
Project Presentation	14