

15-740/18-740 Computer Architecture Fall 2011 Syllabus

1 Course Contacts & Logistics

Onur Mutlu (Instructor)

Office: Hamerschlag Hall A305

Webpage: <http://www.ece.cmu.edu/~omutlu>

Office Hours: Wednesdays 4:30-5:30 PM (or by appointment)

Email: onur@cmu.edu

Phone: 412-268-1186

Justin Meza (Teaching Assistant)

Office: Hamerschlag Hall A5

Office Hours: Thursday 3:00-4:00 PM, Friday 1:00-2:00 PM

Email: justinme@ece.cmu.edu

Phone: 412-268-7079

Yoongu Kim (Teaching Assistant)

Office: Hamerschlag Hall A313C

Office Hours: Monday 1:00-2:00 PM, Tuesday 1:00-2:00 PM

Email: yoonguk@ece.cmu.edu

Phone: 412-268-9388

Course Webpage: <http://www.ece.cmu.edu/~ece740/>

Lecture Time: Mondays, Wednesdays, Fridays - 2:30-4:20 PM

Classroom: Doherty Hall 1112

During some weeks, two out of three days a week will be lectures and the remaining day will be devoted to discussions. **Administrative Assistant:** Laura McGee, lmcgee@andrew.cmu.edu, HH D-Level Course Hub

2 Course Overview

Computer architecture is the science and art of designing, selecting and interconnecting hardware components and co-designing the hardware/software interface to create a computer that meets functional, performance, energy consumption, cost, and other specific goals. This course qualitatively and quantitatively examines fundamental computer design trade-offs, with the goal of developing an understanding that will enable students to perform cutting-edge research in computer architecture. We will learn, for example, how uniprocessors execute many instructions concurrently, how state-of-the-art memory systems deliver data into the processor and why they are so complex, and how/why multiple processors are interconnected to execute portions of a program or multiple programs in parallel, as done in modern multi-core processors. Examining and evaluating trade-offs requires that you already know how to correctly design a computer, as is taught in the important prerequisite 18-447.

Prerequisites - 18-447 or equivalent

3 What This Course is About?

This course has two major goals:

1. to familiarize computer architecture students and those interested in computer system design with both fundamental design tradeoffs and recent research issues/trends processor, memory, and platform architectures in today's and future systems. There will be a strong emphasis in fundamentals and design tradeoffs.
2. to provide the necessary background and experience to advance the state-of-the-art in computer architecture by performing cutting-edge research. There will be a strong emphasis on critically evaluating research papers (through literature review assignments) and developing new mechanisms that advance the state of the art (through the course research project).

This course teaches students how to make design decisions in a computer platform (both in hardware and the hardware/software interface, and sometimes in software) and also how to make them better than past approaches. It is *not an introduction* to computer system design. The scope of the course material is general and fundamental: the techniques and the design decision process taught is fundamentally applicable to different type of computing platforms, including server, desktop, mobile, embedded, and sensor systems.

4 Textbooks & Reading/Research Material

Arguably, there is no perfect textbook for computer architecture. I encourage you to do your own research, consult multiple sources, question assumptions and statements, and talk with me and TAs whenever you have questions. Lectures will serve as the main source of information and they will provide the required references to textbooks or other reading material (such as research articles). A good source of information on all covered topics is the research articles that introduced or built upon the covered topic. These articles are usually published in top conferences (such as ISCA, MICRO, ASPLOS, HPCA) or journals (such as IEEE or ACM Transactions). I strongly encourage you to dig out the original source of the covered topics as well as the research that builds upon it. This will help you become a successful and well-read researcher in computer architecture/systems. When in doubt, ask questions.

The following textbooks could be useful as supplements to lectures:

1. **Computer Architecture: A Quantitative Approach, Fourth Edition** by Hennessy and Patterson, Morgan Kaufmann/Elsevier
2. **Computer Architecture and Implementation** by Harvey Cragon, Cambridge University Press
3. **Computer Organization** by Hamacher, Vranesic, Zaky, McGraw-Hill
4. **Structured Computer Organization** by Andrew Tanenbaum, Prentice Hall

5. **High Performance Computer Architecture** by Harold Stone, Prentice Hall (dated but good reference)
6. **Readings in Computer Architecture** by Hill, Jouppi, Sohi, Morgan Kaufmann

The following websites contain links to original articles as well as articles that refer to them:

1. Google and Google Scholar
2. ACM Digital Library
3. IEEE Explore
4. Microprocessor Report (The CMU E & S Library has a subscription)

Other reading material will be distributed in class and/or will be available on the website electronically.

5 Assignments & Grading

The course will be graded on a curve scale. The tentative breakdown of grades is given below:

10%	Homeworks, Reviews, Quizzes
35%	Research Project (detailed breakdown to follow in project handouts)
20%	Midterm Exam 1
35%	Midterm Exam 2
5%	The teaching team's evaluation of your performance

6 Homeworks & Reviews

The primary purpose of the homeworks is to help you master the material and prepare for both the projects and exams. I encourage you to work together with your classmates to help you understand the basic concepts. However, you are required to do your own homework.

7 Research Projects & Late Policy

This course is a hands-on research oriented course. You (in groups of two) are expected to propose, conduct, and experimentally evaluate a 2-3-month long research project whose goal is to advance the state-of-the-art and/or current understanding in computer architecture or a related subject. The topic of the project is flexible, but it must be approved by me. You will have to find a project partner and conduct research in groups of two. This is your chance to explore in depth a computer architecture topic that interests you and perhaps even publish your innovation in a top computer architecture conference. I strongly encourage you to start thinking about your project topic as early as possible and interacting with me and the teaching assistants to crystallize it over time.

A total of five late days will be allowed for the assignments and project proposal/reports. Once you use up all your late days, your submissions will be graded based on the instructor's discretion. **No late submission will be allowed for the project final report.**

8 Academic Honesty and Integrity

We would like to promote a collaborative environment where people feel free to openly discuss and ask questions. However, when assignments are submitted, the work must be the author's own and any aid received from other people must be documented in the assignment. Simply put, cheating is submitting work that is not your own; material handed in for grading must be the product of individual effort; anything else constitutes cheating. Cheating in any form or shape will result in a failing grade for the course. No exceptions will be made. Students are referred to the University Policy about Cheating and Plagiarism ¹ and the ECE Department Academic Integrity Policy², which both apply, in all respects, to this course.

¹<http://www.cmu.edu/policies/documents/Cheating.html>

²<http://www.ece.cmu.edu/student/integrity.html>

9 Compile Time Course Schedule (Will change at Run Time)

Date	Topic	Homework	Project
8/29-9/2	No Class (CSD Immigration Course)		
9/7	Introduction, Principles, and Tradeoffs	HW0 Assigned	
9/9	ISA, Tradeoffs, and Performance		
9/12	Performance		Topics Out
9/14	Pipelining	HW0 Due	
9/16	Precise Exceptions		
9/19	Virtual Memory		
9/21	Out-of-Order Execution		
9/23	Issues in Out-of-Order Execution		
9/26	Caches		Proposal Due
9/28	Runahead and MLP		
9/30	OoO Wrap-Up and Advanced Caching		
10/3	Advanced Caching		
10/5	More Caching		
10/7	Prefetching		
10/10	Hardware Prefetching		Milestone I Due
10/12	Prefetching Wrap-Up		
10/14	Prefetching, Caching, Multi-core		
10/17	Caching in Multi-core		
10/19	Main Memory I		
10/21	Exam I		
10/24	Main Memory II		Milestone II Due
10/26	Superscalar Processing I		
10/28	Superscalar Processing II		
10/31	Superscalar Processing III		
11/2	Control Flow I		
11/4	Control Flow II		
11/7	Predication and DAE		
11/9	VLIW		Milestone III Due
11/11	SIMD and GPUs		
11/14-18	Multithreading, Multiprocessing		
11/21	Architecture Case Studies		
11/23-25	No Class (Thanksgiving)		
11/28-30	Project Presentations, Case Studies		Presentations
12/2	Exam II		
12/5-9	MICRO conference		
12/12-16	Project Poster Session		Poster Session (TBD)
12/18			Final Report Due