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**Editor:** Justin Perona

# ECS 201A - Advanced Computer Architecture

## Important Information

### *Time and Location*

226 Wellman Hall

Discussion: Monday 3:10 - 4:00 PM

Lecture: Tuesday, Thursday 1:40 - 3:00 PM

### *Instructor*

Professor Jason Lowe-Power (jlowepower@ucdavis.edu)

Office Hours: Wednesday 1:30 - 3:00 PM, or by appointment. You can use my calendar to quickly find a time I am available.

Office Location: 3049 Kemper Hall

I will also hold virtual office hours via Google Hangouts. Check my calendar for each week's link.

### *Teaching Assistant*

Justin Perona (jlperona@ucdavis.edu)

Office Hours: Tuesday, Thursday 3:10 - 4:00 PM

Office Location: 3106 Kemper Hall

### *Canvas*

We will be using Canvas for much of the course administration. This document, as well as all other downloads, are available on the Canvas site. You will use Canvas for turning in your homeworks and paper reviews.

### *Github*

We will use Github to host the latest copies of this document, the course schedule, and the homeworks. If I make changes to those documents, they will appear first on Github.

### *Gradescope*

We will use Gradescope for returning quizzes, the midterm, and the final. Gradescope gives you a graded PDF version of your test, along with a rubric, immediately after we're done grading. You will receive an email from Gradescope to make your account after we grade the first quiz.

### *Piazza*

We will use Piazza for class discussions outside of the classroom. If you haven't used Piazza before, it's a cool tool that is essentially a message board for the class. Both Justin and I will be on Piazza to answer questions.

It's best to ask your questions on Piazza. That way, all of your classmates can see the answer instead of emailing Justin or me. Additionally, you might get a much faster response from one of your classmates!

Through asking and answering questions on Piazza, you improve your understanding of the material, and improve other students' understanding as well. As an incentive to answer other students' questions and participate, I will drop your lowest quiz score if you consistently participate on Piazza. I will check Piazza participation and drop the lowest score at the end of the quarter.

In the spirit of the above, please ask questions as public questions on Piazza, if possible. This way, your question, and the answer to your question, can help somebody else who might have the same question. We will change questions asked privately to public, if we deem it appropriate. If your question involves code you've written, or is about a personal issue, we will leave those private.

### *Regrade Requests*

Regrade requests must be made within one week of the return of the assignment or test.

### *Accommodations*

The exam schedule is available on Canvas, or below. Per official UC Davis policy, if you have an accommodation request from the Student Disability Center, or have any conflicts with exam times for religious observances, you must notify me **by the fourth class, 5 October 2017**.

### *Lecture Videos*

The lectures and discussion will be recorded. The videos for each class will be available on Canvas soon after the lecture. Check the Media Gallery page on Canvas for the lecture videos. You will need to have third-party cookies enabled to access the videos.

## Prerequisites

Undergraduate computer architecture course (e.g., ECS 154B).

I am going to assume you have knowledge of ISAs, simple pipelining, simple caching, and high-level computer organization. These basics are covered in D. A. Patterson and J. L. Hennessy, Computer Organization and Design: The Hardware/Software Interface.

Some of these topics are covered in the appendices of our Hennessy and Patterson book. For instance, Appendix A gives a great overview of ISA design and implications. If you find you do not have enough background on a topic, start by checking the appendices of the book.

## Class Format

### *Lectures (Tuesday, Thursday 1:40 - 3:00 PM)*

Our lecture time will be a traditional lecture structure. You are expected to have read the sections from the book *before* attending lecture. Lectures will not directly cover what is in the book. Instead, lectures will build on what you have read in the book, and cover certain topics in more detail.

### *Discussion (Monday 3:10 - 4:00 PM)*

Discussions will be used for three things:

1. Discussing reading material.
2. Discussing the homeworks.
3. Short quizzes.

Each discussion will be split between discussing the weekly paper and either a short quiz (approximately 25 minutes) or a homework discussion.

# Assignments and Tests

## *Homeworks*

There will be five homeworks throughout the quarter, with one due about every other week. Homeworks will involve a programming assignment and answering a set of questions. Homeworks will be graded based on the *answers to the assigned questions* in the form of a short report.

Turning in the homework consists of:

1. Turning in your code before discussion begins on the due date.
2. Turning in a PDF of your report before discussion begins on the due date.

To turn in your code and your PDF report, we will use Canvas.

*Late homeworks receive an automatic 25% reduction per day they are late. Homeworks will not be accepted for late submission four days after the due date.*

## *Paper Reading and Reviews*

Each week we will be reading a scientific paper from computer architecture literature. This will give you an idea of either the history of architecture techniques discussed in lecture, or a perspective on current research. Students are expected to have completed the assigned readings before attending class, and actively participate in discussions.

For each paper, you will be required to turn in a short review. The purpose of these reviews is to get students to read (and discuss) papers before they are discussed in class. To facilitate great class discussions, students must submit their review of the selected papers by 6:00 AM before the discussion for which the paper is assigned. *Late reviews will not be accepted.*

I encourage students to form study groups to discuss the papers before writing their reviews, but each student must write their own independent review.

Reviews will be submitted through Canvas via a text-only submission. The review should be 20 to 40 lines (maximum 3200 characters) with:

- a short summary of the problem the paper attacks and methods used, if any.
- a short summary of the paper's results or key implications.
- your opinion about what's good and bad about the paper.
- a topic or question for lecture.

The last three points are key and best enable your review to stand out.

Reviews will be graded on a scale of Excellent (10 points), Satisfactory (7 points), and Unsatisfactory (3 points). Most reviews will get a 7. Reviews that are too long will automatically receive an Unsatisfactory grade.

Not all reviews for a paper will be graded. If your review is not graded, it will not count against your grade. If you do not submit a review, however, you will get a 0 for that review.

### *Quizzes*

There will be four quizzes: one background quiz, and three regular quizzes. One will be given about every other week. These quizzes are meant for both you and me, to gauge your current understanding of the course. There will be a mix of questions from the book, and new questions.

The quizzes will be open book, open paper, and open notes. However, I can't allow electronic versions of books, papers, or notes. It would be too easy for you to just Ctrl-F the answer!

(Note: I hate killing trees. If you have a solution that keeps the spirit of open book quizzes, while allowing electronic versions, I am open to amending this policy.)

### *Midterm and Final*

The midterm will be given in class on 31 October 2017.

The final is scheduled for Tuesday, 12 December 2017, from 1:00 - 3:00 PM. The location is the same as the lecture room.

Both the midterm and the final are closed book, closed paper, and closed notes. No electronic devices (including calculators) are allowed.

## Grading

Half of your final grade will come from homework, paper reviews, and quizzes. The other half will come from the midterm and final.

A detailed grading breakdown is below.

| | |
|---|---|
| Homework | 20% |
| Paper Reviews | 10% |
| Quizzes | 20% |
| Midterm | 20% |
| Final | 30% |

## Academic Misconduct

Academic misconduct is a serious issue. You can find the official UC Davis policy on the Office of Student Support and Judicial Affairs website.

You are expected to *cite all of the work you reference*. Any ideas that are not specifically yours or generally known (e.g., caches hold data) should have a citation. When in doubt, cite.

Any violations of this policy will result in reporting the violating student(s) to the Office of Student Support and Judicial Affairs.

## Reading List and Schedule

### *Textbook*

In this class we'll be closely following Computer Architecture: A Quantitative Approach by J. L. Hennessy and D. A. Patterson. You can find the book at the university bookstore or through various sites online. This is a great book. It's easy to read and very thorough. Every computer architect should have a copy!

There is both a physical and a digital copy available. You will be doing *a lot* of reading from the book, so I suggest you choose what is most comfortable for you. We will also have open book quizzes (see above), and you will *not* be able to use the electronic copy during the quizzes.

A PDF version of the book is available through ACM. Getting the book through ACM requires an ACM membership and buying access to the ACM Digital Library. While this is an option, paper copies of the book may be cheaper elsewhere.

## *Reading List*

We will be reading about one paper per week from the current computer architecture literature. Each discussion you will be assigned at least one paper to review, although there may be other optional papers for you to read or skim. You are not *required* to review the optional papers, but they will be discussed in class and will further contribute to your understanding.

The schedule below has links to the papers that will work if you are on campus or logged in with the library VPN. You can find PDFs of these papers on Canvas.

## *Schedule*

See the syllabus PDF on Canvas if the table doesn't appear below.

***Schedule***

| Class | Date | Summary | Reading |
|---|---|---|---|
| Lecture 1 | 28-Sep | Introduction | H&P: 1.1-1.3, Appendix L.1-L.2 |
| | | Homework 1 Release: Measuring Performance | https://github.com/jlpteaching/17fq-cs201a/blob/master/hw1/hw1.rst |
| Discussion 1 | 2-Oct | Background Quiz | |
| | | Paper Discussion 1 | |
| | | Review: Cramming More Components onto Integrated Circuits | http://ieeexplore.ieee.org/document/4785860/ |
| | | Optional: Design of Ion-Implanted MOSFET's with Very Small Physical Dimensions | http://ieeexplore.ieee.org/document/1050511/ |
| Lecture 2 | 3-Oct | Tech Trends | H&P: 1.4-1.7 |
| Lecture 3 | 5-Oct | Performance | H&P: 1.8-1.12 |
| Discussion 2 | 9-Oct | Homework 1 Due, Discussion | |
| | | Paper Discussion 2 | |
| | | Review: Amdahl's Law in the Multicore Era | http://ieeexplore.ieee.org/document/4563876/ |
| | | Review: Retrospective on Amdahl's Law in the Multicore Era | http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7945175 |
| | | Homework 2 Release: Cache and Memory Systems | https://github.com/jlpteaching/17fq-cs201a/blob/master/hw2/hw2.rst |
| Lecture 4 | 10-Oct | Cache Refresher | H&P: 2.1-2.2, B.1-B.3 |

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|---|---|---|---|
| Lecture 5 | 12-Oct | Cache Optimizations | H&P: 2.1-2.2, B.1-B.3 |
| Discussion 3 | 16-Oct | Quiz 1 | |
| | | Paper Discussion 3 | |
| | | Review: Fundamental Latency Trade-offs in Architecting DRAM Caches | http://moin.ece.gatech.edu/papers/micro12.pdf |
| Lecture 6 | 17-Oct | DRAM and Virtual Memory | H&P: 2.3 |
| Lecture 7 | 19-Oct | Virtual Memory | H&P: B.4-B.5 |
| Discussion 4 | 23-Oct | Homework 2 Due, Discussion | |
| | | Paper Discussion 4 | |
| | | Review: Translation Caching: Skip, Don't Walk (The Page Table) | https://dl.acm.org/citation.cfm?id=1815970 |
| Lecture 8 | 24-Oct | Virtualization | H&P: 2.4 |
| Lecture 9 | 26-Oct | Memory Hierarchy Summary | H&P: 2.6-2.8 |
| Discussion 5 | 30-Oct | Review for Midterm | |
| Lecture 10 | 31-Oct | Midterm | |
| | | Homework 3 Release: Pipelining in gem5 | |
| Lecture 11 | 2-Nov | Pipelining 1 | H&P: C.1, 3.1 |
| Discussion 6 | 6-Nov | Discuss Midterm | |
| | | Paper Discussion 5 | |
| | | Review: Instruction-Level Parallel Processing | http://rsim.cs.uiuc.edu/arch/qual_papers/compilers/Rau.pdf |
| Lecture 12 | 7-Nov | Pipelining 2 | H&P: C.2, 3.3 |
| Lecture 13 | 9-Nov | Advanced Pipelining 1 | H&P: C.3-C.5 |
| Discussion 7 | 13-Nov | Homework 3 Due, Discussion | |
| | | Paper Discussion 6 | |
| | | Review: TBA | TBA |
| Lecture 14 | 14-Nov | Advanced Pipelining 2 | H&P: 3.4-3.5 |
| Lecture 15 | 16-Nov | Advanced Pipelining 3 | H&P: 3.5-3.7 |
| Discussion 8 | 20-Nov | Quiz 2 | |
| | | Paper Discussion 7 | |
| | | Review: TBA | TBA |
| Lecture 16 | 21-Nov | Limitations of ILP and Speculation | H&P: 3.9-3.14 |
| Thanksgiving | 23-Nov | NO CLASS | |
| Discussion 9 | 27-Nov | Homework 4 Due, Discussion | |

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| | | Paper Discussion 8 | |
| | | Review: TBA | TBA |
| Lecture 17 | 28-Nov | Parallelism | |
| Lecture 18 | 30-Nov | Issues with Parallelism | |
| Discussion 10 | 4-Dec | Quiz 3 | |
| | | Paper 9 Discussion | |
| | | Review: Attack of the Killer Microseconds | https://dl.acm.org/citation.cfm?id=3015146 |
| Lecture 19 | 5-Dec | Reliability and Security | |
| Lecture 20 | 7-Dec | Slack, Review for Final | |
| | | Homework 5 Due, Discussion | |
| Final | 12-Dec | 1:00 – 3:00 PM, 226 Wellman | |