COS/ELE 375: Computer Architecture & Organization (Fall 2013)

Last updated: August 6, 2013

Instructor:
Professor Margaret Martonosi
204 C.S. Building
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Office hours: 1 hour after each class, or use WASS for an appointment some other time.

Teaching Assistant: TBD

Lecture:
Mondays and Wednesdays: 1:30-2:50 PM.

Where to find things:
Course materials available on blackboard.princeton.edu
Q&A, announcements, and extra blurbs on piazza.
WASS for appointments:

Course Description:
This course is an introduction to computer architecture and organization, with a special focus on the basic principles underlying contemporary, mainstream, microprocessor design. It will explore the interaction of hardware and software, and consider the efficient use of hardware to achieve high performance. Topics will include the MIPS instruction-set architecture, computer arithmetic, processor design, performance measurement and analysis, pipelining, caches and virtual memory, input/output, and design tradeoffs among cost, performance, and complexity.

Prerequisite: The prerequisite for this course is COS 217, Introduction to Programming Systems. While ELE 206/COS 306, has been a prerequisite in the past, it is not this year. This year's offering will give sufficient intro for people who have not taken 206.

Course Grading Overview:
Mid Term Exam - 25%
Final Exam - 25%
Class/Precept Participation - 25%
Problem set(s) - 25%

Requirements

Class participation:
This course uses a discussion format, with less emphasis on traditional lecturing. Each class will cover particular subjects from the assigned reading; particular issues for discussion will be posed in a handout available at least a week in advance (usually via the blackboard page).

The quality and quantity of student participation in class discussions is worth 25% of the course grade. Participation grades will reflect the *quality* of the student's preparation and analysis as well as the student's contribution to the process of discussion: making connections with other students' remarks, raising overlooked issues, asking good questions, making good summaries. Be aware: effective participation requires a great deal more *listening* than speaking, and in particular requires careful listening *to other students*, and not just to the instructors. The goal is to have a truly dynamic discussion, not a student-instructor ping-pong match.

Response Papers and Problem Sets:
Part of the student's preparation for each class will involve problem sets and discussion questions based largely on that day's reading; these will sometimes include exercises from the text. Written homework will be due no

later than the beginning of the class to which it pertains, and no credit will be given for late papers unless there are extraordinary circumstances and/or prior arrangements. Hand-drawn pictures and hand-written text are perfectly fine, as long as they are dark, legible, and clear.

Collaboration on problem sets is allowed, subject to the collaboration policy given below. You may work in twos and threes, but please submit individual write-ups that represent your own final synthesis of the ideas. In addition, if you discuss with others, please put the names of your collaborators on the paper.

Examinations:
A midterm examination will be given on Wednesday, Oct. 23. It will cover material presented and discussed in the classes and assigned reading through Monday, Oct. 21.

A final examination will be given during the fall-term final exam period. It will cover all of the assigned readings and material presented and discussed in class.

Reading:
Textbook: David Patterson and John Hennessy, Computer Organization and Design: The Hardware/Software Interface, Fourth edition "Revised Printing," Morgan Kaufmann Publishers, 2012. NOT the International ARM-based edition! You want the (sadly, more expensive) MIPS edition. The "revised printing" has a mustard-colored cover; the non-revised printing has a blue cover. Either one will be fine for this course, but the mustard one has fewer typos and some other minor repairs.
Other readings: Copies of any supplemental readings will either be handed out in class or linked to on the course website.

Policies

Attendance:
Attendance and participation is a significant fraction of the course grade. Attendance is mandatory; unexcused absences will be penalized. Regular class attendance is required and class participation helps. Unexcused absences are grounds for a failing grade regardless of other performance. This means you.

Collaboration Policy for Assignments:
(Adapted from the COS217 and COS333 webpages.)

Computer architecture and design is, like writing, an individual creative process. Individuals must reach their own understanding of the problem and discover a path to its solution. During this time, discussions with friends are encouraged. However, when the time comes to write the specific solution to the problem, such discussions are no longer appropriate -- the work you hand in must be your own work (although you may ask teaching assistants for help in debugging). The course's piazza page is also intended for sharing insights and clarification's on the meaning of questions, terminology, etc.

Do not, under any circumstances, copy another person's solution for an assignment. Writing code or verbatim text for use by another person or using another person's code or verbatim text violates the University's academic regulations.

Examples of unacceptable behavior for assignments include:
- Copying any part of another person's program files or text into your own. The only exceptions here are code or files explicitly approved in the assignment.
- Consulting or using assignment solutions from any previous offering of this course.
- Helping another student to do any of the above.

If you have questions or need clarification on this policy, please contact MRM.

Approximate Syllabus and Reading Assignments

Week	Dates	Monday	Wednesday
0	Wed Sep 11		**Intro to Course:** *Topics*: Design of simple processor. *Reading*: Patterson & Hennessy text (P&H) Chapter 1
1	Sep 16, 18	**Basic Logic Design (2 lectures):** *Topics*: Combinational logic; state elements; clocks and timing; memory elements; finite-state machines *Reading*: P&H, Appendix C	
2	Sep 23, 25	**The MIPS Instruction-Set Architecture (3 lectures):** *Topics*: Introduction to MIPS architecture; encoding/representation of instructions; memory addressing issues; branching *Reading*: P&H, Chapter 2	
3	Sep 30, Oct 2	**Continue MIPS ISA**	**Arithmetic for Computers:** *Topics*: Integer and logical operations; constructing a simple MIPS ALU; floating point operations *Reading*: P & H, chapter 3
4	Oct 7,9	**MIPS Processor Design (4 lectures):** *Topics*: MIPS datapath; implementing control; single-cycle processor design; multiple-cycle processor design; microprogramming; exceptions *Reading*: P & H, chapter 4 (early sections)	
5	Oct 14, 16	**Continue MIPS Processor Design**	
6	Oct 21, 23	**Processor Performance:** *Topics*: defining and measuring computer performance; bad and good metrics; benchmarks; Amdahl's Law; the Iron Law *Reading*: P & H, parts of chap 1	**In-class Midterm.**
Oct 28, 30		No Class: Fall break	

7	Nov 4,6	**Pipelining (5 lectures)** *Topics*: the idea of pipelining; pipelined MIPS datapath; pipeline control; hazards; stalls and bypassing; exceptions; performance of pipelined systems *Reading*: P & H, chapter 4 (later sections)	
8	Nov 11, 13	**Continue Pipelining as above.** MRM out of town at research meeting on Nov 13, so Prof. Clark will sub.	
9	Nov 18, 20	**Conclude Pipelining**	**Memory Hierarchy (4 lectures)** *Topics*: Caches and locality; virtual memory; translation lookaside buffers; protection and page faults; performance tradeoffs in cache and TLB design *Reading*: P & H, chapter 5
10	Nov 25, 27	**Continue Memory Hierarchy as above.**	**Thanksgiving!**
11	Dec 2,4	**Continue and conclude Memory Hierarchy lectures.**	
12	Dec 9,11	**Parallelism and Future Trends (2 lectures)** *Topics*: cache coherence; out-of-order execution; multicore; future possibilities *Reading*: P & H, chapter 7	