CSEE W3827 - Fundamentals of Computer Systems
Course Information

Course Call #: 22152
Professor Dan Rubenstein Fall 2008

Course Resources

Contact Information		
	Dan Rubenstein (Instructor)	Abhinandan Majumdar (TA)
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Office Hours	Tu,Th 2-3pm or by appt.	M,W 1:30-2:30pm

Course URL: http://www.cs.columbia.edu/∼danr/3827

Course meeting time / location: 2:40 pm - 3:55 pm on M,W in 627 Mudd

Pre-Requisites

An introductory programming course (e.g., COMS 1004 or 1007)

Description

This course explains, from a logic perspective, how computers work, i.e., how 0's and 1's are manipulated to do all the advanced calculations, computations, and services that computers can perform. The first major topic is digital logic, which concerns the design of circuits to implement logic functions using standard components such as AND-gates, OR-gates, and inverters. The circuits might be used to control the flow of data within a computer, or the processing of the data (e.g., arithmetic operations), or to control the overall action of a computer. We will cover how to specify logic functions precisely, to manipulate formal expressions, and to implement them efficiently. We will then cover the design of basic building blocks, including the control, of modern digital computers. Both combinational and sequential circuits will be covered.

The second part of the course involves the structure and software interface of digital computers. Focusing our attention on modern RISC architecture. We will discuss the functional blocks such as the arithmetic unit, register files, and memory. Single-cycle and multiple-cycle implementations will be presented, followed by the concept of pipelining. We will cover the basics of caches and virtual memory. Machine and assembly language programming is a feature of the course. Main memory systems, currently DRAM, will be discussed as well as the operation of magnetic disk drives. Some aspects of I/O will also be introduced.

Grading

Your grade consists of:

25% **Homework:** Unless otherwise specified, homework will be due one week after it is assigned and should be turned in by **beginning** of class. At that time, a physical copy of the assignment must be received (CVN students have an additional 24 hours to send in their homework). If you will not attend class on that day, you should slide the homework under my office door (CEPSR 816) by**2:30 pm on the day it is due**. Before class but after 2:30, I will collect the homeworks from my office. On-campus students: E-mailed/faxed homework and late assignments will not be accepted unless approved in advance. Approval will only be given under extreme circumstances. You are expected to produce your work in a timely manner.

You may discuss and work on questions with other students in the class. However, you should write your solutions on your own. In other words, if I were to later ask you to re-derive one of your homework solutions or to solve a similar problem when you were without your friends, you should be able to do so or have a clear understanding of how to approach the problem. This can only be learned by doing, so you should do your homework.

35% **Mid-term:** October 20, in-class, closed book, closed note, no calculators.

45% **Final:** Date TBD by the registrar

XC **Class / office-hour participation:** If you ace your tests and homeworks, you will get an A+, even if you do not participate in class or come to office hours. However, if you don't ace your tests and homeworks, but you can demonstrate to me that you have learned the material in another fashion (mainly via office-hour discussion in which you work through additional problems), you can improve by up to one letter grade (e.g., C to a B). To reiterate, it is possible to improve your grade by demonstrating an understanding of the material **during the course of the term** (i.e., not just when you get your midterm back)..

A note on exams: I am more interested in your gaining an understanding of and developing an intuition for **why** certain rules, laws, and techniques hold and are used. I am less interested in your ability to memorize these rules, laws and techniques and blindly apply them without intuition as to why they work. Thus, I will try to design the midterm and final questions to test your understanding of the concepts, not your memorization skills. I realize that some memorization will undoubtedly be required, but hopefully the memorized concepts will be those that can be re-derived via your intuition.

A note on effort: Your grade will mainly be a reflection of how you perform on the midterm and final. Homework grades don't have much of an effect, as long as homework is turned in (i.e., most students typically get most of the problems right). **You should do the homework so that you learn the material**. If you find yourself copying or getting solutions from someone else without putting in the effort of solving them yourself, you'll probably find yourself doing poorly on the exams. You won't get much sympathy from me if you come crying to me at the end of the term that you did well on the homework yet poorly on the midterm and final.

If you are a bad test-taker, there is hope! Show me (i.e., in office hours and class) that you understand what is going on, and I take that into account when assigning the final grade.

How much I care about helping students is directly proportional to how much you seem to care about the class (i.e., via attendance, homework, coming to office hours). I have nothing personal against students who think the class is a waste of their time or think they have better things to do with their time. I also have lots to do besides teaching, and will only make the extra effort for those students who earn it by putting in the extra effort themselves (active in class, active at office hours).

Reading / Texts

You should do the assigned reading **before** class.

- **Required:** *Logic and Computer Design Fundamentals (4th edition)*, M. Morris Mano and Charles R. Kime, Prentice Hall. ISBN 0-13-198926-X, ISBN-13: 978-0-13-198926-9
- **Required:** *Computer Organization and Design, The Hardware/Software Interface, 3rd edition, revised printing*, David A. Patterson and John L. Hennessy, Morgan Kaufmann, ISBN 0-12370-606-8

Computing Accounts

The course does not require computing facilities or computing accounts.

Cheating

In short: don't do it. You must use common sense about when to collaborate / use notes / calculators, etc. If you are unsure of a policy, you should ask me or the TA first *before* doing something you (and I) might consider unethical. Both I and Abhinandan have and will be putting a lot of time into teaching you this course. Our goal is to teach you the material. Grades on homeworks, midterms, and finals are not only a means to evaluate you, but also a means to force you to learn the course material. Thus, when you cheat, you not only deceive me and Abhinandan, you also hurt the school's reputation by producing unknowledgeable graduates. In the long run, you hurt yourself, because you wasted your time. If a grade is that important to you then you should be putting in the extra effort, i.e., reading the book, coming to office hours, etc.

If you do your own work but facilitate someone else's cheating, you run a risk of getting in trouble as well. This is because you run the risk of having me determine who copied from whom. If you feel that someone is pressuring you to help them in a way that makes you uncomfortable, come talk to me / send me e-mail. You should feel free (and actually I would encourage you) to

- Discuss homework problems / give hints / work together through a part of a problem that you are stuck on
- Study for the midterm / final together

Student Feedback

I'm always looking for ways to improve the course. If you have any comments or criticism about the course, or find any mistakes or misleading facts / comments in the lecture, please feel free to contact me. This includes comments on the material being covered, teaching style, pace of the class, workload, etc. I will try and accommodate, but I can't make any promises...

Syllabus and Schedule

Listed on the next page. Note schedule subject to change...

Date	#	Topics/chapters covered	Reading	Assigned	Due
9/3	1	Intro; Overview of Computer Architecture; Definitions (bit,byte,word)	M&K Ch 1		
9/8	2	Binary number representations: 2's complement; 1's complement; floating point representations: overflow and underflow	M&K 4.3-4.4, 10.7, P&H 3.6 skip FP in MIPS	HW #1	
9/10	3	Logic gates; XOR; Boolean Algebra; NAND and NOR gates; Taking complements; DeMorgan's Theorem; Duals	M&K 2.1-2.2, 2.8 2.9		
9/15	4	Standard Forms: minterms, maxterms, sum-of-products, product-of-sums	M&K 2.3	HW #2	HW #1
9/17	5	K-maps: simplification with implicants, Don't-care conditions	M&K 2.4-2.5		
9/22	6	***** Catchup *****		HW #3	HW #2
9/24	7	Combinatorial Circuit Design: Multi-bit output functions; standard combinatorial circuits (enabler decoder, encoder, priority encoder, mux	M&K 3.1, 3.3, 3, 3.6-3.9		
9/29	8	Arithmetic funcs: Adder (half, full, ripple-carry, adder-subtractor); Contraction; Shifter	M&K 4.1-4.2, 4.5 9.4	HW #4	HW #3
10/1	9	Sequential Circuitry: Latch, Flip-Flops, timing issues	M&K 5.1-5.3, 5.6		
10/6	10	Sequential Circuit Analysis & Design: State machines	M&K 5.4-5.5	HW #5	HW #4
10/8	11	PLAs; ROM; Register Design: Load and Transfer	M&K 6.8, 7.1-7.3		
10/13	12	Register Design cont'd: MicroOps and Counters, mux and serial transfer	M&K 7.5-7.6, 7.8-7.9		HW #5
10/15	13	***** Catchup and/or Midterm review *****			
10/20	14	**MIDTERM** (in class)			
10/22	15	Memory Design	M&K 8.1-8.7	HW #6	
10/27	16	Processor Design: Datapath, ALU	M&K 9.1-9.5		
10/29	17	Control Word; Simple Arch; Instruction Decoder	M&K 9.6-9.8	HW #7	HW #6
11/3	–	**ELECTION DAY - NO CLASS!**			
11/5	18	Instruction Types and Formats	P&H 2.1-2.5	HW #8	HW #7
11/10	19	Branches, stacks, heaps, immediate addressing	P&H 2.6-2.7, 2.9		
11/12	20	Single Cycle Datapath	P&H 5.1-5.4		HW #8
11/17	21	Single Cycle Datapath cont'd		HW #9	
11/19	22	Multi-Cycle Datapath	P&H 5.5		
11/24	23	Pipelining	P&H 6.1-6.8	HW #10	HW #9
11/26	24	Cache & Cache Replacement Policies	P&H 7.1-7.2		
12/3	25	***** Catchup and/or review *****			HW #10
12/5	26	***** Catchup and/or review *****			
12/8	27	***** Catchup and/or review *****			
Date TBD		**FINAL EXAM**: Location TBD			