Electrical & Computer ENGINEERING

Carnegie Mellon University Course Syllabus

18-447: Introduction to Computer Architecture

Spring Semester, 2012

http://www.ece.cmu.edu/~ece447/

Course Personnel:

Instructor:

Onur Mutlu
Hamerschlag Hall A-305
412-268-1186, onur@cmu.edu, http://www.ece.cmu.edu/~omutlu/
Office Hours: Wed. 2:30pm – 3:30pm

Teaching Assistants:	Email	Office Hours (in HH-1304)
Chris Fallin	cfallin@ece.cmu.edu	Fri 2:00pm — 4:00pm
Lavanya Subramanian	lsubrama@ece.cmu.edu	Thu. 11:30am —1:30pm
Abeer Agrawal	abeera@andrew.cmu.edu	Mon. 3:30pm—4:30pm
		Tue. 6:00pm—7:00pm

Course Management Assistant:	Email	Office	Phone
Shannon Lown	shannonh@ece.cmu.edu	HH-D200	412-268-5448

Course Description:

Computer architecture is the science and art of selecting and interconnecting hardware components and designing the hardware/software interface to create a computer that meets functional, performance, energy consumption, cost, and other specific goals. This course introduces the basic hardware structure of a modern programmable computer, including the basic laws underlying performance evaluation. We will learn, for example, how to design the control and data path hardware for a MIPS-like processor, how to make machine instructions execute simultaneously through pipelining and simple superscalar execution, and how to design fast memory and storage systems. The principles presented in the lecture are reinforced in the laboratory through the design and simulation of a register transfer level (RTL) implementation of a MIPS-like pipelined processor in Verilog. In addition, we will develop a cycle-accurate simulator of this processor in C, and we will use this simulator to explore processor design options. Learning to design programmable systems requires that you already have the knowledge of building RTL systems as is taught in the prerequisite 18-240, the knowledge of the behavior storage hierarchies (e.g., cache memories) and virtual memory as is taught in the prerequisite 15-213, and the knowledge of assembly language programming as is taught in the prerequisites.

Prerequisites: 18-240 and (15/18-213 or 18-243) and (18-340 or 18-341 or 18-348 or 18-349 or 18-320)

Prerequisite for: 18-545, 18-725, 18-740

Undergraduate Area: Computer Hardware

Undergraduate Designation: Coverage, Depth

Course Schedule:

- **Lecture**:
  Monday & Wednesday: 12:30p.m. – 2:20 p.m., HH-B103

- **Labs**:

Section A	T: 10:30 a.m. – 1:20 p.m.	HH-1112
Section B	Th: 1:30 p.m. – 4:20 p.m.	HH-1112
Section C	F: 6:30 p.m. – 9:20 p.m.	HH-1112

  Note: you can attend any section to get your lab checked off. Labs begin on Thursday, Jan19th. Attendance is not required except for check off.

Required Textbooks:

- *Computer Organization and Design: The Hardware/Software Interface, Fourth Edition* by Patterson and Hennessy, Morgan Kaufmann/ Elsevier, 2009. (Required. Please refer to the online course schedule for reading assignments)
- *HDL Compiler for Verilog Reference Manual* by Synopsys, Inc. /afs/ece/class/ece447/docs/synopsys/top.pdf.

Recommended Textbooks:

- *Introduction to Computing Systems: From Bits and Gates to C and Beyond, Second Edition* by Patt and Patel, McGraw-Hill.
- *Computer Organization* by Hamacher, Vranesic, and Zaky, McGraw-Hill.
- *Computer Architecture and Implementation* by Harvey Cragon, Cambridge University Press.
- *Structured Computer Organization* by Andrew Tanenbaum, Prentice Hall.

Course Website: Course announcements, lecture notes, handouts, and other material will be posted on the course website at http://www.ece.cmu.edu/~ece447/ . Please check the course website daily for announcements and handouts.

Course Blackboard: To access the course blackboard, go to the login page at: http://www.cmu.edu/blackboard/.

Grading Methodology:

10%	Homework
30%	Labs
15%	Midterm 1
15%	Midterm 2
30%	Final
5%	Teaching Team's Evaluation of Your Performance

We keep grades on Blackboard. Please review your scores periodically. You have one week after a graded item is returned to request a grade correction.

Homework assignments are due at the start of class on the date due unless otherwise specified. **No late homework accepted**. Discussions about homework in small groups are encouraged. However, homeworks must be written up **individually** and **independently**.

You can get your lab milestone checked off in any of the three lab sections, regardless of which section you are officially registered in. Labs can be checked off up until **Friday** at the end of the Friday lab session (9:20pm). You will have a total of **five lab late days** for the semester that you may use however you wish to turn in late labs. For example, you could turn in one lab five days late, or you could be one day late on five labs. Weekend days are included in this count.

Labs will be done individually unless otherwise specified.

The TAs are available during lab periods to assist you in completing your assignment, but, unlike in 18-240, the length of 18-447 labs and projects are not designed to fit completely within just the lab hours. **You will need to spend a lot of outside time**. On the week a lab is due, you should come to lab with the milestones completed and ready for check-off.

Compile-Time Course Schedule:

Please see the course website (http://www.ece.cmu.edu/~ece447/) to view the most current schedule and to download lecture notes and handouts.

Week	Date	L#	Topic	Readings	Weekly Lab	HW
1	1/16		**No class (Martin Luther King, Jr. Day)**		**No lab meeting this week**	
	1/18	L1	Introduction		**Lab 1 Out**	**HW1 Out**
	1/20					
2	1/23	L2				
	1/25	L3				
	1/27					
3	1/30	L4				**HW1 Due** **HW2 Out**
	2/1	L5			**Lab 2 Out**	
	2/3				**Lab 1 Due**	
4	2/6	L6				
	2/8	L7				
	2/10					
5	2/13	L8				**HW2 Due** **HW3 Out**
	2/15	L9			**Lab 3 Out**	
	2/17				**Lab 2 Due**	

6	2/20	L10				
	2/22	L11				
	2/24					
7	2/27	L12				**HW3 Due** **HW4 Out**
	2/29	L13			**Lab 4 Out**	
	3/2				**Lab 3 Due**	
8	3/5		Midterm 1			
	3/7	L14				
	3/9					
	3/12		**No class (Spring Break)**			
	3/14		**No class (Spring Break)**			
	3/16					
9	3/19	L15				**HW4 Due** **HW5 Out**
	3/21	L16			**Lab 5 Out**	
	3/23				**Lab 4 Due**	
10	3/26	L17				
	3/28	L18				
	3/30					
11	4/2	L19				**HW5 Due** **HW6 Out**
	4/4	L20			**Lab 6 Out**	
	4/6				**Lab 5 Due**	
12	4/9	L21				
	4/11		Midterm 2			
	4/13					
13	4/16	L22				**HW6 Due**
	4/18	L23			**Lab 7 Out**	
	4/20				**Lab 6 Due**	
14	4/23	L24				
	4/25	L25				
	4/27					
15	4/30	L26				
	5/2	L27				
	5/4				**Lab 7 Due**	
	TBD		**Final Exam**			

Education Objectives (Relationship of Course to Program Outcomes):

(a) an ability to apply knowledge of mathematics, science, and engineering: The students will apply classroom knowledge in a series of hands-on lab projects.

(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability: The students will create designs to meet the design specifications of the lab projects.

(d) an ability to function on multi-disciplinary teams: The students will work in teams of 2 or 3 in the lab projects.

(e) an ability to identify, formulate, and solve engineering problems: The students will develop original solutions to open-end design specifications in the lab projects.

(f) an understanding of professional and ethical responsibility.

(g) an ability to communicate effectively: The students will provide written reports with each lab project. Interactive discussions planned into the lectures will encourage the students to communicate questions and answers verbally.

(h) a knowledge of contemporary issues: The students will be introduced to contemporary developments and topics in the computer architecture field.

(i) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice: The students will use industry-standard design tools and methodologies in the lab projects.

Academic Integrity Policy (http://www.ece.cmu.edu/student/integrity.html**):**

The Department of Electrical and Computer Engineering adheres to the academic integrity policies set forth by Carnegie Mellon University and by the College of Engineering. ECE students should review fully and carefully Carnegie Mellon University's policies regarding *Cheating and Plagiarism*; *Undergraduate Academic Discipline*; and *Graduate Academic Discipline*. ECE graduate students should further review the *Penalties for Graduate Student Academic Integrity Violations* in CIT outlined in the CIT Policy on *Graduate Student Academic Integrity Violations*. In addition to the above university and college-level policies, it is ECE's policy that an ECE graduate student may not drop a course in which a disciplinary action is assessed or pending without the course instructor's explicit approval. Further, an ECE course instructor may set his/her own course-specific academic integrity policies that do not conflict with university and college-level policies; course-specific policies should be made available to the students in writing in the first week of class.

In 18-447, discussions about homework in small groups are encouraged. However, homeworks must be written up individually *and* independently. *Labs are to be completed individually unless otherwise specified.*

Carnegie Mellon University's Policy on Cheating and Plagiarism (http://www.cmu.edu/policies/documents/Cheating.html) states the following,

> Students at Carnegie Mellon are engaged in preparation for professional activity of the highest standards. Each profession constrains its members with both ethical responsibilities and disciplinary limits. To assure the validity of the learning experience a university establishes clear standards for student work.
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> In any presentation, creative, artistic, or research, it is the ethical responsibility of each student to identify the conceptual sources of the work submitted. Failure to do so is dishonest and is the basis for a charge of cheating or plagiarism, which is subject to disciplinary action.
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> *Cheating* includes but is not necessarily limited to:
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> 1. Plagiarism, explained below.
> 2. Submission of work that is not the student's own for papers, assignments or exams.
> 3. Submission or use of falsified data.
> 4. Theft of or unauthorized access to an exam.
> 5. Use of an alternate, stand-in or proxy during an examination.
> 6. Use of unauthorized material including textbooks, notes or computer programs in the preparation of an assignment or during an examination.
> 7. Supplying or communicating in any way unauthorized information to another student for the preparation of an assignment or during an examination.
> 8. Collaboration in the preparation of an assignment. Unless specifically permitted or required by the instructor, collaboration will usually be viewed by the university as cheating. Each student, therefore, is responsible for understanding the policies of the department offering any course as they refer to the amount of help and collaboration permitted in preparation of assignments.
> 9. Submission of the same work for credit in two courses without obtaining the permission of the instructors beforehand.
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> *Plagiarism* includes, but is not limited to, failure to indicate the source with quotation marks or footnotes where appropriate if any of the following are reproduced in the work submitted by a student:
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> 1. A phrase, written or musical.
> 2. A graphic element.
> 3. A proof.
> 4. Specific language.
> 5. An idea derived from the work, published or unpublished, of another person.