

CS2214 COMPUTER ARCHITECTURE & ORGANIZATION SPRING 2012

SYLLABUS

1. Professor : Haldun Hadimioglu

Office : 10.009 2MTC

Tel : (718) 260-3101
Fax : (718) 260-3609

haldun at photon dot poly dot edu
<http://cis.poly.edu/haldun>

2. Course format :

Lectures : 3 hours/week

Lecture Section : **2682**

Recitations : 2 hours/week

Recitation Sections :

⇒ **A (2683, Friday 9 - 10:50)**

⇒ **B (2685, Friday 2 - 3:50)**

3. Prerequisites : *One* of the following two :

⇒ CS2204 (Digital Logic and State Machine Design, C- required)

⇒ CS2134 (Data Structures and Algorithms, C- required) and
MA2312&MA2322 (Discrete Mathematics 1&2)

4. Course web page : <http://cis.poly.edu/cs2214>

⇒ Course handout and presentation files are at the course web site

5. CS2214 is the **first** course to **design digital systems**, such as **microprocessors & computers** !

6. Textbook :

Computer Organization and Design : The Hardware/Software Interface, D. A. Patterson and J. L. Hennessy, **revised print** 4th edition, Morgan Kaufman, 2012. ISBN : 978-0-12-374750-1

⇒ Publisher's web site, <http://books.elsevier.com> and the CD that comes with the book have a large amount of material. Students are strongly suggested that they study them. The CD has various sections related to the chapters and tutorials, software packages and other supporting material.

7. Professor's message :

→ *Target learning and **thinking**, not the **grade** nor **pattern matching** (problem solutions) !*

⇒ *Do **not** go for memorizing patterns (problem solutions)*

→ *Knowledge is **not** finite **nor** independent pieces of patterns*

→ *Knowledge is a **hierarchy** of unmeasurable width and depth of interconnected entities*

→ *Knowledge generates knowledge : Knowledge helps us **think** which leads us to discover new knowledge*

→ *Knowledge also helps us solve **problems** by means of **thinking***

⇒ *Learning means one acquires knowledge which helps for both **thinking** and **solving problems***

→ *Lectures are **interdependent**, recitations are **interdependent** and courses are **interdependent***

8. Benefitting from the course for the years before and after graduation :

→ Do not go for *passing the course*, but *learning*

- Industry and academia look for graduates who can **solve problems**, are **systems oriented** and **creative**
 - ⇒ In order to accomplish those you need to have
 - Analytical skills, synthesis skills and team work skills
 - ⇒ For these three skills, you will need to develop **critical thinking** and **personal skills** for which you need to do the following
 - **Learning is your target !**
 - If you study **past exams**, without studying the book and others, you do **pattern matching**, not thinking !
 - ⇒ You need to study **books, notes, handouts !**
 - If you **miss classes** and **recitations**, you are not learning enough !
 - ⇒ **You interact with people to work on a problem, to exchange ideas, to help, etc. !**
- All of these are possible by doing the following
 - ⇒ You **care** for the course and show with your own actions.
 - ⇒ You take the course to **learn**, not to pass !
 - ⇒ You take the course for its **content**, not for the grade !
 - ⇒ You **attend** classes and recitations and **do** the homework !
- Then, you will enjoy the course and appreciate it which will make you more interested in the course !
- After graduation, the most common way you will be judged is how you write
 - ⇒ Concentrate on **documentation !**
 - Homework and exams help you practice writing : Students show work, not just the final answer

→ Students understand and satisfy the **goals** of the course that are *intellectual*, *technical* and *non-technical* :

- 1) The *intellectual* goals are that students **learn how to learn fast** and are **critical thinkers**. This is necessary during one's lifetime.
 - The more you learn, the better for you. That is, do not go for the grade !
- 2) *Technical* goals are for a successful technical career : Acquiring skills to be **systems oriented** and a **problem solver** as well as acquiring the necessary course content which is *digital logic* :
 - **Main technical topic : Digital systems**, such as microprocessors, computers, calculators, digital camcorders, DVDs, iPhones. The course focuses on developing a computer, by designing its *architecture* and then the *organization (microarchitecture)* layers :
 - ⇒ Designing the architecture : Machine language instruction set design and programming
 - ⇒ Designing the organization includes learning the skills to design a computer with a single processor (single-core) and understand its subsystems and their interaction.
 - The processor, one of the three subsystems of a computer, is the Central Processing Unit, the **CPU**. The other two subsystems are the **memory** and **Input/Output (I/O)** controller. The computer we design is named EMY and is based on a commercial microprocessor, the **MIPS**.
 - ⇒ Digital system design is covered in the context of state machine design & EMY computer.
- 3) The *non-technical* goals include acquiring and improving skills needed for **interacting with** and **managing people** in various environments. They are needed in the technical world which is **team-based** and becoming more **global**.

9. CS2214 Recitations :

Recitations aim at reinforcing and complementing the lectures. They help students understand subjects discussed in class better.

- ⇒ Recitations cover **new** topics besides covering lecture topics in detail. It also presents practical aspects of topics covered during the lecture. In addition, the recitations are intended to discuss homework assignments.
 - *Students who attend recitations are faster at solving problems.*

⇒ The recitations are given in **several** different sections. Each section has one hour and 50 minutes a

week. Recitation sessions are given by teaching assistants (TAs). Students **cannot** attend the recitation of other sections. Attendance is recorded in every recitation.

- ⇒ Students in each recitation section form **3-** or **4-**member teams by the *third* week of the semester. Team members do the homework assignments together until the end of the semester.

10. Homework :

There will be seven homework assignments. The homework will be submitted by teams. **A late submission will not be accepted.**

- ⇒ *Students who do homework are faster at solving problems.* Students are suggested to study the textbook problems that are on the textbook CD, besides the ones given in the textbook. **Showing work** (intermediate steps) is **required** to get full/partial credits on a question. The homework is graded by the section TA. Although, the homework will **not** affect the term grade, it can help raise grades as described below.
- ⇒ Homework assignments include **modified** past exam questions and answers to help learn chapters and solve homework problems. Students need to study them **before they solve homework problems**, not before exams. Note that, these past exam questions are samples and do **not** give hints about exams this semester.

11. Exams :

There will be **two** 110-minute midterm exams and a three-hour final exam. *The exams will cover class and recitation topics.*

- ⇒ **Showing work** (showing intermediate steps) is required to get full credits on a question. That is, both the final answer and the steps to get it, the **approach**, are important.
 - These steps are given in class and past exam solutions. Therefore, students are expected to solve exam questions as such. Showing the approach also helps students acquire and improve their **documentation** skills, critical for the technical world.
 - ⇒ In order to facilitate this, the exams are **open book** exams : Students can use their own material, i.e. their books, notebooks, homework and handouts during the exams. Note that once the exam starts there is **no** sharing.
 - ⇒ **Students must prepare for the exams as if they are closed book exams !**
- ⇒ In addition, remembering the following is needed during the exams : (i) No multiple answers to a question, (ii) precise answers to questions, no answers like “the rest is similar;” (iii) answering the question asked, and (iv) using the exam booklet space well : For example, start a new question on a new page.

12. Term Grade :

The term grade is calculated as follows :

25% Exam I

25% Exam II

50% Final Exam

- ⇒ The homework does **not** affect the term grade directly but it is taken into account when a student’s term grade is near a grade “border.” Also, taken into account is attendance. If they are good, the grade is raised. Finally, the professor may change the term grade computation. Thus, students are strongly suggested that they fulfill the requirements of the course, i.e. recitations, lectures and homework assignments.

13. Office Hours :

The professor has an **open-door** policy that if he is not busy, students can ask questions in his office. If the door is closed, he might be teaching or at a meeting. If a student wants to see the professor at a certain time, he/she makes an appointment with the professor.

- ⇒ Students can use email. But, they are strongly suggested that they **see** the professor to ask questions, instead of sending email. If email is sent, a Polytechnic email address must be used and student's name and section must be included. Broadcast messages will be sent to the class to make announcements. Note that grades are **not** given out to students via email or telephone. Students need to see the professor to learn their grades.
- ⇒ TA assignments and their contact information will be given later in the semester.

14. Material Coverage :

All chapters, except Chapter 6, will be covered, some partially, some completely this semester. Students will be given additional material in class. The tentative schedule is as follows :

Day(s)	Subject	Chapters
Jan 23, 25	Introduction. Computer systems overview. Layered computer design	1, B
Jan 25, 30, Feb 1, 6, 8, 13, 15, 22	The architecture of the EMY computer	2, 3, B, E
Feb 29	EXAM I	HW : 1 - 2
Feb 22, 27	Digital system design fundamentals	4, B, C, D
Mar 5, 7, 19	The organization of the EMY computer. EMY CPU design. Hardwiring	4, B, C, D
Apr 2	EXAM II : Cumulative	HW : 1 - 4
Mar 21	EMU CPU design. Microprogramming.	4, B, C, D
Mar 26, 28, Apr 4	Pipelining	4, B
Apr 9, 11, 16, 18, 20, 23	Semiconductor memory. Memory hierarchies	5, B, C
Apr 23, 25	Performance measures	1, 4, B, C, D
Apr 30	High-speed computer design and future projections	7, A
TBA	Final Exam : Cumulative	All the above chapters

15. The theme of the course :

a) Many digital products we use today are **digital systems**, such as microprocessors, computers, calculators and iPhones. CS2214 covers digital systems. To study them, a computer containing three smaller interconnected digital systems is designed : the **CPU**, **memory** and **I/O controller**. We will concentrate heavily on the CPU (the processor) of the computer since it is the most important unit of the computer. Also, we will use the state machine design technique when we design the CPU as a digital system.

b) The CS2214 computer, EMY, is a MIPS-microprocessor-based computer. To simplify the design process, we follow a top-down (layered) design technique where initial design steps (higher layers) are relatively simple and as we move down, layers become increasingly complex. The layers we focus on in varying details are from top to bottom, application, architecture, organization, logic and transistor layers. Our major design steps are as follows :

- ⇒ We determine the **application** set aimed for the EMY, where the application layer is the top layer.

- ⇒ We determine the **architecture** of the EMY, i.e. the register set, data types, **machine language instructions**, etc. based on the application layer.
- ⇒ We move on to the next level below which is the **organization (microarchitecture)** layer, first, we design the **hardwired** CPU. Then, a slower but cheaper way of realizing the EMY CPU is done : the **microprogrammed** CPU. Both designs are based on the architecture.
- ⇒ We improve the performance of the EMY CPU by pipelining (the organization layer).
- ⇒ We discuss **memory** subsystem design alternatives to improve the capacity of the computer (the organization layer).
- ⇒ Finally, we study **performance measures** used to evaluate computer systems. These measures help us see if our architectural and organizational decisions are sound.

16. References :

Students are suggested that they study **recent** computer architecture books since the field advances rapidly. The following references are recommended with respect to their relevance to the course and the textbook :

- a) *MIPS RISC Architecture*, G. Kane and J. Heinrich, Prentice-Hall, 1992.
- b) *MIPS Assembly Language Programming*, R. L. Britton, Prentice-Hall, 2004.
- c) *Digital Design & Computer Architecture*, D. M. Honey & S. L. Harris, Morgan Kaufman, 2007.
- d) *Microprocessor Architecture : From Simple Pipelines to Chip Multiprocessors*, J.-L. Baer, Cambridge, 2010.
- e) *Introduction to Logic and Computer Design*, A. B. Marcovitz, McGraw-Hill, 2007.
- f) *Computer Organization and Architecture : Designing for Performance*, W. Stallings, 8th ed., Prentice-Hall, 2010.
- g) *CPU Design : Answers to Frequently Asked Questions*, C. M.R. Thimmannagari, Springer, 2005
- h) *Computer Organization and Embedded Systems*, C. Hamacher, et.al., 6th ed., McGraw-Hill, 2012
- ⇒ A book giving insight on microprocessor design from the concept phase to the production phase :
 - *The Pentium Chronicles : The People, Passion, and Politics Behind Intel's Landmark Chips*, R. P. Colwell, John Wiley, 2005.
- ⇒ A book describing how and why technical work involved in computer design and development is just a small part of a larger picture with emotions, ambitions and conflicting goals of many people involved :
 - *Dealers of Lightning : Xerox Parc and the dawn of the Computer Age*, Michael A. Hiltzik, Harper Business, 1999.

17. Reminders about the course:

Students are required to read the web pages whose links are provided with at the course web site :

- 1) **NYU-Poly Code of Conduct web page** : <http://www.poly.edu/academics/code-of-conduct>
- 2) **NYU-Poly Life page web page with links to Health+Wellness, Campus Safety, Students Resources and other**. In addition, keep the following in mind :
 - a) **A successful course experience** : To enjoy the course as much as possible and **be ready for the follow**

up courses, students need to be **committed** to the course

⇒ **Attending classes and recitations and doing the work** are needed.

➤ Lectures are **dependent** on each other and recitations are also **dependent** on each other.

⇒ **Study** the notes, books, handouts. But, just reading does not mean studying ! Also, do the homework !

➤ **Do not study past exams, without studying books, notes and handouts.**

b) Students must realize that every action they take has consequences. They also should **not** make assumptions and decisions on the course (the exams, lectures, recitations, the homework and attendance) without asking the professor. An assumption that is often made by students is that every course is the same. This is not the case !

c) Students are asked that the professor does his assigned job : **Teaching** ! Any time the professor is not doing it means students are not benefitting from the course. Examples of when the professor is **not** doing teaching include discussions involving submitting late homework, late attendance, missing exams, etc.

d) A reason for a low grade is **missing classes** and recitations. Even if one gets the notes, it does **not** help. This is because, first, the notes taken from the board may not be correct. Second, someone taking the notes may not write down all the verbal comments and suggestions made by the professor. Third, attending classes and recitations forms better memory because of visual (seeing the writing on the board), audio (listening to the professor) and tactile (writing down the notes) inputs. In addition, during lectures and recitations, the professor refers to earlier lectures and recitations (past topics, comments, suggestions, etc.) which refreshes students' memory and further reinforces their knowledge. Overall, students learn and remember more. Finally, since their memory is fresh, students save time when they study for exams.

e) Missing an exam is **not** a minor case. A careful assessment is made to excuse a student or to grant an incomplete to a student. The professor makes the decision. The decision is made also based on the information by the student's academic department and the Student Affairs Office. One of the requirements to excuse a student is that at the time the student is not able to take the exam, he/she **be in good standing in class**, i.e. has good attendance, a good homework performance, a good recitation performance and a good exam performance : The professor wants to see that the student has been committed to the course and learning the material has been his/her main objective.

A student who is excused from a midterm exam is **not** given a make-up exam. The weight of the midterm exam is distributed to the other exams at the discretion of the professor. The make-up exam for the final exam will be harder than the one given to the whole class.

If a student experiences **any** problem, including health/personal problems, he/she must immediately contact Judith Simonsen who is the director of the Student Development Office : jsimonse@poly.edu. Her number is (718) 260-3197.

f) For a course, the semester is over when the final exam is over. Students are **not** given extra work, a project, a make-up exam or any other kind of special treatment to raise their grade during or after the semester.

g) It has been observed that a student pays unnecessary penalty, because he/she does not know/follow NYU-Poly and CS2204 rules and regulations. They also do not seek advice from Polytechnic staff. Therefore, students, especially, **transfer students**, are strongly suggested that **they speak with the professor**, the TAs, the major advisor, the personnel of the Student Affairs Office, and the Counseling Center.

18. ABET Core Competencies :

CS2214 addresses the following ABET **a-k** competencies :

- a) Students apply mathematics, science and engineering knowledge to design and analyze advanced systems.
- c) Students design a digital system that meets the desired speed, space and cost constraints.
- e) Students identify, formulate and solve engineering problems.