Introduction to Computer Architecture
HT2013

Teaching Staff
Instructor: David Black-Schaffer  Office Hours: Wednesdays 13:00-15:00
TAs: Germán Ceballos, Ricardo Alves  Office Hours: In Lab

If you cannot make these times please contact us and we will arrange another time.

Course Contents
This is an introductory course to computer architecture and will cover MIPS assembly language, the MIPS processor architecture, the memory hierarchy, input/output, performance analysis, the basic design and implementation of a the data path, and the basics of parallelism in modern multicore processors. The exam for the course will cover all lecture and lab material.

Course Basics
This class will be taught using the “flipped classroom” approach. Students will view online lectures on their own and work in pairs to solve practice problems. For the on-campus course, students will spend their in-class time working in small groups on practice problems. For the distance course, students will arrange meeting times (virtual or physical) with other students to work on the practice problems. This method of teaching has been shown to produce substantially better student learning outcomes compared to traditional lectures because it focuses on active learning.

To do this we will use a combination of three online tools linked from the course webpage:

- Lectures will be available through scalable-learning.com.
- The class forum will be available through piazza.com.
- Assignments will be turned in through studentportalen.uu.se.

Please note that the exact same course is taught for both distance and local students. The distance course is spread out over periods 1 and 2 while the local course is just during period 2. Both groups of students are responsible for the same material and will share the class website, TAs, and discussion forum.

Requirements
To complete the course you are required to:

- View the online lectures and answer the online self-assessment quizzes, on time.
- Do the practice problems, on time.
- Complete the labs in groups of two, on time.
- Pass the written final exam.

Please pay special attention to this list. Online lectures, practice problems, and labs are all required and have strict due dates. If you do not complete them on time it will hurt your grade. (See below.) We have this policy because we need you to keep up with the material during the class.

We estimate your time requirements will be as follows:
- Lectures: 13x2h = 26h
- Practice problems: 13x2h = 26h
- Labs: 4x10h = 40h
- Exam review: 16h
This is a total of 108 hours during the quarter. A 5.0hp course is supposed to be the equivalent of 133 hours of work. In the past students have told us that this course is more work than an average class but worth it. If the time you are spending is exceeds the amount of time expected for the number of units you are receiving please let us know.

**Prerequisites**

Formally: Programmeringsteknik II. Students are expected to have a background in imperative programming, e.g., C/C++/Java. You should be familiar with loops, if/then/else, arrays, and walking through strings.

**Grading**

This course is graded as U, 3, 4, 5, with the final grade weighted 40% for participation and 60% for the final. You must pass both portions to pass the course. The participation portion of the grade is intended to encourage you to work on the material before the exam and is not optional. To receive credit for the participation portion you must complete the online lectures, practice problems, and all labs, and do so on time. The participation grade is based on the average grade of your labs, but will be a U if you do not complete the lectures or participate in the practice sessions.

To provide students with flexibility, each student will receive 8 late days to use during the course. Students may use these as they see fit for a total of 8 days of extension on the lectures, practice problems, and/or labs. To use a late day, you must notify the teaching assistant before the deadline. We will keep track of how many late days you have remaining. Note that using a late day will not increase the amount of time you have until the next assignment.

**Contacting the Teaching Staff**

Please use the course forum for all electronic contact with the teaching staff. Do not email the TAs or teachers directly. This allows us to avoid duplicate answers and respond more quickly to all students. You can post private and public questions on the course forum. You can find a link to forum from the class website and studentportalen.

- If you have a private question you can post it just to the instructors.
- Please tag your question with the appropriate folder. (E.g., “lab 2” or “hazards”)
- Please take a look at other student’s questions before you post.
- Please feel encouraged to respond to other students’ questions and vote on the responses.

We will try to respond as soon as possible, but no later than our next scheduled office hours.

**Reading (optional, but recommended)**

“Computer Organization & Design: The Hardware/Software Interface” by Patterson and Hennesy. 4th Edition, Morgan Kaufman 2007. *The third edition does not have the right content.* This book is very clear and easy to read, if a bit long-winded. You will need to have access to the CD content of the book for appendices C and D. **The reading is optional, and the exam will be based on the lecture and lab material.** However, the book is an excellent reference. Students have told us that they really appreciated skimming through the book after watching the lectures to get a second perspective on some topics. The reading in section 4.1-4.4 is particularly useful for the datapath lab.

<table>
<thead>
<tr>
<th>Lecture</th>
<th>Recommended Reading</th>
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<tr>
<td>1. Introduction</td>
<td>1.1-1.9</td>
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<tr>
<td>2. Instruction Sets 1</td>
<td>2.1-2.7</td>
</tr>
<tr>
<td>3. Instruction Sets 2</td>
<td>2.8-2.10, 2.12, 2.13, 2.16, 2.18-2.19</td>
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<tr>
<td>4. Arithmetic</td>
<td>3.1-3.5, 3.8-3.9</td>
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<tr>
<td>5. Logic</td>
<td>C.1-C.3, C.5-C.8, C.10, D.1-D.2</td>
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<tr>
<td>6. Processor 1: Control and Datapath</td>
<td>4.1-4.4</td>
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<tr>
<td>7. Processor 2: Pipelining</td>
<td>4.5-4.6</td>
</tr>
<tr>
<td>8. Processor 3: Hazards and Forwarding</td>
<td>4.7</td>
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</table>
9. Processor 4: Branching 4.8-4.9, 4.13-4.14
11. Caches 5.1-5.3
12. Virtual Memory 5.4 (skip handling of faults in 5.4), 5.5, 5.7, 5.11-5.12
13. Parallelism 2.11, 3.6, 4.10, (4.11 optional), 5.8, 6.9, 7.1-7.5
(For fun) Roofline 7.10-7.13

Lectures
All lectures will be provided online through the scalable-learning website. Lectures will contain short, non-graded, self-assessment quizzes designed to help you understand how well you understood the material and tell us what we should review. These lectures are required and you are expected to have viewed them and answered the quizzes before coming to class for the on-campus students and before doing the practice problems for the distance students. The lectures are due at midnight on the date specified.

We will try to post lectures at least one week before their due dates so you have flexibility as to when to watch them. Your performance on the quizzes will not affect your grade, so you are encouraged to re-take any quizzes you get wrong and to see why the wrong answers are incorrect to help you learn. You are also free to rewind/review the material the lectures as much as you like. You must watch all lectures and take all quizzes by their assigned dates.

Practice Problems (On-Campus Students)
Practice problems will be done by on-campus students during their regularly scheduled 2x45 minute lecture sections. Lack of participation in the practice sessions will result in a U for the participation portion of the course. You will be required to sign in for each class session so we can keep track of who is attending. The practice problems are for your benefit and will not be graded. You will not have to turn them in if you do them in class. If you decide to use a late day and not attend the class or did not watch the online lecture before class, then you must turn in written solutions to the TA the next day. (Or the day after that if you use two late days.) It is our experience that students find it more effective to come to class and work on the problems in groups, and we want to encourage that.

Practice Problems (Distance Students)
Distance students will work on the practice problems in pairs. They are responsible for finding a partner at the start of the course and arranging regular meeting times (either virtual or physical) to work together on the problems and the labs. You can use the course forum and post under “distance-only” to coordinate. The problems will be posted on the course website and while students are required to submit solutions, they will not be graded. The TAs will provide feedback on the solutions and help with the problems via online discussions. Lack of participation in the practice sessions will result in a U for the participation portion of the course.

Labs
The course will have four labs. Students should work in pairs to complete the labs and one lab assignment should be submitted for each pair. If you cannot find partner within the first week please post on the class website and we will find one for you. The TAs will provide online tutorials for the labs to get you started with the software, answer questions in the course forum, and will be present in the lab for several hours every week to help you with any problems you may have. (Distance students may call the TAs during these times if they wish.)

<table>
<thead>
<tr>
<th>Lab</th>
<th>Topic</th>
<th>Tutorial</th>
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<tbody>
<tr>
<td>1</td>
<td>Introduction to MIPS assembly</td>
<td>Introduction to SPIM simulator</td>
</tr>
<tr>
<td>2</td>
<td>MIPS datapath</td>
<td>Introduction to LogicSIM</td>
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</table>
All lab assignments must be submitted to receive any credit for the lab portion of the course. Students are required to submit their lab by midnight on the specified date. Graded labs will be returned within a week. You may request a re-grade of the lab within one week of receiving the grade. No re-grades will be offered after that time. Note that re-grades may result in lowered grades. Missed labs may only be turned in after the course is finished, but any late missed labs will limit the maximum grade lab portion of the course to 3. If you wish to re-submit a new version of a lab for re-grading you may do so after the course is finished, but you will not be able to raise your grade for the labs above 3 as with missed labs.

Submitted labs will be graded as follows:

1 point  Poor quality and/or largely non-functional
2 points  Poor quality and not completely functional
3 points  Acceptable quality but not completely functional
4 points  Acceptable quality and completely functional
5 points  Good quality and completely functional

Quality includes the clarity of the solution, e.g., efficiency of implementation, clarity of comments, variable names, layout, etc. The grade for the participation portion of the course will be determined by the average score across all labs. Averages under 3 will receive a U for the participation portion of the course. Note that it is essential that you turn in your lab by the due date to get any credit for the participation portion of the course, even if it is not fully functional.

You can ask questions about the lab solutions during the office hours after the lab has been submitted.

**Grading Summary**

60%: written final exam.
40%: participation, which is determined as follows:

- Average of lab grades. (An average less than 3.0 will result in a U.)
- U if lectures and quizzes are not completed on time.*
- U if no/insufficient participation in practice sessions.
- U if not all labs turned in on time.*

*You may use your late days to extend these deadlines, but not to skip the assignments.

**Honor Code**

The standard honor code for the department applies. You are expected to have read and understood this document. (http://www.it.uu.se/edu/cheating.pdf). The key definition of cheating is: “Students who ... by forbidden aids or in any other way attempt to mislead/deceive during a test or other student assignment which is to be assessed.”

In the context of this course, the following general rules should be respected. This is not a complete list. If you have questions please contact us for clarification.

- Students work together in pairs on lab assignments and are expected to contribute equally to each lab. Each lab group is expected to submit their own work. If this is not working as expected please contact the teaching staff.
- Lab assignments must be completed without examining existing solutions. This does not prohibit you from obtaining assistance, but you may not consult solutions to the same problem. E.g., in a lab about building ALUs, it is okay to search for “how does a MUX
work” but not okay to search for “how do I use a MUX in an ALU”. In a lab about building
a MUX, the first search would not be acceptable.

Since all of labs are submitted electronically, we reserve the right to use automated tools to detect
plagiarism.

**Any instance of cheating will be pursued to the fullest extent of the department and university
policies. Don’t cheat. If you are in doubt, ask.**

**Schedule (Distance)**
The distance course will have one lecture every week. The Lectures are due by midnight on
Wednesday. Students will then have until the following Tuesday at midnight to complete and turn
in the practice problems. The four labs are spread throughout the course with three weeks per lab
(only two for the last lab).

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<thead>
<tr>
<th>Week</th>
<th>Problems: due</th>
<th>Lecture: due</th>
<th>Labs: due</th>
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<tr>
<td>36</td>
<td>Tuesday at midnight</td>
<td>Intro</td>
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<td>37</td>
<td>ISA 1</td>
<td>ISA 2</td>
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<tr>
<td>38</td>
<td>ISA 2</td>
<td>Arithmetic</td>
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<td>Logic</td>
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<td>40</td>
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<td>Datapath</td>
<td>Lab 1: Assembly</td>
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<td>Datapath</td>
<td>Pipelining</td>
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<tr>
<td>42</td>
<td>Pipelining</td>
<td>Hazards</td>
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<td>43</td>
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<td>Branch</td>
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<tr>
<td>44</td>
<td>Branch</td>
<td>IO</td>
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<td>45</td>
<td>IO</td>
<td>Caches</td>
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<td>46</td>
<td>Caches</td>
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<td>47</td>
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<td>48</td>
<td>Parallelism</td>
<td>Lab 4: Caches</td>
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<td>49</td>
<td>On-campus review lecture to be scheduled</td>
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**Schedule (On-campus)**
The on-campus course schedule is determined by the university. Lectures will be due at midnight
the day before the in-class meetings. Practice problems will be done in the in-class meeting the
following day. There will be one lab typically every week or week and a half.