

# CS 3220 Processor Design - Spring 2014

## Course Description

This is an intermediate-level course that follows CS 2200. It is a project-based course in which you will learn the principles in pipelined processor design by actually implementing a fully functional (but simple) pipelined processor using an FPGA (Field-Programmable Gate Array) board, together with a simple application that will run on this processor. In addition to learning about processor design, you will also learn about the interaction between architecture (hardware functionality) and code generation (how machine-language programs can be produced for that architecture).

## Prerequisites

CS 2200 - We will assume that you have taken CS 2200 or an equivalent course, as well as its prerequisites (i.e. 2110). In particular, we will assume that you understand the basics of digital logic (e.g. how to put together a 1-bit adder using AND, OR, and NOT logic gates) and of computer organization (e.g. how single-cycle, multi-cycle, and pipelined processors can be put together using of adders, registers, wires, multiplexers, etc.).

## Instructor

Milos Prvulovic (Mee-losh Purr-voo-loh-vich) Office: KACB 2332 Office hours: Tuesdays and Thursdays 12:30pm-1:30pm

## Textbook, Software, and Required FPGA Boards

There is no required textbook in this class, but **you will need to purchase your own Altera DE1 board**. The boards cost \$125 with the academic discount, and we hope to get them for \$99 and possibly without shipping charges, but have not confirmed this with Altera yet. Once the arrangements have been made, students can order the boards.

Instead of a textbook, we will use a combination of class notes and online resources. These online resources include free software that will translate and load your hardware designs into the FPGA board. To run this software and connect to the FPGA board, you will need access to a Windows-based computer with a USB port. You may be able to get this software running on a Mac or in a virtual machine running on a Mac, but at this time we don't know if that will work.

## Attendance Policy

Attending lectures and taking good notes will be very important, especially because 1) there is no textbook, 2) important announcements (e.g. about project requirements or changes in due dates) will be made in some lectures, and 3) some things you will need to know for the project cannot be adequately explained only via lecture slides, so they will be shown (demonstrated) in lectures. To encourage attendance, there will be two unannounced (surprise) pop-quizzes during the semester, in addition to in-class demos and the mid-term exam that appear in the schedule. In summary, we will not be taking attendance in every lecture, but it will be very, very hard to earn a passing grade without attending lectures.

## Grading

The grade for this course will be based on the following:

	Weight	Comment
Project assignment 1	5%	Grade is assigned based on the report.
Project assignment 2	10%	Grade is assigned based on the report.
Project assignment 3	15%	Grade is assigned based on the report.
Project assignment 4	15%	Grade is assigned based on both the demo and the report.
Project assignment 5	15%	Grade is assigned based on both the demo and the report.
Midterm exam	10%	In-class, will be graded before drop-day
Final exam	20%	Comprehensive (covers entire semester)
Pop-Quizzes	10%	Two unannounced in-class quizzes, each weighted 5% of the final grade

I plan to use two policies to assign final (letter) grades. Each student's grade will be computed using both policies, and the actual final grade will be the better of the two grades. The first policy is not curved, with 90% or more of the maximum possible score yielding an A, 80%-90% yielding a B, 70%-90% yielding a C, 60%-70% yielding a D, and <60% yielding an F. The second policy is the traditional curve-based policy, using the average (AVG) and standard deviation (STD) of scores in the class. Earning more than  $AVG+STD$  (one standard deviation above the average) will yield an A, earning  $AVG$  to  $AVG+STD$  points will yield a B, earning  $AVG-STD$  to  $AVG$  points will yield a C, earning  $AVG-2*STD$  to  $AVG-STD$  points will yield a D, and earning fewer than  $AVG-2*STD$  (two standard deviations or more below the class average) will result in an F grade. Because this second policy is curve-based, the only way to be certain you will get a particular grade is to earn it according to the first policy.

There will be **no make-up assignments**, so if you need a particular grade plan to perform accordingly on homework, projects, and exams. Because of the large number of assignments in this class, exam re-grades can only be requested during 14 days that follow the release of scores from that assignment/exam.

The exception to this is the final project assignment and the final exam. For assignment 6, re-grades can only be requested until the Wednesday of the finals week. For the final exam, no re-grades will be possible until final grades are officially released (in OSCAR). You can still see your final exam and request a re-grade during the first two weeks of classes in the Fall semester. When requesting a re-grade, keep in mind that the entire submitted assignment or exam will be re-graded, so a **re-grade may result in a loss of points**.

The grade in this class will be based solely on demonstrated performance. Once an assignment or exam is over and graded, the only way the score on that assignment or exam will be changed is if a legitimate mistake in grading has been made. No grade will ever be changed because the student **needs** a better grade to stay in the program, to keep a fellowship, to get a job, or any other reason. If you believe you need some particular grade in this class, the only way to get that grade is to earn it through homework, projects, and exams.

#### No deficiency exam

If you are a gradating senior, keep in mind that this is a **project-based class** for the purposes of GT Rules and Regulations section 7.B.3. More specifically, a graduating senior who has a single-course deficiency usually has a right to be permitted a re-examination, and passing that re-examination would allow the student to graduate. However, **this right to a re-examination does not apply to CS 3220** or any other "courses in which a significant portion of the grade is based upon projects". Please keep this in mind if you are planning to graduate this semester.

#### Policy for Late Assignment Submission

The policy is very simple:

**T-Square will not accept late assignments, and we will ONLY grade what you submit in T-Square.**

All homeworks and projects are due on the day specified by the problem set or announced in T-Square or in class (later announcements take precedence over prior ones). **No late assignments will be accepted and no credit will be given for any late submission.** An assignment is only considered submitted when it is submitted through T-Square, and the files that will be graded will be those submitted in T-Square. So please **make sure that the files you submitted in T-Square are indeed the ones you want graded**. We will not accept a late submission if the file is elsewhere, even if the file modification time and date are before the deadline (those can be forged).

Students who face emergency situations *outside their control* that prevent them from completing an assignment in time should contact the professor before the assignment is due or, if that is impossible, as soon as possible. After receiving an extension, the student must submit the assignment before the extended deadline and will be required to provide documentation or other proof of the emergency situation.

Note that needs, wants, and emergencies within the student's control do not qualify for an extensions. In particular, the student is responsible for keeping adequate backups of their work and submitting the assignments ahead of time if needed. Examples of what does not qualify for an extension include (but are not limited to): the student needs a particular grade to graduate, the student wants to go on a cruise with their extended family, the student goes spelunking when the assignment is due and the cave does not have WiFi, the student tries to submit the assignment from a coffee shop and WiFi is down, the student misreads the date when the assignment is due, pet rhinoceros ate student's laptop, laptop fell out during a bungee-jump, etc.

#### Collaboration Policy

##### Exam or Pop-Quiz

Absolutely no collaboration is allowed. Copying or receiving *any information* from another person or from another person's exam, with or without their consent, is unethical and unacceptable. The *only* exception to this are the TAs and the professor, whom you can ask for clarification of an exam question during the exam. Cheating on exam is a direct violation of the GT Academic Honor Code and will be dealt with accordingly.

##### Project Assignments

Project assignments will be done in groups of two, but each student is to write their report and demo their project individually. Absolutely no collaboration is allowed between students in different groups. Collaboration with students or other persons outside your group (for example, a friend at another institution) is prohibited, and will be reported as Unauthorized Collaboration, which is a violation of the Academic Honor Code. Submitting any work other than your own (including content from the Internet) without proper attribution (specifying the source) will also be reported as Plagiarism (which is also a violation of the Academic Honor Code). Note that this is different from discussing lecture material (such as re-explaining an idea covered in class in a different manner or with a new example, or discussing what is being asked in the project assignment). Helping someone understand what is being asked in a problem is OK, but giving them hints or helping them actually do what is being asked is not OK.

Collaboration within the group is allowed only for the implementation part or the project assignment, i.e. for writing Verilog code, programming the board, collecting required files, etc. However, each student in the group is responsible for **individually** writing up and submitting a report and all the required files in T-Square, without any help from other members of their group. Working with or copying from **anyone (including your group partner)** on writing the project report will be reported as Unauthorized Collaboration and/or Plagiarism.

Note that each student's grade will be based on what that particular student submits in T-Square. For example, if a group completes an assignment but one student in that group submits the wrong (e.g. old) files, the two students will have very different scores on that assignment. A consequence of this is that the students in each group are allowed (but not encouraged) to complete the project independently (if they want to do that and if they figure out how to share the board).

Also note that each student will demo their project individually, and that each student is responsible for understanding all aspects of the work they submitted (regardless of whether the student or their group partner did the work). Note that a student's score on Assignment 5 and 6 will be significantly reduced if the student cannot demo the work or explain how the implementation or the code works.

#### Ambiguities, Clarifications, Questions?

If you're unsure about anything, ask the professor and/or consult the Academic Honor Code at [www.honor.gatech.edu](http://www.honor.gatech.edu). A violation of the rules will still be treated as a violation of the rules, regardless of whether you understood the rules or interpreted them correctly - if you are not sure that you understand how the rules apply to a particular situation, you should ask.

#### Tentative Schedule

Week	Date	Topics	Notes
1	1/7	Introduction, Preassessment test	
	1/9	Review: Number Representation, Boolean logic	
2	1/14	Basic Verilog, FPGA Board and Tools Demo	Student group requests due
	1/16	Verilog "always" blocks, clocks, and PLLs	
3	1/21	Memory in Verilog, Debugging Demo	PRJ1 Released
	1/23	Project ISA and Assembler	
4	1/28	Project ISA and Assembler	
	1/30	PRJ 1 Tips and Tricks	
5	2/4	Multi-Cycle Processor Implementation	PRJ 2 Released
	2/6	Single-Cycle Implementation	PRJ1 Due
6	2/11	Midterm Review	
	2/13	Midterm exam	
7	2/18	Basic Pipelining	PRJ 3 Released
	2/20	Hazards, Stalls, and Forwarding	
8	2/25	Performance Optimization Demo	PRJ 2 Due.
	2/27	Branch Prediction	Last day to drop with "W" grade is Feb 28.
9	3/4	Exceptions	
	3/6	Timers and I/O Devices	
10	3/11	Interrupt Support	PRJ 4 Released
	3/13	Optimizing Pipeline Stages	PRJ 3 Due
11	3/18	Spring Break - No class	
	3/20		
12	3/25	Optimizing ALUs and Multiplexers	
	3/27	Basic OS Support - System Calls and Context Switching	
13	4/1	Caching and Cache Hierarchies	PRJ 5 Released
	4/3	Beyond Pipelining - Multi-core	PRJ4 Due
14	4/8	PRJ 4 Demos	
	4/10	PRJ 4 Demos	
15	4/15	Beyond Pipelining - Instruction Scheduling, Power, and Temperature	PRJ 5 Due
	4/17	Beyond Pipelining - Paging, Virtual Memory, and Security	
16	4/22	PRJ 5 Demos	
	4/24	PRJ 5 Demos	
	4/29/2014 (Tue)	Final exam 2:50pm-5:40pm	