CPS311 - COMPUTER ORGANIZATION

Professor:	Russell C. Bjork russell.bjork@gordon.edu	Fall Semester, 2021
Office:	KOSC 235 x4377	MWF 1:50-2:50 pm KOSC 125
Hours:	MWF 3:00-4:30 pm; and by appointment	Lab L1: T 9:45am-12:45pm Lab L2: T 1:15-4:15 pm Both in KOSC 241 or 244 (beginning 8/31)

Course Site: Canvas site and http://www.cs.gordon.edu/courses/cps311

PREREQUISITE: Computer Science 122

CATALOG DESCRIPTION:

Introduces computers as physical devices composed of gates, binary representation of information, and the assembly-language level of computer description. Methods of improving performance including various forms of parallelism in hardware.

COURSE OBJECTIVES:

In general, this course is intended to familiarize you with the fundamental building blocks of modern computer systems, and with the way that computer systems are built up from the fundamental building blocks to form complete systems. The goal is not to have you learn how to design a computer system, but rather to help you become a more knowledgable user of computer hardware. In particular, upon completion of this course you should be able to

1. Explain the levels of computer structure.
2. Carry out the rudiments of digital logic design.
3. Convert between decimal, binary, and hexadecimal representations for numbers.
4. Discuss methods for representing other sorts of information (e.g. text, sounds, graphics, and more complex data structures) using binary numbers.
5. Describe the implementation of basic arithmetic operations by hardware.
6. Describe the architecture, organization and major components of a typical "Von Neumann architecture" computer.
7. Describe a typical RISC architecture (MIPS).
8. Write and run simple programs in MIPS assembly language.
9. Describe the implementation of basic instruction-set level functionality by means of register-transfer level operations.
10. Describe the organization of a RISC CPU
11. Describe the structure of the system bus and the memory and I/O subsystems.
12. Interface IO devices to a simple microprocessor bus system.
13. Describe various hardware mechanisms for supporting parallelism.
14. Describe how GPUs can be used for general-purpose computation
15. Discuss the measurement of computer system performance

TEXT: Harris, David and Sarah. *Digital Design and Computer Architecture* 2nd ed. (Waltham, MA: Morgan Kauffman, 2013)

ON RESERVE: Patterson, David and John Hennessy. *Computer Organization and Design: The Hardware / Software Interface*. (5th ed)

COURSE TECHNIQUES AND PROCEDURES

The college has adopted the following statement regarding work expectations for courses; "For each semester hour of credit, students should expect to spend a minimum of 2-3 hours per week outside of class in engaged academic time. This time includes reading, writing, studying, completing assignments, lab work, or group projects, among other activities." Since this is a 4-credit course, this translates of 8-12 hours per week outside of class lecture time, but including lab.

The primary goal of this course is for you to gain familiarity with the architecture and implementation of a modern computer, in order to be able to more intelligently purchase / use / develop software for such a machine. We will draw many of our examples from the MIPS architecture and implementation (a contemporary commercial architecture). However, our goal is not to become familiar with this particular architecture per se, but rather to become familiar with computer architecture at the instruction-set level, and how these capabilities are actually implemented in hardware.

As with other Computer Science courses, much of the learning will take place in the laboratory as you develop the various skills listed in the Course Objectives. Some of the laboratory sessions will focus on software - specifically machine and assembly language programming. Other laboratories will be hardware-oriented, both at the individual chip level early in the course, and through the use of a one-board computer.

In view of the complexity of some of the material, it is absolutely imperative that you keep up on your reading and your homework, and that you come to class prepared to ask questions about things you don't understand. Prior to each class period you should carefully read the assigned material in the textbook. Because the material is more technical than in some courses, you will probably find a greater than normal need to obtain personal help from the instructor. Please feel free to seek this.

COURSE REQUIREMENTS AND EVALUATION:

1. You will be expected to read material from the textbook, as assigned in the schedule below. Reading assignments should be completed **before** the class hour in which the topic is discussed. Lecture presentations will assume that you have read the text, and it is expected that your participation in the class will reflect that fact. However, our classroom discussion will not rigidly follow the order of material in the text, nor will it be confined to material covered there.

2. Homework will be assigned for most classes. Homework assignments will be posted on the course Home Page in Canvas, and will be turned in under Assignments on Canvas. Solutions to homework problems will be discussed in class, and will eventually also be posted on Canvas.

    All together, homework will be worth 30% of the final course grade, with the weight assigned to each assignment based on the number and difficulty of the problems. (The size of the assignments, and hence the weight, will tend to be higher in the first part of the course.) Credit for homework will be awarded on the basis of the completeness and correctness of your solutions, with significant credit given for a reasonably complete attempt at solving each problem, even if the final answer is not correct.

   • Homework must be turned in **BEFORE** the start of class on the date indicated. Late problem sets will **NOT** be accepted unless an extension is granted **IN ADVANCE**.

- Homework should be turned in electronically via Canvas, but if this doesn't work for some reason email can be used (but Canvas is preferable if at all possible).

- You may work together with another student on a problem set provided each of you works on each problem, and each turns in his/her own work.

- Where a problem calls for writing a program, it is sufficient to write it out by hand; you need not enter it into the computer unless you are explicitly told to do so.

- Often, solutions to problems in the book has been posted illicitly or by "cheat" sites on the web. You may **NOT** use these for homework. If homework is turned in that is obviously derived from such a source, it will be treated as a form of plagiarism.

3. Weekly laboratories will focus on gaining practical experience with the material covered in the book and/or in lecture. Lab assignments will be posted on Blackboard, and **must** be read over carefully **before** coming to lab.

   For each laboratory, there will be a writeup to turn in. One of the labs will run for two weeks, with everything due the second, but will be counted as two labs in grade computation. There may also be a quiz given at the start of the lab hour (based on your reading of the lab assignment) and/or a quiz based on the work done in lab given at the start of class on the due date. Each laboratory writeup and quiz(zes) will be worth 2% of the final course grade. (26% total for the 13 labs).

   The tentative emphases for the lab sessions is shown in the course schedule below *(subject to change)*.

4. A Computer-Aided Instruction program called BINARY will be made available for you to run. It is designed to give you thorough drilling in the use of binary, octal and hexadecimal representations of information. (Mastery of these representations is absolutely vital.) You may earn up to 100 points by completing the various drills quickly and accurately. You may repeat the drills as often as you like, and you will receive credit for the highest score attained on each of the topics prior to 4:00 pm on the due date. (You may continue working on the drill after then - but any additional points you earn will be for your own satisfaction only.) You may **NOT** use a calculator while doing these drills. This exercise will be worth 4% of the final course grade.

5. There will be two hour exams (worth 10% of the final course grade each) and a final exam (worth 20%) given as shown in the course schedule. Each exam will assume familiarity with material in the text, covered in lecture, and/or used in homework problems. The final exam will focus - but not exclusively - on material on implementation, memory, and IO from the second half of the course, but will also include some material from the first half of the course. Exams will be open book (course text only), open notes.

6. Your final grade will be computed on the basis of a weighted sum of the items listed above.

Summary:	Homework	30%
	Labs	26%
	Binary Drills	4%
	Exams	40%
		100%

The following are minimum guaranteed grades for the percentages indicated:

	93% - 100%: A	90% - 92.9%: A-
87% - 89.9%: B+	83% - 86.9%: B	80% - 82.9%: B-
77% - 79.9%: C+	73% - 76.9%: C	70% - 72.9%: C-
67% - 69.9%: D+	63% - 66.9%: D	60% - 62.9%: D-

ACADEMIC DISHONESTY

From the Gordon College Student Handbook: "Academic dishonesty is regarded as a major violation of both the academic and spiritual principles of this community and may result in a failing grade or suspension. Academic dishonesty includes plagiarism (see Plagiarism in Student Handbook), cheating (whether in or out of the classroom) and abuse or misuse of library materials when such abuse or misuse can be related to course requirements." For the purposes of this course, abuse or misuse of Gordon computer systems or networks related to course requirements will also be viewed as academic dishonesty.

Academic dishonesty will not be tolerated. You know better. Just don't!

POLICY STATEMENT ON EXTENSIONS AND INCOMPLETES:

1. Extensions of the due dates for homework or projects MAY be given in the event of extenuating circumstances IF you submit a brief written request to the professor as soon as possible after the circumstances arise - before the due date if at all possible. (Just having a lot of work due in other courses is not grounds for an extension!)

2. A grade of Incomplete MAY be given without penalty IF you are unable to complete the course work by the last day of the term due to major illness or other similar emergency. You must apply for this using the form provided by the registrar. Such a request will only be granted if you are substantially up-to-date with your course work and were making good progress in the course up to the time that the difficulty arose. Of course, you must complete all work for the course by the midpoint of the next semester in accordance with College policy.

ATTENDANCE POLICY:

Regular class attendance is expected of all students, and class attendance will be recorded. Absences from class will be classified as "excused" or "unexcused". An excused absence is one where the student misses class for a compelling reason (such as sickness, a field trip for another course, or an athletic competition, but not something like alarm clock issues) and has requested an excused absence. A student may request an excused absence up to three times in the semester by simply notifying the professor via email of the reason for the absence - prior to missing the class if possible. If it is necessary to miss more than three classes, the student must provide written documentation (such as a health center or doctor's note, or a notification from an athletic coach) for additional absences - otherwise they will be considered unexcused. A student who anticipates the need to miss multiple classes due to athletic competitions or other student activities must furnish written documentation, should review the college's attendance policy in the catalog, and must then discuss alternatives to class attendance with the professor at the start of the semester.

If a student has an excused absence from a class where there was a quiz, at the professor's option either the student may make up the quiz or the quiz will not be counted in calculating the final grade. Normally homework or other written work due at a class where the student has an excused absence must be turned in prior to the class, but the professor may choose to allow work to be turned in late without penalty in the case of an unanticipated absence.

At the end of the semester, the student's final average will be reduced 1% for each unexcused absence after the first. A student who has more than 12 unexcused absences will fail the course automatically.

A student who is habitually late will have late arrival for class counted as a half absence for that class, and a student who sleeps through most or all of a given class session will be counted as absent for that class.

You may ask the professor to waive this policy for you if you earned an A in the prerequisite course, or if you have an A average in this course as of the mid-term exam. If you wish to take advantage of this exemption, you must so inform the professor. However, the attendance policy will be reimposed if your subsequent work deteriorates.

STUDENTS WITH DISABILITIES:

Our academic community is committed to providing access to a Gordon education for students with disabilities. A student with a disability who intends to request academic accommodations should follow this procedure:

1. Meet with a staff person from the Academic Success Center (ASC) and provide them with current documentation of the disability.
2. Obtain a Faculty Notification Form from the Academic Success Center, listing appropriate accommodations
3. Submit this form to professors and discuss those accommodations with them, ideally within the first two weeks of classes.

Some accommodations need more time to arrange so communicating early in the semester is important. For more information consult the Academic Success Center webpage: http://www.gordon.edu/academicaccessibility or email asc@gordon.edu

TENTATIVE COURSE SCHEDULE

Date	Topic(s)	Reading	Written Work Due
		(All in main text by Harris unless otherwise stated)	
W 8/25	Course Introduction; The Levels of Computer Structure; Architecture and Organization		
F 8/27	A Bit of History; A Bit of Binary	§1.1-1.4	
M 8/30	Introduction to Combinatorial Logic:	§1.5, 2.1, 2.3-2.4	
T 8/31	Lab: Levels of Computer Structure (1) KOSC 241		
W 9/1	Combinatorial Logic (continued)	§2.2, 2.5-2.7; §1.6; optional §1.7-1.9, 2.9	**LAB 1 DUE**
F 9/3	Sequential Logic	§3.1-3.2	
M 9/6	*Labor Day (no class)*		
T 9/7	Lab: Realizing Boolean expressions with TTL SSI gates (2) KOSC 241		
W 9/8	Sequential Logic (continued)	§3.3-3.5	**LAB 2 DUE**
F 9/10	(continued)	§3.6-3.7	
M 9/13	Representing Information in Binary	reread §1.4	
T 9/14	Lab: Sequential Circuits (3) KOSC 244		
W 9/15	Representing Information in Binary (continued)	§5.3.2	**(One writeup due next week for Labs 3 and 4)**
F 9/17	Error Detecting and Correcting Codes		
M 9/20	CPU Building Blocks	§2,8; §5.1-5.2 through top of p. 252	
T 9/21	Lab: Sequential Circuits ctd (4) KOSC 241		
W 9/22	Introduction to the MIPS Architecture and Assembly Language	§6.1-6.4.1; §6.7.3; MIPS ISA Handout	**LABS 3-4 DUE**
F 9/24	(continued)	§6.4.2, 6.4.5	
M 9/27	Control Structures; MIPS Branch and Jump Instructions	§6.4.3-6.4.4	**START BINARY DRILLS**
T 9/28	Lab: MIPS Machine and Assembly Language (5) KOSC 244		

W 9/29	Control Structures (continued)		**LAB 5 DUE**
F 10/1	Review and Catch Up		
M 10/4	**HOUR EXAM #1 - DIGITAL LOGIC, BINARY ENCODING, ECC, BUILDING BLOCKS**		
T 10/5	Lab: Using the MIPS Assembler and Debugger (6) KOSC 244		
W 10/6	Procedures and Parameter Passing	§6.4.6; MIPS Procedures Handout	**LAB 6 DUE**
F 10/8	(continued)	§6.6	
M 10/11	Exceptions and Interrupts	§6.7.2; Exception-Handling Handout	
T 10/12	Lab: Data Structures and Addressing Memory (7) KOSC 244		
W 10/13	Other CPU Architectures: 0, 1, 2 and 3 address machines; addressing modes; CISC's vs RISC's	§6.5, 6.8-6.9	**LAB 7 DUE**
F 10/15	*No class - quad break*. Binary Drills due by 4 PM		**BINARY DRILLS DUE**
M 10/18	Other Architectures (continued)		
T 10/19	Lab: Procedures; Recursion (8) KOSC 244		
W 10/20	CPU Implementation; Data Paths	§7.1, 7.3	**LAB 8 DUE**
F 10/22	(continued)	§7.4	
M 10/25	CPU Implementation: The Control Unit; Hardwired and Microprogrammed Control.	**BRING RTL HANDOUT TO CLASS**	
T 10/26	Lab: Data Paths and MUXes (9) KOSC 244		
W 10/27	Pipelining; Superscalar Computers; Instruction-Level Parallelism	7.2; 7.5; **BRING RTL HANDOUT TO CLASS**	**LAB 9 DUE**
F 10/29	Review and Catch Up		
M 11/1	**HOUR EXAM #2 - MIPS AND OTHER ISA's**		

T 11/2	*Day of Prayer - No Lab*		
W 11/3	Pipelining etc. (continued)	§7.8	
F 11/5	Hardware Support for Parallelism	§ 3.6; Computer Organization and Design (on reserve) §6.1-6.8	
M 11/8	(continued)		
T 11/9	Lab: Control Units (10) KOSC 244		**BRING RTL HANDOUT TO LAB**
W 11/10	Semiconductor Memory Devices	§5.5,2-5.5.4	**LAB 10 DUE**
F 11/12	(continued)	§5.5.6	
M 11/15	(continued)	§5.5.1	
T 11/16	Lab: Parallel Computing (11) KOSC 244		
W 11/17	Memory Hierarchies	§8.1-8.3	**LAB 11 DUE**
F 11/19	(continued)		
M 11/22	(continued)	§8.4, §8.8-8.9	
T 11/23	Lab: TBA		
W 11/24	*Thanksgiving Break - no class*		
F 11/26	*Thanksgiving Break - no lab*		
M 11/29	Memory Hierarchies (continued)		
T 11/30	Lab: Memory Devices (12) KOSC 241		
W 12/1	The Input-Output Subsystem; Bus Structures; Inerrupts and DMA	§8.5 quickly skim §8.6-8.7	**LAB 12 DUE**
F 12/3	(continued)		
M 12/6	(continued)		
T 12/7	Lab: IO Interfacing (13) KOSC 241 and 244		
W 12/8	Review and Catch Up		**LAB 13 DUE**

MONDAY, DECEMBER 13 - 12-2 PM - FINAL EXAM