CSC 320-01,03,04 Computer Organization and Architecture Fall 2019

Meeting Times and Location: 01:W 4:00pm, 03: MWF 9:00am, 04:MWF 8:00am SCI 139
Instructor: Joel Rosiene, rosienej@easternct.edu
Office Hours: MWF: 10:00am – 12:00pm
Office Location: SCI 2nd Floor
Final Exam: A final point opportunity will be offered online during the final exam times.

Course Text: William Stallings, Computer Organization and Architecture, 11th ISBN: 9780134997193
Course Text Website: http://williamstallings.com/ComputerOrganization/
Programming Language: Arm Assembly and Standard C
Programming Device: Raspberry PI 3.0+ or Raspberry PI 4.0

Course Description:

Eastern Connecticut State University Catalog Entry
CSC 320 - Computer Organiz And Architect

Computer Organization and Architecture

Prerequisite: CSC 210 and (MAT 230 or CSC230)

This course is an introduction to the fundamental concepts of the structure and logical design of components of digital computers. Topics include assembly languages and instruction sets, data representation, basic digital logic, CPU design, pipelining, memory system, I/O interfaces, and multiprocessors.

3.000 Credit hours

3.000 Lecture hours

Levels: Undergraduate **ACM 2013 Computer Science Recommendations**
Architecture and Organization (AR) (page 62)

Computing professionals should not regard the computer as just a black box that executes programs by magic. The knowledge area Architecture and Organization builds on Systems Fundamentals (SF) to develop a deeper understanding of the hardware environment upon which all computing is based, and the interface it provides to higher software layers. Students should acquire an understanding and appreciation of a computer system's functional components, their characteristics, performance, and interactions, and, in particular, the challenge of harnessing parallelism to sustain performance improvements now and into the future. Students need to understand computer architecture to develop programs that can achieve high performance through a programmer's awareness of parallelism and latency. In selecting a system to use, students should be able to understand the tradeoff among various components, such as CPU clock speed, cycles per instruction, memory size, and average memory access time. The learning outcomes specified for these topics correspond primarily to the core and are intended to support programs that elect to require only the minimum 16 hours of computer architecture of their students. For programs that want to teach more than the minimum, the same AR topics can be treated at a more advanced level by implementing a two-course sequence. For programs that want to cover the elective topics, those topics can be introduced within a two course sequence and/or be treated in a more comprehensive way in a third course.

Student Time Commitment

The student should plan for the following commitment per week: Reading/Quizzes (3 Hours); Homework/Projects (3 Hours); Class (3 Hours) for a total of 9 Hours. Friday will be Pi-Day the student should plan bring the raspberry pi to class on Friday.

Coverage:

I. Introduction

0. Review and Background
1. Basic Concepts and Computer Evolution
2. Performance Concepts

II. The Computer System

3. A Top-Level View of Computer Function and Interconnection
4. The Memory Hierarchy: Locality and Performance
5. Cache Memory
6. Internal Memory
7. External Memory
8. Input/Output
9. Operating System Support

III. Arithmetic and Logic

10. Number Systems
11. Computer Arithmetic
12. Digital Logic

IV. Instruction Sets and Assembly Language

13. Instruction Sets: Characteristics and Functions
14. Instruction Sets: Addressing Modes and Formats
15. Assembly Language and Related Topics

V. The Central Processing Unit

16. Processor Structure and Function
17. Reduced Instruction Set Computers
18. Instruction-Level Parallelism and Superscalar Processors
19. Control Unit Operation and Microprogrammed Control

There will be three large multiple part assembly projects for the Raspberry PI

1) Assembly Language Programing Concepts
2) Advanced Assembly Language Development
3) Operating Systems vs Bare Metal Programming

ACM Student Learning Outcomes:

The ACM provides a partial list of expected student outcomes related to computer architecture (https://ai.stanford.edu/users/sahami/CS2013/exemplars.html) (Area, Topic, Level, Outcome, Item #). The intent is to cover most/all of the Level 2 outcomes)

AR Digital logic and digital systems 0 3

- AR Digital logic and digital systems 2 Familiarity 1 Describe the progression of computer technology components from vacuum tubes to VLSI, from mainframe computer architectures to the organization of warehouse-scale computers.
- AR Digital logic and digital systems 2 Familiarity 2 Comprehend the trend of modern computer architectures towards multi-core and that parallelism is inherent in all hardware systems.
- AR Digital logic and digital systems 2 Familiarity 3 Explain the implications of the "power wall" in terms of further processor performance improvements and the drive towards harnessing parallelism.
- AR Digital logic and digital systems 2 Familiarity 4 Articulate that there are many equivalent representations of computer functionality, including logical expressions and gates, and be able to use mathematical expressions to describe the functions of simple combinational and sequential circuits.
- AR Digital logic and digital systems 2 Usage 5 Design the basic building blocks of a computer: arithmetic-logic unit (gate-level), registers (gate-level), central processing unit (register transfer-level), memory (register transfer-level).
- AR Digital logic and digital systems 2 Usage 6 Use CAD tools for capture, synthesis, and simulation to evaluate simple building blocks (eg, arithmetic-logic unit, registers, movement between registers) of a simple computer design.
- AR Digital logic and digital systems 2 Assessment 7 Evaluate the functional and timing diagram behavior of a simple processor implemented at the logic circuit level.

AR Machine level representation of data 0 3

- AR Machine level representation of data 2 Familiarity 1 Explain why everything is data, including instructions, in computers.
- AR Machine level representation of data 2 Familiarity 2 Explain the reasons for using alternative formats to represent numerical data.
- AR Machine level representation of data 2 Familiarity 3 Describe how negative integers are stored in sign-magnitude and twos-complement representations.
- AR Machine level representation of data 2 Familiarity 4 Explain how fixed-length number representations affect accuracy and precision.
- AR Machine level representation of data 2 Familiarity 5 Describe the

internal representation of non-numeric data, such as characters, strings, records, and arrays.

- AR Machine level representation of data 2 Usage 6 Convert numerical data from one format to another.
- AR Machine level representation of data 2 Usage 7 Write simple programs at the assembly/machine level for string processing and manipulation.

AR Assembly level machine organization 0 6

- AR Assembly level machine organization 2 Familiarity 1 Explain the organization of the classical von Neumann machine and its major functional units.
- AR Assembly level machine organization 2 Familiarity 2 Describe how an instruction is executed in a classical von Neumann machine, with extensions for threads, multiprocessor synchronization, and SIMD execution.
- AR Assembly level machine organization 2 Familiarity 3 Describe instruction level parallelism and hazards, and how they are managed in typical processor pipelines.
- AR Assembly level machine organization 2 Familiarity 4 Summarize how instructions are represented at both the machine level and in the context of a symbolic assembler.
- AR Assembly level machine organization 2 Familiarity 5 Demonstrate how to map between high-level language patterns into assembly/machine language notations.
- AR Assembly level machine organization 2 Familiarity 6 Explain different instruction formats, such as addresses per instruction and variable length vs fixed length formats.
- AR Assembly level machine organization 2 Familiarity 7 Explain how subroutine calls are handled at the assembly level.
- AR Assembly level machine organization 2 Familiarity 8 Explain the basic concepts of interrupts and I/O operations.
- AR Assembly level machine organization 2 Usage 9 Write simple assembly language program segments.
- AR Assembly level machine organization 2 Usage 10 Show how fundamental high-level programming constructs are implemented at the machine-language level.

AR Memory system organization and architecture 0 3

- AR Memory system organization and architecture 2 Familiarity 1 Identify the main types of memory technology (eg, SRAM, DRAM, Flash, magnetic disk) and their relative cost and performance.
- AR Memory system organization and architecture 2 Familiarity 2 Explain the effect of memory latency on running time.
- AR Memory system organization and architecture 2 Familiarity 3 Describe how the use of memory hierarchy (cache, virtual memory) is used to reduce the

effective memory latency.

- AR Memory system organization and architecture 2 Familiarity 4 Describe the principles of memory management.
- AR Memory system organization and architecture 2 Familiarity 5 Explain the workings of a system with virtual memory management.
- AR Memory system organization and architecture 2 Usage 6 Compute Average Memory Access Time under a variety of cache and memory configurations and mixes of instruction and data references.

AR Interfacing and communication 0 1

- AR Interfacing and communication 2 Familiarity 1 Explain how interrupts are used to implement I/O control and data transfers.
- AR Interfacing and communication 2 Familiarity 2 Identify various types of buses in a computer system.
- AR Interfacing and communication 2 Familiarity 3 Describe data access from a magnetic disk drive.
- AR Interfacing and communication 2 Familiarity 4 Compare common network organizations, such as ethernet/bus, ring, switched vs routed.
- AR Interfacing and communication 2 Familiarity 5 Identify the cross-layer interfaces needed for multimedia access and presentation, from image fetch from remote storage, through transport over a communications network, to staging into local memory, and final presentation to a graphical display.
- AR Interfacing and communication 2 Familiarity 6 Describe the advantages and limitations of RAID architectures.

Outcomes Associated with Computer Architecture

OS Memory Management 0 3

- OS Memory Management 2 Familiarity 1 Explain memory hierarchy and cost-performance trade-offs.
- OS Memory Management 2 Familiarity 2 Summarize the principles of virtual memory as applied to caching and paging.
- OS Memory Management 2 Assessment 3 Evaluate the trade-offs in terms of memory size (main memory, cache memory, auxiliary memory) and processor speed.
- OS Memory Management 2 Assessment 4 Defend the different ways of allocating memory to tasks, citing the relative merits of each.
- OS Memory Management 2 Familiarity 5 Describe the reason for and use of cache memory (performance and proximity, different dimension of how caches complicate isolation and VM abstraction).
- OS Memory Management 2 Familiarity 6 Discuss the concept of thrashing, both in terms of the reasons it occurs and the techniques used to recognize and manage the problem.

Course Approach and Grading:

Attendance is required since the student is responsible for material presented in class.

The student will be provided with several opportunities to collect "points", with extra credit points built into the opportunities. If the student wishes to put in additional effort on a portion of the assignments and forgo some problems, it is fine. The student may focus of their effort on topics of interest to the student. The common core of knowledge is developed from the quizzes.

The quizzes highlight the common core of knowledge that the students should plan (or need) to acquire. The quizzes are to be taken outside of class, are associated with the reading or video assignments, and should be attempted prior to class. The quizzes are open note, open "google", and phone a friend. The students are expected to discuss the quiz topics.

Three larger programming/homework assignments will be offered. Programs must be turned in in a form I can assemble and run. You may work together, but you need to provide a list of people you worked with and state what you contributed to the work.

Grading Policy

- 10 Quizzes/HW and Final Point Opportunity: 1500 points (minimum) available
- Programs/labs: 1500 points (minimum) available

Grade Levels:

Points:	Grade
2000:	A
1900:	A-
1800:	B+
1700:	B
1600:	B-
1500:	C+
1400:	C
1300:	C-
1200:	D+
1100:	D
1000:	F

Homework/Program/Section Grading Per Problem/Aspect

- Missing: 0
- Mostly Correct: 1 points (No Discussion)
- Correct: 10 points (Full Credit!!)
- Extra Effort: 25 points (Bonus)
- Perfect: 50 points (Notable)

Program/Lab Grading Aspects (multiplier) Full Credit = 200 Points

- Introduction (2)
- Problem Discussion (3)
- Testing Plan (4)
- Testing Documentation (6)
- Commented Program Listing (3)
- Quality (2)

Syllabus Statements

Required Syllabus Statement:

Accommodations for Students with Disabilities
Eastern Connecticut State University is committed to following the requirements of the Americans with Disabilities Act (ADA) of 1990, the ADA Amendment Act of 2008, and Section 504 of the Rehabilitation Act of 1973, as amended in 1998. If you are a student with a disability (or think you might have a disability) and require accommodations or assistance evacuating a building in the case of an emergency, please contact the Office of AccessAbility Services (OAS) at 860-465-0189 to discuss your request further. Please note that accommodations are not retroactive and must be communicated through a Letter of Accommodation, which is drafted by the OAS.

Student Crisis Statement
Any student who is facing challenges (i.e. mental health, securing food/housing) and believes this may affect their performance in the course is urged to contact the Dean of Students at 860-465-5244 for support. Students experiencing an immediate threat to their safety or wellbeing should contact 24-hour emergency services by dialing 911 or the Eastern's University Police Department: 860-465-5310.

Final Examination Statement
University policy states that, "No examination shall be given during the final week of scheduled classes of a full semester course." Faculty must receive prior approval from the Vice-President of Academic Affairs in order to schedule an examination during the final week of classes.
Faculty may, with approval from the Vice-President of Academic Affairs in consultation with the Academic Dean and Registrar, hold a single exam session for all sections of the same course. Students will be notified of the exam date, time, and place on the course syllabus.

Suggested Syllabus Statement/s:

Student Sexual Misconduct Policy
Title IX of the Education Amendment of 1972, as well as the Board of Regents Policy on Sexual Misconduct Reporting, Support Services and Processes, prohibit acts of sexual misconduct – sexual harassment, sexual assault, sex-based discrimination, dating violence, domestic violence, stalking, and inappropriate relationships between employees and students. If you or someone you know has been or experiences harassment or assault, resources are available with the Sexual Assault & Interpersonal Violence Response Team (SAIV-RT). Alleged violations can be reported to the Title IX Coordinator in the Office of Equity and Diversity at 860-465-5791. Reports to law enforcement can be made to Eastern Connecticut State University Police Department at 860-465-5310. **To receive support and advocacy, please contact the Coordinator of the Sexual Assault & Interpersonal Violence Response Team (SAIV-RT) at 860-465-4314. You may also visit the SAIV-RT website at www1.easternct.edu/saiv for more information including a list of confidential resources.**

Cheating, Plagiarism, and Personal Misconduct
Students are responsible for familiarizing themselves with the University's numerous policies and procedures contained in the University Catalog and Student Handbook. The Code of Conduct policies and the Policy on Academic Misconduct are of special significance, since cheating, plagiarism, and personal misconduct are strictly prohibited and carry severe penalties. Students should read and understand Eastern's Academic Misconduct Policy, which can be found in the student handbook.
http://ecsu-svkb2.easternct.edu/index.php?View=entry&EntryID=307
All violations will be handled under the procedures established in this policy.

Assistance at the Writing Center
The Eastern Writing Center, located in the ASC and staffed by trained peer tutors, is available to help all students with their writing. The Writing Center supports the liberal-arts mission of Eastern by helping students with their writing from any class, at any stage, from brainstorming and drafting to revision to proofreading and editing. We help students do their own work, and do it more comfortably and confidently. Any student can and should use the Writing Center. The process of talking with readers about writing and getting feedback on student writing is something all writers do and can benefit from. Students can either drop into the Center or make an appointment by going to the "Useful Links" column on the Current Students webpage and selecting "GradesFirst" (http://www.easternct.edu/index/current-students/).
Students are asked to bring copies of any assignment sheets to the Writing Center, so tutors know what is expected of the assignment.

Assistance with Academic Advising and Subject Tutoring at the Academic Service Center
Students are encouraged to use the support offered by the Academic Services Center (ASC) located on the ground floor of the Library. Advising Services and tutoring in math, writing, and other subjects, including supplementary instruction, are available. The ASC also offers Peer Academic Coaching (PAC) assistance with study techniques, time management, "Eastern in 4" planning and understanding learning styles. For further information about our services, please call 465-4625 or check the ASC website at http://www.easternct.edu/asc/.