UMD UNIVERSITY OF MINNESOTA DULUTH
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CS 2521: Computer Organization and Architecture

Fall 2021

Lecture 12:30-13:45 T,Th Montague Hall 70

Instructor: Julian Nowaczek

Office: MWAH 189C / HH 334

Office Hours: T,Th: 14:00-15:30, or by appointment

Office Phone: (218) 726-7917

Course Description

Internal representation of programs and data. Computer organization and introduction to computer architecture. Machine and assembly language programming. Data and procedural structures. Addressing methods. Systems software including linking and loading. Introduction to hardware performance analysis and measurements.

Prerequisites: 1521 or instructor consent, a grade of C- or better is required in all prerequisite courses
Max credits: 4, Max completions: 1

Course Objectives

In previous computer science courses, you learned programming using the high-level programming language C++. High-level languages are designed to specify programs without regard to the machine on

which the program runs. Thus, programmers need not be concerned with the details of coding and arranging information or specifying operations in a manner that is understood by the machine.

In this course we will look behind the scenes. We will see how machines code the various kinds of data and instructions, how they handle input and output, how they implement control structures, how they are organized using logic circuits, and how system software provides an interface to computer systems.

Grading Basis

Item	Percent
Midterm Exam 1	20%
Midterm Exam 2	20%
Final Exam	25%
Programming Assignments (10)	10%
Homework (10)	10%
Quiz Participation	5%
Short Quiz (10)	10%
Total	**100%**

Highest	Lowest	Letter
100.00 %	94.00 %	A
93.99 %	91.00 %	A-
90.99 %	88.00 %	B+
87.99 %	82.50 %	B
82.49 %	79.00 %	B-
78.99 %	77.00 %	C+
76.99 %	73.00 %	C
72.99 %	70.00 %	C-
69.99 %	67.00 %	D+
66.99 %	60.00 %	D
59.99 %	0.00 %	F

These cutoff percentages may be raised or lowered at the instructors' discretion.

Course Outcomes and Expectations

Outcome 1: To demonstrate proficiency in instruction design

a) Apply different formats of data representation and number systems

b) Use Boolean algebra as related to designing computer logic

Outcome 2: To demonstrate proficiency with digital logic

a) Design and evaluate combinational and sequential logic circuits with multiple inputs and outputs

b) Design simple combinational and sequential logic circuits, using a small number of logic gates

Outcome 3: To demonstrate proficiency with basic computer architecture

a) Arithmetic/Logic unit, control unit, and data, instruction and address flow,

b) Design assembly language programs that make appropriate use of a registers and memory.

UMD Student Learning Outcomes (SLOs)

(SLO 1) Knowledge - acquisition, construction, integration, application

- Students understand the fundamentals of computer organization and architecture.

(SLO 2) Thinking - cognitive complexity

- Students can apply computer science principles & practices to a variety of problems.

- Students understand the mathematics and statistics that underlie scientific applications.

Expectations

You are responsible for:

- Knowing the course syllabus (especially exam dates and assignment due dates)

- Reading and understanding the assigned textbook material

- Attending lectures and asking questions if you have them

- Participating in discussion sections

- Completing exercises and quizzes in class

- Demonstrating your programming projects on time in lab

- Seeking help as you need it (the earlier the better)

As an instructor, I will endeavor to:

- Provide comprehensive materials online

- Discuss course concepts in detail during lecture

- Demonstrate the implementation of concepts

- Be responsive to your inquiries

- Maintain office hours in which you can come see me

If there are additional ways that the instructor can assist you please let them know.

Course Structure and Materials

Class Meeting Dates

Section	Time	Location
Lecture (001)	T,Th 12:30 - 13:45	Montague Hall 70
Laboratory (002)	M 11:00 - 11:50	M W Alworth Hall 175
Laboratory (003)	M 12:00 - 12:50	M W Alworth Hall 175
Laboratory (004)	M 13:00 - 13:50	M W Alworth Hall 175
Laboratory (005)	M 14:00 - 14:50	M W Alworth Hall 175

Final Exam

Date and Time – TBD
http://www.d.umn.edu/onestop/calendar/final-exam-dates.html

Faculty

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Office Hours: T,Th: 14:00-15:30, or by appointment

Teaching Assistants

Alex Bleth
Email: bleth009@d.umn.edu
Office: VKH 17B
Office Hours: T,W,Th 11:00-12:00, or by appointment

Sushmeendra Rudravaram
Email: rudra016@d.umn.edu
Office: MWAH 175
Office Hours: M,W,F 10:00-11:00, or by appointment

Note: If you contact your instructor or TA by email, please include the class (CS-2521) in the Subject line. Do not expect replies to be immediate (especially on weekends or in the evening). *Do not attach program files to be graded or debugged.* Programs are only graded in lab.

Exam Dates

The dates may change depending on the material covered during lectures.

Exam	Coverage	Date
Midterm Exam 1	Ch. 1, 2, App. A	2021-09-30
Midterm Exam 2	Ch. 3, App. B	2021-10-21
Midterm Exam 3	Ch. 4, 5	2021-11-18
Final Exam	Cumulative	TBD

Exams

Most exams are a mixture of multiple choice and programming problems. You should expect to write Assembly language code program segments from start to finish without the aid of any course materials or the text. Exams will be handed back, reviewed and re-collected.

Required Lab Materials

The course lab requires each student to purchase a set of electronic components. The list of components and a breakdown of their cost is available in [this spreadsheet](#). The total cost is approximately $30-45 depending on component prices. It is recommended to purchase these materials early to ensure you are prepared for the lab exercises in which they will be used.

Any students experiencing difficulty acquiring the listed materials due to availability, cost, or any other reason should contact the instructor as soon as possible.

Recommended Text

Computer Organization and Design: The Hardware/Software Interface, 5th ed, By Patterson.
ISBN: 978-0-12-407726-3

The Course Management System (Canvas)

This course is maintained on the Canvas course management system. All course documents (syllabus, calendar, PowerPoint slides, etc.) are available to students through Canvas. To access course materials please visit https://canvas.umn.edu.

MARS Simulation Software

Programming assignments in this course are done using MARS. You are not required to purchase this software for this course as it is free to download. MARS - MIPS Assembly and Runtime Simulator is written in Java and requires at least Release 1.5 of the J2SE Java Runtime Environment (JRE) to work. The graphical IDE is implemented using Swing. It has been tested on Windows, macOS, and Linux. It is available from http://courses.missouristate.edu/KenVollmar/MARS/download.htm.

As of V4.0, MARS requires Java SE 1.5 (or later) installed on your computer. Java SE can be found at https://www.oracle.com/java/technologies/javase-downloads.html

Syllabus or Calendar Revision

The instructor reserves the right to make changes in the syllabus or the course calendar at any time, and without prior notice. However, I will endeavor to announce any changes to the class and provide opportunities for feedback.

Typical Course Calendar

The following is a list of topics typically covered throughout the 15 weeks of the semester. Variation may occur in any particular semester. See the detailed course calendar on Canvas for a daily schedule for this course.

Week	Topic or Reading	Due
Week 1	Syllabus, Moodle, policies, Course expectations, Computer Classes, Computer Components, CPU Performance, P&H Ch. 1.1-1.3, 1.4, 1.7, 1.8	
Week 2	CPU Performance, P&H Ch. 1.4, 1.7, 1.8, IC Manufacturing, Power, P&H Ch. 1.5-1.7, Translating C Control Structures, P&H Ch. 2.1-2.4, 2.7	
Monday (lab)	HW1, Introduction to MAL	
Week 3	MAL Subprograms, P&H Ch. 2.8, MAL Data Structures, P&H Ch. 2.9, 2.14, 2.15, MAL Instruction Coding, P&H Ch. 2.5, 2.10, 2.16, 2.17	
Monday (lab)	HW2, L1	HW1
Week 4	Assembler Organization, P&H Ch. 2.12, 2.15, Program Translation, Language Translation, P&H Ch. 2.12, 2.15, Operating Systems: Virtualization of Resources, The Operating System Interface	

Monday (lab)	HW3, L2	HW2, L1
Week 5	Review for Midterm 1, P&H Ch. 4.1, 4.2, MIPS Implementation Introduction, Midterm 1	
Monday (lab)	L3	HW3, L2
Week 6	Processes and Threads, Operating Systems, Program Files, Linking, and Loading, P&H, Implementing Objects, P&H Ch. 2.15Ch. 2.12	
Monday (lab)	HW4, L4	L3
Week 7	P&H Ch. 4.1, 4.2, MIPS Execution Activities, MIPS Instruction Types, P&H Ch. 4.3, 4.4, MIPS Single-Cycle Implementation, P&H Ch. 4.4	
Monday (lab)	HW5, L5	HW4, L4
Week 8	Review for Midterm 2, Midterm 2	
Monday (lab)	HW6, L5	HW5
Week 9	The ALU, Shifting, Multiplication and Division, P&H Ch. 3.3, 3.4, Floating-Point Numbers, P&H Ch. 3.5, 3.6, MIPS Multicycle Implementation, P&H Ch. 4.4	
Monday (lab)	HW7, L5	HW6
Week 10	Pipelining, P&H Ch. 4.5, Pipelining Obstacles, P&H Ch. 4.6, 4.7, Register Renaming	
Monday (lab)	L6	HW7, L5
Week 11	Register Renaming Performance, Midterm Review, Friday Midterm 2	
Monday (lab)	HW8, L6	
Wed	MIPS Single-Cycle Implementation, P&H Ch. 4.4, Logic Circuits, Integer Addition and Subtraction, P&H Ch. 3.1, 3.2, App. C.6, Lookahead Carry, P&H App. C.5	
Week 12	Midterm 3	
Monday (lab)	HW9, L7	HW8, L6
Week 13	Virtual Memory, P&H Ch. 5.4, Memory Hierarchies, P&H Ch. 5.5, Disk Storage, Reliability, P&H Ch. 6.1-6.4	
Monday (lab)	HW10, L8	HW9, L7
Week 14	System Interconnection P&H Ch. 6.5-6.8, RAID P&H Ch. 6.9, Networks, Network Layers, P&H Ch. 6.11	

Monday (lab)	P&H Ch. 5.1, 5.2, Caching, P&H Ch. 5.2, 5.3, Cache Addressing, P&H Ch. 5.3, Cache Performance	HW10, L8
Week 15	Multiprocessor Systems, P&H Ch. 7.1-7.4, Multiprocessor Systems, P&H Ch. 7.5-7.8, Review for the Final Exam	
Week 16	Final exam	

Course Policies

Use of Laptop Computers and Other Electronics

Please feel free to use whatever tools aid your learning as long as they do not constitute a distraction for other students. If you are causing a disturbance during class you may be asked to stop and/or leave the classroom.

Absence from Class

Failure to attend class is the quickest way to a poor grade. If you are unable to attend a class meeting, it is your responsibility to obtain class notes and other materials. There are no makeups for missed labs, exercises, quizzes or exams unless you have an excused absence that qualifies under the UMD Excused Absence Policy and have cleared it with the instructor beforehand.

Lecture Hall Etiquette

Large lecture halls are sometimes difficult places in which to learn. You can improve your chances by sitting up front or in the middle. Here are other guidelines that apply to this course:

- If you come in late sit toward the back (last 5 rows).

- If you must leave during lecture sit toward the back (last 5 rows).

- Please do not distract others trying to have a conversation during lecture. Everything you say can usually be heard by those around and in front of you in this lecture hall.

- No food or drink in the lecture halls.

Late Assignments

All assignments are due at the beginning of class on the due date listed. Late assignments will face a 10% deduction to the maximum credit earned for each day it is late, before reaching a minimum of 50% of the original point value after five (5) days.

Extra Credit

There is no guaranteed extra credit work beyond that listed in the syllabus and course calendar. Additional extra credit opportunities may be added at the instructor's discresion.

Withdrawal Policy

In accordance with UMD policy, cancellation of courses after the end of the eighth week is not permitted. If you are doing poorly in the class, it is your responsibility to talk with the instructor prior to the 8th week to determine what course of action to take.

Start Early!

You may have taken classes in which an assignment can be thrown together at the last minute - that strategy never works in computer science. Putting off programming assignments until the last minute has been proven by many former students to be the fastest route to a poor grade.

Help with Projects

Your instructor and your Graduate Teaching Assistants are available during their office hours to answer questions and help you with your programs, although they will not write code for you or tell you any part of the solution. Check with your TA for office hours and locations.

Final Exam

The date and time of the final examination can be found on the [UMD Regular Final Exam Schedule](). Final exam conflicts are handled according to the [UMD Final Exam Policies]().

Academic Integrity

Academic dishonesty tarnishes UMD's reputation and discredits the accomplishments of students. UMD is committed to providing students every possible opportunity to grow in mind and spirit. This pledge can only be redeemed in an environment of trust, honesty, and fairness. As a result, academic dishonesty is regarded as a serious offense by all members of the academic community. In keeping with this ideal, this course will adhere to policies administered by [The UMD Office of Student Conduct](). This policy sanctions students engaging in academic dishonesty with penalties up to and including expulsion from the university for repeat offenders.

ACM Standards

Most professional computer scientists belong to the [Association for Computing Machinery (ACM)]() which has its own code of ethics. These are the guidelines for this course and include such concerns as respecting the privacy and property of others, giving proper credit for intellectual property and being honest and trustworthy.

Standards for this Class

From the standpoint of this class, scholastic dishonesty includes the following:

- You may not take credit for work you did not do.

- You may not use any form of outside help on exams (books, notes, computing devices, conversations, etc.)

- You may not assist another in an act of scholastic dishonesty (letting someone else use code you possess, or devise is prohibited).

- All incidents of cheating, no matter how small, are reported to the UMD Office of Student Conduct.

NOTE: There are severe consequences for cheating on exams. If you are caught cheating on an exam the penalty is an F for the exam AND for the entire course. The penalty for cheating on projects or other assignments is a 0 on the assignment plus a 50 point deduction from your total points.

Distribution and Sale of Course Materials

Course materials are provided solely for educational purposes for students enrolled in this course. Course materials are copyrighted by the instructor or the publisher of your textbook and may not be distributed to others, in whole or in part, except as permitted under university policy: http://www.d.umn.edu/vcaa/ClassNotesAppropriateUseof.html

General Information

The Department of Computer Science

The Department of Computer Science is part of the College of Science and Engineering at the University of Minnesota Duluth, a campus of the University of Minnesota system. The Department was established in 1986. It offers programs leading to the Bachelor of Science and Master of Science degrees in Computer Science and the Bachelor of Science degree in Computer Information Systems.

The mission of the Department of Computer Science is four-fold:

1. To conduct scholarly research.

2. To provide an instructional environment that leads to careers and research in computer science and information systems.

3. To contribute to the liberal education mission of the University.

4. To serve the community, state, region, and the profession.

Accreditation

The Bachelor of Science program with a major in Computer Science is accredited by the Computing Accreditation Commission of the [Accreditation Board for Engineering and Technology (ABET)](#), a specialized accrediting body recognized by the Council for Higher Education Accreditation.

Liberal Education Fulfillment

This course satisfies a Liberal Education requirement under Category 3 -Communication, Computer Science, and Foreign Languages. Courses in this category should develop the ability to use and analyze human and computer languages. Emphasis should be on the theory and/or development of skills in the methods of human and computer languages, and rhetoric. Specifically, the goals and objectives of this course that contribute to this liberal education requirement are as follows:

- to understand the basic concepts in the field of computer science,

- to develop competency in computer-related skills, and

- to provide students with the skills necessary to use computer systems as an effective tool for electronic communication, knowledge acquisition, and personal productivity.

Policy Statements

Student Conduct Code

Appropriate classroom conduct promotes an environment of academic achievement and integrity. Disruptive classroom behavior that substantially or repeatedly interrupts either the instructor's ability to teach, or student learning, is prohibited. Student are expected adhere to [Board of Regents Policy](#).

Teaching & Learning: Instructor and Student Responsibilities

UMD is committed to providing a positive, safe, and inclusive place for all who study and work here. Instructors and students have mutual responsibility to insure that the environment in all of these settings supports teaching and learning, is respectful of the rights and freedoms of all members, and promotes a civil and open exchange of ideas. Reference the full policy [here](#).

Academic Integrity

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Final Exams

All 1xxx-5xxx courses offered for undergraduate credit should include a final graded component or end of term evaluation that assesses the level of student achievement of one or more course objectives. All final graded components are to be administered or due at the time and place according to the final exam schedule and not during the last week of class. Reference the full policy [here](#).

Excused Absences

Students are expected to attend all scheduled class meetings. It is the responsibility of students to plan their schedules to avoid excessive conflict with course requirements. However, there are legitimate and verifiable circumstances that lead to excused student absence from the classroom. These are subpoenas, jury duty, military duty, religious observances, illness, bereavement, and NCAA varsity intercollegiate athletics. Find complete information [here](#).

Appropriate Student Use of Class Notes and Course Materials

Taking notes is a means of recording information but more importantly of personally absorbing and integrating the educational experience. However, broadly disseminating class notes beyond the classroom community or accepting compensation for taking and distributing classroom notes undermines instructor interests in their intellectual work product while not substantially furthering instructor and student interests in effective learning. Find additional information [here](#).

Students with Disabilities

It is the policy and practice of the University of Minnesota Duluth to create inclusive learning environments for all students, including students with disabilities. If there are aspects of this course that result in barriers to your inclusion or your ability to meet course requirements such as time limited exams, inaccessible web content, or the use of non-captioned videos, please notify the instructor as soon as possible. You are also encouraged to contact the Office of Disability Resources to discuss and arrange reasonable accommodations. Call [218-726-6130](#) or visit the [Disability Resources](#) web site for more information.

Sexual Harassment

"Sexual harassment" means unwelcome sexual advances, requests for sexual favors, and/or other verbal or physical conduct of a sexual nature. Such conduct has the purpose or effect of unreasonably interfering with an individual's work or academic performance or creating an intimidating, hostile, or offensive working or academic environment in any University activity or program. Such behavior is not acceptable in the University setting. Reference the full policy [here](#).

Equity, Diversity, Equal Opportunity, and Affirmative Action

The University provides equal access to and opportunity in its programs and facilities, without regard to race, color, creed, religion, national origin, gender, age, marital status, disability, public assistance status,

veteran status, sexual orientation, gender identity, or gender expression. [Equal Opportunity and Affirmative Action](#) and the [Office of Student Conduct & Conflict Resolution](#) are both available to all UMD employees, students, and participants in University-related activities [to discuss issues or concerns](#) regarding University policies or practices involving potential bias, discrimination, harassment or retaliation that an individual may have experienced or observed. Reference the full policy [here](#).

Mental Health and Stress Management

Feelings such as anxiety, anger, depression, low self-esteem, or tension are a normal part of being human and can affect anyone. Sometimes these feelings are temporary and can be eased by rest, relaxation, exercise, good nutrition and the support of trusted friends. At other times, stressors, relationships or past family experiences cannot be managed so easily and become overwhelming. If this happens, and you find it hard to function, you may want to seek professional help. Counseling Services are available at UMD Health Services to assist you. If you are in need of mental health support when Health Services is closed, or in case of an emergency, please contact The Birch Tree Center's Crisis line at 218-623-1800 or go to the emergency room/urgent care at either St. Luke's Hospital or St. Mary's Hospital. If an ambulance is needed, call 911. If the emergency is non-life-threatening and you do not have a means of transportation, call Campus Police at 218-726-7000). If you have needs that Counseling Services does not treat, they have a case manager who helps connect students to referrals as well as navigating issues with insurance. You can learn more about the broad range of confidential mental health services available on campus at [UMD Health Services](#).

[Academic Freedom and Responsibility](#)

Thoughtful dialog is a cornerstone of higher education. This expectation is upheld in the University of Minnesota's [Board of Regents Policy: Academic Freedom and Responsibility](#), which says in part:

SECTION II. ACADEMIC FREEDOM.
Academic freedom is the freedom, without institutional discipline or restraint, to discuss all relevant matters in the classroom, to explore all avenues of scholarship, research, and creative expression, and to speak or write on matters of public concern as well as on matters related to professional duties and the functioning of the University.

 For a full overview see [Board of Regents Policy: Academic Freedom and Responsibility](#).

Mask Requirement

As of August 3, 2021 the University of Minnesota requires all students, staff, and faculty to wear masks when indoors regardless of vaccination status. Visit the the [UMD Safe Campus webpage](#) for up-to-date COVID information.