CS465, Spring 2025
Computer Systems Architecture

1 Course Basics

1.1 Class Time and Location

- Tue, Thu 10:30-11:45pm, in ENT 178
- Here's a campus map, for reference

1.2 Instructor: Prof. Radu Negulescu, PhD

- **Email:** rnegules (at) gmu (dot) edu
- **Office hours:** Thu 1-2 pm in RSCH 364 (Research Hall – the building with a little tower next to ENGR)
- **Additional office hours:** Mon 3-4 pm, Wed 6-7 pm (for another course; CS 465 students are very welcome as well)

1.3 GTA: Daehyun Lee

- **Email:** dlee217@gmu.edu
- **Office hours:** Tue 1-2 pm in ENGR 4456 (the CS TA room)

1.4 Course Outcomes

- Be able to analyze and compare performance characteristics of a computer.
- Be able to demonstrate knowledge of instruction set architectures; be able to show how instructions are represented at both the machine level and in the context of a symbolic assembler; be able to read and write small assembly programs.
- Be able to manipulate low-level data representations and understand the implementation of computer arithmetic operations.
- Be able to explain how an instruction is executed; be able to explain the role of datapath and control; be able to explain pipelining and the relevant improvement technologies.

- Be able to understand the effect and implementation of memory hierarchy, in particular, the role of cache and virtual memory.
- Be able to explain the reasons for the performance impact of choosing RISC vs CISC and assess tradeoffs and developments in computer architecture.

1.5 Prerequisite

C or better in CS 367.

1.6 Textbook

- **Required -** Computer Organization and Design: the Hardware/Software Interface, 5th edition (MIPS edition), John L. Hennessy and David A. Patterson, Morgan Kaufmann, 2014. Free Online with Library Access Physical Copies in the Libraries Companion Material
- **Optional -** Computer Organization and Design: the Hardware/Software Interface, 6th edition (MIPS edition), John L. Hennessy and David A. Patterson, Morgan Kaufmann, 2020.

1.7 Other Useful Resources

- **Canvas:** Course schedule, lecture slides, assignments, and quizzes.
- **Piazza**: Will be used for most announcements instead of Canvas, as well as discussion forum. Follow the link on Canvas to sign up.
- **Gradescope**: Homework submission. Link will be available from Canvas.

1.8 Hardware and Software Needs

- For in-class coursework, including in-class exercises and **exams**, you will need a laptop computer with at least 2 GB of RAM and a fast, reliable wifi card. The recommended computer monitor and laptop screen size is 13-inches or larger. You may need computer speakers or headphones to listen to recorded

content. A webcam and headset microphone are required for live audio sessions using course tools like Honorlock.

- For the computer hard disk space required, consider and allow for the space needed to:
  - Install the required and recommended software (a JVM and the MARS MIPS simulator)
  - Save your course assignments
- Students are strongly encouraged to back up all contents of your computer on a regular basis. Loss of data will not excuse late or unsubmitted assignments.
- During our exams, a 4-way calculator will be made available for each student. Although more sophisticated calculators can be used, we require that they do not have programming capabilities or base conversion, eg. hexadecimal. If your calculator does not obviously lack these features, an adequate calculator will be supplied by the teaching staff.

2 Tentative Schedule

Week	Date	Topic	Textbook	Exercise	Homework	Quiz	Admin
1	1/21	Introdution	1.1-1.3				
	1/23	Performance	1.4-1.9	Exe 1 Performance		Quiz 1: Introduction	
2	1/28	MIPS	2.1-2.4				Last day to add
	1/30	MIPS	2.5-2.7			Quiz 2: Performance	
3	2/4	MIPS II	2.8-2.14				Last day to drop w full refund
	2/6	MIPS II	2.18-2.19	Exe 2 MIPS		Quiz 3: MIPS Basics	
4	2/11	Int Arithmetic	3.1-3.2		HW1 due: Performance, MIPS		Last day to drop w 50% refund
	2/13	Int Arithmetic	3.3-3.4	Exe 3 Int Arithmetic		Quiz 4: MIPS Encoding	
5	2/18	FP Arithmetic	3.5				
	2/20	FP Arithmetic	3.9	Exe 4 FP Arithmetic		Quiz 5: MIPS Procedures	
6	2/25	Digital Design	Appendix B		HW2 due: MIPS II, Arithmetic		Last day unrestricted wdraw
	2/27	Digital Design	Appendix B	Exe Bonus Digital Design			
7	3/4	Midterm 1	-				
	3/6	Datapath	4.1-4.3			Quiz 6: FP, Components	
Spring Break							
8	3/18	Control	4.4	Exe 5 Datapath, Control			
	3/20	Pipelining	4.5			Quiz 7: Datapath, Control	
9	3/25	Pipelining	4.6				
	3/27	Hazards	4.7-4.8	Exe 6 Pipelining (Bonus)		Quiz 8: Pipelining, Hazards	
10	4/1	Advanced ILP	4.10		HW3 due: Datapath, Pipelining, Hazards		
	4/3	Advanced ILP	4.14-4.15	Exe 7 Hazards		Quiz 9: ILP	

11	4/8	Midterm 2			
	4/10	Chiplets	Guest Lec.		
12	4/15	Memory	5.1-5.3		
	4/17	Cache	5.4	Exe 8 Cache	Quiz 10: Locality
13	4/22	Cache	5.5		
	4/24	Virtual Memory	5.7-5.9	Exe 9 Error Correction	Quiz 11: Cache
14	4/29	Multiprocessors	6.1-6.5, 6.7	HW4 due: Cache, Memory	
	5/1	Cache Coherence	5.10	Exe 10 Cache Coherence	Quiz 12: VM, Multiprocessors
Final exam	**5/13**		**Good luck, and Have Fun!**		**time slot 10:30 am - 1:15 pm**
Commencement	**5/15**				☺

3 Grading

Type of evaluation	Percentage in the course grade
Homework assignments	30%
Quizzes	10%
In-class exercises	10%
Midterms	20%
Final exam	30%

3.1 Assessment

- Letter grades shall be assigned based on the weighted average of coursework, as shown in the table below.
- Cutoff levels will be applied ***without*** rounding.

GRADE	CUTOFF
A+	98%
A	92%
A-	90%
B+	88%
B	82%
B-	80%
C+	78%
C	72%
C-	70%
D	60%
F	Less than 60%

3.2 Homework

- Homework assignments might require some programming.
- Homework assignments must be completed individually unless stated otherwise.
- All assignment grades are normalized and each contributes to your final grade evenly.
- Incorrect/broken submissions:
  - Turning in wrong or corrupted files will result in a zero.
  - Code that doesn't compile/assemble/run will get a low score.
- **Late Policy**:
  - Homework can be turned in **at most 24 hours** late.
  - Submitting an assignment late incurs a **25%** ceiling penalty so that RecordedGrade = min(75%, RawGrade).
  - Catastrophic computer failure will not be cause for an extension. Even if the event is out of your control, we lack the logistic capabilities to check it. Use a backup service such as OneDrive (or any cloud service), emailing yourself, making multiple rounds of submissions to Canvas/Gradescope, whatever it takes. Be sure to turn in your submissions early.

3.3 In-class Exercises

- In-class exercises provide opportunities for collaboration and active learning, and validate understanding of the course material before homework and exams.
- In-class exercises will be completed in groups, during lectures.
- The two lowest grades for in-class exercises will be dropped.
- Late policy: late submissions will not be accepted. We lack the resources to micromanage low-weight coursework. In case of university-accepted extenuating circumstances on top of the two dropped grades, the average of other in-class exercises will be applied to the exempted exercises.

3.4 Quizzes

- Practice questions will be released weekly, in the form of Canvas quizzes.

- Practice quizzes will be completed individually under Honorlock. If this causes too much stress, we will waive the Honorlock requirement on prior request from the student. However, solving the quizzes without aids will prepare students well for the exams.
- The two lowest quiz grades will be dropped.
- Late policy: late submissions will not be accepted. We lack the resources to micromanage low-weight coursework. In case of university-accepted extenuating circumstances on top of the two dropped grades, the average of other quizzes will be applied to the exempted exercises.

3.5 Exams

- All students must have their GMU identification available on testing days.
- Exams are closed book unless specified otherwise by the instructor.
- A double sided study sheet can be used during each exam. The study sheets cannot be shared among students. Each study sheet must have the student's name, G#, NetID written on it prior to use during an exam. Any font size is fine as long as the student can read it without eyewear, or with their usual eyewear. Either printed or handwritten sheets are fine, or combinations thereof.
- No computing or communicating devices are allowed during an exam. 4-way calculators or similar will be provided.
- Missing an exam due for any non-university-accepted reason (such as not paying attention to when the exam is), will result in a zero.
- If you miss an exam due to a university-accepted excused absence (such as an illness or car accident the day and time of the exam), you must notify your professor within 24 hours of your absence to make arrangements for a makeup, and hand-in approved documentation. Failure to follow either of these policies will result in a zero.
- There will be two midterm exams, equally weighted. We may elect to replace a missed midterm with some (or all) of the final exam grade rather than offering a makeup exam.

- Unless otherwise announced via Canvas Announcements, the final exam will be based on lecture material from throughout the term. A higher percentage grade in the final will replace lower percentage grades in any of the midterms.
- The final can only be written during the time slot in the Registrar schedule. See GMU's Final Exam Calendar for the latest schedule, updated as weather events require. Look for the entry that matches our lecture time, TR 10:30-11:45am.

3.6 Discussion Board

- Students are encouraged to use the discussion board, **Piazza**, to ask and answer questions. *Link/access code to Piazza will be available on Canvas*.
- No sharing of answers to coursework assignments is permitted on the discussion board. Any student posts or replies that contain homework solutions, partial solutions, or solution ideas, must have private visibility, that is, cannot only be seen by the respective students and the instructors. Posts with solutions to in-class exercises must have group visibility.
- The instructors might make any Piazza posts visible to the entire class, so that other students can see the thread.
- For any issues that are not suitable for public visibility, please email the professor and TA, or use our office hours.

3.7 Other Grading Policies

- **Contested Grades**: Contesting of grades on any/all submissions must be requested within one week of receiving the grade. No grade change requests will be considered past that deadline.
- There will be no make-up or extra-credit assignments at the end of the semester; your grade should be a measure of your semester-long progress.
- IN (Incomplete) policy as indicated in the catalogue will be strictly adhered to. Students who wish to use it must provide the necessary back-up documentation (e.g. medical certificate) for their application to be considered favourably. A written

request for an IN grade, with complete back-up documentation, must be received before the final exam week.

4 University and Departmental Policies

4.1 Academic Standards

Academic standards exist to promote authentic scholarship, support the institution's goal of maintaining high standards of academic excellence, and encourage continued ethical behavior of faculty and students to cultivate an educational community which values integrity and produces graduates who carry this commitment forward into professional practice.

As members of the George Mason University community, we are committed to fostering an environment of trust, respect, and scholarly excellence. Our academic standards are the foundation of this commitment, guiding our behavior and interactions within this academic community. The practices for implementing these standards adapt to modern practices, disciplinary contexts, and technological advancements. Our standards are embodied in our courses, policies, and scholarship, and are upheld in the following principles:

- Honesty: Providing accurate information in all academic endeavors, including communications, assignments, and examinations.
- Acknowledgement: Giving proper credit for all contributions to one's work. This involves the use of accurate citations and references for any ideas, words, or materials created by others in the style appropriate to the discipline. It also includes acknowledging shared authorship in group projects, co-authored pieces, and project reports.
- Uniqueness of Work: Ensuring that all submitted work is the result of one's own effort and is original, including free from self-plagiarism. This principle extends to written

assignments, code, presentations, exams, and all other forms of academic work.

Violations of these standards—including but not limited to plagiarism, fabrication, and cheating—are taken seriously and will be addressed in accordance with university policies. The process for reporting, investigating, and adjudicating violations is outlined in the university's procedures (https://academicstandards.gmu.edu/). Consequences of violations may include academic sanctions, disciplinary actions, and other measures necessary to uphold the integrity of our academic community.

The principles outlined in these academic standards reflect our collective commitment to upholding the highest standards of honesty, acknowledgement, and uniqueness of work. By adhering to these principles, we ensure the continued excellence and integrity of George Mason University's academic community.

Student responsibility: Students are responsible for understanding how these general expectations regarding academic standards apply to each course, assignment, or exam they participate in; students should ask their instructor for clarification on any aspect that is not clear to them.

4.2 Accommodations for Students with Disabilities

Disability Services at George Mason University is committed to upholding the letter and spirit of the laws that ensure equal treatment of people with disabilities. Under the administration of University Life, Disability Services implements and coordinates reasonable accommodations and disability-related services that afford equal access to university programs and activities. Students can begin the registration process with Disability Services at any time during their enrollment at George Mason University. If you are seeking accommodations, please visit https://ds.gmu.edu/ for detailed information about the Disability Services registration process. Disability Services

is located in Student Union Building I (SUB I), Suite 2500. Email: ods@gmu.edu. Phone: (703) 993-2474.

Student responsibility: Students are responsible for registering with Disability Services and communicating about their approved accommodations with their instructor in advance of any relevant class meeting, assignment, or exam.

4.3 FERPA and Use of GMU Email Addresses for Course Communication

The Family Educational Rights and Privacy Act (FERPA) governs the disclosure of education records for eligible students and is an essential aspect of any course. Students must use their GMU email account to receive important University information, including communications related to this class. Instructors will not respond to messages sent from or send messages regarding course content to a non-GMU email address.

Student responsibility: Students are responsible for checking their GMU email regularly for course-related information, and/or ensuring that GMU email messages are forwarded to an account they do check.

4.4 Title IX Resources and Required Reporting

As a part of George Mason University's commitment to providing a safe and non-discriminatory learning, living, and working environment for all members of the University community, the University does not discriminate on the basis of sex or gender in any of its education or employment programs and activities. Accordingly, all non-confidential employees, including your faculty member, have a legal requirement to report to the Title IX Coordinator, all relevant details obtained directly or indirectly about any incident of Prohibited Conduct (such as sexual harassment, sexual assault, gender-based stalking, dating/domestic violence). Upon notifying the Title IX Coordinator of possible Prohibited

Conduct, the Title IX Coordinator will assess the report and determine if outreach is required. If outreach is required, the individual the report is about (the "Complainant") will receive a communication, likely in the form of an email, offering that person the option to meet with a representative of the Title IX office.

For more information about non-confidential employees, resources, and Prohibited Conduct, please see University Policy 1202: Sexual and Gender-Based Misconduct and Other Forms of Interpersonal Violence. Questions regarding Title IX can be directed to the Title IX Coordinator via email to TitleIX@gmu.edu, by phone at 703-993-8730, or in person on the Fairfax campus in Aquia 373.

Student opportunity: If you prefer to speak to someone confidentially, please contact one of Mason's confidential employees in Student Support and Advocacy (SSAC), Counseling and Psychological Services (CAPS), Student Health Services (SHS), and/or the Office of the University Ombudsperson.

4.5 Honor Code

All students are expected to abide by the GMU Honor Code. This policy is rigorously enforced. The Department of Computer Science has additional CS Honor Code Policies that you are also required to follow. Professors are required to report cheating on any assignments or exams to the GMU Academic Integrity Committee, which will assign a grade of 'F' for the entire course to any students who are found at fault. Unauthorized sharing, collaboration, or copying of any piece of code or assignment solution that is not your own (or outside the group for group assignments), including resources from the Internet, using large language models to generate homework, is considered cheating.

Confirmed cases of cheating almost always translate into course failure (grade of F).

4.6 Land Acknowledgment Statement

Land acknowledgment engages all present in an ongoing indigenous protocol to enact meaningful, reciprocal relationships with ancestors and contemporary tribal nations. As a state university, we have a responsibility to include and support indigenous communities and sovereign tribes in our work. At the place George Mason University occupies, we give greetings and thanksgivings to these Potomac River life sources, to the Doeg ancestors, who Virginia annihilated in violent campaigns while ripping their lands apart with the brutal system of African American enslavement, to the recognized Virginia tribes who have lovingly stewarded these lands for millennia including the Rappahannock, Pamunkey, Upper Mattaponi, Chickahominy, Eastern Chickahominy, Nansemond, Monacan, Mattaponi, Patawomeck, and Nottaway, past, present, and future, and to the Piscataway tribes, who have lived on both sides of the river from time immemorial.

Source: https://legacies.gmu.edu/about/land-acknowledgement-statement

5 Other Resources

The Stearns Center for Teaching and Learning has pointers to useful resources to students, such as free tutoring by volunteers, career services which can facilitate applications to internships, and university life: Student Support Resources on Campus

6 Acknowledgment

The present document and our course materials are based in large part on previous offerings of this course, taught by Professor Yutao Zhong and Professor Daniel A. Menascé.