

# CSE 420 and CSE 520 (Computer Architecture I & II)

Welcome to CSE 420 and CSE 520, a joint course for Computer Architecture I and II. All of the lectures, assignments, projects, exams, materials, and policies are the same between both courses will be treated as one joint course. Canvas will serve as the primary medium of information for the course. Please make sure to actively check Canvas for any updates, announcements, and resources that you may need during the course.

## Important Dates and Times

Regular Lecture: T Th 10:30 am - 11:45 am, COOR L1-20

Add Deadline: Sunday, January 14th, 2024

Drop Deadline: Sunday, January 21st, 2024

Course Withdrawal Deadline: Sunday, March 31st, 2024

Session Withdrawal Deadline: Friday, April 26th, 2024

Midterm Exam: Thursday, February 29th, 2024: 10:30 am - 11:45 am @ COOR L1-20

Final Exam: Tuesday, April 30th, 2024: 9:50 am - 11:40 am @ COOR L1-20

More dates can be found at the [ASU Academic Calendar](#)

## Course Staff

**Instructor: Professor Hokeun Kim**

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- Office hours: T Th, 1:15 pm - 2:00 pm @ Centerpoint 202-03A or Zoom

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## Course Description

"It (Computer Architecture) is not a dreary science of paper machines that will never work. No! It's a discipline of keen intellectual interest, requiring a balance of marketplace forces to cost-performance-power, leading to glorious failures and some notable successes." - John Hennessy

and David Patterson. This course will start with bridging the gap between the high-level programming languages (e.g., C/C++, Java, Perl, Python) that we so conveniently use, and the low-level electronic components (e.g., transistors, AND gate, OR gate, multiplexors). This Computer Architecture course then delves into the details of designing a processor. The class is divided into 4 modules, i) A simple processor design, ii) Out-of-Order Execution, iii) Memory Organization, iv) Multi-core processors. Starting from a simple design, we will strive to make it better. We will learn several fundamental techniques, like pipelining, caching, and parallel execution, which enable the modern computing-based world. Although this course takes the MIPS architecture as a vehicle to explain the complexities and trade-offs in computer architecture, the concepts are applicable in a much broader scope. We will take a hands-on approach to understanding computer architecture. We'll develop simulators to model and thereby understand computer architecture.

## **Course Outline**

- Introduction and Basics - Instruction set architectures, CISC vs. RISC, VLIW vs. Superscalar
- Out of Order Execution - Register Scoreboarding, Tomasulo's Algorithm, Speculative Execution
- Branch Prediction - Local and global branch prediction, Gselect and gshare branch predictor, Tournament branch predictor
- Control Hazards - Delay Slots, load/store ordering hazards, branch penalties
- Caches - Direct Mapped Caches, Set Associative Caches, Cache Replacement Policies, Multi-level Caches, Snooping Cache coherence protocols, directory-based cache coherence protocols
- Cache Coherence - Directory protocol, Snooping protocol, Write Update, Write Invalidate, MSI, MESI
- Memory Consistency - Sequential consistency models, Relaxed consistency models
- Virtual Memory - Address Translation, Single- and multi-level Page Tables, Integration of TLB with caches

## **Course Structure**

**Lectures:** The lectures will be fast-paced and will cover stuff not in the textbook. Lecture slides will be posted on Canvas, and will contain the reading/reference lists. I recommend you go through the slides and reading/reference lists before coming to the lecture. Lectures are conducted in person in the designated lecture room and will not be recorded. Additionally, for legal copyright and permission reasons, students will not be allowed to record the lectures.

**Programming Projects:** 3 programming projects will be given in the course. A lot of programming will be involved in the course. There will be at least 3 weeks to complete each project. For each day after the deadline that the project is late, a penalty of -25% will be applied to the earned score.

**Homeworks:** There will be 5 homework assignments given throughout the course. The objective of the homework is for you to keep up with the course content and learn about how the course

topics are being used practically in research. Homework will usually involve reading a part of a research paper and answering questions or writing a summary. Late submission of homework will earn 0 points.

**Exams:** There will be 1 midterm exam and 1 final exam. Both will be administered online through the Lockdown Browser. All students need to show up in person with their laptops (and charged batteries) to take the midterm exam and final exam. Exceptions will not be made to students who miss the exam for non-medical or non-emergency reasons.

**Textbook and Reference Materials:** There are no mandatory textbooks for this course. However, it is strongly recommended that you use the following textbooks as a reference and for supplemental material in the course:

- **Computer Architecture - A Quantitative Approach 6th Edition** by John L. Hennessy, David A. Patterson, Morgan Kaufman (now Elsevier), ISBN-10: 0128119055, ISBN-13: 978-0128119051
- **Computer Organization and Design, The Hardware/Software Interface, 5th Edition** by David A. Patterson and John L. Hennessy, Morgan Kaufman (now Elsevier), ISBN-10: 0124077269, ISBN-13: 978-0124077263

### **Enrollment Prerequisites**

Students must have completed CSE 230 (Computer Organization and Assembly Language Programming) or an equivalent course with a passing grade before enrolling in this course. This course expects knowledge of basic computer organization, instruction set architectures, assembly languages, and pipelined processors. If these are not familiar to you, then it is highly recommended that you brush up on these topics before taking this course. Students must have C/C++ and Python programming skills to work on projects.

### **Grading Policy**

- 5 Homeworks: 2 points each. Total of 10 points
- 3 Projects: 10 points each. Total of 30 points
- 1 Midterm Exam: 25 points
- 1 Final Exam: 35 points

There will be a total of 100 points possible to earn in the course. Grading will not be determined by percentages. Instead, your grade in the course will be directly determined from your score by the following formula:

[95, 100]	: A+
[90, 95)	: A
[85, 90)	: A-
[80, 85)	: B+
[75, 80)	: B
[70, 75)	: B-

[65, 70)	: C+
[60, 65)	: C
[50, 60)	: D
[0, 50)	: E

Where "[X, Y) : Z" means that a letter grade of "Z" will be the result if your point total in the course is between X (inclusive) and Y (not inclusive). The thresholds for letter grades are tentative and may be lowered later if the exams turn out to be too difficult. (Thresholds will not be raised.)

### **Attendance (Not Applicable to Exams)**

This class is an in-person class. Attendance is not mandatory and will not be checked; however, it is each student's responsibility to keep track of announcement details and any materials discussed in lectures. **Any disadvantages caused by not attending classes fall under the responsibility of the student.**

### **Project Group Policy**

Programming projects can be done in a group of 1, 2, or 3 students. You have to make your own group. Start a discussion on Canvas discussions to find group members. **All the members of the group will receive the same score for a project.** So make sure that you choose your group partners carefully, as groups are final and cannot be changed for the duration of the course. If there are issues within a group, we expect you to resolve these as working in a group is a part of the learning process. Make sure to be in touch with your group members to ensure the progress of the project. Students do drop out of the course. In case your partner drops, the deadline for the project will not change and it is still your responsibility to finish the project and submit it before the due date and time.

### **Project Submission and Evaluation**

For each programming project, you will be given a rubric. Your project will be evaluated against the rubric. Only one (any) group member per team should make the project submission on Canvas before the due date and time (Please note that you will not be able to submit after the due date and time). Submissions will NOT be accepted through email. All members of a group will receive the same grade regardless of participation level. For each day that the project is late, a -25% penalty will be applied to the earned score. This includes submissions that are even a few minutes overdue.

### **Exam Policy**

You have to be physically present in the classroom during the midterm exam and final exam. The exams will be administered through Lockdown Browser on Canvas, which means that you need to bring your laptop with Lockdown Browser installed to the classroom to take the exam. All exams in the course permit paper-based notes, textbooks, and cheat sheets. The use of all other electronics is prohibited during any examination (including but not limited to calculators,

mobile phones, tablets, smart watches, AI assistants, etc.). All electronics must be inside your backpack as you enter the classroom (except for the laptop on which you are taking the exam). You cannot communicate with anybody else during the exams, either directly or electronically. Violation of this policy will result in 0 points on the exam.

### **Technology Requirements**

Students will need access to a laptop that has access to Wi-Fi and can be sustained by charge for at least 2 hours. Laptops will be used in class for the midterm exam and final exam. Outside of class, in order to complete the homework assignments, students can use any device that will provide them access to type text onto Canvas forms. Finally, for the programming projects, students will need a device with an operating system that can run a virtual machine or that has access to a web browser like Google Chrome.

### **Course Communication Policy**

Please email the course staff for private concerns only. This would include any personal issues, grading issues, or anything else that may be too sensitive for other students to hear. The subject of all emails must start with "[CSE 420]". With a course of over 100 students, the course staff will not be able to answer all project questions or clarifications to the sample questions. This is where the Canvas Discussion Forum comes in. For questions regarding homework assignments and projects, you can post your questions which will be seen by everyone else in the class, and someone will be able to answer them. For general or specific questions regarding course content and course policies, please make use of the discussion board on Canvas under the relevant thread. The discussion forum is a good platform to get queries resolved and it helps many other students learn by allowing discussions on common queries.

### **Course Withdrawal Policy**

University policies will be adhered to for course withdrawal. There will be no exceptions to this course withdrawal policy.

### **Absence & Make-Up Policies**

Excused absences for classes will be given without penalty to the grade in the case of:

- (1) a university - sanctioned event [ ACD 304 - 02 ];
- (2) religious holidays [ ACD 304 - 04 ] ; a list of religious holidays can be found here <https://eoss.asu.edu/cora/holidays> ];
- (3) work performed in the line - of - duty according [ SSM 201 - 18 ].

Students who request an excused absences must follow the policy/procedure guidelines. Excused absences do not relieve students of responsibility for any part of the course work required during the period of absence. Accommodations will be made for the above excused absences provided

that students notify the instructor at the beginning of the semester concerning those dates. Students who expect to miss class due to officially university-sanctioned activities should inform the instructor early in the semester. Alternative arrangements will generally be made for any examinations and other graded in-class work affected by such absences. All other absences are considered unexcused absences and will not warrant the rights given for excused absences (i.e. there will be no make-up opportunities for homeworks, exams, or projects, due to absences).

### **Policy Regarding Expected Student Classroom Behavior**

Students in this class are expected to acknowledge and embrace the FSE student professionalism expectation located at: <https://engineering.asu.edu/professionalism>. Cell phones and pagers must be in silent mode during class and office hours. Any violent or threatening conduct by an ASU student in this class will be reported to the ASU Police Department and the Office of the Dean of Students. The use of recording devices is not permitted during class. Laptop computers are not allowed for non-course-related activities that distract the students from paying attention during class. Any violent or threatening conduct by an ASU student in this class will be reported to the ASU Police Department and the Office of the Dean of Students. Some content in this course may be deemed offensive by some students. If you find any material objectionable you may first talk to the instructor and then with your Program Chair to identify appropriate accommodations.

### **Academic Integrity**

Students in this class must adhere to ASU's academic integrity policy, which can be found at <https://provost.asu.edu/academic-integrity/policy>. Students are responsible for reviewing this policy and understanding each of the areas in which academic dishonesty can occur. All engineering students are expected to adhere to the ASU Academic Integrity [Honor Code](#). All work submitted for the course cannot have been submitted for any other course or any previous section of this same course. Student academic integrity violations are reported to the Fulton Schools of Engineering Academic Integrity Office (AIO). Withdrawing from this course will not absolve you of responsibility for an academic integrity violation and any sanctions that are applied. The AIO maintains a record of all violations and has access to academic integrity violations committed in all other ASU college/schools. Unless explicitly allowed by your instructor, the use of generative AI tools on any course assignment or exam will be considered academic dishonesty and a violation of the [ASU Academic Integrity Policy](#). Students confirmed to be engaging in non-allowable use of generative AI will be sanctioned according to the academic integrity policy and FSE sanctioning guidelines.

### **Student Copyright Responsibilities**

You must refrain from uploading to any course shell, discussion board, or website used by the course instructor or other course forum, material that is not the student's original work, unless the student first complies with all applicable copyright laws; faculty members reserve the right to delete materials on the grounds of suspected copyright infringement. The contents of this course, including lectures and other instructional materials, are copyrighted materials. Students may not share outside the class, including uploading, selling or distributing course content or notes taken during the conduct of the course. Any recording of class sessions by students is prohibited,

except as part of an accommodation approved by the Disability Resource Center. (see [ACD 304 - 06](#), “Commercial Note Taking Services” and ABOR Policy [5 - 308 F.14](#) for more information).

### **Policy Against Threatening Behavior**

Students, faculty, staff, and other individuals do not have an unqualified right of access to university grounds, property, or services (see [SSM 104 - 02](#)). Interfering with the peaceful conduct of university - related business or activities or remaining on campus grounds after a request to leave may be considered a crime. All incidents and allegations of violent or threatening conduct by an ASU student (whether on - or off - campus) must be reported to the ASU Police Department (ASU PD) and the Office of the Dean of Students.

### **Disability Accommodations**

Suitable accommodations are made for students having disabilities. Students needing accommodations must register with the ASU Student Accessibility and Inclusive Learning Services (SAILS) office and provide documentation of that registration to the instructor. Students should communicate the need for an accommodation in enough time for it to be properly arranged. See [ACD 304 - 08](#) Classroom and Testing Accommodations for Students with Disabilities.

### **Harassment and Sexual Discrimination**

Arizona State University is committed to providing an environment free of discrimination, harassment, or retaliation for the entire university community, including all students, faculty members, staff employees, and guests. ASU expressly prohibits discrimination, harassment, and retaliation by employees, students, contractors, or agents of the university based on any protected status: race, color, religion, sex, national origin, age, disability, veteran status, sexual orientation, gender identity, and genetic information. Title IX is a federal law that provides that no person be excluded on the basis of sex from participation in, be denied benefits of, or be subjected to discrimination under any education program or activity. Both Title IX and university policy make clear that sexual violence and harassment based on sex is prohibited. An individual who believes they have been subjected to sexual violence or harassed on the basis of sex can seek support, including counseling and academic support, from the university. If you or someone you know has been harassed on the basis of sex or sexually assaulted, you can find information and resources at <https://sexualviolenceprevention.asu.edu/faqs>. As a mandated reporter, I (the Instructor) am obligated to report any information I become aware of regarding alleged acts of sexual discrimination, including sexual violence and dating violence. ASU Counseling Services, <https://eoss.asu.edu/counseling> is available if you wish to discuss any concerns confidentially and privately. ASU online students may access 360 Life Services, <https://goto.asuonline.asu.edu/success/online-resources.html>.

### **Special Notices**

Any information in this syllabus (other than grading and absence policies) may be subject to change with reasonable advance notice. All contents of these lectures, including written materials

distributed to the class, are under copyright protection. Notes based on ACD 304-06, these materials may not be sold or commercialized without the explicit permission of the instructor.

### **Additional Notes on Generative AI**

Use of generative AI (e.g., Chat GPT, Bard) for any deliverables of the course, including all assignments and exams, is not allowed. If any use of generative AI is discovered, it will be treated as a violation of academic integrity and will be reported to the Dean's office, who maintains records of all offenses. Students are expected to abide by the FSE Honor Code (<http://engineering.asu.edu/integrity/>).

### **Photo Requirement**

Arizona State University requires each enrolled student and university employee to have on file with ASU a current photo that meets ASU's requirements (your "photo"). ASU uses your photo to identify you, as necessary, to provide you with educational and related services as an enrolled student at ASU. If you do not have an acceptable photo on file with ASU, or if you do not consent to the use of your photo, your access to ASU resources, including access to classes (online or in person) may be negatively affected or denied.

### **Class COVID-19 Policy**

We will follow [ASU COVID policy](#) in the class.