

# SER 450 Microprocessor Architecture, S2024A

## Catalog Description

Price/performance analysis, instruction set design, RISC/CISC, processor design and implementation, pipelining, instruction-level parallelism, memory hierarchy, storage and I/O systems.

## 1. Contact Information

Instructor: Doug Sandy  
Office: Zoom – posted on Canvas  
Class Website: Canvas

I will attempt to answer all course-related questions made through electronic media within one business day. Grade related questions should be sent to my ASU email address ([douglas.sandy@asu.edu](mailto:douglas.sandy@asu.edu)) from your ASU e-mail account. All other questions should be made through Slack.

I teach multiple courses. Please give me your full name, course number, and course modality (on-campus, or online) within the body of your messages so that I can assist you in a more timely manner.

## 2. Office Hours

Instructor Office Hours: Posted on Canvas

In order to avoid double-booking, I request that you please send me a quick note letting me know when you plan to come to office hours.

## 3. Overall Course Objectives and Expected Learning Outcomes

In this course, students will build understanding of Microprocessor Architecture with an emphasis on how higher-level languages utilize the available hardware resources. Focus will be given to coding practices and principles that can be employed in order to cost-effectively improve system performance.

- **Course Outcome 1** Students are able to identify major design principles for processor architecture development and analyze trade-offs in architecture structure including instruction set, pipelines, cache and memory hierarchy.
  - **Related Program-Level Outcome: ABET-6** an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
- **Course Outcome 2:** Students are able to identify and apply software techniques to improve application performance based on hardware architecture specifics.
  - **Related Program-Level Outcome: ABET-1** An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
- **Course Outcome 3:** Students can analyze how microprocessor architecture relate to business impact including development cost/time and operational costs.
  - **Related Program-Level Outcome: ABET-2** An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors

## 4. Grade Policies

Student's grades consist of the following components.

Design Projects (including final project)	50%
Quizzes	30%
Practice Problems	20%

Assignment due dates will be posted on the Canvas course shell. No late assignments will accepted except for reasons of excused absence.

The grade of "I" (incomplete) can be given ONLY when a student, who is doing otherwise acceptable work (passing grade), is unable to complete a part of work (e.g., the final exam) because of documented illness or other conditions beyond the

student's control. In the latter case, the student must discuss with the instructor and complete an application form from the department before the part of work is due or as soon as the circumstances are known. Please see ASU grading policies at: <http://students.asu.edu/grades-grading-policies>

Assignments must be submitted using the online submission site (assignments submitted over e-mail will not be accepted).

The nominal course grading scale is shown in the following table. Grading is not curved.

A+	100 %	to 97.0%
A	< 97.0 %	to 94.0%
A-	< 94.0 %	to 90.0%
B+	< 90.0 %	to 87.0%
B	< 87.0 %	to 84.0%
B-	< 84.0 %	to 80.0%
C+	< 80.0 %	to 77.0%
C	< 77.0 %	to 70.0%
D	< 70.0 %	to 60.0%
E	< 60.0 %	to 0.0%

**Late Assignments:**

Late assignments (those posted to canvas after the deadline) will not be given credit. Please make sure that you plan accordingly.

**Grade Appeals:**

Students may appeal a scored assessment within one week of the grade's posting online. Appeals are in written form only (including email) and must point to specific evidence of why the grade should be revised (for example: "it appears that my grade was totaled incorrectly"). Arbitrary "please regrade because I want a higher score" queries will be discarded without a response. I reserve the right to assign a lower score on appeal.

**Course Time Commitment:**

This three-credit course requires approximately 135 hours of work. Please expect to spend around 18 hours each week preparing for and actively participating in this course.

## 5. Absence and Make-Up Policies

There is not a mandatory attendance policy for this course. However, assessments under "in-class assessments" are not excused. Students unable to attend class due to a medical condition must present a doctor's signed excuse and notify the instructor as soon as the condition affects the student's work.

- excused absences related to religious observances/practices that are in accord with [ACD 304-04](#), "Accommodation for Religious Practices"
- excused absences related to university sanctioned events/activities that are in accord with [ACD 304-02](#), "Missed Classes Due to University-Sanctioned Activities"
- Excused absences related to missed class due to military line-of-duty activities that are in accord with [ACD 304-11](#), "Missed Class Due to Military Line-of-Duty Activities," and SSM 201-18, "Accommodating Active Duty Military"

## 6. Readings, Special Materials, and Required Activities

**Readings:** The required text for this course is "Computer Organization and Design MIPS Edition: The Hardware/Software Interface", 5<sup>th</sup> or 6<sup>th</sup> Edition, Patterson and Hennessy.

There will be substantial reading from this text comprising approximately 550 pages over the period of the class.

**Special Materials:** Students will be expected to write code in Java and C/C++. Students will need to have development and build tools installed locally on their computers (not in a virtual machine). In addition, students will be asked to analyze code performance and make calculations. Access to a spreadsheet program (e.g. Microsoft Excel, Google Sheets) will be helpful.

## **Representative Activities:**

### **Module 1**

#### **Lecture Topics:**

- The 8 Great Principles of Computer Architecture
- Performance Prediction with the Classical Performance Model
- The Importance of Business Impact

#### **Reading:**

Computer Organization and Design, Chapter 1

#### **Assignments:**

- Practice Problems (from text)
- Checkpoint Quiz
- Coding Project 1 - Performance Prediction

### **Module 2**

#### **Lecture Topics**

- The CPU as a Simple Machine
- Encoding and Executing Instructions Part 1
- Encoding and Executing Instructions Part 2
- High-Level Language Translation
- Dynamic vs. Static Linking
- Measuring Execution Time
- The Impact of Setters and Getters

#### **Reading:**

Computer Organization and Design, Chapter 2

#### **Assignments:**

- Practice Problems (from text)
- Checkpoint Quiz
- Project 2 - Language and Compiler Optimization as it relates to Computer Architecture

### **Module 3**

#### **Lecture Materials**

- Integer Numeric Representation
- Integer Numeric Operations
- Floating-Point Numeric Representation
- Floating-Point Operations
- Trade-Offs Related to Mathematical Operations

#### **Reading:**

Computer Organization and Design, Chapter 3

**Assignments:**

- Practice Problems (from text)
- Checkpoint Quiz
- Project 3 - Numeric Operation Analysis and Optimization

**Module 4a****Lecture Topics**

- Single-Cycle Processor Datapath
- Single-Cycle Processor Control
- Limitations of Single-Cycle Processor
- Introduction to Pipelining

**Reading:**

Computer Organization and Design, Chapter 4, sections 4.1-4.7

**Assignments:**

- Practice Problems (from text)
- Checkpoint Quiz
- Project 4a - The single-cycle processor and performance

**Module 4b****Lecture Topics**

- Pipelined Datapath and Control
- Hazards and Exceptions Part 1
- Hazards and Exceptions Part 2
- Trade-Offs Related to Pipelining

**Reading:**

Computer Organization and Design, Chapter 4, Sections 4.8-4.15

**Assignments:**

- Practice Problems (from text)
- Checkpoint Quiz
- Project 4b - The Processor Pipeline and performance

**Module 5****Lecture Content:**

- The Memory Hierarchy
- Cache Basics
- Associativity and Multi-Level Cache Architectures
- Virtual Memory
- Software Techniques - Blocking and Banding
- Software Techniques - Managing Data

**Reading:**

Computer Organization and Design, Chapter 5

**Assignments:**

- Practice Problems (from text)
- Checkpoint Quiz
- Project 5 - Cache Analysis and performance

**Module 6****Lecture Content**

- Introduction to Parallel Processing
- Multithreading
- Shared Memory Systems and Networking

**Reading:**

Computer Organization and Design, Chapter 6

**Assignments:**

- Practice Problems (from text)
- Checkpoint Quiz
- Project 6 – Multiprocessing Scalability Analysis

**7. Classroom Behavior**

N/A. Course is online only.

**8. Academic Integrity and Copyright Laws****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. In addition, all engineering students are expected to adhere to both the ASU Academic Integrity [Honor Code](#) and the Fulton Schools of Engineering [Honor Code](#). All academic integrity violations will be reported to the Fulton Schools of Engineering Academic Integrity Office (AIO). The AIO maintains 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.

The Student Academic Integrity Policy of Arizona State University requires each student to act with honesty and integrity and to respect the rights of others in carrying out all academic assignments. There are a number of actions that constitute a violation of the policy. These actions in this course include, but are not limited to:

- 1) practicing any form of academic deceit;
- 2) referring to materials or sources or employing devices (e.g., audio recorders, crib sheets, calculators, solution manuals, or commercial research services) not specifically authorized by the instructor for use during tests, quizzes, homework, and class activities;
- 3) acting as a substitute for another person in any academic evaluation or using a substitute in any academic evaluation;
- 4) possessing, buying, selling, or otherwise obtaining or using, without appropriate authorization, a copy of any materials intended to be used for academic evaluation in advance of its administration;
- 5) depending on the aid of others to the extent that the work is not representative of the student's abilities, knowing or having good reason to believe that this aid is not authorized by the instructor;
- 6) providing inappropriate aid to another person, knowing or having good reason to believe the aid is not authorized by the instructor;
- 7) submitting the ideas or work of another person or persons without customary and proper acknowledgment of sources (i.e., engaging in plagiarism);

- 8) permitting one's own ideas or work to be submitted by another person without the instructor's authorization; or attempting to influence or change any academic evaluation or record for reasons having no relevance to class achievement.
- 9) turning in work/code done by someone else or another pair/group
- 10) copying work/code done by someone else or another pair/group
- 11) writing code together with someone else or with another pair/group (unless expressly allowed by the instructor)

In practice, most programmers use reference examples found in print or online. This is not acceptable in situations where you are using code to proxy *your understanding of the coding concepts* applied in a class assignment. Students should verify directly with the instructor before submitting an assignment using code from outside sources. If allowed, students are still required to

- a) adhere to all originating author's constraints on the use and licensing of the code, and
- b) provide proper attribution (full URL to the code snippet or bibliographic reference to a print item).

Failure to do so constitutes a violation of this Academic Integrity Policy.

The recommended sanctions for Academic Integrity Violations will be a reduction of a course letter grade for the first offense, and failure of the course for a second offense. All academic integrity violations will be referred to the Dean's Office of the Ira A. Fulton Schools of Engineering. Ethical and Academic Integrity violations will also negatively impact the Ethics portion of the course grade.

### **Copyright**

Course content, including lectures, are copyrighted materials and students may not share outside the class, upload to online websites not approved by the instructor, sell, or distribute course content or notes taken during the conduct of the course (see [ACD 304-06](#), "Commercial Note Taking Services" and ABOR Policy [5-308 F.14](#) for more information).

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 students first comply with all applicable copyright laws; faculty members reserve the right to delete materials on the grounds of suspected copyright infringement.

## **9. Policy against threatening behavior, per the Student Services Manual, SSM 104-02**

Students, faculty, staff, and other individuals do not have an unqualified right of access to university grounds, property, or services. 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.

## **11. Disability Accommodations**

Suitable accommodations will be made for students having disabilities. Students needing accommodations must register with the ASU disabilities resource Center and provide documentation of that registration to the instructor. Students should communicate the need for an accommodation in sufficient time for it to be properly arranged.

## **11. 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>.

**Mandated sexual harassment reporter:** As an employee of the University I am considered a mandated reporter and therefore obligated to report any information regarding alleged acts of sexual discrimination that I am informed of or have a reasonable basis to believe occurred.

ASU Counseling Services, <https://eoss.asu.edu/counseling>, is available if you wish to discuss any concerns confidentially and privately.

### **Additional Notices**

Notice: Any information in this syllabus may be subject to change with reasonable advance notice.

### **ADDITIONAL COURSE INFORMATION**

#### **Prerequisites or co-requisites.**

Prerequisite(s): CSE 230 or SER 250 with C or better OR Software Engineering graduate student

# Online Course Notices

## Communicating With the Instructor

This course uses a combination of tools for synchronous and asynchronous communication. ASU email and Slack are the official means of communication among students, faculty, and staff. Instructors use email and Slack to communicate important class information on a regular basis. Students are expected to read and act upon these messages in a timely fashion. Students bear the responsibility of missed messages and should check their ASU-assigned email and Slack accounts regularly. Students wishing to communicate with the instructor should read the following guidelines:

- **Email**

Use email to direct questions of a personal or grade nature to the instructor or assigned TA. You can expect a response within 1 business day. **Note that the majority of faculty and staff communication will occur during Arizona daylight hours.** If you are in another time zone, communication may take longer due to availability differences.

**All instructor correspondence will be sent to your ASU email account or Slack account. Grade related information will only be sent to ASU addresses.**

General questions regarding course material are more suitable for Slack, since students can receive input from the instructor as well as discuss it with peers. We highly encourage discussions on Slack since publicly available answers benefit everyone in the course.

- **Office Hours**

Office hours for this course are available online via *Zoom*. Zoom (zoom.us) is a free software conference tool that enables voice and text communication, together with desktop streaming. During office hours you can speak with the instructor to discuss the materials being presented in class or other related interests you have. You are encouraged to ask questions about the assignments or the course content.

Office hours are also held by the course coordinators of each course. Course coordinators are the individual faculty responsible for course content and consistency across sections and semesters. These hours provide an avenue for you to provide course feedback in a direct manner, ask about the software engineering program, ask about professional development, as well to get help on course material.

## Communicating with Classmates

This course uses a combination of tools for synchronous and asynchronous communication. The primary communication method is email. This course also uses Slack for general questions about the course. Prior to posting a question, please check the syllabus, announcements, and existing posts. If you do not find an answer, post your question. Both instructors and TAs will check this forum regularly. On these platforms, you are encouraged to respond to the questions of your classmates by referring them to instructor provided answers to the questions. However, these platforms are not appropriate for you to publicly post solutions (or partial solutions) to course assignments.

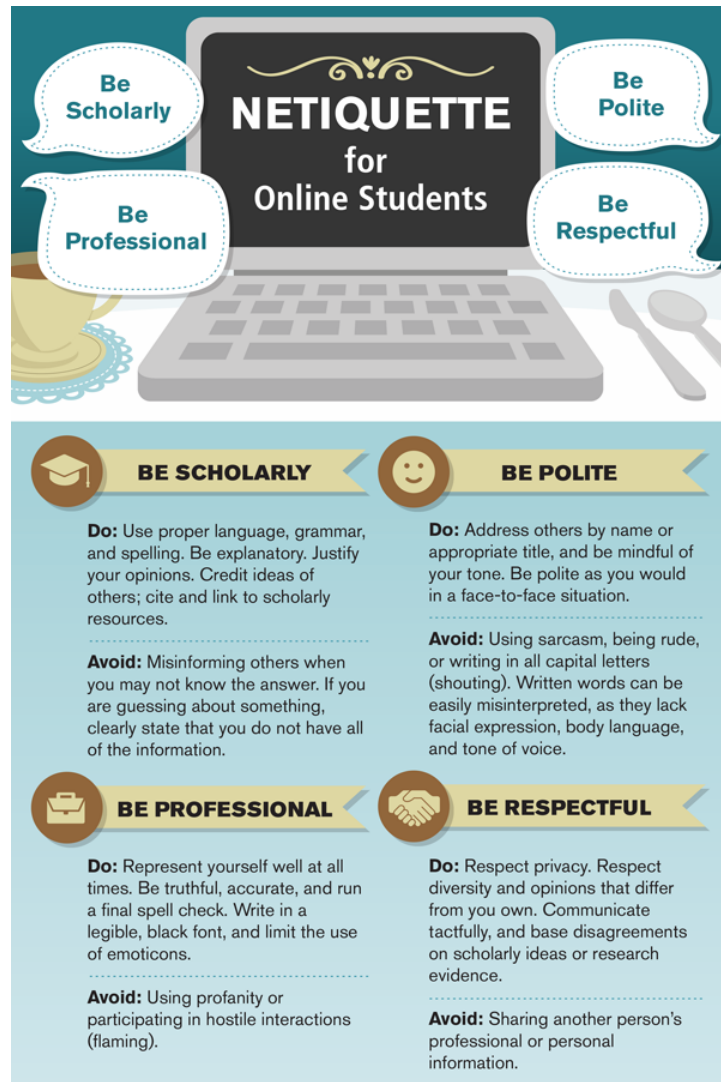
## Time Zones

All published due dates (for assignments, exams, office hours, etc.) are Arizona Mountain Standard time. Be aware that that Arizona does not observe daylight savings time. It is your responsibility during the course to track how your local time relates to Arizona.

## Netiquette

**During all communication, across platforms, students are expected to follow netiquette policy.** The netiquette policy for the course is ASU's [netiquette policy](#), also shown in the infographic below. Further, specific ASU netiquette policies concerning Discussion Board behavior are in effect. All students are expected to be familiar with, and maintain compliance to, these policies.





## Content Release Schedule

This course is released using weekly pages. At the beginning of the course, the first week will be made available. Additional content will be released in segments of a week, typically on Saturday, to give you around 7 days to work on the material before its due date (the following Friday). Material will not be released early as it is being continuously updated before release. Weeks are listed in Canvas as Sunday to Saturday but may be released before Sunday or may have assignments due after Saturday. Be sure to review the course schedule after each week is released to ensure you are aware of all due dates.

## Accessibility Statement

In compliance with the Rehabilitation Act of 1973, Section 504, and the Americans with Disabilities Act as amended (ADAAA) of 2008, professional disability specialists and support staff at the Disability Resource Center (DRC) facilitate a comprehensive range of academic support services and accommodations for qualified students with disabilities.

Qualified students with disabilities may be eligible to receive academic support services and accommodations. Eligibility is based on qualifying disability documentation and assessment of individual need. Students who believe they have a current and essential need for disability accommodations are responsible for requesting accommodations and providing qualifying documentation to the DRC. Every effort is made to provide reasonable accommodations for qualified students with disabilities.

Qualified students who wish to request an accommodation for a disability should contact the DRC by going to <https://eooss.asu.edu/drc>, calling (480) 965-1234 or emailing DRC@asu.edu. To speak with a specific office, please use the following information:

### ASU Online and Downtown Phoenix Campus

University Center Building, Suite 160 602-496-4321 (Voice)

### Polytechnic Campus

480-727-1165 (Voice)

**West Campus**

University Center Building (UCB), Room 130 602-543-8145 (Voice)

**Tempe Campus**

480-965-1234 (Voice)v

**Computer Requirements**

This course requires a computer with reliable Internet access and the following:

- Web browsers (Chrome, Internet Explorer, Mozilla Firefox, or Safari)
  - Must be capable of streaming video (e.g., YouTube).
- Adobe Acrobat Reader (free)
- Adobe Flash Player (free)
- Microphone (for office hours) and speakers
- RPNOW (or other proctor software as directed by the instructor)

During a course, students may be asked to install relevant software, which have specific recommended system requirements. Students are encouraged to review the course syllabus and content to determine what software they will be expected to use.

Students using proctoring software are required to have access to a private environment satisfying exam rules.

**1.8 Technical Support**

This course uses Canvas to deliver content. It can be accessed through MyASU at <http://my.asu.edu> or the Canvas home page at <https://canvas.asu.edu>

To monitor the status of campus networks and services, visit the System Health Portal at <http://syshealth.asu.edu/>.  
To contact the help desk call toll-free at 1-855-278-5080.

**1.9 Student Success**

This is an online course. To be successful:

- view and/or read all required content
- carefully read all instructions provided
- check the course daily
- read announcements
- read and respond to course email messages as needed
- complete assignments by the due dates specified
- communicate regularly with your instructor and peers
- create a study and/or assignment schedule to stay on track