

ECE 568/668 – Computer Architecture
College of Engineering
Electrical and Computer Engineering Department
Fall 2022

General

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Office Hours: Tu-Th: 11:00am-12:00Noon

Catalog Description

Quantitative study of pipelined processor architectures, memory hierarchy, cache memory, Input/Output, RISC processors and vector machines.

Course Overview

The goal of this course is for students to better understand the interaction between software and hardware and know how hardware is designed so as to provide the required functionality at the highest possible performance. The course begins with basic processor design and proceeds to advanced concepts implemented in modern microprocessors. We cover pipelining, superscalar, speculative and out-of-order execution, vector units, VLIW machines and multithreading. We also cover the design principles of memory systems including virtual memory, cache units, DRAM and storage systems like hard drives and Solid-state drives. We conclude with high-level performance analysis of input/output systems. The course emphasizes quantitative evaluation of the benefits and cost of all the performance enhancement techniques that are currently integrated into modern processor.

Course Learning Objectives

- Develop an understanding of computer architecture and performance measures
- Analyze characteristics of pipelines, control signals, datapaths, and control hazards
- Demonstrate understanding of various types of scheduling
- Explore various types of prediction and branch handling schemes
- Analyze techniques, advantages, and disadvantages related to types of compilers
- Compare types of memory and input/output systems

Course Requirements & Prerequisites

ECE 112 and ECE 232 (331) or equivalent courses in Digital Design and Hardware Organization

Course Materials

Required Text:

Hennessy, J. L., & Patterson, D. A. (2019). *Computer architecture: A quantitative approach* (6th ed.), Elsevier, ISBN: 978-0-12-811905-1 (5th. ed. "2012" is OK)

Recommended Resources:

- 1) Flynn, M. J. (1995). *Computer architecture: Pipelined and parallel processor design*. Boston, MA: Jones and Bartlett. Huring, V. P., & Jordan, H. F. (2004). *Computer systems design and architecture* (2nd ed.). Upper Saddle River, NJ: Pearson.
- 2) Hwang, K. (1993). *Advanced computer architecture: Parallelism, scalability, programmability*. New Delhi: McGraw- Hill.
- 3) Shen, J. P., & Lipasti, M. H. (2005). *Modern processor design: Fundamentals of superscalar processors*. Long Grove, IL: McGraw-Hill.

Recommended Technical Papers

- Davidson, E. S., Shar, L. E., Thomas, A. T., & Patel, J. H. (n.d.). Effective control for pipelined computers. 181–184.
- Hinton, G., Sager, D., Upton, M., Boggs, D., Carmean, D., Kyker, A., & Roussel, P. (2001). The microarchitecture of the Pentium® 4 processor. *Intel Technology Journal*, Q1, 1–13.
- McFarling, S. (1993). WRL technical note TN-36: Combining branch predictors. *Digital Equipment Corporation*.
- Smith, J. E., & Pleszkun, A. R. (1988). Implementing precise interrupts in pipelined processors. *IEEE Transactions on Computers*, 37(5), 562–573.
- Srinivasan, S. K., & Velev, M. N. (2003). Formal verification of an Intel XScale processor model with scoreboarding, specialized execution pipelines, and imprecise data-memory exceptions. *Formal Methods and Models for Codesign (MEMOCODE '03)*, 65–74.

Course Grading

		<u>568</u>	<u>668</u>
Midterm 1:	After Lecture 08 (Oct. 07 – TBD : 6-8pm)	25	20 Points
Midterm 2:	After Lecture 17 (Nov. 04 – TBD : 6-8pm)	25	20 Points
Final:	After Lecture 26 (TBD– See SPIRE for details)	40	30 Points
Quizzes/Homework Assignments		10	10 Points
Project/Research + Presentation		-	20 Points
Total:		100	100 Points

Your Grade | Your Total Points

A	93 -100
A-	90 - 92
B+	87 - 89
B	83 - 86
B-	80 - 82
C+	77 - 79
C	73 - 76
C-	70 - 72
D+	67 - 69
D	63 - 66
D-	60 - 62
F	0 – 59

Outline:

- I. Introduction
- II. Performance Analysis (Ch.1+)
- III. Processor Design: Instruction-level Parallelism, Pipelining (App. C, Ch.3)
- IV. Memory Design: Memory Hierarchy, Cache Memory, Secondary Memory (App. B, Ch.2)
- V. Storage systems and Input/Output (App. D)
- VI. Vector Computers and GPUs (Ch.4) [Time permitting]

Credits

This course is worth 3 credits.

Attendance

Officially, you are supposed to attend all lectures.

Useful Links

[WWW Computer Architecture Page](#)

Disclaimer

The materials on this syllabus by no means, direct or indirect, should be interpreted as complete and comprehensive. When in doubt contact the instructor for clarifications. Also, the instructor reserves the rights to make changes to the items on this syllabus as found appropriate for better learning of the course materials by the students. Such changes will be immediately communicated to the students in class and via Email.

Health and Wellbeing

You are not alone at UMass – many people care about your wellbeing and many resources are available to help you thrive and succeed. The College recognizes that coursework is challenging and that classes are not the only demand in your life. Success in this course and the College of Engineering depends heavily on your personal health and wellbeing. Recognize that while stress is an expected part of the college experience, it can be compounded by unexpected setbacks or life changes outside the classroom. Strive to reframe challenges as an unavoidable pathway to success. Reflect on your role in taking care of yourself throughout the term, before the demands of exams and projects reach their peak. Please feel free to reach out to me about any difficulty you may be having that may impact your performance as soon as it occurs and before it becomes too overwhelming.

You can learn about the confidential mental health services available on campus by calling the Center for Counseling and Psychological Health (CCPH) by visiting their website at [umass.edu/counseling](https://www.umass.edu/counseling). There are many other resources on campus for students facing personal, financial or life challenges to find support, stay in school, and graduate (<https://www.umass.edu/studentlife/single-stop>). Within the College, you may reach out to myself, your academic advisor, the Office of Student Affairs

(<http://engineering.umass.edu/current-students/academics-advising>) or the Office of Community Equity and Inclusion (rees@umass.edu). I encourage you to contact support services on campus that stand ready to assist you. Remember that I am here to help you find the resources you need.

Recognizing the health and safety needs of all in the UMass living and learning community and reflecting our mutual responsibilities to all in the community, UMass has adopted a policy which requires that masks be worn at all times in classrooms and other indoor public spaces (<https://www.umass.edu/coronavirus/news/face-covering-faqs-start-fall-2021-semester>). If there is some circumstance that affects your compliance, e.g. if you have been granted a medical accommodation, please contact me immediately so that I will understand your circumstances. Absent communication with you about the policy, I respectfully request that you fully comply with this policy at all times

Accessibility Support Services

Your success in this class is important to me. We all learn differently and bring different strengths and needs to the class. The University of Massachusetts Amherst is committed to making reasonable, effective and appropriate accommodations to meet the needs of all students and help create a barrier-free campus. If you have a qualifying disability and require accommodations while participating in this course, please work with Disability Services to have an accommodation letter sent to me in a timely manner. If you have a disability but are not yet affiliated with Disability Services, please register with Disability Services (<https://www.umass.edu/disability/students>). Information on services and materials for registering are also available on their website www.umass.edu/disability.

If you are eligible for exam accommodations, your exams will be administered by the exam proctoring center. Contact Disability Services immediately, and comply with their exam scheduling policies, including the requirement that you book your exams at least seven days in advance of the exam date. It is incumbent upon you contact me during the first few weeks of the semester, or shortly following registration with Disability Services, to ensure that your accommodations are being sufficiently met, including extra time and note-taking access, as applicable.

Finally, beyond disability accommodations, if there are aspects of the course that prevent you from being fully included in the class, please let me know as soon as possible.

Together we'll develop strategies to meet both your needs and the requirements of the course.

Academic Honesty Statement

Maintaining the integrity of scholarship and research within institutions of higher education requires a cultural commitment. All members of the UMass Amherst community are expected to

be knowledgeable of and uphold our academic honesty policies (<https://www.umass.edu/honesty/>). Academic dishonesty includes but is not limited to cheating, fabrication, plagiarism, and abetting or facilitating dishonesty. Instructors are requested to take reasonable steps to address academic misconduct, and appropriate sanctions may be imposed on any student who has committed an act of academic dishonesty. Any person who has reason to believe that a fellow student has committed academic dishonesty should bring such information to the attention of the appropriate course instructor or an alternate, trusted member of the faculty or College administration as soon as possible. Instances of academic dishonesty not related to a specific course should be brought to the attention of the appropriate department Head or Chair. Community members may fill out the College's classroom experience form (<https://tinyurl.com/UMassEngineerClassroom>) to report academic dishonesty anonymously. Since students are expected to be familiar with this policy and the commonly accepted standards of academic integrity, ignorance of such standards is not normally sufficient evidence of lack of intent.

Cheating and Plagiarism Policy

The University Academic Honesty Policy Applies in this and all courses. This policy can be found on the University Web Page (<https://www.umass.edu/honesty/>). Appendix B covers plagiarism, cheating, fabrication, and facilitating dishonesty. Students are expected to be familiar with the definitions and examples provided.

Inclusivity

Everyone should feel that they are an integral part of the community and that all individuals and their perspectives are respected. A diversity of perspective and experience provides a valuable source of ideas, problem solving strategies, and engineering creativity. If you feel that your contribution is not being valued or respected for any reason, please speak with me privately. If you wish to communicate with someone else in the College or University, there are several ways to do so anonymously or to provide contact information if you so choose:

1. Notify the University Diversity, Equity, and Inclusion Office through the "Report a Climate Incident" form: <https://www.umass.edu/diversity/incident-report-form>

Note that this form requires sharing name and contact information. 2. Speak with Assistant Dean Dr. Paula Rees (rees@umass.edu).

3. Report an incident anonymously to the College of Engineering Diversity, Equity, and Inclusion Office • Climate Concerns and Suggestions - <https://tinyurl.com/UMassEngineerClimate> • Classroom Experience - <https://tinyurl.com/UMassEngineerClassroom>

4. Reach out to the departmental DEI Committee – (<https://ece.umass.edu/ece-diversity-equity-inclusion>)

- Reach out to a member of the BME committee. See member list here: <https://bme.umass.edu/diversity>

- Reach out to a member of the CHE committee. See member list here: <https://che.umass.edu/che-diversity-equity-inclusion> • Anonymous CEE feedback form: <https://cee.umass.edu/cee-diversity-equity-inclusion/feedback> • Anonymous ECE feedback form: <https://ece.umass.edu/ece-diversity-equity-inclusion> (scroll down for feedback link)

We are all members of an academic community with a shared responsibility to cultivate a climate where all individuals are valued and where both they and their ideas are treated with respect.

Pronouns and Names

Everyone has the right to be addressed by the name and pronouns that they use for themselves. Students can indicate their preferred/chosen first name and pronouns on SPIRE, which appear on class rosters. Please let me know what name and pronouns I should use for you if they are not on the roster. A student's chosen name and pronouns are to be respected at all times in the classroom. To learn more, please see this resource: https://www.umass.edu/stonewall/sites/default/files/pronouns_intro.pdf

Gender Respect and Title IX

The University of Massachusetts Amherst aspires to be a university environment that is free of discrimination, sexual harassment, and sexual violence. Faculty have the responsibility to inform students of resources and reporting options. If you or someone you know has experienced sexual assault, sexual misconduct, or sexual discrimination please see <https://www.umass.edu/titleix/what-to-do> for information about resources and reporting options. A report to the Title IX Coordinator may be made at any time (including during non-business hours) by using the Title IX Coordinator's email (TitleIXCoordinator@umass.edu), telephone number (413.545.6124) or mail. UMass Amherst is committed to supporting community members who report concerns of prohibited conduct. Please reach out to me if you would like assistance connecting with any of these resources/options.