CPE 110408343
Fundamentals of Computer Architecture

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Faculty of Engineering

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Contact Info

- Course Instructor:
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    - Will respond within 24 hours during weekdays and 48 hours during weekends.
  - Office: E3053
    - Send to me an email if you are planning to come

Office Hours

- I will hold office hours each week according to the schedule posted on the door of my office and handed to you in the syllabus.

  – Please email me advance notice if you plan to attend

Course Overview

- Prerequisite
- Course Objectives
- Course Policies
- Course Flow and Schedule
- Course Administrative

Prerequisite

- Computer Organization (110408240)

The Course

- This is an advance course on Computer and Processor Architectures.

- The course will cover a range of topics in the area of computer architecture
  - The objective is to provide you with an exposure to current and emerging trends in Computer Architectures, focusing on the performance and the hardware/software interface.

- The emphasis is on studying and analyzing fundamental issues in architecture design and their impact on performance.

- The course will have a mix of <u>theory</u>, hardware, and software

Course goals

- Computer architecture is the science and art of selecting and interconnecting hardware components to create a computer that meets functional, performance, and cost goals.

- This course introduces principles of computer architecture.

- We will focus on the <u>logical design</u> of the computer (architecture) and cover some <u>physical design</u> of the computer (organization).

- At the end of the course, you shall become sufficiently well acquainted with the principles of computer architecture and be able to make intelligent use of computers for designing and simulating engineering systems, components, and devices.

Course Learning Outcomes (CLO's)

1. **List** components and principles of computer architecture and the computer evolution. Also being able to understand and list some examples of existing computer architectures (CISC and RISC). SO(1)

2. **Discuss**, explain, and evaluate different performance metrics of computer systems in terms of space and time tradeoffs, and possible performance speed-up gain. SO(1)

3. **Compare** between different classes of computers using CPU execution time. SO(1)

4. **Determine** possible speed-up gain obtained from using some sort of parallel processing (Amdahl's law). SO(1)

5. **Analyze** a memory hierarchy in addition to interfacing processors and peripherals. SO(1)

6. **Understand** and analyze the mapping of the cache memory system. SO's (1, 4)

7. **Distinguish** between different I/O techniques for performing the I/O operations. SO's (1, 4)

8. **Understand** the needs for having the RISC architecture and distinguish between hardware and software techniques to exploit parallelism. SO's (1, 4)

9. **Understand** and analyze the Superscalar architecture and its main operations and employed techniques. SO's (1, 4)

10. **Know** about the control unit and its importance of how things get to be performed on the computer (e.g. the execution of instructions). SO's (1, 4)

ABET Student Outcomes (SO's)

ABET Student Outcomes (SO) Addressed by the Course:

#	Outcome Description	Contribution
General Engineering Student Outcomes		
(1)	An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics. *(Previously SO's (a, e, k))*	*H*
(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. *(Previously SO's (c, k))*	
(3)	An ability to communicate effectively with a range of audiences. *(Previously SO (g))*	
(4)	An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts. *(Previously SO's (f, h, j))*	*H*
(5)	An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives. *(Previously SO (d))*	
(6)	an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions. *(Previously SO's (b, k))*	
(7)	An ability to acquire and apply new knowledge as needed, using appropriate learning strategies. *(Previously SO (i))*	

H=High, **M**= Medium, **L**=Low

Detailed Course Outcomes

- Students who complete the course will have demonstrated the ability to do the following:
  - Argue about the distinction between computer architecture and computer organization.
  - List the functional components of a computer.
  - List the structural components of a computer and that of a processor.
  - Analyze the three basic ways to implement a system component; Hardware (HW), Software (SW) and Firmware (FW).
  - Explain the computer evolution and performance (vacuum tubes, transistors, IC's, etc.).
  - Describe what is an embedded system, its organization and what are its design requirements.
  - Describe the ARM and x86 architectures and their design categories.

Detailed Course Outcomes (Cont…)

– Describe the computer performance in terms of the execution time and throughput and how to compare two different computers using these metrics and the ability to compute the amount of speedup that can be achieved by changing the design parameters (Instruction count,   CPI, IPC, clock cycle time, clock rate, etc.) of a given system.

– Describe Amdahl's law and it mathematical expression.

– Provide a detailed performance assessment of a given computer system in terms of the execution time, Effective CPI, Average CPI, etc.

– List and describe the key characteristics of computer memory systems.

– Describe the levels of the memory hierarchy and why they are needed.

– Describe the principle of locality of reference.

– Describe the cache memory principles, its operation, organization, structure, design, mapping functions (direct, associative, set-associative) and replacement algorithms.

– Describe the Input/Output module and why it is needed.

Detailed Course Outcomes (Cont…)

– Describe the I/O Module functions.

– Describe the Input/Output techniques (Programmed I/O, Interrupt driven, and Direct Memory Access (DMA)).

– Describe RISC computers and their main characteristics.

– Describe the instruction execution characteristics; HLL and semantic gap and the techniques (software and hardware) to improve RISC computers performance.

– Describe the Graph Coloring technique.

– Describe the RISC pipelining techniques (two stages, three stages, and four stages) and the methods used for optimizing the pipelining (delayed branch, delayed load, and loop unrolling).

– Describe the Instruction Level Parallelism and Superscalar processors.

– Know the difference between the Superscalar and superpipelined systems.

– Describe the limitations on the instruction level parallelism (ILP).

– Describe the instruction issue policies in superscalar processors.

– Describe the processor control unit micro-operations, instruction execution cycle and stages, control unit diagram, control unit functions, and control unit structural components.

Participation and Attendance

- Participation means coming to class, asking questions, taking part in discussions, not falling asleep, not using your phone ,and so on.

- **Strict Policy:**
    - Every class you miss without an excuse, you will punished by deducting 1 point from your final grade (%100)
    - Spring & Fall Semesters (With or without an excuse):
        - 3 days per week: **6 absences** ≡ Fail the course
        - 2 days per week: **4 absences** ≡ Fail the course
    - Summer Semester:
        - 4 days per week: **4 absences** ≡ Fail the course

تعليمات منح درجة البكالوريوس في الهندسة في الجامعة الهاشمية: – المواظبة

المادة (10):

a. تشترط مواظبة الطالب على حضور جميع المحاضرات النظرية وساعات العمل المخبري والتطبيق العملي والمشاغل الهندسية المقررة لكل مادة في الخطة الدراسية.

b. لا يسمح للطالب بالغياب عن أكثر من (15%) من مجموع الساعات المقررة لكل مادة.

c. إذا غاب الطالب عن أكثر من (15%) من مجموع الساعات المقررة لدراسة المادة دون عذر مرضي أو قهري يقبله عميد الكلية التي تدرس المادة يحرم من حضور المحاضرات والتقدم للإمتحانات بما فيها الإمتحان النهائي بتنسيب من المدرس وموافقة العميد ويعد راسباً في المادة وتعتبر علامته فيها (هـ)، ويقوم مدرس المادة بإبلاغ الطالب بالقرار وترصد علامة الحرمان له من خلال نظام الإرشاد الأكاديمي وذلك عند تجاوز غياب الطالب نسبة الغياب المبينة أعلاه، وعلى عميد الكلية إعلان قوائم الحرمان قبل موعد عقد الامتحانات النهائية بأسبوع كحد أقصى.

d. إذا غاب الطالب عن أكثر من (15%) من الساعات المقررة لمادة ما، وكان هذا الغياب بعذر مرضي أو قهري يقبله عميد الكلية التي تطرح المادة، يعد الطالب منسحباً من تلك المادة وتطبق عليه أحكام الانسحاب، ويبلغ عميد الكلية التي تطرح المادة عميد كلية الطالب ومدير القبول والتسجيل قراره بذلك، وتثبت ملاحظة (منسحب) إزاء تلك المادة في السجل الأكاديمي للطالب. وفي حال عرض موضوع الطالب على اللجنة الطبية العليا وأوصت باعتباره منسحباً من مادة أو أكثر وكان قرار رئيس الجامعة بالموافقة على التوصية تقوم وحدة القبول والتسجيل بتنفيذ الانسحاب مباشرة. أما الطلبة الذين يمثلون المملكة أو الجامعة في النشاطات الرسمية فيسمح لهم بالتغيب بنسبة لا تتجاوز (20%)، وبخلاف ذلك تطبق عليهم أحكام الانسحاب.

e. يشترط في العذر المرضي أن يكون بتقرير طبي صادر عن طبيب الجامعة أو معتمد منه، وأن يقدم هذا التقرير الى عميد الكلية التي تطرح المادة قبل الغياب أو حال زوال أسباب المرض. وفي الحالات القهرية يقدم الطالب ما يثبت عذره لعميد الكلية التي تطرح المادة حال زوال الأسباب أما في حالة التغيب عن الامتحانات النهائية فيشترط في العذر المرضي أن يكون صادراً عن طبيب الجامعة أو من قسم طوارئ في مستشفى معتمد من وزارة الصحة وفي كل الأحوال للجنة الطبية في الجامعة رفض التقارير الطبية التي لا تقتنع بها.

f. عمداء الكليات وأعضاء هيئة التدريس والمحاضرون ومدير القبول والتسجيل كل فيما يخصه، مسؤولون عن تنفيذ أحكام المواظبة.

Textbook

- Required:
  - Computer Organization and Architecture: Designing for Performance: 8th, 9th, 10th or 11th Edition, William Stallings, Pearson, 2018.

- Optional:
  - Computer Organization and Design: The Hardware-Software Interface, Third Edition, David Patterson and John Hennessy, 2003.
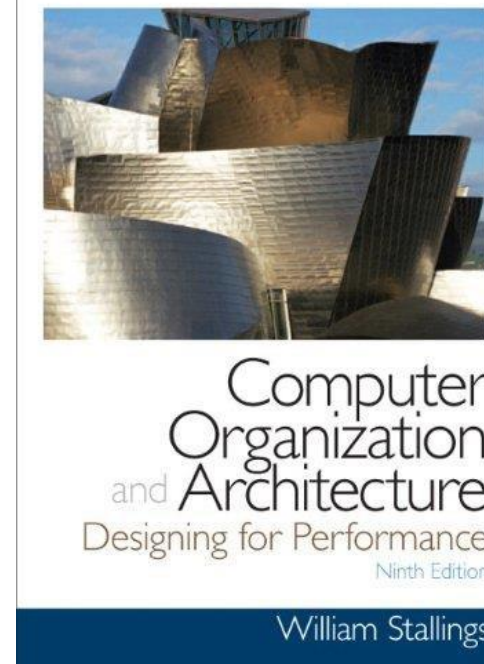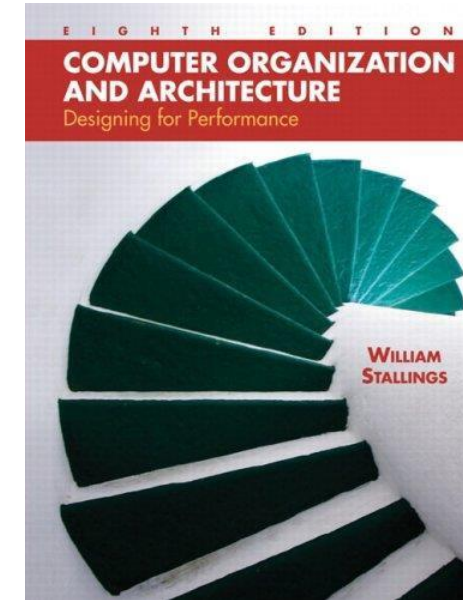

http://williamstallings.com/ComputerOrganization/
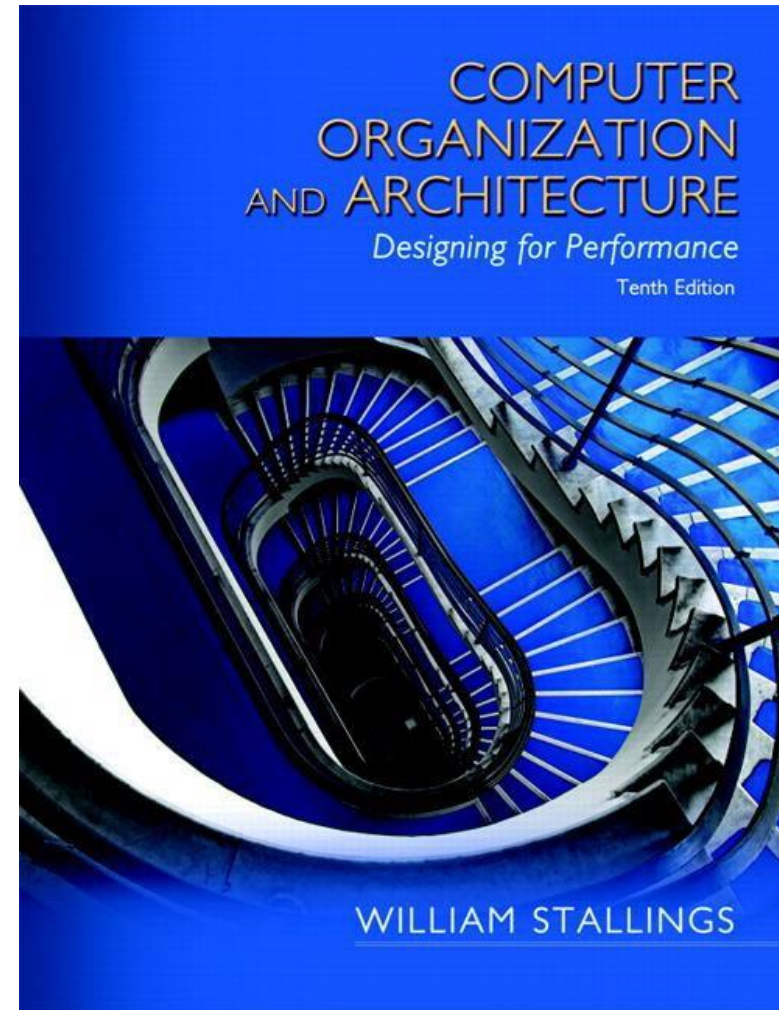
Old Versions of Textbook

- Computer Organization and Architecture: Designing for Performance, 8th + 9th Editions, William Stallings, published by Prentice Hall, 2010, and 2012 respectively.

http://williamstallings.com/ComputerOrganization/

Course Material + Course Plan

Week no.	Topic	chapter
1 **08/10 -12/10**	Introduction + Computer Evolution	1
2 **15/10-19/10**	Computer Performance	2
3 **22/10-26/10**	Computer Performance, Cache Memory	2,4
4 **29/10-02/11**	Cache Memory	4
5 **05/11 - 09/11**	Cache Memory	4
6 **12/11 - 16/11**	<mark>First Midterm Exam (Monday, 13/11, 2023), 09:30-10:30 am,</mark> <mark>Rooms: TBA</mark> First Midterms Official period: 05/11/2023 - 16/11/2023 Input/Output	7
7 **19/11 - 23/11**	Input/Output	7

Course Material + Course Plan

Week	Topic	Chapter
8 **26/11 - 30/11**	**Reduced Instruction Sets Computers**	**13 (8th), 15 (9th)**
9 **03/12 - 07/12**	Reduced Instruction Sets Computers	13 (8th), 15 (9th)
10 **10/12 - 14/12**	Instruction-Level Parallelism and Superscalar Processors	14 (8th), 16 (9th)
11 **17/12 - 21/12**	Instruction-Level Parallelism and Superscalar Processors Second Midterm Exam (Wednesday, 20/12, 2023), 09:30-10:30 am, Rooms: TBA Second Midterms Official period: 17/12/2023 - 28/12/2023	14 (8th), 16 (9th)
12 **24/12-28/12**	Control Unit Note: Monday is an official holiday (Christmas)	15 (8th), 19 (9th)
13 **31/12-04/01**	Control Unit Note: Monday is an official holiday (New Year) Note: Thursday 04/01/2024 is the last day to withdraw a course.	15 (8th), 19 (9th)
14 **07/01-11/01**	Control Unit	15 (8th), 19 (9th)
	University Period for conducting the Final Exams (14/01/2024 - 25/01/2024)	

List of Topics Covered in the Course

- Introduction to Computer Organization and Architecture

- Computer Evolution and Performance

- Memory Systems - Cache Memory

- Input/Output

- Reduced Instruction Sets Computers

- Instruction-Level Parallelism and Superscalar Processors

- Control Unit

Exams

- 3 Exams (Two Midterms and Final)
  - Test your knowledge individually and to show your skills.
  - Will count towards 100% of your final grade.

- Note:
  - The first and second midterm exams dates: Announced on the Moodle
  - The Final exam date: Announced by the registrar

  - There will be NO consideration for rescheduling the tests and exams individually.
  - There will be **no make-up exams.**
    - Completed proofs are required for emergency and/or exceptional situations.

  - Let me know about any exam conflicts ASAP

Grade Allocation

- Grading Policy
  - Frist Midterm Exam………………………………………………….……..30%
  - Second Midterm Exam……………………………………………….…..30%
  - Final Comprehensive Exam……………………………………...40%

Regrade Requests

- Exams may be submitted for regarding up to one week after they are returned to the class.

- To request a regrade, write an explanation of your request on the front of the exam and attach it to the assignment or exam, then give the assignment to me

Final Grades

- A+ : >95
- A   : 90-95
- A- : 85-90
- B+ : 80-85
- B   : 75-80
- B- :70-75
- C+: 65 -70
- C   : 60-65
- C- : 55-60
- D+: 50 -55
- D : 45 - 50
- F   : 0 – 45 (at minimum)

Cheating

- You are expected to behave professionally and ethically
- You will be treated as an engineer

- Examples of cheating:
  - Turning in a HW identical to anyone else's
  - Using past homework's as templates for your own work

- Zero Tolerance policy
  - Formal University procedures will apply.
  - An F for the course
  - Administrative action will be taken
    - All cases will be handed over to the department head to handle

Moodle

- The course materials will be available online on the Moodle
  - http://www.mlms.hu.edu.jo/

Safety

- Check your self before leaving the class room in order not to forget any of your belongings

Learning Support Outside of Class

- Myself
  - I will have reserved hours for consultation with students.

- Your Colleagues

- The Internet