

# ICS 233 – Spring 2009

## Computer Architecture & Assembly Language

College of Computer Sciences & Engineering  
King Fahd University of Petroleum & Minerals

**Professor:** Muhamed Mudawar, Room 22/328, Phone 4642  
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**Course URL:** <http://faculty.kfupm.edu.sa/coe/mudawar/ics233/>  
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### Catalog Description

Machine organization; assembly language: addressing, stacks, argument passing, arithmetic operations, decisions, modularization; Input/Output Operations and Interrupts; Memory Hierarchy and Cache memory; Pipeline Design Techniques; Super-scalar architecture; Parallel Architectures.

**Prerequisite:** COE 202, ICS 201

### Textbooks

David A. Patterson and John L. Hennessy, *Computer Organization and Design: The Hardware / Software Interface*, Third Edition, Morgan Kaufmann Publishers, 2005.

Robert L. Britton, *MIPS Assembly Language Programming*, Pearson Prentice Hall, 2004,

### Course Learning Outcomes

Towards the end of this course, students should be able to:

- Describe the instruction set architecture of a MIPS processor
- Analyze, write, and test MIPS assembly language programs
- Describe the organization/operation of integer & floating-point arithmetic units
- Design the datapath and control of a single-cycle CPU
- Design the datapath/control of a pipelined CPU and handle hazards
- Describe the organization/operation of memory and caches
- Analyze the performance of processors and caches

### Grading Policy

Lab Work	15%
Homework and Quizzes	10%
Programming Assignments	15%
Project	10%
Midterm Exam I	15%
Midterm Exam II	15%
Final Exam	20%

- Written assignments should be submitted at the beginning of class time in the specified due date. Late written assignments are not accepted.
- Late projects are accepted up to 3 days late, but will be penalized 5% for each late day.
- No makeup will be made for missing quizzes or exams.

## Software Tools used in Projects

- MARS simulator: runs MIPS-32 assembly language programs
- Logisim simulator: educational tool for designing and simulating CPUs

## Course Topics

### Introduction

- Introduction to computer architecture, assembly and machine languages, components of a computer system, memory hierarchy, instruction execution cycle, chip manufacturing process, technology trends, programmer's view of a computer system.

### Review of Data Representation

- Binary and hexadecimal numbers, signed integers, binary and hexadecimal addition and subtraction, carry and overflow, characters and ASCII table.

### Instruction Set Architecture

- Instruction set design, RISC design principles, MIPS instructions and formats, registers, arithmetic instructions, bit manipulation, load and store instructions, byte ordering, jump and conditional branch instructions, addressing modes, pseudo instructions.

### MIPS Assembly Language Programming

- Assembly language tools, program template, directives, text, data, and stack segments, defining data, arrays, and strings, array indexing and traversal, translating expressions, if-else statements, loops, indirect jump and jump table, console input and output.

### Procedures and the Runtime Stack

- Runtime stack and its applications, defining a procedure, procedure calls and return address, nested procedure calls, passing arguments in registers and on the stack, stack frames, value and reference parameters, saving and restoring registers, local variables on the stack.

### Interrupts

- Software exceptions, syscall instruction, hardware interrupts, interrupt processing and handler, MIPS coprocessor 0.

### Integer Multiplication and Division

- Integer multiplication, shift-add multiplication hardware, Shift-subtract division algorithm and hardware, MIPS integer multiply and divide instructions.

### Floating-point

- Floating-point representation, IEEE 754 standard, FP addition and multiplication, rounding, MIPS floating-point coprocessor and instructions.

### CPU Performance

- CPU performance and metrics, performance equation, average CPI, MIPS, Amdahl's law.

### Single-Cycle Datapath and Control Design

- Designing a single-cycle processor, register transfer, datapath components, register file design, multifunction ALU design, clocking methodology, control signals, implementing the control unit, estimating longest delay, multi-cycle instruction execution versus single-cycle performance.

### Pipelined Datapath and Control

- Pipelining concepts, timing and performance, 5-stage MIPS pipeline, pipelined datapath and control, pipeline hazards, data hazards and forwarding, control hazards, branch prediction.

### Memory System Design

- Memory hierarchy, SRAM, DRAM, pipelined and interleaved memory, cache memory and locality of reference, cache memory organization, write policy, write buffer, cache replacement, cache performance, two-level cache memory.