Name: Id#

COE 301/ICS 233, Term 172

Computer Architecture & Assembly Language

Quiz# 7

 Date: Tuesday, May 1, 2018

# **Q1.** A benchmark program runs for 100 seconds. We want to improve the speedup of the benchmark by a factor of 3. We enhance the floating-point hardware to make floating point instructions run 5 times faster. How much of the initial execution time would floating-point instructions have to account for to show an overall speedup of 3 on this benchmark?

# **Q2.** Consider the following fragment of MIPS code. Assume that **a** and **b** are arrays of words and the base address of **a** is in **$a0** and the base address of **b** is in **$a1**. How many instructions are executed during the running of this code? If ALU instructions (**addu** and **addiu**) take 1 cycle to execute, load/store (**lw** and **sw)** take 5 cycles to execute, and the branch (**bne**) instruction takes 3 cycles to execute, how many cycles are needed to execute the following code (all iterations). What is the average CPI?

**addu $t0, $zero, $zero # i = 0**

**addu $t1, $a0, $zero # $t1 = address of a[i]**

**addu $t2, $a1, $zero # $t2 = address of b[i]**

**addiu $t3, $zero, 101 # $t3 = 101 (max i)**

**loop: lw $t4, 0($t2) # $t4 = b[i]**

**addu $t5, $t4, $s0 # $t5 = b[i] + c**

**sw $t5, 0($t1) # a[i] = b[i] + c**

**addiu $t0, $t0, 1 # i++**

**addiu $t1, $t1, 4 # address of next a[i]**

**addiu $t2, $t2, 4 # address of next b[i]**

**bne $t0, $t3, loop # loop if (i != 101)**

# **Q3.** We want to compare the performance of a **single-cycle CPU design** with a **multicycle CPU**. Suppose we add the multiply and divide instructions. The operation times are as follows:

Instruction memory access time = 190 ps, Data memory access time = 190 ps

Register file read access time = 150 ps, Register file write access = 150 ps

ALU delay for basic instructions = 190 ps, Delay for multiply or divide = 550 ps

Ignore the other delays in the multiplexers, control unit, sign-extension, etc.

Assume the following instruction mix: 30% ALU, 15% multiply & divide, 30% load &

store, 15% branch, and 10% jump.

## What is the total delay for each instruction class and the clock cycle for the single-cycle CPU design?

## Assume we fix the clock cycle to 200 ps for a multi-cycle CPU, what is the CPI for each instruction class and the speedup over a fixed-length clock cycle? Note that this implies that multiply and divide operations will be performed in multiple cycles.