CDA 3101 Assignment 6
Due in class on Friday, Nov.5

Turn hardcopy in class, stapled, with your name and "CDA 3101 Assignment 6" clearly written on it.

Assignments submitted after Nov. 5, 12:35 pm but before Nov. 8, 12:35 pm will be considered one day late.

1. (7 points) Consider the following MIPS assembly language code.

```
bzero: beq $a1, $zero, end
loop:  sb $zero, 0($a0)
       addi $a0, $a0, 1
       addi $a1, $a1, -1
       bne $a1, $zero, loop
end:   jr $ra
```

Given a **2GHz processor** with the CPI's in the table below, **what would be the exact CPU time of this function** if the **initial value of $a1= 3**?

Instruction	Type	CPI
Arithmetic	(add, sub, addi)	3
Memory	(load, store)	5
Control	(branches and jumps)	4

$53 \times (1 / (2 \times 10^9)) = 26.5 \times 10^{-9}$ seconds

2. (5 points) Suppose a computer runs at 2GHz. If this computer runs an MPEG-4 video encoder that takes 1 billion instructions and has the following distribution of instructions.

20% Floating point	CPI = 3	10% Integer	CPI = 1
30% Load	CPI = 2	20% Store	CPI = 1
15% Branches	CPI = 4	5% Other	CPI = 1.5

a. What is the effective or average CPI for this video encoder?

$0.2 \times 3 + 0.1 \times 1 + 0.3 \times 2 + 0.2 \times 1 + 0.15 \times 4 + 0.05 \times 1.5 = 2.175$ CPI

b. How long does it take the encoder to execute?

$10^9 \times 2.175 \times (1 / (2 \times 10^9)) = 1.0875$ seconds

3. (5 points) Suppose we enhance the floating point unit of a computer to make all floating-point instructions run five times faster. We are looking for a benchmark to show off the new floating-point unit, and we want the overall benchmark to show a speedup of 3. One benchmark we are considering runs for 100 seconds with the old floating-point hardware. 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?

Let F be execution time of floating point instructions.
100 / 3 = F / 5 + (100 - F)
F = 83.33 seconds

4. (6 points) You are going to enhance a computer, and there are two possible improvements: either makes multiply instructions run four times faster than before, or make memory access instructions run two times faster than before. You repeatedly run a program that takes 100 seconds to execute. Of this time, 20% is used for multiplication, 50% for memory access instructions, and 30% for other tasks. What will the speedup be if you improve only multiplication? What will the speedup be if you improve only memory access? What will the speedup be if both improvements are made?

Improve multiplication only:
Time after improvement = (20/4) + 80 = 85
Speedup = 100/85 = 1.18;

Improve memory access only:
Time after improvement = (50/2) + 50 = 75
Speedup = 100/75 = 1.33;

Improve both:
Time after improvement = (20/4) + (50/2) + 30 = 60
Speedup = 100/60 = 1.67;

5. Suppose 3 computers are being benchmarked to determine which is better for security analysts. The following shows their performance on various benchmark categories.

(times in seconds)	Encryption	Password Cracking	Decryption
Computer 1	10	10	40
Computer 2	20	11	8
Computer 3	28	4	4

a. (6 points) Find the average execution time of each computer through all benchmarks. Which computer is fastest according to these statistics?

	Average execution time
Computer 1	**(10 + 10 + 40) / 3 = 20**
Computer 2	**(20 + 11 + 8) / 3 = 13**

Computer 3	**(28 + 4 + 4) / 3= 12**

Computer 3 is the fastest.

b. (6 points) Suppose encryption is done 5 times as much as decryption, and we're not going to be doing any password cracking. Compute the weighted average execution time of each computer given this weighting. Which computer is fastest according to these statistics?

	Weighted Average execution time
(Fastest) Computer 1	**(5 × 10 + 40) / 6 = 15**
Computer 2	**(5 × 20 + 8) / 6 = 18**
Computer 3	**(5 × 28 + 4) / 6 = 24**

Computer 1 is the fastest.

6. (15 points) Consider two different implementations, I1 and I2, of the same instruction set. There are three classes of instructions (A, B, and C) in the instruction set. I1 has a clock rate of 6 GHz, and I2 has a clock rate of 4 GHz. The average number of cycles for each instruction class on I1 and I2 is given in the following table.

Class	CPI on I1	CPI on I2	C1 Usage	C2 Usage
A	2	1	40%	50%
B	3	2	20%	25%
C	5	2	40%	25%

The table also contains a summary of average proportion of instruction classes generated by two different compilers (C1, and C2). **Assume each compiler uses the same number of instructions for a given program but that the instruction mix is as described in the table.**

a. If you purchased I1, which compiler would you use i.e. which compiler produces programs with the lower average CPI?

C1: $0.4 \times 2 + 0.2 \times 3 + 0.4 \times 5 = 3.4$ CPI

➔ **C2: $0.5 \times 2 + 0.25 \times 3 + 0.25 \times 5 = 3$ CPI**

So, C2.

b. If you purchased I2, which compiler would you use?

C1: $0.4 \times 1 + 0.2 \times 2 + 0.4 \times 2 = 1.6$ CPI

➔ **C2: $0.5 \times 1 + 0.25 \times 2 + 0.25 \times 2 = 1.5$ CPI**

So, C2.

c. Which computer and compiler would you purchase if all other criteria are identical, including the cost?

I1 + C2: $3.0 \times IC / (6 \times 10^9) = .5 \times IC \times 10^{-9}$

I2 + C2: $1.5 \times IC / (4 \times 10^9) = .375 \times IC \times 10^{-9}$

So, I2 + C2.