Princess Sumaya University for Technology
جامعة الأميرة سمية للتكنولوجيا

Dept. of Computer Engineering
22541 Computer Architecture
Spring 2022- Midterm Exam

Name: Solution
Student ID: .....
Instructors: Dr. Awos Kanan
Duration: 60 minutes.
Date: 8/5/2022

Instructions:.
- *Exam consists of six questions, with total of 30 points.*
- *Show your work, final answer by itself does not count.*
- *MIPS Instruction Set Sheet is provided in the last page*
- *Cell phones not allowed.*

Q 1	/5	Q 4	/6
Q 2	/6	Q 5	/5
Q 3	/4	Q 6	/4

Total Grade: /30

Question 1: Multiple Choice **(5 points)**

1. The word size of a 64-bit CPU is :

A. One byte.
B. Two bytes.
C. Four bytes.
D. Eight bytes.

2. The clock rate of a processor that has clock cycle of 0.25ns is:

A. 2GHz
B. 3GHz
C. 4GHz
D. 8GHz

3. If computer A executes a program in 10 seconds and computer B runs the same program in 15 seconds, how much faster is computer A than computer B

A. 1.4 times
B. 1.5 times
C. 5 times
D. 0.67 times

4. A computer system has 456 instructions. What would be the minimum width of the Opcode field?

A. 8 bits
B. 10 bits
C. 11 bits
D. 9 bits

5. In immediate addressing mode, the operand is placed in:

A. CPU register
B. Instruction
C. Memory
D. Stack

Question 2: Consider two processors P_1 (Clock Rate = 3 GHz) and P_2 (Clock Rate = 2.5 GHz) that implement the same instruction set with three classes of instructions A, B, and C. The average CPIs are given in the following table: **(6 points)**

Processor	CPI (Class A)	CPI (Class B)	CPI (Class C)
P1	3	4	2
P2	2	3	1

For a given program that has half of its instructions from Class A and the remaining half evenly divided between Class B and Class C:

a) What is the Global CPI for each processor? (2 points)

$CPI_{P_1} = 0.5 * 3 + 0.25 * 4 + 0.25 * 2 = 3$

$CPI_{P_2} = 0.5 * 2 + 0.25 * 3 + 0.25 * 1 = 2$

b) Which processor is faster? By how much (factor)? (2 points)

$CPU\ Time(P_1) = \frac{IC * 3}{3 * 10^9} = IC * 10^{-9}$ Sec

$CPU\ Time(P_2) = \frac{IC * 2}{2.5 * 10^9} = 0.8\ IC * 10^{-9}$ sec

P_2 is $\left(\frac{IC * 10^{-9}}{0.8 * IC * 10^{-9}}\right) = \frac{1}{0.8} = 1.25$ times faster than P_1

c) By how much (percentage) do we need to increase the clock rate of the slower processor so that it has the same performance as the faster one? (2 points)

$0.8 * 10^{-9} IC = \frac{IC * 3}{\text{clock rate}_{new}} \rightarrow$ clock rate$_{new}$ = 3.75 GHz

need to be increased by $\left(\frac{3.75 - 3}{3}\right) =$ 25 %

Question 3: Floating-Point operations account for 30% of the execution time of a program on some computer. What is the overall speedup of executing the same program on an enhanced version of this computer that takes 60% less time to execute Floating-Point operations? **(4 points)**

$T_{orginal} = T$

$T_{enhanced} = 0.3 * 0.4 * T + 0.7\ T = 0.12\ T + 0.7\ T = 0.82\ T$

$Speedup = \frac{T_{orginal}}{T_{enhanced}} = \frac{T}{0.82\ T} = \frac{1}{0.82} = 1.22$

Question 4: Translate the following C code to RISC-V assembly language. Assume that the variables a, b, and c are already stored in registers X3, X4, and X5 respectively, **a and b are positive numbers**, **subtraction** and **multiplication** instructions are **not available**.

(6 points)

```
if (b != c) c = a-b;
else c = a*b;
```

```
beq  X4, X5, ELSE     % if (b==c) goto ELSE   0.5
xori X5, X4, -1       % c=1's comp. of b
addi X5, X5, 1        % c = c+1 (2's comp. of b)
add  X5, X5, X3       % c = a + 2's comp. of b (a-b)      } 2
beq  X0, X0, Exit     % skip ELSE code.   0.5

ELSE: add X5, X0, X0  % c = 0
      add X6, X0, X0  % i = 0 (loop index)                } 1
Loop: bge X6, X3, Exit % exit loop if i >= a
      add X5, X5, X4  % c += b
      addi X6, X6, 1  % i++
      beq X0, X0, Loop % goto Loop                        } 2

Exit:
```

Question 5: For the following piece of RISC-V assembly code: **(5 points)**

Assume that the first instruction is at memory location 0xFFFF000C.

```
L:   sll  X2, X3, 2
     add  X2, X3, X6
     ld   X3, 0(X5)
     bne  X3, X5, Exit
     addi X4, X3, 1
     add  X2, X4, X6
     jal  X0, L
Exit: ...
```

-At what memory address (Hex) is the label "Exit"?

= FFFF000C + (28)10 (1C)16 = FFFF0028

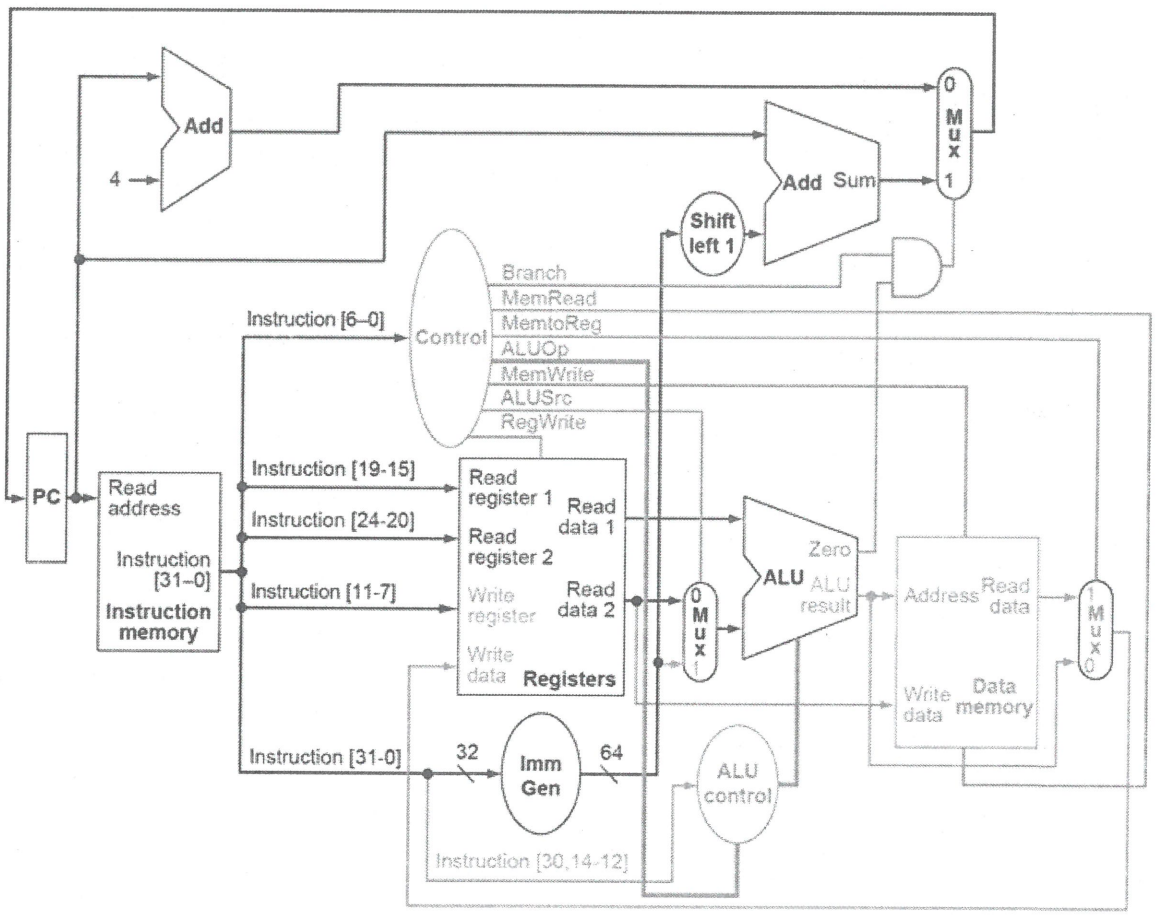
- What is the value **(Decimal)** of the immediate field (Exit) in the **bne** instruction?

4*2 = 8

- What is the value **(Decimal)** of the immediate field (L) in the **jal** instruction?

-(6*2) = -12

Question 6: Refer to the RISC-V Datapath below to answer the following questions: **(4 points)**



a) What is the main advantage of having a separate ALU Control Unit?

Modular design → can modify it independently of main control unit.

b) What are the two adders (on top of the figure) used for?

-Top Left Adder:

Increment PC to fetch next instruction

-Top Right Adder:

Calculate "Branch Target Address"

c) Complete the table below with the control signals values generated by the Control Unit for **addi** and **sd** instructions:

	ALUSrc	RegWrite
addi	1	1
sd	1	0