Faculty of Engineering and Computer Science
Expectations of Originality

This form sets out the requirements for originality for work submitted by students in the Faculty of Engineering and Computer Science. Submissions such as assignments, lab reports, project reports, computer programs and take-home exams must conform to the requirements stated on this form and to the Academic Code of Conduct. The course outline may stipulate additional requirements for the course.

1. Your submissions must be your own original work. Group submissions must be the original work of the students in the group.
2. Direct quotations must not exceed 5% of the content of a report, must be enclosed in quotation marks, and must be attributed to the source by a numerical reference citation[1]. Note that engineering reports rarely contain direct quotations.
3. Material paraphrased or taken from a source must be attributed to the source by a numerical reference citation.
4. Text that is inserted from a web site must be enclosed in quotation marks and attributed to the web site by numerical reference citation.
5. Drawings, diagrams, photos, maps or other visual material taken from a source must be attributed to that source by a numerical reference citation.
6. No part of any assignment, lab report or project report submitted for this course can be submitted for any other course.
7. In preparing your submissions, the work of other past or present students cannot be consulted, used, copied, paraphrased or relied upon in any manner whatsoever.
8. Your submissions must consist entirely of your own or your group's ideas, observations, calculations, information and conclusions, except for statements attributed to sources by numerical citation.
9. Your submissions cannot be edited or revised by any other student.
10. For lab reports, the data must be obtained from your own or your lab group's experimental work.
11. For software, the code must be composed by you or by the group submitting the work, except for code that is attributed to its sources by numerical reference.

You must write one of the following statements on each piece of work that you submit:
For individual work: **"I certify that this submission is my original work and meets the Faculty's Expectations of Originality",** with your signature, I.D. #, and the date.
For group work: **"We certify that this submission is the original work of members of the group and meets the Faculty's Expectations of Originality",** with the signatures and I.D. #s of all the team members and the date.

A signed copy of this form must be submitted to the instructor at the beginning of the semester in each course.

I certify that I have read the requirements set out on this form, and that I am aware of these requirements. I certify that all the work I will submit for this course will comply with these requirements and with additional requirements stated in the course outline.

Course Number:	COEN 316	Instructor:	Fadi Alzhouri
Name:	Samson Kaller	I.D. #	40136815
Signature:		Date:	02/01/2023

[1] Rules for reference citation can be found in "Form and Style" by Patrich MacDonagh and Jack Bordan, fourth edition, May, 2000, available at http://www.encs.concordia.ca/scs/Forms/Form&Style.pdf.
Approved by the ENCS Faculty Council February 10, 2012

COEN 316 – Computer Architecture and Design

Department of Electrical and Computer Engineering

Assignment 1, Winter 2023

Due: Wednesday, Feb. 1st, 2023
In this assignment, you will answer the following questions. Write your answer in the exact place:

Your Information:	
First Name:	Samson
Last Name:	Kaller
Student ID:	40136815
Grade:	

Expectations of originality:
Paste the signed form here or submit it as a separate file with this assignment

Question 1	**Grade**
1- Consider a machine with four instruction classes, whose CPI and code size (IC_i) for each instruction class for a program are given below:	**20**

Instruction class	CPI for the instruction class	IC for the instruction class (Millions)
ALU	1	900
Load	2	500
Store	2	100
Branch	3	200

(i) Find the execution time on a 3GHz processor.

(ii) What is the speedup if the number of ALU instructions can be reduced by one-quarter?

i) $t_{exe} = [CPI_A \cdot IC_A + CPI_L \cdot CI_L + CPI_S \cdot IC_S + CPI_B \cdot IC_B] \cdot (1/f_{clk})$

$t_{exe} = [\underbrace{1 \cdot 900}_{900} + \underbrace{2 \cdot 500}_{1000} + \underbrace{2 \cdot 100}_{200} + \underbrace{3 \cdot 200}_{600}](10^6) \cdot \frac{1}{3 \cdot 10^9}$

$t_{exe} = (2700) \cdot \frac{1}{3 \cdot 10^3} = \frac{27}{30} = \frac{9}{10} = 0.9$ SECONDS

i) ANS: EXECUTION TIME IS 0.9 SECONDS

ii) NEW $IC_{ALU} = (1 - 1/4) \cdot 900 = 675$ MILLION

$$t = \frac{1}{f_{clk}} \cdot \sum CPI \cdot IC$$

$$t = \frac{1}{5 \cdot 10^9} \cdot (1 \cdot 675 + 2 \cdot 500 + 2 \cdot 100 + 3 \cdot 200)(10^6)$$

$$t = \frac{2475}{3000} = 0.825 \text{ SECONDS}$$

SYSTEM SPEEDUP $= t_{OLD} / t_{NEW} = 0.9 / 0.825 = 12/11$

SPEEDUP = 1.09091

ii) ANS: THE SYSTEM SPEEDUP IS 1.09091 IF THE NUMBER OF ALU INSTRUCTIONS IS REDUCED BY 1/4.

Question 2

Grade

30

Suppose that a new MIPS instruction, called bcp, was designed to copy a block of words from one address to another. Assume that this instruction requires that the starting address of the source block is in register $t1 and that the destination address is in $t2. The instruction also requires that the number of words to copy be in $t3 (which is > 0). Furthermore, assume that the values of these registers as well as register $t4 can be destroyed in executing this instruction (so that the registers can be used as temporaries to execute the instruction).

a. Write the MIPS assembly code to implement a block copy without this instruction.

c. Estimate the total cycles necessary for each realization to copy 100-words on the multicycle machine.

a)

$t1 : SOURCE BLOCK
$t2 : DESTINATION BLOCK
$t3 : WORD COUNT ($t3 > 0)
$t1 – $t4 : CAN BE DESTROYED

```
        #$t3 ASSUMED TO BE >0, LOOP AT LEAST ONCE
LOOP:   lw $t4, 0($t1)      #LOAD WORD FROM SOURCE BLOCK (ADDRESS IN $t1) INTO $t4
        sw $t4, 0($t2)      #STORE WORD FROM $t4 INTO DESTINATION BLOCK (ADDRESS IN $t2)
        addi $t1, $t1, 4    #INCREMENT $t1 (SOURCE ADDRESS) BY 1 WORD (4 BYTES)
        addi $t2, $t2, 4    #INCREMENT $t2 (DESTINATION ADDRESS) BY 1 WORD (4 BYTES)
        addi $t3, $t3, -1   #DECREMENT WORD COUNT IN $t3 BY 1
        bne $t3, $zero, LOOP #JUMP TO LOOP LABEL IF $t3 IS NOT ZERO

        #BLOCK COPY FINISHED WHEN $t3 = 0
```

c)

- MIPS MULTICYCLE CPIs: - BRANCH: 3 - ALU: 4 - LOAD: 5
  - JUMP: 3 - STORE: 4
- ONE LOOP OF CODE a) HAS THE FOLLOWING ICs: 1 BRANCH, 3 ALU, 1 STORE, 1 LOAD
- CLOCK CYCLES PER LOOP: $\text{CYCLES} = CPI_B \cdot IC_B + CPI_A \cdot IC_A + CPI_S \cdot IC_S + CPI_L \cdot IC_L$

  $\text{CYCLES} = 3 \cdot 1 + 4 \cdot 3 + 4 \cdot 1 + 5 \cdot 1 = 24$
- FOR 100 WORD BCP, LOOP RUNS 100 TIMES → TOTAL CYCLES = $100 \cdot 24 = 2400$

c) ANS: THE MULTICYCLE MACHINE WILL TAKE AROUND 2400 CLOCK CYCLES TO BLOCK COPY 100 WORDS USING CODE a).

Question 3

Grade

30

1. consider the following processors:

Processor	Clock rate	CPI
P1	3 GHz	2.5
P2	3.5 GHz	4
P3	4 GHz	3

a) If the same ISA is used for the three machines. Which machine is faster? Why?

b) What is the MIPS for each machine?

c) It is desired to run a program in 5 seconds on each machine by using suitable ISA for each case. How many instructions are needed for each processor?

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2. The following are three different implementations of the same ISA where the instruction set are divided into 3 classes: A, B and C

Processor	Clock rate	CPI of class A	CPI of class B	CPI of class C
P1	3 GHz	2	4	3
P2	2.5 GHz	3	5	3
P3	4 GHz	3	3	2

A program with 5.0E4 instructions is divided into the classes as follows: 40% class A, 35% class B and 25% class C.

a) What is the average CPI for each machine?

b) Which machine is faster?

1.a) Execution times: $t = \frac{CPI \cdot IC}{f_{CLK}}$

$t_1 = \frac{2.5 \cdot X_1}{3 \cdot 10^9} = \frac{0.833}{10^9} \cdot X_1$ seconds

$t_2 = \frac{4 \cdot X_2}{3.5 \cdot 10^9} = \frac{1.14}{10^9} \cdot X_2$ seconds

$t_3 = \frac{3 \cdot X_3}{4 \cdot 10^9} = \frac{0.75}{10^9} \cdot X_3$ seconds ← FASTEST

→ Let $X_1 = X_2 = X_3 = 10^9$, then

$t_3 = 0.75\ s < t_1 = 0.833\ s < t_2 = 1.14\ s$

For the same instruction count & ISA, processor P3 will execute the fastest.

1.b) $MIPS = \frac{f_{CLK}}{CPI \cdot 10^6}$

$MIPS_1 = \frac{3 \cdot 10^9}{2.5 \cdot 10^6} = 1200 = MIPS_1$

$MIPS_2 = \frac{3.5 \cdot 10^9}{4 \cdot 10^6} = 875 = MIPS_2$

$MIPS_3 = \frac{4 \cdot 10^9}{3 \cdot 10^6} = 1333 = MIPS_3$

1.c) Use data from a).

$5 \text{ seconds} = \frac{2.5}{3 \cdot 10^9} \cdot X_1 = \frac{4}{3.5 \cdot 10^9} \cdot X_2 = \frac{3}{4 \cdot 10^9} \cdot X_3$

$X_1 = \frac{5 \cdot 3 \cdot 10^9}{2.5} = 6 \text{ billion} = IC_1$

$X_2 = \frac{5 \cdot 3.5 \cdot 10^9}{4} = 4.375 \text{ billion} = IC_2$

$X_3 = \frac{5 \cdot 4 \cdot 10^9}{3} = 6.67 \text{ billion} = IC_3$

2.a) $CPI_{AVG} = \%_A \cdot CPI_A + \%_B \cdot CPI_B + \%_C \cdot CPI_C$

P1: $CPI_{AVG} = 0.40 \cdot 2 + 0.35 \cdot 4 + 0.25 \cdot 3 = 2.95 = CPI_1$

P2: $CPI_{AVG} = 0.40 \cdot 3 + 0.35 \cdot 5 + 0.25 \cdot 3 = 3.7 = CPI_2$

P3: $CPI_{AVG} = 0.40 \cdot 3 + 0.35 \cdot 3 + 0.25 \cdot 2 = 2.75 = CPI_3$

2.b) $t_1 = \frac{CPI_1 \cdot IC}{f_1} = \frac{2.95 \cdot 5 \cdot 10^4}{3 \cdot 10^9} = 49.2\ \mu s$

$t_2 = \frac{CPI_2 \cdot IC}{f_2} = \frac{3.7 \cdot 5 \cdot 10^4}{2.5 \cdot 10^9} = 74\ \mu s$

$t_3 = \frac{CPI_3 \cdot IC}{f_3} = \frac{2.75 \cdot 5 \cdot 10^4}{4 \cdot 10^9} = 34.4\ \mu s$ t_3

ANS: FOR THE GIVEN PROGRAM, P3 EXECUTES THE FASTEST.

Grading Policy:

The assignment score is out of 100 points.
Here are some aspects that may lead to points deduction:

- The answers are missing.
- Missing steps.
- Inappropriate data to answer your question.
- Do your best to include exhaustive details, the final answer alone is not enough to get points.
- Collaborate on the individual assignment.