

OLLSCOIL NA hÉIREANN, CORCAIGH
THE NATIONAL UNIVERSITY OF IRELAND, CORK

COLÁISTE NA hOLLSCOILE, CORCAIGH
UNIVERSITY COLLEGE, CORK

Examination Session and Year	Winter 2022
Module Code	CS2507
Module Title	Computer Architecture
Paper Number	1
External Examiner	Prof. Pete Sawyer
Head of School/ Department	Professor Utz Reoding
Internal Examiners	Dr. Ahmed Zahran
Instructions to Candidates	Do not use red pen in the answer sheet. Please clearly label your answer to each question and sub-question. Closed book exam. This exam is worth 80 module marks .
Duration of Paper	90 minutes
Special Requirements	Calculators are not allowed

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THEN ENSURE THAT YOU HAVE THE CORRECT EXAM PAPER**

Question #1 [30 Marks]

- A. [5 marks] Compare the impact of doubling the processor clock speed and doubling the processors cores on the performance. Why is increasing the clock speed getting challenging?
- B. [5 Marks] "Smaller is faster" represents one of MIPS processor design principles. Explain.
- C. [5 marks] Consider the following C statement.
float x2=15.25;
i. How many bytes are allocated for x2?
ii. Derive the binary value stored in the memory allocated to x2.
- D. [5 marks] The implementation of MIPS processor has several cost-performance tradeoffs. Identify two design aspects that illustrate these cost-performance tradeoffs.
- E. [5 marks] Increasing the number of processor pipeline stages has advantages and disadvantages. Discuss.
- F. [5 marks] Explain the role of cache associativity and hierarchy in improving the memory performance.

Question #2 [30 Marks]

A. [24 marks] Consider the code shown to the right
Data segment starts at: 0x 1001 0000
Code segment starts at: 0x 0040 0000

i- [2 marks] Identify the binary content in the first word in the data segment.

ii- [2 marks] What address does the label ss points to?

iii- [2 marks] Identify all pseudo instructions in the code.

iv- [2 marks] Identify three basic MIPS instructions with different formats.

v- [4 marks] Identify the value of \$s0, \$s1, \$t0, \$t1, \$t3 after executing line 9.

vi- [2 marks] How many times would line 10 be executed?
How many times will line 12 be executed?

vii- [2 marks] How many memory bytes are read when executing this code?

viii- [2 marks] What is the purpose of the main program? (Hint: what is it calculating for the array?)

ix- [6 marks] Rewrite lines 7-19 as a function and show the whole code.

```
1 .data
2 X: .word 10, 45, 33, 4
3 ss: .word 4
4 .text
5 la $s0, X
6 lw $s1, ss
7 lw $t0, 0($s0)
8 lw $t1, 0($s0)
9 addi $t3, $0, 0
10 L1: addi $t3, $t3, 1
11 beq $t3, $s1, end
12 addu $s0, $s0, 4
13 lw $t4, 0($s0)
14 bgt $t0, $t4, L2
15 add $t0, $zero, $t4
16 j L1
17 L2: blt $t1, $t4, L1
18 add $t1, $zero, $t4
19 j L1
20 end: li $v0, 10
21 syscall
```

B. [6 marks] Identify two pipelining hazards of **distinct types** in the code.

For each one, identify the instruction line(s) and hazard type.

Additionally, indicate if such hazard can be completely avoided or not. If yes, explain how; otherwise, explain why.

Question #3 [20 Marks]

A. [9 marks]

Consider a direct-mapped cache with the address specifications shown in the table

Tag	Block ID	Block offset
31-16	14-7	6-0

a. [1 mark] What is the cache block size (in words)?

b. [1 mark] How many blocks does the cache have?

c. [1 mark] What is the cache size?

d. [2 mark] Which cache block would be used for the following address 0x F0 AB 88 66?

e. [2 mark] If the memory is using a two-way set associative caching, which block can the address 0x F0 AB 88 66 use?

f. [2 mark] If the memory is using a fully associative cache, which block can the address 0x F0 AB 88 66 use?

B. [6 Marks] Sketch a figure that illustrates the virtual address resolution to cache address showing all steps and involved components. Briefly highlight why TLB (Translation Look aside Buffer) is needed.

C. [5 Marks] You are given a library that has individual methods to calculate the minimum, maximum average, and median of a large array. It is required that you extend it by developing a new method that calculates and returns all the aforementioned values. Compare the following implementation options and explain which one you would choose.

1. Implement the new method as a function that calls the existing methods,
2. Implement the logic needed to calculate these values in one array scan.