Durham University

Examination Paper

Examination Session:	Year:	Exam Code:
May/June	2023	COMP1071-WE01

Computer Systems

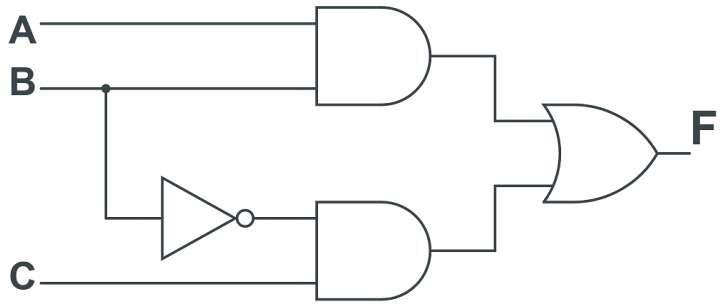
Release Date/Time	15/05/2023 14:30
Latest Submission Date/Time	15/05/2023 17:30
Format of Exam	Restricted window exam
Duration:	2 hours
Word/Page Limit:	
Additional Material provided:	
Expected form of Submission	A SINGLE PDF file submitted to Gradescope
Submission method	Gradescope

Instructions to Candidates:	Answer ALL questions

Section A Machine Architecture and Digital Electronics (Dr Farshad Arvin & Dr Ioannis Ivrissimtzis)

Question 1

(a) Consider the following logic gate implementation



i. Write a Boolean representation of F. **[3 Marks]**

ii. Assume that the gates have finite propagation delay. Describe in detail what happens at the output F when the inputs (A, B, C) change from $(1, 1, 1)$ to $(1, 0, 1)$. Explain step by step. **[3 Marks]**

iii. Complete the following Karnaugh map for the given logic implementation in Q1(a). **[2 Marks]**

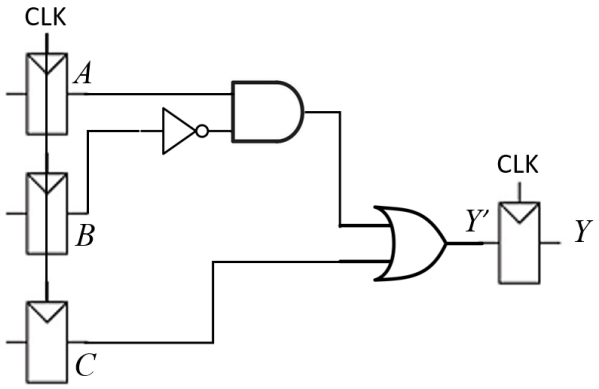
A \ BC	00	01	11	10
0				
1				

iv. Using the Karnaugh map in part Q1(a)iii, determine a modified SoP expression for F that will eliminate the behaviour of the output observed in part Q1(a)ii. Explain your working. **[3 Marks]**

v. Draw the new logic gate implementation based on the modification in part Q1(a)iv. **[2 Marks]**

continued

(b) Consider the following circuit,



The propagation and contamination delays of each logic gate are $t_{pd} = 0.5$ ns and $t_{cd} = 0.3$ ns, and the clock-to-Q propagation and contamination delays of the flip-flops are $t_{pcq} = 2$ ns and $t_{ccq} = 0.5$ ns. The setup and hold times of each flip flop are $t_{setup} = 1.5$ ns and $t_{hold} = 1$ ns.

i. What is the maximum clock frequency that you could safely set for this circuit? **[2 Marks]**

ii. Show that there is a hold time violation in the circuit. **[2 Marks]**

(c) Assume that a, b, c, d are stored in registers \$t0, \$t1, \$t2, and \$t3, respectively. Translate the following high-level programming language statement into MIPS assembly code:

$$a = (a - b) + (c - d) - 1;$$

[4 Marks]

(d) Translate the following instruction into MIPS machine language:

addi \$t0, \$t0, -4

Write your answer in hexadecimal. Show how you arrived at your answer.

The binary op-code of the addi instruction is 001000. The decimal register number of \$t0 is 8. **[6 Marks]**

(e) Consider the following AVR assembly language snippet:

```
                    . . . . . . . . . . . .
1                   .equ  myValue, 200
                    . . . . . . . . . . . .
2                   delay:
3                   LDI  R20, myValue
4                   loop:
5                     SUBI  R20, 1
6                     BRNE  loop
7                   RET
                    . . . . . . . . . . . .
```

i. Give a technical description of each line of the snippet. **[5 Marks]**

ii. Give a high-level description of the whole snippet. **[2 Marks]**

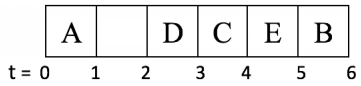
The line numbering at the left is not part of the code. It is just for you, if you want to refer to it when you explain what each line does.

End of Section A **continued**

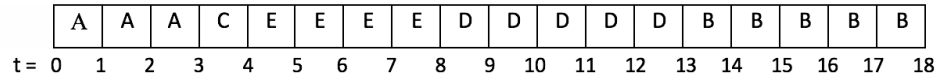
Section B Operating Systems (Dr Anish Jindal)

Question 2

(a) Suppose that a set of processes A to E arrive at the ready queue at different times (represented by t) as shown below:



The priority of processes {A, B, C, D, E} is {5, 3, 2, 4, 1}, respectively, where a lower value indicates higher priority and the following Gantt chart shows the execution of Shortest Job First (SJF) algorithm.



Draw a Gantt chart showing the execution of the processes for each of the following CPU scheduling algorithms.

i. Shortest Remaining Time First. **[2 Marks]**

ii. Round Robin with time slice of 2 units. **[2 Marks]**

iii. Pre-emptive priority. **[2 Marks]**

iv. For each of the three scheduling algorithms above, give the average waiting time. **[3 Marks]**

(b) Suppose the realisation of an unknown page reference string is:

$$\_, \_, \_, \_, \_, \_, 2, \_, 2, 1, 3, \_, 3, 2, \_, 4, \_$$

where _ represents an unknown page number.
Consider the First In First Out (FIFO) algorithm with three frames that are initially empty, gives the following frame allocation.

1	1	1	4	4	4	2	2	2	1	1
	2	2	2	5	5	5	3	3	3	5
		3	3	3	1	1	1	4	4	4

i. Identify the page reference string. **[1 Mark]**

continued

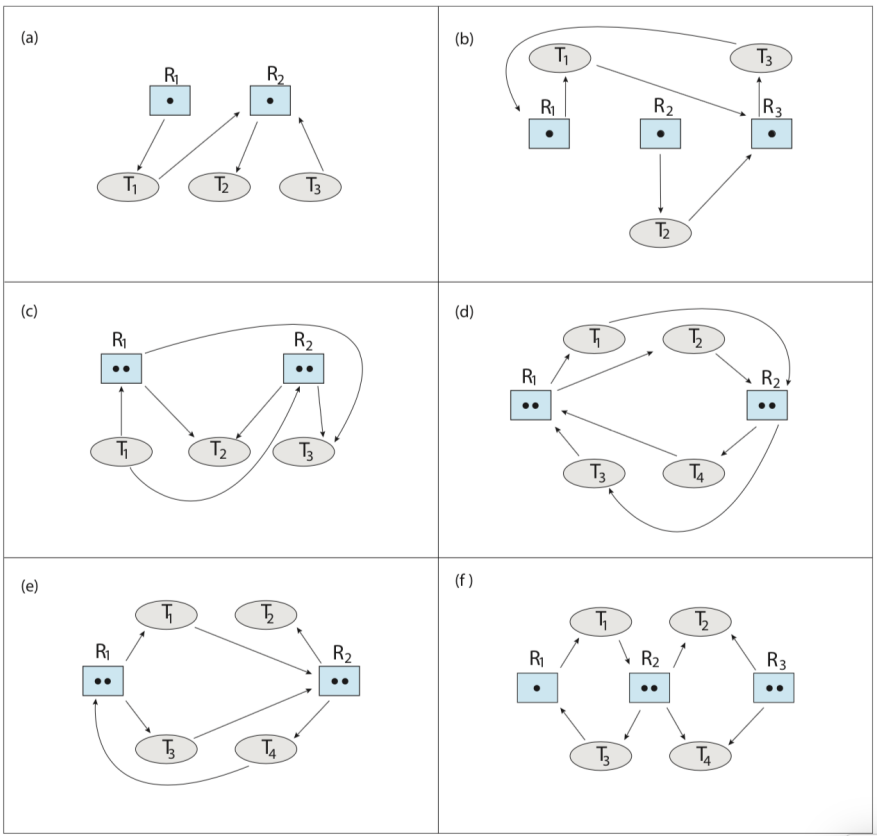
ii. Find the total number of page faults for Least Recently Used (LRU) that would occur with a three-frame reference memory allocation assuming that the frames are initially empty. Show your working. **[3 Marks]**

iii. Given that a program has referenced an address in virtual memory, describe the scenario of how the following can or cannot happen.

Scenario	TLB status	Page fault	How?
1	Miss	No	
2	Miss	Yes	
3	Hit	No	
4	Hit	Yes	

[2 Marks]

(c) From the six resource allocation graphs shown in the following figure, choose any five and discuss whether the deadlock can occur or not? If the deadlock occurs, present your answer in terms of which threads and resources lead to a deadlock. If there is no deadlock, present the order in which the threads may complete execution. **[10 Marks]**



(d) Consider a disk with 300 cylinders (from 0 to 299). The head is currently serving request at cylinder 115 with the previous request at cylinder 85.

The queue of pending requests to cylinders, in FIFO order, is:

$$169, 121, 130, 185, 246, 90, 110, 38, 130, 256$$

Calculate the total seek time in cylinders for each of the following disk scheduling algorithms.

i. First Come First Served (FCFS) **[2 Marks]**

ii. Scan (SCAN) **[2 Marks]**

iii. Look (LOOK) **[2 Marks]**

iv. Can you suggest and discuss any modification in the question (except changing the head value) to decrease the total movement between cylinders for the above algorithms? **[2 Marks]**

End of Section B **continued**

Section C Databases
(Dr Robert Lieck)

Question 3

(a) This part of the question is about the Relational Data Model. Consider a situation where you need to store information about the 5 most famous composers of every decade in the second half of the 19th century. You need to store the decade, their surname, year of birth, and country of origin. To avoid name clashes, each composer is identified by a unique ID. What is the cardinality and the degree of the resulting relation? What is the domain for the year of birth? **[3 Marks]**

(b) For the following scenario, draw the Entity-Relationship (ER) diagram using the UML notation, clearly showing the entities, their named relationships and the constraints of these relationships. In your diagram, indicate many-to-many relationships with a dashed line and resolve them.

> Every house is designed by one architect. An architect can design one or more houses or no houses at all. Every client buys one house and a house can be bought by one client or no clients at all. Building a house can require the work of one or more specialists, or no specialist at all. A specialist is working on one or more houses.

[10 Marks]

(c) Consider the relation "HotelVisit", which has the following relation schema:

> **HotelVisit** (<u>hotelID</u>, <u>guestID</u>, visitDate, hotelCapacity, hotelCompany, companyAddress, guestName, guestPhone)

where the attributes of the primary key are underlined.

i. Specify all functional dependencies that you can infer from the attributes' names (omit any dependencies that could additional be inferred using Armstrong's axioms). **[4 Marks]**

ii. Normalize the relation to the 2nd normal form (2NF) and specify which are the primary keys (underline) and the foreign keys (mark with an asterisk *). **[2 Marks]**

continued

iii. Normalize the relation to the 3rd normal form (3NF) and specify which are the primary keys (underline) and the foreign keys (mark with an asterisk *). **[2 Marks]**

(d) Consider the following relations "Hotel" and "City" with schemata:

Hotel (hotelID, name, capacity, constructionYear, cityID)
City (cityID, name, population)

Write an SQL statement for each of the following queries (use JOIN clauses if you need to combine tables):

i. List the name and capacity of all hotels constructed in London after 1990. **[3 Marks]**

ii. Get the number of hotels that have the same name as their city. Also show how many guest could stay in all of these hotels together if they were all half-full. **[4 Marks]**

iii. For every city, list its name and the number of hotels that have a capacity below the average (of all hotels in all cities). Order the cities alphabetically. **[5 Marks]**

END OF PAPER