Examination Paper

Examination Session:	Year:	Exam Code:
May/June	2021	COMP1071-WE01

Title: Computer Systems

Release Date/Time	9.30am 20/05/2021
Deadline Date/Time	9.30am 21/05/2021
Format of Exam	Take home exam
Duration:	2 hours
Word/Page Limit:	None
Additional Material provided:	None
Expected form of Submission	A SINGLE PDF file (handwritten or typed) submitted onto Gradescope. Upload your submission with a file name comprising of your student ID and the Exam Code e.g 00001234532 COMP1071-WE01.
Submission method	Gradescope

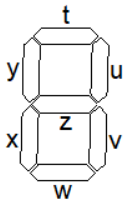
Instructions to Candidates:	Answer ALL questions.

Section A Machine Architecture and Digital Electronics (Dr Ioannis Ivrissimtzis & Dr Eleni Akrida)

Question 1

(a) Consider the 7-segment display which takes as input a 4-bit binary number and displays a single digit corresponding to the hexadecimal number equivalent to the 4-bit binary input. So, for input values 0-9 it displays the digits 0-9, and for input values 10-15 it displays A, b, C, d, E, F.

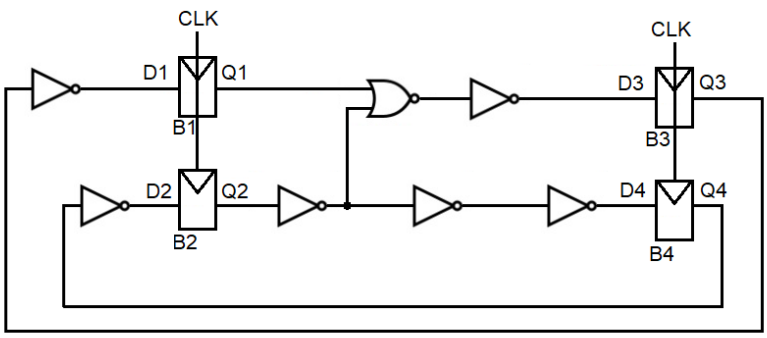
Let the 7 segments of the display be named t-z, as shown below.



We wish to create a circuit to drive the segment labelled w (bottom horizontal line) where an output 1 will indicate that the segment should be present, and an output 0 will indicate that it should not be present. Use a Karnaugh map to obtain a simple Boolean expression for w. **[5 Marks]**

(b) Give a circuit diagram consisting only of up to 4 in total NOR gates for the Boolean formula $F = (A + \overline{B}) \cdot (C + D)$. Show your working. **[4 Marks]**

(c) Consider the circuit shown below. Let the propagation delay of each NOT gate, $t_{pd_{NOT}}$, and the clock-to-Q propagation delay, t_{pcq}, of the flip-flops B1 to B4 range from $0.4ns$ to $0.9ns$. Let also the propagation delay of the NOR gate, $t_{pd_{NOR}}$, be in the range from $0.7ns$ to $1.3ns$. The setup and hold times of each flip flop are $t_{setup} = 1.5ns$ and $t_{hold} = 1ns$.



i. What is the maximum clock frequency that you could set for this circuit? **[3 Marks]**

ii. Show that there is a hold time violation in the circuit. **[3 Marks]**

iii. Would you be able to eliminate the hold time violation knowing, in addition to the above, that the clock-to-Q contamination delay, t_{ccq}, of the flip-flops B1, B2, and the contamination delay of each NOT gate range from $0.3ns$ to $0.38ns$? Justify your answer. **[2 Marks]**

(d) Assume that a, b, c are stored in registers \$s1-\$s3. Translate the following high-level programming language statement into MIPS assembly code.

$$a = a + b + c - 1;$$

[4 Marks]

(e) Consider the following MIPS assembly language snippet.The hexadecimal numbers to the left of each instruction indicate the instruction address.

```
. . . . . .
0x00400028          li    $t1, 10
0x0040002C  loop:   addi  $t1, $t1, -1
0x00400030          beq   $t1, $0, print
0x00400034          j     loop
0x00400038  print:  li    $v0, 4
. . . . . .
```

The binary op-codes for the instructions addi and j are 001000 and 000010, respectively. The register number of \$t1 is 9.

i. How many bits of memory does this snippet occupy? **[2 Marks]**

ii. Translate into MIPS machine language the addi instruction stored in address 0x0040002C. Write your answer in hexadecimal. Show how you arrived at your answer. **[6 Marks]**

iii. Translate into MIPS machine language the j instruction stored in address 0x00400034. Write your answer in hexadecimal. Show how you arrived at your answer. **[5 Marks]**

End of Section A **continued**

Section B Operating Systems (Dr Barnaby Martin)

Question 2

(a) Suppose that a set of processes A to E arrive at the ready queue at different times where the first time is 0.

i. Suppose the following Gantt chart shows the execution of First Come First Served (FCFS). What can you say about the arrival times of the processes A to E? **[2 Marks]**

D	D	D	D	D	D	C	C	C	C	C	C	B	B	B	A	A	E	E	E

Suppose now the table below shows the actual arrival and burst times together with priority (smaller numbers indicate higher priority).

Process	Priority	Arrival Time	Burst Time
A	5	7	2
B	3	4	3
C	1	2	6
D	2	0	6
E	4	9	3

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

ii. Shortest Job First (SJF). **[2 Marks]**

iii. Round Robin (RR) with priority and a time slice of 2 units. **[4 Marks]**

(b) For each of the scheduling algorithms in parts (a) give the average waiting time. **[6 Marks]**

(c) Consider a disk with 250 cylinders (from 0 to 249). Suppose the head is on cylinder 11 and is tracking backwards. It then receives requests for I/O to blocks in cylinders

$$3, 32, 68, 200, 47, 193, 23, 156, 204, 36$$

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

i. First Come First Served (FCFS)

ii. Shortest Seek Time First (SSTF)

continued

iii. Cyclic Scan (C-SCAN)

iv. Cyclic Look (C-LOOK) **[8 Marks]**

(d) Consider the page reference string which is $\_, \_, \_, 1, 1, 0, \_, 0\_, \_, \_, 1$ in which $\_$ represents an unknown page number. Suppose its realisation under a First In First Out (FIFO) algorithm gives the following frame allocation where we assume there are three frames and the frames are initially empty.

1	1	1	1	1	1	4	4	4	4	3	3
	0	0	0	0	0	0	0	5	5	5	5
		2	2	2	2	2	2	2	1	1	1

i. Give the page reference string. **[1 Marks]**

ii. How many page faults did FIFO produce? **[2 Marks]**

Find the total number of page faults for each of the page replacement algorithms listed below that would occur with a three frame reference memory allocation assuming that the frames are initially empty. Show your working.

iii. Least Recently Used (LRU) **[4 Marks]**

iv. Optimal (OPT) using numeric minimum for ties **[4 Marks]**

End of Section B **continued**

Section C Databases
(Dr Konrad Dabrowski)

Question 3

(a) This question is about the Relational Data Model. Consider the following relation:

CustomerID	Surname	FirstInitial	Age	City
C01	Smith	P	34	Durham
C02	Jones	J	25	London
C03	Smith	P	42	Edinburgh
C04	Lonsdale	A	21	Paris

What is the cardinality of this relation and what is the degree of this relation? What is the domain of FirstInitial? **[3 Marks]**

(b) For the following scenario draw the Entity-Relationship (ER) diagram using the Crows Foot notation, clearly showing the entities, their named relationships and the cardinalities of these relationships. In your diagram, resolve the many-to-many relationships.

> Every film uses one or more actors. An actor can act in one or more films or no films at all. Every film is directed by one director, who might direct one or more films or no films at all. Every studio employs one or more directors, but a director can only work for one studio or no studio at all.

[10 Marks]

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

> **Subscription** (customer_ID, subscription_Name, customer_Phone, customer_Name, customer_City, customer_Country, expiry_Date)

In the schema of this relation the attributes of the primary key are underlined, according to the standard notation.

i. Normalize the relation to the 2nd normal form (2NF) and specify which are the primary keys and the foreign keys. **[4 Marks]**

continued

ii. Normalize the relation to the 3rd normal form (3NF) and specify which are the primary keys and the foreign keys. **[4 Marks]**

(d) Based on the following relation schemas of the relations "Product" and "Style", write an SQL statement for each of the given queries:

Product (ProductID, ProductName, Weight, Price, StyleID, YearOfManufacture)

Style (StyleID, Designer, BrandName)

i. List the name and price of all products manufactured after 2018 whose brand is Gucci. **[3 Marks]**

ii. List ID of each style together with the number of products with price greater than 100. **[4 Marks]**

iii. For every style, list the number of products with price less than the average price of all products. Order your results (in increasing order) according to the StyleID. **[5 Marks]**

End of Section C **continued**