FACULTY OF SCIENCE

ACADEMY OF COMPUTER SCIENCE AND SOFTWARE ENGINEERING

MODULE	**COMPUTER SCIENCE 3B** CSC3B
CAMPUS	AUCKLAND PARK CAMPUS (APK)
SUPPLEMENTARY EXAM	JANUARY 2021
DATE: 2021-01	**SESSION:** Normal
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MODERATOR:	**EXTERNAL: MR. J. PRINSLOO (NWU)**
DURATION: 180 MINUTES	**MARKS:** 150

Please read the following instructions carefully:

1. You are not allowed to assist or gain assistance from anyone during the assessment.
2. Complete the **Honesty Declaration: Online Assessment** and submit it.
3. If you **do not have access to a computer** then you can do a pen and paper submission. Write legibly and use CamScanner to create a PDF.
4. No communication concering this test is permissible during the assessment session except with **ACSSE** staff members.
5. Answer each of the five main questions in its own pdf document.
6. Upload each pdf document seperately to eve.
7. This paper consists of **7** pages (**10** questions).

QUESTION 1: Operating Systems - General

(a) **Discuss** how ***multithreaded*** *processors* differ from ***multi-core*** *processors*? **[04]**

(b) **Discuss** the ***memory hierarchy*** found in a *computer*. Your discussion must include access times and capacity as well as why this concept is important to programmers. You may use diagrams to aid in your discussion. **[04]**

(c) **State** whether the following instructions should be run in ***user mode*** or ***kernel mode***.

i. Disable all interrupts **[01]**

ii. Read the time of day clock **[01]**

iii. Set the time of day clock **[01]**

iv. Change the memory map **[01]**

(d) **Name** the three (3) *groups* of ***system calls***. **[03]**

Total: 15

QUESTION 2: Processes and Threads

(a) **List** two (2) *events* that result in ***process creation*** **[02]**

(b) **Describe** the ***concept of pseudoparallelism***. **[02]**

(c) **Discuss** ***monitors***, ***semaphores***, and ***locking variables*** as *methods of synchronisation*. **[06]**

(d) Consider the following processes in a *preemtive* system (Highest priority = 0): **[05]**

Process	Priority	Burst Time (msec)
A	1	3
B	0	6
C	1	12
D	2	14

Using the ***priority scheduling with priority decrease*** algorithm with a `5 msec` quanta provide the order execution in the following format (copy and complete the table into your answer sheet):

Time Spent	...	...
Process	...	...
Priority when run	...	...

Total: 15

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QUESTION 3: Memory Management

(a) Given a fictional CPU. **Determine the 7-bit physical memory address in decimal** for the following 8-bit virtual address, given the following page table. **[06]**

Virtual address: 227.

Index	Page Frame	Present
7	01	1
6	00	1
5	00	0
4	00	0
3	10	1
2	00	0
1	00	0
0	01	1

Show all the steps from converting from decimal to binary and then from looking up the address to converting back from binary to decimal.

(b) A computer has four page frames. The time of loading, time of last access and the R and M bits for each page are shown below:

Pages	Loaded	Last ref.	R	M
A	173	340	1	1
B	188	213	0	1
C	126	362	1	0
D	210	295	0	0

Answer the following in context of page replacement algorithms.

i. Which page will Not Recently Used (NRU) replace? **[01]**

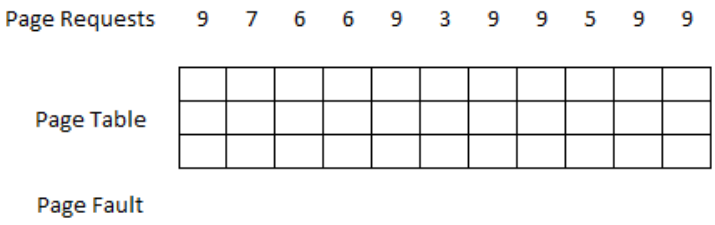
ii. Which page will First In First Out (FIFO) replace? **[01]**

iii. Which page will Least Recently Used (LRU) replace? **[01]**

iv. Which page will second chance replace? **[01]**

(c) The following diagram shows a page table with three entries. The diagram further describes a sequence of requests for pages. **Redraw** the diagram on your answer sheet and indicate how pages are paged into and out of the page table given the ***FIFO*** page replacement algorithm for each request in the sequence. **[05]**

Clearly indicate the number of page faults and where they occur.



Total: 15

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QUESTION 4: File System

(a) Given the command prompt below, **answer** the following questions:

```
E:\Reports>tree \ /F
Folder PATH listing for volume SYSRCD603
Volume serial number is 269A-47DE
E:\
├──Reports
│       Summary.docx
│
└──Data
    ├──2020
    │       Infect.dat
    │
    └──2019
```

i. **Provide** the *absolute path* for the ***working directory***. **[02]**

ii. **Provide** the *relative path name* for the file called `Infect.dat` from the current working directory **[02]**

(b) Answer the following questions, given the following directory and file allocation table (FAT).

File Name	Starting Block
.	1
..	15
File A	3
File B	12
File C	7

Table 1: Directory

0	FREE	11	EOF
1	EOF	12	9
2	10	13	FREE
3	19	14	EOF
4	2	15	EOF
5	8	16	FREE
6	FREE	17	FREE
7	11	18	FREE
8	EOF	19	5
9	4	20	FREE
10	14	21	FREE

Table 2: File Allocation Table

i. **Name** the block number of the current working directory. **[01]**

ii. **Name** the block number of the parent directory. **[01]**

iii. **List** the blocks that stores the content of File . **[02]**

iv. **Draw** and i-node representation for File B **[03]**

(c) You have been asked to help configure a server. The server will store a mixture of both large database files and small system files. Taking into consideration block sizes, data rates and disk utilisation, **describe** how you will format the hard disk volumes on the server. **[04]**

Total: 15

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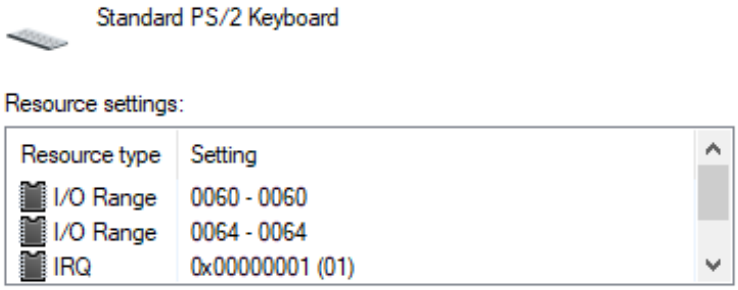
QUESTION 5: Input/Output

(a) The following picture describes the resources used by the PS/2 Keyboard. Answer the following questions related to this resource



i. **Name** the approach the CPU can use to interface with the control registers and data buffers of the keyboard **[01]**

ii. **Write** a realistic assembly instruction that will be able to read from one of the two ports. **[01]**

iii. **Discuss** three disadvantages of the methods depicted in this scenario **[03]**

(b) The image displayed in Question 5(a) shows an IRQ as one of the resources available to a PS/2 Keyboard. **[05]**
Discuss the fundamental method used by the code to perform I/O. Include in your discussion the following aspects:

- The name of the fundamental method.
- The CPUs involvement in the method.
- One advantage of the method.
- One disadvantage of the method.

(c) **Discuss** the problem of an input buffer in a user process. Include in your discussion the following aspects: **[05]**

- What problems can occur with only an input buffer in a user process.
- A possible solution to this problem and why the solution will solve the problem.

(d) On an imaginary disk with 40 cylinders a request comes in to read cylinder 14. While the hard disk is busy servicing the request on cylinder 14, requests to the following cylinders come in: ***21,19,1,40,36***. Given these cylinders, if the operating system uses the ***elevator*** algorithm, **write** the order in which the cylinders will be serviced. **[02]**

The directional bit for the elevator algorithm is currently set to **0**, which indicates an **downwards** (descending) direction.

Write only the cylinder numbers in order of service.

(Example if you think it will be cylinder 1 then 2 then 3 etc, write 1 2 3).

(e) **Describe** how the keyboard software interprets the fact that a '@'-key has been pressed by the user. **[03]**

Total: 20

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QUESTION 6: Deadlocks

(a) **Draw** a ***resource allocation graph*** for the following states **and** specify whether the system is in a deadlock: **[04]**

- Process A holds 1 and requests 2
- Process B holds 2 and 3 and requests 4

(b) Consider the following resource matrices and vectors (E - existing resources, A - available resources): **[05]**

	Printers	DVD Roms	Scanners	Tape Drives
E = (	5	3	6	3)

	Printers	DVD Roms	Scanners	Tape Drives
A = (	2	1	0	0)

Current allocation matrix

Process 1	1	1	4	1
Process 2 C =	2	0	1	1
Process 3	0	1	1	1

Request matrix

	2	1	0	0
R =	1	1	4	0
	5	0	5	0

Use the deadlock detection algorithm to determine if the current state is in a deadlock. For each round of the algorithm provide the available resource vector (A vector).

After the final round of the algorithm state whether system is **deadlocked or not**.

(c) **Discuss** two (2) solutions for deadlock preventions. Include in your discussion the following aspects: **[06]**

- A description of the prevention technique.
- A realistic example that implements the technique.

Total: 15

QUESTION 7: Virtualization and MPS

(a) You have been employed at a small insurance organisation. Part of your job responsibility is to develop software that can work on multiple operating systems. You require a testing environment that you can easily start on your development server. Your development server runs Windows Server 2018. **[05]**

Name the hypervisor type (Type-1 or Type-2) and **motivate** why you have chosen the hypervisor type for the test server.

(b) You have noticed that a number of the hardware servers at one of your clients are using NUMA architectures. Your line manager would like to know more about NUMA and how your software can make user of NUMA architectures. **[06]**

Discuss NUMA architecture. Include in your discussion the following aspects related to the above scenario.

- Why server hardware may require a NUMA architecture.
- Comment on whether you need to do anything specific in the application software to ensure it continues running on NUMA architecture.
- Comment on whether you can build in extra features if you make your software NUMA-aware

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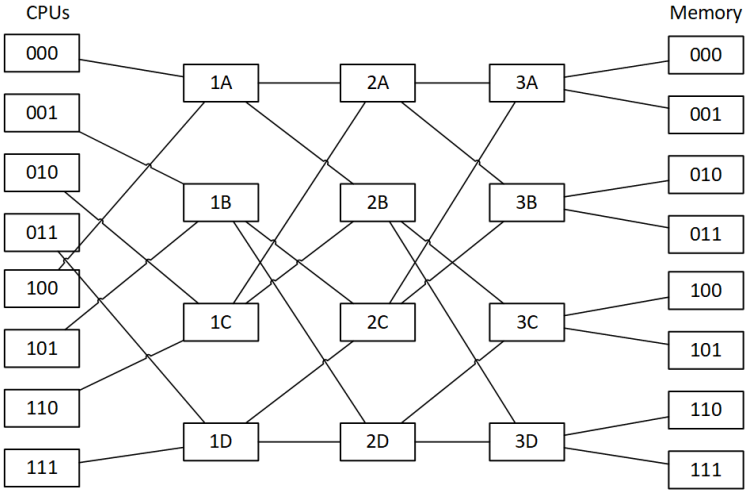
(c) Given the following ***omega switching network*** answer the questions which follow:



i. **Which** switches will be accessed when CPU 110 needs to access Memory 111. **[01]**

ii. **Which** switches will be accessed when CPU 100 needs to access Memory 000. **[01]**

iii. Can the request in (i) and (ii) be simultaneously processed? Justify your answer. **[02]**

Total: 15

QUESTION 8: Security

(a) **Name** an example of an attack or that threatens each of the following security goals of an operating system desing:

i. Confidentiality **[02]**

ii. Integrity **[02]**

iii. Availability **[02]**

(b) Given the following protection matrix. **List** the ***capability lists (C-List)*** for users on the databases. **[02]**

	PracMarks_DB	ExamMarks_DB	FinalMarks_DB
Lecturer	Read and Write		Read
HOD	Read	Read	Read

(c) Given the following mono alphabetic substitution cipher, and cipher text. **Provide** the plain text for the following cipher text. **[02]**

Key: A -> H **Cipher text**: mpupzo

Total: 10

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QUESTION 9: 80x86 Theory

(a) **Discuss** how ***division*** is handled when using *CPU arithmetic* in 80x86 assembly. Your discussion must include instructions used, the registers that are affected, the data types involved and procedure followed. **[05]**

(b) **Draw** the stack as it will exist after the following function in the **C** programming language is called (after the stack frame is set up). The function contains local variables. **[05]**

```c
void add(int* destination, int* source)
{
  int tau = 3;
  int rat = 66;
}
```

(c) **Show** the conversion of 48.125_{10} into ***IEEE Single-Precision Representation***. Show *all the steps of your calculation* and show the final result as a *hexadecimal number*. **[05]**

Total: 15

QUESTION 10: 80x86 Cold code

Write an 80x86 assembly program that contains the following function:

```
.386
.MODEL flat
.STACK 4096
ExitProcess PROTO NEAR32 stdcall, dwExitCode : DWORD
.DATA
  ; code omitted
.CODE
  ; function code here
_start:
  ; code omitted
PUBLIC start
END
```

A iterative ***paws*** function that takes the following parameters:

`arrRef` array address
`size` array length

The function will subtract each element in the array by 5. The function operates iteratively.

Note: The function must make use of iteration. (If you provide a solution that does not use iteration you will not be eligible for the full allocation of marks)

Total: 15

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