THE UNIVERSITY OF ADELAIDE
AUSTRALIA

The University of Adelaide

Examination for
Bachelor of Computer Science
Graduate Diploma in Computer Science

Supplementary Examination, [redacted]

Operating Systems
COMPSCI 3004, 7064

Official Reading Time:	10 mins
Writing Time:	120 mins
Total Duration:	130 mins

Questions	Time	Marks
Answer all 6 questions	120 mins	120 marks 120 Total

Instructions

- Begin each answer on a new page
- Examination material must not be removed from the examination room

Materials

- 1 Blue book
- Foreign Language Dictionaries are Permitted

DO NOT COMMENCE WRITING UNTIL INSTRUCTED TO DO SO

Processes & Threads

Question 1

(a) Explain the difference between a *process* and a *thread*.

[4 marks]

(b) Name, and briefly describe, two interprocess communication mechanisms.

[5 marks]

(c) How does an operating system prevent one process from writing to memory used by another process?

[3 marks]

(d) What is meant by the term *system call*? Give one example.

[3 marks]

(e) Is time slicing necessary in a multi-processor system? Explain.

[3 marks]

[Total for Question 1: 18 marks]

CPU Scheduling

Question 2

(a) Briefly explain why it is desirable for a CPU scheduler's dispatch latency to be very much less than the CPU burst time in a system with premptive multitasking?

[1 mark]

(b) Describe the process involved in switching context from one process to another in a multitasking system.

[3 marks]

(c) Consider the following table of processeses and their corresponding arrival time and burst times:

Process	Arrival time	Burst time
P1	0	8
P2	2	3
P3	4	2
P4	5	4

Now, answer the following questions.

i. Calculate the average waiting time for the processes above using *non-pre-emptive* shortest job first scheduling. Show your working.

[5 marks]

ii. Calculate the average waiting time for the process above using *pre-emptive* shortest job first scheduling. Show your working.

[6 marks]

(d) One challenge for pre-emptive shortest job first scheduling is accurately predicting CPU burst times.

Name one other disadvantage of pre-emptive shortest job first sheduling? Briefly describe one way this disadvantage could be overcome.

[2 marks]

[Total for Question 2: 17 marks]

Process Synchronisation

Question 3

(a) Explain, using an example, the term *race condition*.

[4 marks]

(b) Give two reasons why interrupt disabling is not a good strategy to provide mutual exclusion.

[4 marks]

(c) Name, and briefly describe, the requirements that a solution to the critical-section problem must satisfy.

[3 marks]

(d) Consider the following variable definitions:

```
semaphore s1 = 0
semaphore s2 = 1
int x = 3
```

And the following pieces of code:

signal is equivalent to post

Thread A	Thread B	Thread C
`wait(s2)`	`wait(s1)`	`wait(s1)`
`x = 3`	`wait(s2)`	`wait(s2)`
`signal(s2)`	`x = x + 1`	`x = x * 2`
`signal(s1)`	`print x`	`print x`
`signal(s1)`	`signal(s2)`	`signal(s2)`

Show all possible outputs that could be produced by this program. Explain your reasoning.

[5 marks]

[Total for Question 3: 16 marks]

Input/Output

Question 4

(a) Describe the steps of the process by which a direct memory access transfer (DMA transfer) from disk to memory can take place.

[6 marks]

(b) Name two types of locality of reference. Explain how these types of locality can be used to speed access to disk.

[4 marks]

(c) Deadlock prevention and deadlock recovery are two strategies which may be adopted by an operating system to deal with deadlock. Compare and contrast these two methods.

[5 marks]

[Total for Question 4: 15 marks]

Memory Management

Question 5

(a) Describe how *first-fit* allocation works. Name and very briefly describe two alternatives to worst fit.

[4 marks]

(b) Is it possible to get internal fragmentation with first-fit allocation? Briefly justify your answer.

[2 marks]

(c) A machine has 32 bit virtual and physical addresses. The page size is 4K bytes. Here is the TLB:

Page number	Frame number
0x00719	0x00030
0x00208	0x0070a
0x00041	0x00032
0x00104	0x00484

What physical address corresponds to the virtual address 0x002084f0?

[4 marks]

(d) In a paging system the following page accesses are recorded in a page reference string:

1, 2, 5, 6, 1, 3, 5, 2, 4, 7, 5, 7, 5, 2, 4, 5, 7, 2, 4, 7, 8, 7, 2, 9, 5

How many page faults would occur under FIFO replacement and Optimal replacement assuming the physical memory has 4 frames? Show your working.

[8 marks]

(e) Briefly describe two ways to keep track of least recently used pages for an LRU page replacement algorithm.

[4 marks]

(f) Briefly explain why it is useful to have a dirty bit associated with each physical page in a paged memory system.

[2 marks]

[Total for Question 5: 24 marks]

Filesystems

Question 6

(a) What is meant by the terms *relative* and *absolute* path?

[2 marks]

(b) Explain the difference between *hard links* and *soft links*.

[4 marks]

(c) Explain why ext2 uses multiple block groups.

[4 marks]

(d) What is the complexity, in big-O notation, of performing a logical-to-physical block mapping in an i-node based filesystem? Explain why.

[2 marks]

(e) Consider a file system with a capacity of 16 blocks, which uses a bit map to keep track of free blocks. The following sequence of operations is performed on a newly initialised filesystem:

1. Create file A, initially containing 2 blocks
2. Create file B, initially containing 2 blocks
3. Create file C, initially containing 3 blocks
4. Append 3 blocks to A
5. Append 2 blocks to B
6. Append 4 blocks to C
7. Delete file B

Show the state of the bitmap after operations 3, 6, and 7. You may optionally annotate each bit with the file it is associated with it, but you must show the bits themselves.

[8 marks]

(f) You are designing a file system for a facility in which some files that need to be stored are very large, up to 20TB in size (1TB, or terabyte, is 1000 GB).

Such files are too large to store on disc. We want to use tapes to store these files. Devices exist called tape robots that organize a large number of tape cartridges in a way that a particular tape can be brought to a tape drive. The tape drives are designed such that reading successive blocks from the tape in a streaming manner can be done rapidly and efficiently, but modifying the file once it is on tape is not permitted.

In answering the questions below, state clearly any assumptions you make.

i. How would you integrate the tape storage unit into the facility file system so that files can be referred to by users using paths, in the usual way?

[2 marks]

ii. It is necessary to store files on tapes. It is inefficient, and sometimes impossible, to allocate one file per tape. Hence, files need to be allocated across tapes, using a suitable storage allocation scheme.
Consider the storage allocation schemes that we have looked at in this course, and discuss which you consider to be the most suitable for this task: justify your choice, and explain how it might be used to allocate files to tape, under the assumption that files can be inserted into, and deleted from, the tape file system, but not modified while on tape.

[6 marks]

iii. As noted above, a file in the tape file system cannot be modified. It is only disc-based files that can be modified. However, some users have programs that access and change the files; these programs access files through standard path-based file naming.
Outline informally a file management strategy that would allow tape-based files to be used by such programs.

[2 marks]

[Total for Question 6: 30 marks]

End of exam