THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

This exam paper must not be removed from the venue

Venue								
Seat Number								
Student Number								
Family Name								
First Name								

School of Electrical Engineering & Computer Science

Semester Two Examinations, 2023

COMP3301 Operating Systems Architecture

This paper is for St Lucia Campus students.

Examination Duration: 120 minutes

Planning Time: 10 minutes

Exam Conditions:

•This is a Closed Book examination - no written materials permitted
•Casio FX82 series or UQ approved and labelled calculator only
•During Planning Time - Students are encouraged to review and plan responses to the exam questions
•This examination paper will be released to the Library

Materials Permitted in the Exam Venue:
(No electronic aids are permitted e.g. laptops, phones)

None

Materials to be supplied to Students:
Additional exam materials (e.g. answer booklets, rough paper) will be provided upon request.

None

Instructions to Students:
If you believe there is missing or incorrect information impacting your ability to answer any question, please state this when writing your answer.
Answer all questions.
Answer questions in the spaces provided on the exam paper.
Total 120 Marks

For Examiner Use Only

Question	Mark
1	
2	
3	
4	
5	
6	

Total _____

Question 1. (20 marks)

Calculate performance metrics for various process schedulers.

All of the schedulers are pre-emptive – a process is pre-empted as soon as a higher priority process appears. The larger the priority number, the higher the priority level.

In the following tables, times are all in milliseconds.
Assume processes do not stall for I/O. Ignore scheduler delays.
The CPU time of aborted processes is included in CPU utilisation.

(a) Complete the following tables for a Round Robin (RR) Scheduler with a time quantum of 4ms.

Process Number	Arrival Time	Execution Time	Priority	Completion Time	Turnaround Time	Waiting Time
P1	0	4	1			
P2	5	5	2			
P3	6	1	2			
P4	10	4	3			
P5	13	6	4			
P6	14	4	1			

Average Waiting Time	
Average Turnaround Time	
Actual CPU Utilisation	
Average Throughput	

Process Timeline Table. Mark where a process Starts (S), Runs (R), Pauses (P), Ends (E). You can add more columns if required.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
P1																																								
P2																																							
P3																																							
P4																																							
P5																																							
P6																																							

/10

../Question 1 continued over the page

Question 1 (continued).

(b) Repeat part a) but now assume that two CPU cores (core 1 and core 2) can be used to run processes, concurrently. Complete the following tables for a Round Robin (RR) Scheduler with a time quantum of 4ms. You must consider the core affinity (core 1, core 2 or X – any core). You can assume that a process with no affinity (X) can run on any core.

Process Number	Arrival Time	Execution Time	Priority	Core Affinity	Completion Time	Turnaround Time	Waiting Time
P1	0	4	1	1			
P2	5	5	2	2			
P3	6	1	2	X			
P4	10	4	3	2			
P5	13	6	4	1			
P6	14	4	1	X			

Average Waiting Time	
Average Turnaround Time	
Actual CPU Utilisation	
Average Throughput	

Process Timeline Table (Mark where a process Starts (S), Runs (R), Pauses (P), Ends (E). You can add more columns if required.

Core 1

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
P1																																								
P5																																							
P3																																							
P6																																							

Core 2

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
P2																																								
P4																																							
P3																																							
P6																																							

/10

Total ____ / 20

Question 2. (20 marks)

Suppose that a disk drive has 2000 cylinders, numbered 0 to 1999. The disk rotates at 250 rpm. The drive is currently serving a request at cylinder 103, and the previous request was at cylinder 101. The queue of pending requests, in FIFO order, is:

201; 210; 1800; 530; 1500; 300; 1200; 655;

For each of the indicated disk scheduling algorithms (a) to (b) below, calculate the following information:

(i) Starting from the current head position, where a block has just been read, and assuming the previously read block was in cylinder 101, what is the order in which pending blocks are read?

(ii) Assume that a disk seek takes 10ms + 5 μs per cylinder. Assume that the rotational latency is 50% of the rotation time, and also assume that there are 500 blocks per track. Based on the block read order, calculate the total time to read each block (latencies + read time).

(iii) Then calculate the total time to read the 8 blocks, starting from the time the read at 103 was completed.

(a) FCFS

(i)Block Read Order:

103								
(ii)Block Read Time								
(iii) Total Time								

/5

(b) SCAN

(i)Block Read Order:

103								
(ii)Block Read Time								
(iii) Total Time								

/5

../Question 2 continued over the page

Question 2 (continued)

(c) For a magnetic disk, describe what the following terms are.

i) Read/Write Head

ii) Sector

iii) Track

iv) Cylinder

v) Spindle

/5

(d) For magnetic disk performance, write the equations to calculate the average access time and the average IO time. Use the terms: *average seek time, average latency, transfer amount, transfer rate and controller overhead*

i) Average access time = _____ + _____

ii) Average IO time = Average access time + (_____ / _____) + _____

/5

Total ____ / 20

Question 3. (20 marks)

A process accesses the following data memory pages, as seen in the table below. During each iteration, the corresponding pages are accessed, e.g. pages 0 and 1 are accessed in iteration 0.

Table showing Memory Pages Numbers accessed

Iteration 0	0	1	1	2	3
Iteration 1	1	1	2	3	5
Iteration 2	2	1	3	4	7
Iteration 3	3	1	4	5	9
Iteration 4	4	1	5	6	11

(a) At the end of iteration 2, calculate the total number of page faults generated if the First In First Out (FIFO) page replacement algorithm is used, with **i)** 3 page buffer and **ii)** 5 page buffer. Also state what the minimum buffer size is to ensure that no page faults occur.

i)

ii)

iii) minimum buffer size = _____

__/5

(b) At the end of iteration 3, calculate the total number of page faults generated if the Least Recently Used (LRU) page replacement algorithm is used, with **i)** 3 page buffer and **ii)** 5 page buffer. Also state what the minimum buffer size is to ensure that no page faults occur.

i)

ii)

iii) minimum buffer size = _____

__/5

../Question 3 continued over the page

Question 3 (continued)

(c) Describe three possible solutions to minimise the number of page faults. At least two solutions should assume no more physical memory is available.

i)

ii)

iii)

/3

(d) For memory paging, explain what happens to a 'dirty' victim frame?

/3

(e) Explain how the LRU page replacement algorithm is implemented with a counter. You must also explain how a page is replaced using the LRU page replacement counter.

/4

Total ____/ 20

Question 4. (20 marks)

(a) Give two examples of what a process can be doing in a critical section.

i)

ii)

/2

(b) Write example pseudo code for a critical section. It must use a critical, entry, exit and remainder sections.

/4

../Question 4 continued over the page

Question 4 (continued)

(c) Explain what the following critical section solutions are.

i) Mutual Exclusion

ii) Progress

iii) Bounded Waiting

/6

(d) What is an atomic instruction and list two possible operations of atomic instructions.

/6

(e) When a process enters its critical section, what hardware feature must be disabled?

/2

Total ____ / 20

Question 5 (20 marks)

(a) For the following access permissions, fill in the below access matrix. Use R for Read, W for Write, S for Switch, X for Execute, O for Owner and ** for Copy Rights.

i) When in Domain1 (D1), a user can execute object 2 (O2) and read object 1 (O1).
ii) When in Domain 2 (D2), a user can write object 1 (O1) and execute object 2 (O2).
iii) When in Domain 3 (D3), a user can read object 3 (O3) with ownership and switch to Domain 2 (D2).
iv) When in Domain 4 (D4), a user can switch to Domain 3 (D3) and copy the write permission of Object 3 (O3).
v) When in Domain 2 (D2), a user can access the printer.

Fill in spaces with answers

Object / Domain	O1	O2	O3	Printer	D1	D2	D3	D4
D1								
D2								
D3								
D4								

/10

(b) For a lock-key protection access matrix, what elements are the locks and keys used for?

/2

../Question 5 continued over the page

Question 5 (continued)

For an access matrix, describe the four special access rights, below.

i) Owner

ii) Copy Operation

iii) Control

iv) Transfer

/8

Total ____ / 20

Question 6. (20 marks)

You have been asked to design an operating system for a web based AI Chatbot called ChatHPT. ChatHPT can be used for many applications, including generating code. ChatHPT uses a large language model and requires RAID storage. ChatHPT is accessed by users via a web page interface that takes user input and returns the output. As a free service, ChatHPT must be able to service millions of users, every hour. ChatHPT is also a target for malicious users and therefore needs to ensure that only authorised users and administrators can access ChatHPT. To save power costs and to achieve carbon neutral usage, the power to run ChatHPT is supplied by solar panels and battery storage. This means that power outages can occur for short periods of time and without warning. This may cause errors in files that are used. The operating system should use multiple CPU cores for parallelism.

You can also assume the following:

- The operating systems uses multiple CPU cores for redundancy.
- Magnetic disk mass storage is used, to save cost.

For each of the indicated aspects of the operating system:

(i) Describe your suggested design alternative,

(ii) Give one other less favourable choice,

(iii) Explain two advantages of the suggested alternative compared to the less favourable choice

(a) What type of Parallelism should be used (Data vs Task)? (i) Suggested solution (ii) Less favoured alternative (iii) Two advantages of suggested solution
/5

../Question 6 continued over the page

Question 6 (continued)

(b) What type of CPU scheduler should be used?
(i) Suggested solution (ii) Less favoured alternative
(iii) Two advantages of suggested solution

/5

../Question 6 continued over the page

Question 6 (continued)

(c) What security mechanism should be used to ensure that only authorised users and administrators can have access?
(i) Suggested solution (ii) Less favoured alternative
(iii) Two advantages of suggested solution

/5

../Question 6 continued over the page

Question 6 (continued)

(d) What RAID Disk level (0 to 6) should be used?
(i) Suggested solution (ii) Less favoured alternative
(iii) Two advantages of suggested solution

/5

Total ____ / 20

BLANK PAGE FOR WORKING

END OF EXAMINATION