THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

This exam paper must not be removed from the venue

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Family Name _____
First Name _____

School of Information Technology and Electrical Engineering

EXAMINATION

Semester Two Final Examinations, 2021

COMP3301 Operating Systems Architecture

This paper is for St Lucia Campus students.

Examination Duration: 120 minutes

Reading Time: 10 minutes

Exam Conditions:

This is a Closed Book examination - no written materials permitted
Casio FX82 series or a calculator on the UQ approved list
During reading time (= 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:

None

Instructions To Students:

Additional exam materials (e.g. answer booklets, rough paper) will be provided upon request.

Answer all questions.
Answer questions in the spaces provided on the exam paper.
Total 120 Marks

For Examiner Use Only

Question	Mark

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.

In the following tables, times are all in milliseconds.
Assume processes do not stall for I/O. Ignore scheduler delays.
Processes that miss their deadline are not included in the calculation of individual and average completion time, turnaround time, waiting time or throughput. The CPU time of aborted processes is included in CPU utilisation.

(a) Complete both of the following tables for a Shortest Job First (SJF) Scheduler. (10 marks)

Process Number	Arrival Time	Execution Time	Deadline	Completion Time	Turnaround Time	Waiting Time
P1	0	5	7			
P2	5	4	10			
P3	6	3	11			
P4	10	2	14			
P5	13	1	20			
P6	14	5	25			
P7	20	3	30			

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																																							
P7																																							

../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 three following tables for a Shortest Job First (SJF) Scheduler. 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. (10 marks)

Process Number	Arrival Time	Execution Time	Deadline	Core Affinity	Completion Time	Turnaround Time	Waiting Time
P1	0	5	7	1			
P2	5	4	10	2			
P3	6	3	11	X			
P4	10	2	14	2			
P5	13	1	20	1			
P6	14	5	25	X			
P7	20	3	30	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																																							
P7																																							

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																																							
P7																																							

Question 2. (20 marks)

Suppose that a disk drive has 3000 cylinders, numbered 0 to 2999. The disk rotates at 250 rpm. The drive is currently serving a request at cylinder 303, and the previous request was at cylinder 101. The queue of pending requests, in FIFO order, is:

201; 310; 2200; 330; 1500; 300; 1200; 655;

For each of the indicated disk scheduling algorithms (a) to (d) 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 15ms + 20 μs per cylinder. Assume that the rotational latency is 50% of the rotation time, and also assume that there are 250 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 303 was completed.

(a) FCFS (5 marks)

(i)Block Read Order:

303								
(ii)Block Read Time								
(iii) Total Time								

(b) SCAN (5 marks)

(i)Block Read Order:

303								
(ii)Block Read Time								
(iii) Total Time								

../Question 2 continued over the page

Question 2 (continued)

Cylinders: 0-2999 Previous:101 Current 303
201; 310; 2200; 330; 1500; 300; 1200; 655;

(c) C-SCAN (5 marks)

(i)Block Read Order:

303								
(ii)Block Read Time								
(iii) Total Time								

(d) C-LOOK (5 marks)

(i)Block Read Order:

303								
(ii)Block Read Time								
(iii) Total Time								

Question 3. (20 marks)

The following memory pages are accessed:

7,0,1,2,0,3,0,7,2,3,0,3,0,3,2,1,2,0,1,7,0,1

(a) Calculate the number of page faults if the First In First Out (FIFO) page replacement algorithm is used, with a 3 page buffer. (5 marks)

(b) Calculate the number of page faults if the Least Recently Used (LRU) page replacement algorithm is used, with a 3 page buffer. (5 marks)

(c) Calculate the number of page faults if the Optimal page replacement algorithm is used, with a 3 page buffer. (5 marks)

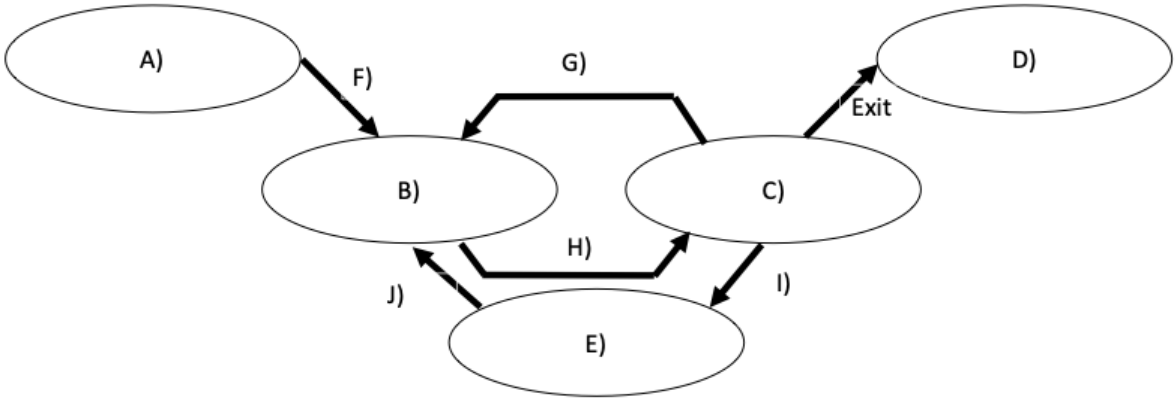
../Question 3 continued over the page

Question 3 (continued)

(d) What is demand paging? (2 marks)

(e) What is page ‘thrashing’ and how can it be avoided? (3 marks)

Question 4. (20 marks)



(a) For the Process State Machine shown above, what is represented by letters A) to J)? List each item (A to J). (10 marks)

(b) Using the previous diagram, what possible action (e.g. what c function called) will cause a process to move from state C) to E) to B). (2 marks)

../Question 4 continued over the page

Question 4 (continued)

(c) What Kernel based operation will manipulate the process state in the PCB? (2 marks)

(d) What is the difference between a job and a process (2 marks)

(e) Describe what the following Scheduler Queues do? Also state which Queue will have the longest wait time and why? (4 marks)

i) Job Queue

ii) Ready Queue

iii) IO Device Queue

Question 5 (20 marks)

(a) CPU emulation is program that emulates a CPU and Memory. Answer the following (8 marks)

i) What key element must CPU emulation represent and maintain the state of?

ii) How is memory emulated?

iii) What memory is the code loaded into?

iv) What are the loaded instructions applied to?

../Question 5 continued over the page

Question 5 (continued)

(b) Device emulation is similar to CPU emulation. If read and write register operations for devices become messages passed to a device emulator process, then what must the “read register” message contain? And what does a “write register” message contain? (4 marks)

(c) A virtual machine consists of three components: host, Virtual Machine Manager (VMM) or Hypervisor and a guest. Describe each component. (6 marks)

../Question 5 continued over the page

Question 5 (continued)

(d) What is paravirtualization? (2 marks)

Question 6. (20 marks)

You have been asked to design an operating system for a weather satellite. The weather satellite takes periodic images of the earth, using a camera (high latency, high priority, no security), infrared sensor (high latency, low priority, requires security) and a radar (low latency, high priority, no security). All the image and sensor data is periodically transmitted to an earth ground station. If transmission is not possible, then all data must be stored on the satellite. The satellite is powered by solar panels but must also operate in reduced power mode when sunlight is not available. The satellite must operate in harsh radiation and extreme temperature conditions. Harsh radiation environments can cause errors in various electronic devices such as hard drive storage. Extreme temperatures can affect the running of CPU cores. The operating system should use multiple CPU cores for parallelism.

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) (5 marks) (i) Suggested solution (ii) Less favoured alternative (iii) Two advantages of suggested solution

../Question 6 continued over the page

Question 6 (continued)

(b) Reduce deadlock and starvation of resources (e.g. transmission link). (5 marks)
(i) Suggested solution (ii) Less favoured alternative
(iii) Two advantages of suggested solution

../Question 6 continued over the page

Question 6 (continued)

(c) What security mechanism should be used to ensure that the data is only received by the intended recipient. (5 marks)
(i) Suggested solution (ii) Less favoured alternative
(iii) Two advantages of suggested solution

./Question 6 continued over the page

Question 6 (continued)

(d) RAID Disk level (0 to 6) (5 marks) (i) Suggested solution (ii) Less favoured alternative (iii) Two advantages of suggested solution

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