COMP3301: 2021 Exam solutions

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> Type answers in blue beneath each question.
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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 20/11/2023, 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	5	5	0
P2	5	4	10	9 miss	4 n/a	0 n/a
P3	6	3	11	12 9	3	0
P4	10	2	14	14 12	2	0
P5	13	1	20	15 14	1	0
P6	14	5	25	20 19	5	0
P7	20	3	30	23	3	0

Average Waiting Time	0
Average Turnaround Time	3.28ms 3.17ms
Actual CPU Utilisation	100% 91%
Average Throughput	304 jobs/second 260 job/s

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	x	x	x	x	x																																		
P2						x	x	x	x																														
P3										x	x	x																											

P4																																		
P5																																	
P6																																	
P7																																	

../Question 1 continued over the page

Since at 6 seconds when P3 arrives the job P2 now only has 3 seconds left to execute?

My answer had P2 miss. When P3 arrives it has a shorter initial execution time, but a longer remaining execution, so P2 is made to wait for P3. My understanding of a Shortest Job First scheduler was that only the initial execution time is compared? Otherwise it is a Shortest Remaining Job First scheduler?

Yeah that makes more sense I think I wasn't sure.

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	5	5	0
P2	5	4	10	2	9	4	0
P3	6	3	11	X	9	3	0
P4	10	2	14	2	12	2	0
P5	13	1	20	1	14	1	0
P6	14	5	25	X	19	5	0
P7	20	3	30	X	23	3	0

Average Waiting Time	0ms
Average Turnaround Time	3.29ms
Actual CPU Utilisation	50%
Average Throughput	304 job/s

Unsure about CPU Utilisation

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: +1

303	201	310	2200	330	1500	300	1200	655
(ii)Block Read Time								
	138	138.14	173.76	173.36	159.36	159.96	153.96	146.86
(iii) Total Time 1243.4ms = 1.24 seconds								

250 rpm = 1/250 minute per rotation * 60 sec p min * 1000 ms p sec = 240ms/rotation
Rotational latency = 50% 240ms = 120ms
Block read = 240 ms rot / 250 = 0.96 ms/block read time.

I.e. 303 to 201 = 102 cylinders. Block read time = 15ms + 0.02(102) + 120ms + 0.96ms = 138ms

(b) SCAN (5 marks) (i)Block
Read Order: +1

303	310	330	655	1200	1500	2200	->2999->300	201
(ii)Block Read Time								
	136.1	136.36	142.46	146.86	141.96	149.96	205.92	137.94
(iii) Total Time 1197.56ms = 1.19s								

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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: +1

303	310	330	655	1200	1500	2200	->2999->0->201	300
(ii)Block Read Time								
	136.1	136.36	142.46	146.86	141.96	149.96	215.94	137.94
(iii) Total Time 1207.58 =1.2s								

(d) C-LOOK (5 marks)

(i)Block Read Order: +1

303	310	330	655	1200	1500	2200	201	300
(ii)Block Read Time								
	136.1	136.36	142.46	146.86	141.96	149.96	175.94	137.94
(iii) Total Time 1167.58 = 1.16s								

Question 3. (20 marks)

The following memory pages are accessed：

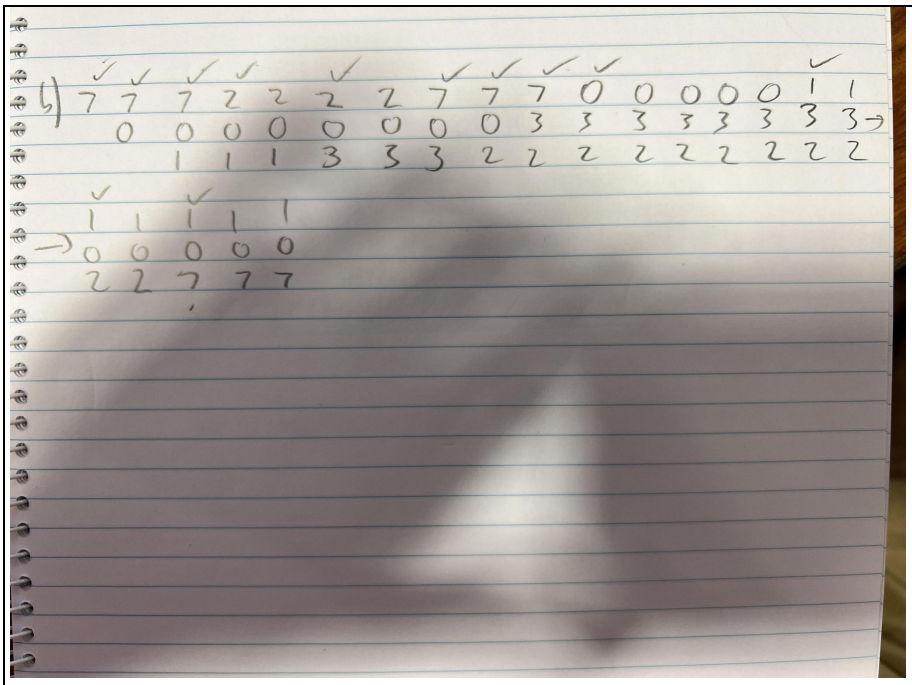
7,0,1,2,0,3,0,7,2,3,0,3,0,3,2,1,2,0,1,7,0,1

(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)

15? +2

(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)

12? +2



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

8 +2

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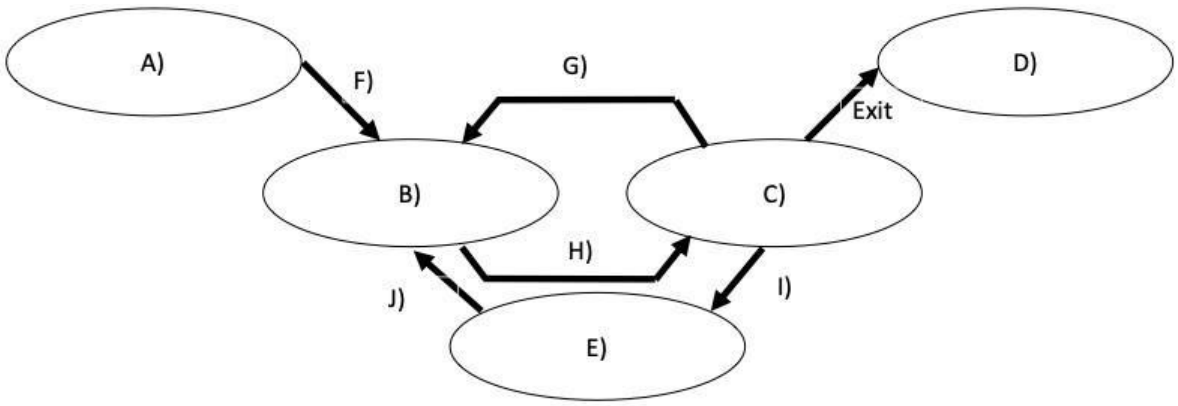
Question 3 (continued)

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

Demand paging is where the OS only brings pages into memory when they are required, otherwise they remain on mass storage.

(e) What is page 'thrashing' and how can it be avoided? (3 marks) **Question 4. (20 marks)**

Page thrashing is where the system is constantly having page faults and the overhead of having to swap pages is too high. This can be avoided by increasing the size of the page buffer.



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

A = New
B = Ready
C = Running
D = Terminated
E = Waiting
F = admitted
G = Interrupt
H = Scheduler Dispatch
I = IO/event wait
J = IO/event complete

(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)

Tsleep will wait until “wakeup” is called on a specific variable.

../Question 4 continued over the page

Question 4 (continued)

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

A context switch

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

A job is something that is required to be done whereas a process is the actual execution of a job.

(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

The job queue stores jobs which the OS is required to execute next

ii) Ready Queue

Stores all processes which are ready to be executed by the OS next

iii) IO Device Queue

IO information which is incoming or outgoing to a device. This one will have the longest wait time as it requires the transport of data to the device and back.

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?

CPU emulation is emulated as a data structure and must represent and maintain the state of the registers

ii) How is memory emulated?

Memory is emulated by assigning memory with bound checks

iii) What memory is the code loaded into?

Virtual memory

iv) What are the loaded instructions applied to?

The loaded instructions are applied to the data structure which stores the emulated CPU

../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)

The read register must contain an address and produce a value to store in the CPU registers. The write register must store an address and a value

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

Host is the native operating system of the computer and is the actual computer upon which all other VMS are launched. The Hypervisor is a program which generates,manages and controls the VMs on a host. Guest is an OS in a VM which is running atop a host

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Question 5 (continued)

(d) What is paravirtualization? (2 marks)

Paravirtualization is where the OS is modified to work in conjunction with a VMM to increase the efficiency. It allows VMS to have an interface similar to the underlying hardware

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.

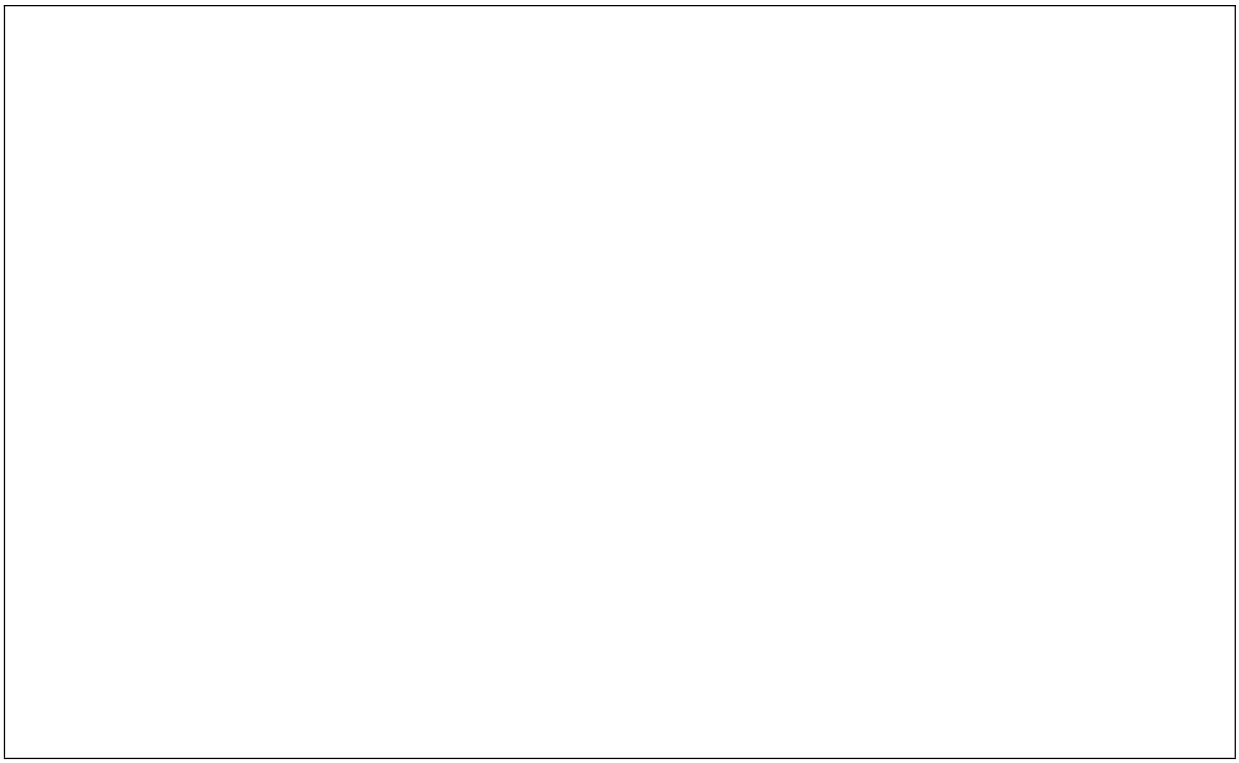
For each of the indicated aspects of the operating system:

(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
i)Data ii) Task iii) Data is more favourable as it allows all the data from the different sensors to be distributed over the different processors. This means that the data from each sensor can be processed quicker as opposed to the task parallelism which would do it for each task



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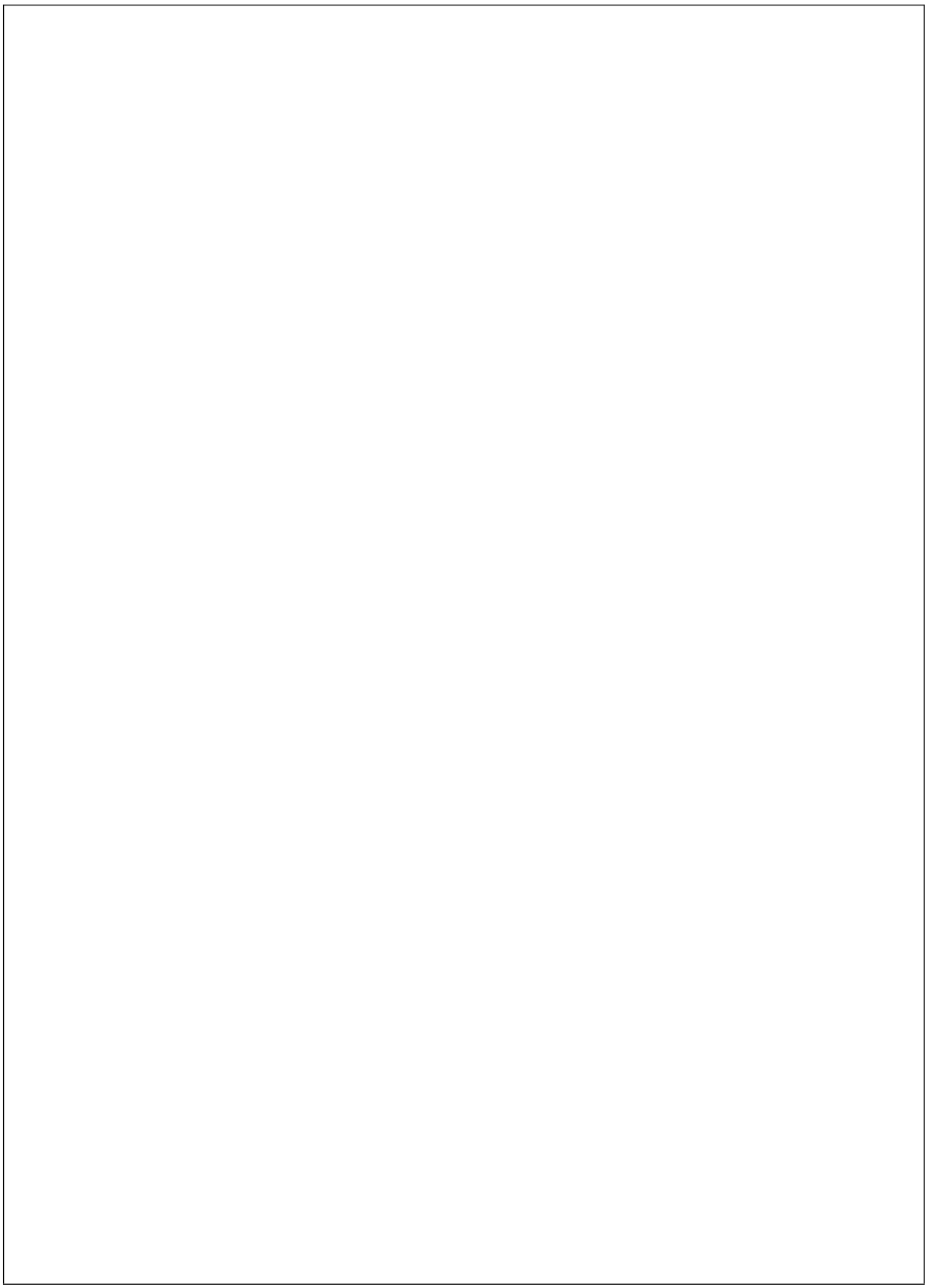
(b) Reduce deadlock and starvation of resources (e.g. transmission link). (5 marks)
(i) Suggested solution (ii) Less favoured alternative
(iii) Two advantages of suggested solution

i)resource preemption ii)process termination iii) Resource preemption is better in this case as it will release resources until a deadlock is removed which will prevent resource starvation?

../Question 6 continued over the page

(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

i) Public key encryption of data ii) digital signature iii) Public key encryption of the data can be used to ensure that only the intended recipient receives the data. By encrypting it with the recipients public key only the recipient will be able to see the data by decrypting it with it's private key. A digital signature is only able to detect whether the data has been modified and therefore does not prevent an attacker from seeing the data.



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

i) RAID 6 ii) RAID 1.
iii) RAID 6 has parity error bits which are great for error detection which might be caused by the extreme temperatures. RAID 1 does not have this error detection as it only mirrors the data. RAID 6 also stripes the data making it easier to access across multiple disks and it provides best parity protection in case of 2 drive crash.

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END OF EXAMINATION