Question 1

(a) **Process Synchronisation**: What three requirements must a solution to the critical-section problem satisfy?

[6 marks]

(b) What is a binary semaphore? Describe in detail its two atomic operations.

[6 marks]

(c) Illustrate with examples two different uses of a semaphore.

[6 marks]

[Total Marks for Question 1: 18 Marks]

Question 2

CPU Scheduling: The table below describes the CPU-I/O Burst cycles for processes P1, P2 and P3. Assume the processes arrived in the order P1, P2, P3, all at time 0.

Process	Priority	CPU Burst 1	I/O Burst 1	CPU Burst 2	I/O Burst 2	CPU Burst 3
P1	1	12	4	12	-	-
P2	1	2	10	2	12	3
P3	0	6	2	6	-	-

(a) Draw the Gantt chart timeline, illustrating the interleaving of processes, and calculate the average waiting time for each process under

1. a non-preemptive priority scheduling algorithm

[7 marks]

2. a *round robin* scheduling algorithm with quantum = 4.

[7 marks]

(b) Should you increase the time quantum? Explain your answer.

[4 marks]

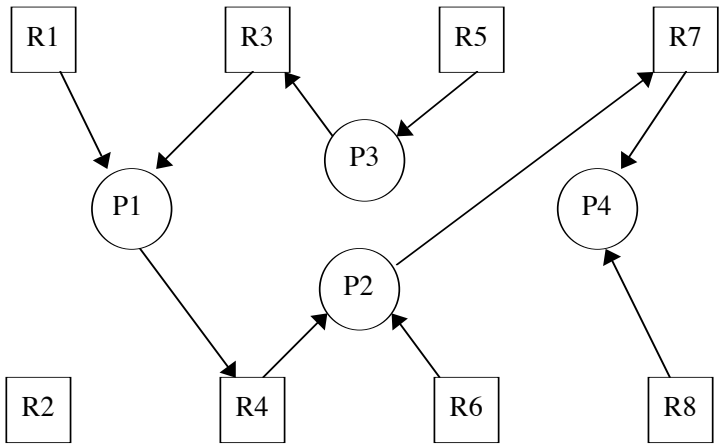
[Total Marks for Question 2: 18 Marks]

Question 3

(a) **Deadlock:** Describe two ways in which we can use resource ordering to prevent deadlock.

[5 marks]

(b) If all resources have only a single instance, we can define a deadlock detection algorithm that uses a variant of the resource-allocation graph called a *wait-for* graph. Show how this algorithm works on the following resource-allocation graph:



[4 marks]

(c) Consider the following snapshot of a system with 5 processes P_0 to P_4 and three resource types A, B and C.

	Allocation			**Request**			**Available**		
	A	B	C	A	B	C	A	B	C
P_0	0	0	1	0	3	0	0	2	1
P_1	4	2	1	0	4	3			
P_2	0	2	5	2	1	0			
P_3	0	3	0	0	0	1			
P_4	3	0	1	1	0	4			

Prove that this system is deadlocked.

[8 marks]

(d) Use the system from 3(c) to illustrate the two options for breaking the deadlock.

[3 marks]

[Total Marks for Question 3: 20 Marks]

Question 4

(a) **Disk Systems:** Consider a file currently consisting of 30 blocks. Assume we are currently at logical block 10 (the last block accessed was block 10) and the information about the file is already in memory.

Two common methods of allocating disk space are *contiguous* and *indexed* allocation. For each allocation strategy, calculate how many disk accesses are required to:

i. read logical block 22

ii. delete logical block 22

[6 marks]

(b) Can a direct access file be read sequentially? Explain your answer.

[4 Marks]

(c) What is the goal of a disk scheduling algorithm?

[2 Marks]

(d) If you are working on a new operating system, which disk scheduling algorithm would you select? Explain your answer.

[6 marks]

[Total Marks for Question 4: 18 Marks]

Question 5

(a) **Paging**: A computer system which uses byte addressing has a 46 bit virtual address space and 4 gigabytes of physical memory available for paging. Given that pages are 64 kilobytes, how many entries would there be in a normal (single level) page table?

How many entries for an inverted page table?

[3 marks]

(b) What is compaction? Explain when it is used and why.

[4 marks]

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

10, 8, 3, 7, 8, 3, 9, 10, 3, 5, 7, 10, 3, 10, 5, 7, 12, 10, 7, 5, 12

How many page faults would occur under LRU replacement, FIFO replacement and Optimal replacement assuming the physical memory has four frames?

[9 marks]

(d) Which of the above replacement algorithms would you choose to implement?

[4 Marks]

[Total Marks for Question 5: 20 Marks]

Question 6

(a) **Protection and Security**: What is the *need-to-know* principle? Why is important for a protection system to adhere to this principle?

[4 marks]

(b) Define and relate the following terms:

domain, access matrix, copy right

[6 marks]

(c) Why can it be difficult to revoke access to an object in a system using capabilities? Describe one technique to make the revocation of capabilities easier.

[3 marks]

(d) You are operating a system with password security. The passwords are stored in encrypted form in a "passwd" file. The "passwd" file is readable to anyone on the system. The encryption algorithm is publicly known. Can this system be reasonably secure? Explain your answer.

[3 marks]

[Total Marks for Question 6: 16 Marks]

Question 7

(a) Describe two types of transparency that are desirable in a distributed system.

[3 marks]

(b) Remote Procedure Calls (RPC) can be classified as having *exactly-once*, *at-most-once* and *at-least-once* semantics. Briefly describe what is meant by each of these three terms.

[4 marks]

(c) A distributed system has no shared clock. How can events in such a system be ordered?

[3 marks]

[Total Marks for Question 7: 10 Marks]

END OF EXAMINATION