Question 1

(a) **Process Synchronisation**: Briefly describe how a counting semaphore can be used to implement a monitor without condition variables.

[12 marks]

(b) Briefly describe how a monitor with condition variables can be used to implement a counting semaphore.

[12 marks]

[Total Marks for Question 1: 24 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	CPU Burst 1	I/O Burst 1	CPU Burst 2	I/O Burst 2	CPU Burst 3
P1	12	4	12	-	-
P2	2	10	2	12	3
P3	6	2	6	-	-

(a) Draw the Gantt chart timeline, illustrating the interleaving of processes, and calculate the average waiting time for each process under a *round robin* scheduling algorithm with quantum = 3.

[7 marks]

(b) Which of the above processes are CPU bound?

[2 marks]

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

[3 marks]

[Total Marks for Question 2: 12 Marks]

Question 3

(a) **Deadlock:** Name and briefly compare the three strategies to deal with deadlock.

[6 marks]

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

	Allocation			**Max**			**Available**		
	A	B	C	A	B	C	A	B	C
P_0	0	0	3	0	3	3	0	3	1
P_1	3	2	1	3	7	4			
P_2	1	2	2	1	3	8			
P_3	0	3	0	0	3	2			
P_4	1	0	1	2	0	5			

Answer the following questions using the banker's algorithm:

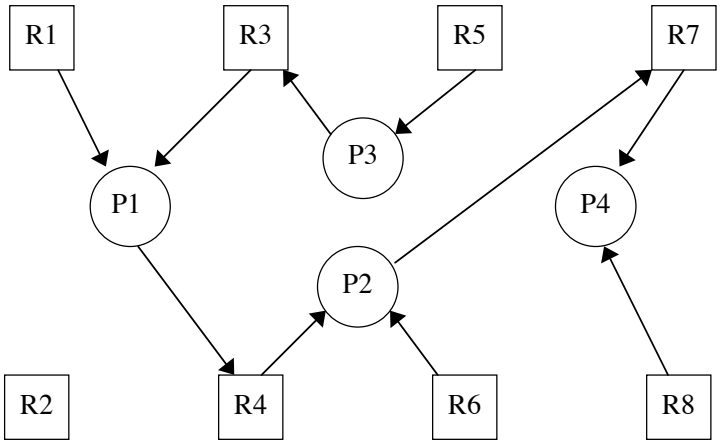
i. What is the content of the matrix *Need*?

[2 marks]

ii. Is the system in a safe state?

[8 marks]

(c) If all resources have only a single instance, we can detect deadlock by examining a variant of the resource-allocation graph called a wait-for graph. Show how this algorithm works based on the following resource-allocation graph:



[4 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 13 (the last block accessed was block 13) and the information about the file is already in memory.

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

i. read logical block 25

ii. delete logical block 25

[9 marks]

(b) Suppose I/O requests for disk tracks 36, 21, 47, 17, 52 and 61 have been submitted (in that order) and the disk arm is currently at track 40. Given that head movement costs 2 ms per track of movement, how much seek time (time spent in moving the head) is required for each of the following disk arm scheduling algorithms:

i. First come first served.

ii. Shortest seek time first.

iii Look.

[9 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 the physical memory is divided into pages of 64 kilobytes. Explain the need for a two level page-table scheme.

[4 marks]

(b) Why is the page size always in powers of 2?

[2 marks]

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

[5 marks]

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

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

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

[9 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 invalidation of capabilities easier.

[3 marks]

(d) Briefly explain what is a denial of service.

[3 marks]

[Total Marks for Question 6: 16 Marks]

Question 7

(a) Name the three actions required for a distributed system to be robust.

[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 common clock. How can we order events?

[3 marks]

[Total Marks for Question 7: 10 Marks]