

1. i) Using the Banker's Safety algorithm, determine whether or not the state is unsafe. If the state is safe, illustrate the order in which the processes may complete. Otherwise, illustrate why the state is unsafe. You must calculate the Need matrix.

	Allocation			Max			Available		
	R1	R2	R3	R1	R2	R3	R1	R2	R3
P0	2	5	0	8	5	9	10	7	7
P1	1	1	1	5	6	8			
P2	2	5	2	6	10	8			
P3	4	0	3	5	6	10			
P4	0	3	0	9	5	9			

- ii) If a request from process P3 arrives for [0, 2, 7], can the request be granted immediately? If yes then after accepting the request does the system remain in the safe state?

**Answer:** i)  $P1 \rightarrow P2 \rightarrow P3 \rightarrow P4 \rightarrow P0$

ii) Yes. If granted,  $P3 \rightarrow P4 \rightarrow P0 \rightarrow P1 \rightarrow P2$

2. i) Using the Banker's Safety algorithm, determine whether or not the state is unsafe. If the state is safe, illustrate the order in which the processes may complete. Otherwise, illustrate why the state is unsafe. You must calculate the Need matrix.

	Allocation			Max			Available		
	R1	R2	R3	R1	R2	R3	R1	R2	R3
P0	0	2	3	10	7	6	2	5	7
P1	2	3	2	6	6	5			
P2	5	4	5	7	7	7			
P3	3	2	5	5	5	7			
P4	3	2	0	6	10	6			

- ii) If a request from process P3 arrives for [0, 1, 2], can the request be granted immediately? If yes then after accepting the request does the system remain in the safe state?

**Answer:** i)  $P2 \rightarrow P3 \rightarrow P4 \rightarrow P0 \rightarrow P1$

ii) Yes. If granted,  $P2 \rightarrow P3 \rightarrow P4 \rightarrow P0 \rightarrow P1$

3. i) Using the Banker's Safety algorithm, determine whether or not the state is unsafe. If the state is safe, illustrate the order in which the processes may complete. Otherwise, illustrate why the state is unsafe. You must calculate the Need matrix.

	Allocation			Max			Available		
	R1	R2	R3	R1	R2	R3	R1	R2	R3
P0	5	1	5	10	7	7	2	9	1
P1	3	0	5	8	9	5			
P2	0	1	4	5	7	9			
P3	4	1	2	7	10	5			
P4	4	1	5	5	8	5			

ii) If a request from process P0 arrives for [2, 3, 0], can the request be granted immediately? If yes then after accepting the request does the system remain in the safe state?

**Answer:** i)  $P4 \rightarrow P0 \rightarrow P1 \rightarrow P2 \rightarrow P3$

ii) No. If approved, no safe sequence was found.

4. Consider the following resource allocation graph has:

Set of processes,  $P = \{P1, P2, P3, P4\}$

Set of resources,  $R = \{R1, R2, R3\}$

Set of edges,  $E = \{P1 \rightarrow R3, P2 \rightarrow R1, P3 \rightarrow R2, R1 \rightarrow P1, R1 \rightarrow P3, R2 \rightarrow P1, R2 \rightarrow P2, R2 \rightarrow P4, R3 \rightarrow P2, R3 \rightarrow P4\}$

- Resource type R1 has 2 instances.
- Resource type R2 has 3 instances.
- Resource type R3 has 2 instances.

Draw the resource allocation graph and explain the possibility of deadlock.

**Answer:** No deadlock.

5. Consider the following resource allocation graph has:

Set of processes,  $P = \{P1, P2, P3, P4\}$

Set of resources,  $R = \{R1, R2, R3\}$

Set of edges,  $E = \{P1 \rightarrow R2, P2 \rightarrow R3, P3 \rightarrow R3, P4 \rightarrow R2, R1 \rightarrow P1, R1 \rightarrow P3, R1 \rightarrow P4, R2 \rightarrow P2, R2 \rightarrow P3, R3 \rightarrow P1\}$

- Resource type R1 has 3 instances.
- Resource type R2 has 2 instances.
- Resource type R3 has 1 instance.

Draw the resource allocation graph and explain the possibility of deadlock.

**Answer:** Deadlock.