(1)

acquired resources table:

Process	r_1	r_2	r_3	r_4	r_5
P_1	0	1	1	1	2
P_2	0	1	0	1	0
P_3	0	0	0	0	1
P_4	2	1	0	0	0

Maximum remaining resource needs table:

Process	r_1	r_2	r_3	r_4	r_5
P_1	1	1	0	2	1
P_2	0	1	0	2	1
P_3	0	2	0	3	1
P_4	0	2	1	1	0

$E = [2, 4, 4, 4, 4]$

$A = [0, 1, 0, 2, 1]$

Step 1: release P_2

$A \pm [0, 1, 0, 1, 0] = [0, 2, 0, 3, 1]$

Step 2: release P_3

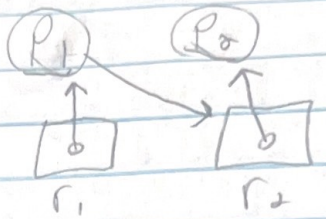
$A \pm [0, 0, 0, 0, 1] = [0, 2, 0, 3, 2]$

There is a deadlock involving P_1 and P_4
- P_1 is blocked on r_3 (requesting r_1)
- P_4 is blocked on r_1 (requesting r_3)

- r_1 and r_3 are not available resources

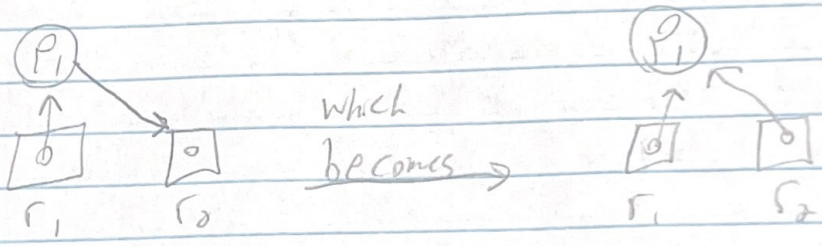
(2)

Consider the following resource allocation graph:



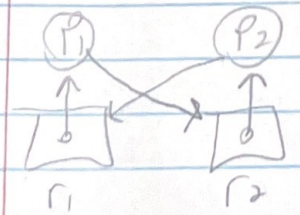
This graph represents an unsafe system, which means the graph could become a deadlocked state, but it is not deadlocked currently.

P2 is not blocked and could be released giving the following graph:



which is not a deadlocked state, as P1 is not blocked.

However, returning to the original graph, if P2 requests r1, both P1 and P2 become blocked and the system is deadlocked, as shown below



which shows the original graph to not be safe, nor deadlocked.

(3) allocated resources table:

Processes	r_1	r_2	r_3	r_4	r_5
P_1	1	0	2	1	1
P_2	2	0	1	1	0
P_3	1	1	0	1	0
P_4	1	1	1	1	0

Maximum needs table:

Processes	r_1	r_2	r_3	r_4	r_5
P_1	1	1	2	1	3
P_2	2	2	2	1	0
P_3	2	1	3	1	0
P_4	1	1	2	2	1

Maximum remaining resource needs table:

Processes	r_1	r_2	r_3	r_4	r_5
P_1	0	1	0	0	2
P_2	0	2	1	0	0
P_3	1	0	3	0	0
P_4	0	0	1	1	1

$E = [5, 2, 4+x, 5, 2]$

$A = [0, 0, x, 1, 1]$

if x=0: E = [5, 2, 4, 5, 2]
A = [0, 0, 0, 1, 1]

- no processes can be released, which results in a deadlock with all processes.

if x=1: E = [5, 2, 5, 5, 2]
A = [0, 0, 1, 1, 1]

can only release P_4

$A = [1, 1, 1, 1, 0] = [1, 1, 2, 2, 1]$

- no more processes can be released, which results in a deadlock with P_1, P_2, and P_3.

if x=2: E=[5, 2, 6, 5, 2]
A=[0, 0, 2, 1, 1]

Can only release P_4

$A \pm [1, 1, 1, 1, 0] = [1, 1, 3, 2, 1]$

Can only release P_3

$A \pm [1, 1, 0, 1, 0] = [2, 2, 3, 3, 1]$

Can only release P_2

$A \pm [2, 0, 1, 1, 0] = [4, 2, 4, 4, 1]$

No more processes can be released as P_1 requests 3 units of r_5, and there only exists 2 units of r_5.

This is shown below: