Problem 1

max - Allocat^n

Process	Allocation A	B	C	MAX Need A	B	C	Available A	B	C	Remaining A	B	C
P_1	0	1	0	7	5	3	3	3	2	7	4	3
P_2	2	0	0	3	2	2				1	2	2
P_3	3	0	2	9	0	2				6	0	0
P_4	2	1	1	4	2	2				2	1	1
P_5	0	0	2	5	3	3				5	3	1

Need matrix (Remaining Need) = Max - Allocation.

Total resources = Allocated + Available.

Initial total: A = 10, B = 5, C = 7.

P_1: Available → A : 10 - (Column of A) = 10 - (2+3+2) = 3

B : 5 - (1+1) = 3

C : 7 - (2+1+2) = 2

P_2: Remaining need [1 2 2] <= Available [3 3 2] → True → P_2 = Available [3 3 2] + Allocat^n [2 0 0]

= [5 3 2] → New available

P_3: Remaining need [6 0 0] $\cancel{<=}$ [5 3 2] ∴ go to P_4

P_4: [2 1 1] <= [5 3 2] → True → P_4 = [5 3 2] + [2 1 1]

= [7 4 3]

P_5: [5 3 1] <= [7 4 3] → True → P_5 = [7 4 3] + [0 0 2]

= [7 4 5]

P_1 $\begin{bmatrix} 7 & 4 & 3 \end{bmatrix} \leq \begin{bmatrix} 7 & 4 & 5 \end{bmatrix} \rightarrow$ True

$P_1 = \begin{bmatrix} 7 & 4 & 5 \end{bmatrix} + \begin{bmatrix} 0 & 1 & 0 \end{bmatrix}$

$= \begin{bmatrix} 7 & 5 & 5 \end{bmatrix}$

P_3 $\begin{bmatrix} 1 & 2 & 2 \end{bmatrix} \leq \begin{bmatrix} 7 & 5 & 5 \end{bmatrix} \rightarrow$ True

$P_3 = \begin{bmatrix} 7 & 5 & 5 \end{bmatrix} + \begin{bmatrix} 3 & 0 & 2 \end{bmatrix}$

$= \begin{bmatrix} 10 & 5 & 7 \end{bmatrix}$

$==$ Total

$\therefore$ Safe sequence $= \langle P_2\ P_4\ P_5\ P_1\ P_3 \rangle$

(2)

Process	Allocation A B C D	MAX Need A B C D	Available A B C D	Remaining need A B C D (max − Allocat^n)
P_0	0 0 1 2	0 0 1 2	1 5 2 0	0 0 0 0
P_1	1 0 0 0	1 7 5 0		0 7 5 0
P_2	1 3 5 4	2 3 5 6		1 0 0 2
P_3	0 6 3 2	0 6 5 2		0 0 2 0
P_4	0 0 1 4	0 6 5 6		0 6 4 2

full column (allocat^n) + Available

Total : A = 3 , B = 14 , C = 12 , D = 12

$P_0 \rightarrow$ Available $= \begin{bmatrix} 1 & 5 & 3 & 2 \end{bmatrix}$

$\begin{bmatrix} 0 & 0 & 0 & 0 \end{bmatrix} \leq \begin{bmatrix} 1 & 5 & 2 & 0 \end{bmatrix} \Rightarrow \begin{bmatrix} 1 & 5 & 2 & 0 \end{bmatrix} + \begin{bmatrix} 0 & 0 & 1 & 2 \end{bmatrix}$

$= \begin{bmatrix} 1 & 5 & 3 & 2 \end{bmatrix}$

$P_1 \rightarrow \begin{bmatrix} 1 & 5 & 3 & 2 \end{bmatrix} \cancel{\leq} \begin{bmatrix} 0 & 7 & 5 & 0 \end{bmatrix}$

$\therefore$ skip.

$\begin{bmatrix} 1 & 5 & 3 & 2 \end{bmatrix} + \begin{bmatrix} 1 & 3 & 5 & 4 \end{bmatrix}$

$P_2 \rightarrow \begin{bmatrix} 1 & 0 & 0 & 2 \end{bmatrix} \leq \begin{bmatrix} 1 & 5 & 3 & 2 \end{bmatrix} \Rightarrow \begin{bmatrix} 2 & 8 & 8 & 6 \end{bmatrix}$

$P_3 \rightarrow$ 0 0 2 0 <= 2 8 8 6

$\therefore$ New $\rightarrow$ [2 8 8 6] + [6 6 3 2]
= [2 14 11 8]

$P_4 \rightarrow$ 0 6 4 2 <= 2 14 11 8

New $\rightarrow$ [2 14 12 12].

$P_1 \rightarrow$ 0 7 5 0 <= 2 14 12 12

New $\rightarrow$ [3 14 12 12] == Total

$\therefore$ System is in safe state.
Safe seq : P_0 P_2 P_3 P_4 P_1

After New, do like prev eg.

③

		Allocation			Max need.			Available			Remaining need		
		X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z
P_0	Before	0	0	1	8	4	3	3	2	~~2~~ 0	8	4	~~2~~ 0
P_1		3	2	0	6	2	0				3	0	0
P_2		2	1	1	3	3	3				1	2	2

New

Req 1 : 0 0 2 from P_0 → 2 extra units from Z are used $\therefore$ subtract 2 from available.

$\therefore$ New allocatn = [0 0 2 + 0 0 1] = [0 0 3]

$\therefore$ [8 4 3] − [0 0 3] = [8 4 0]

New Rem. need

Allocatn

[0 0 3] <= 3 2 2

$\therefore$ New available $\Rightarrow$ [3 2 2] − [0 0 2]
= [3 2 0]

PTO

New need matrix.

$$\begin{bmatrix} 8 & 4 & 0 \\ 3 & 0 & 0 \\ 1 & 2 & 2 \end{bmatrix}$$

× $P_0 \rightarrow [8\ 4\ 0] \not\leq [3\ 2\ 0]$

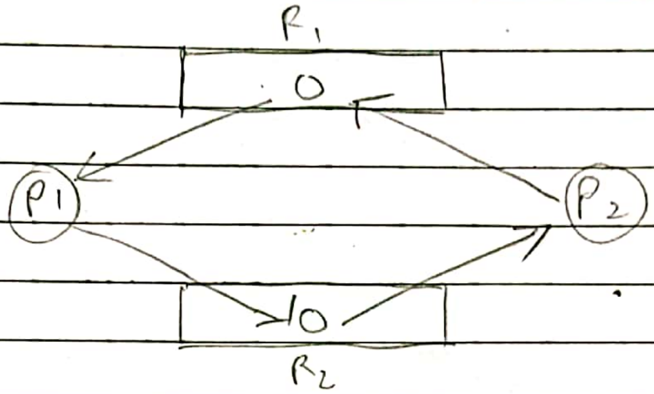
✓ $P_1 \rightarrow [3\ 0\ 0] \leq [3\ 2\ 0]$.

$\therefore$ New available: $[3\ 2\ 0] + [3\ 2\ 0]$
$= [6\ 4\ 0]$.

× $P_2 \rightarrow [1\ 2\ 2] \not\leq [6\ 4\ 0]$

× $P_0 \rightarrow [8\ 4\ 0] \not\leq [6\ 4\ 0]$

Cant satisfy both P_2, P_0
Hence not safe ; deadlock.

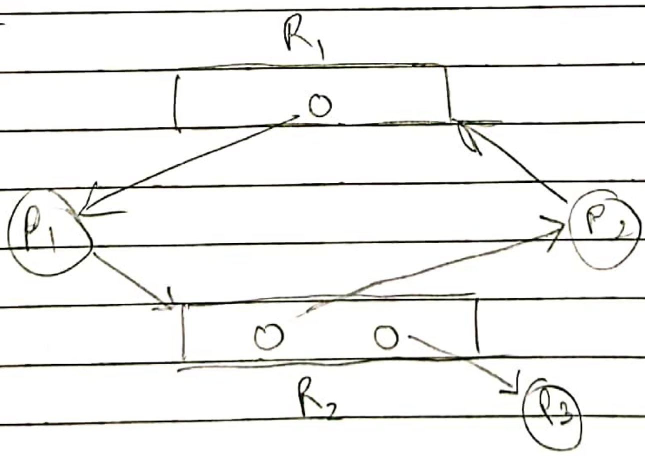


Cycle ∴ deadlock.

$[R_1 \; R_2] = [0 \; 0]$

	Allocation		Need	
	R_1	R_2	R_1	R_2
P_1	1	0	0	1
P_2	0	1	1	0

Problem 2



	Allocation		Need	
	R_1	R_2	R_1	R_2
P_1	1	0	0	1
P_2	0	1	1	0
P_3	0	1	0	0