Q1: The following matrices illustrate the situation of a computer system.

Max

	R_0	R_1	R_2	R_3
P0	3	2	1	1
P1	1	2	0	2
P2	1	1	2	0
P3	3	2	1	0
P4	2	1	0	2

Allocation

R_0	R_1	R_2	R_3
2	0	1	1
1	1	0	0
1	1	0	0
1	0	1	0
0	1	0	1

Assume that the total number of each system resource is < 10, 10, 7, 8 > where $< R_0, R_1, R_2, R_3 >$ and R_i means the amount of resource P_i .

i. What are the contents of the matrix NEED?

$NEED = Max(R_i) - Allocation(R_i)$

NEED

	R_0	R_1	R_2	R_3
P0	1	2	0	0
P1	0	1	0	2
P2	0	0	2	0
P3	2	2	0	0
P4	2	0	0	1

ii. Is the system a safe state? If yes, write a safe sequence.

$Work = Total\ Number(R_i) - Total\ Allocation(R_i)$

Work

R_0	R_1	R_2	R_3
5	7	5	6

Condition $NEED \leq WORK$

$\boldsymbol{P0}$ 1 2 0 0 $\leq$ 5 7 5 6 $\quad$ ***Yes***

$\boldsymbol{Work} = 5\ 7\ 5\ 6 + 2\ 0\ 1\ 1 = \mathbf{7\ 7\ 6\ 7}$

$\boldsymbol{P1}$ 0 1 0 2 $\leq$ 7 7 6 7 $\quad$ ***Yes***

$\boldsymbol{Work} = 7\ 7\ 6\ 7 + 1\ 1\ 0\ 0 = \mathbf{8\ 8\ 6\ 7}$

$\boldsymbol{P2}$ 0 0 2 0 $\leq$ 8 8 6 7 $\quad$ ***Yes***

$\boldsymbol{Work} = 8\ 8\ 6\ 7 + 1\ 1\ 0\ 0 = \mathbf{9\ 9\ 6\ 7}$

$\boldsymbol{P3}$ 2 2 0 0 $\leq$ 9 9 6 7 $\quad$ ***Yes***

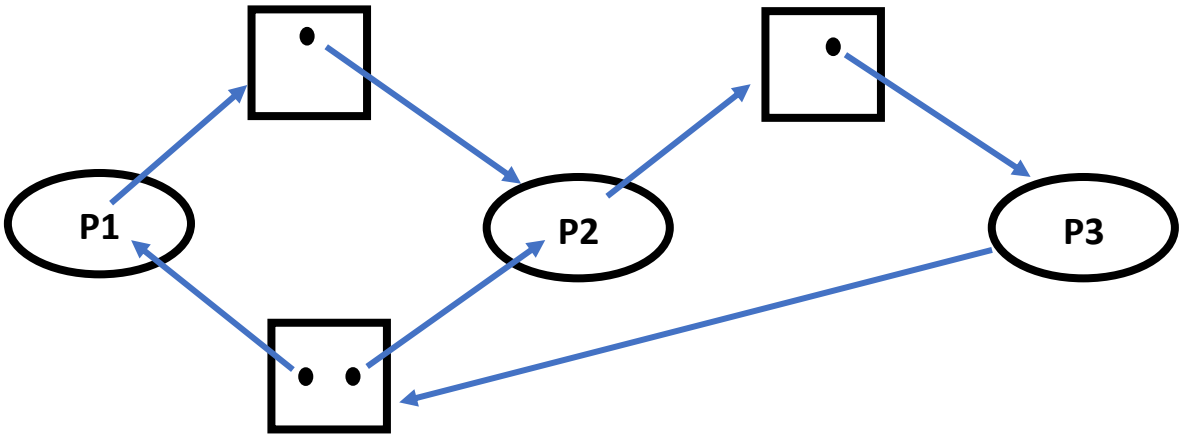
$\boldsymbol{Work} = 9\ 9\ 6\ 7 + 1\ 0\ 1\ 0 = \mathbf{10\ 9\ 7\ 7}$

$\boldsymbol{P4}$ 2 0 0 1 $\leq$ 10 9 7 7 $\quad$ ***Yes***

$\boldsymbol{Work} = 10\ 9\ 7\ 7 + 0\ 1\ 0\ 1 = \mathbf{10\ 10\ 7\ 8}$

$Safe\ State = \boldsymbol{P0, P1, P2, P3, P4}$

Q2: Referring to following figure find out whether there is deadlock in the system. If so, what are the deadlocked processes?



i. Is there deadlock in the system?

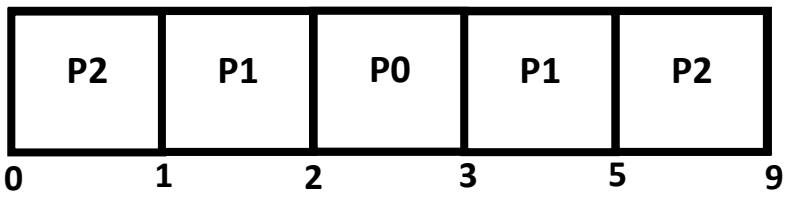
Yes, there is deadlock in the system

ii. If the answer is "Yes", the deadlocked processes are:
All Processes (P1, P2, P3)

Q3: Consider the following set of processes:

Process ID	Arrival Time	CPU Burst Time
P_0	2	1
P_1	1	3
P_2	0	5

a) Draw Gantt charts illustrating the execution of these processes using the Shortest Remaining Time First (SRTF) algorithm.



b) Based on your work above, fill in the table below giving both the **waiting time (Wait)** and **turnaround time (tat)** for each process:

Scheduling Algorithm	Parameter	Process ID		
		P0	P1	P2
SRTF	Wait	0 ms	1 ms	4 ms
	Tat	1 ms	4 ms	9 ms

Wait = (زمن الدخول) – (arrival زمن الوصول)

W(P0) = 2 – 2 = 0 ms

W(P1) = (1 – 1) + (3 – 2) = 1 ms

W(P2) = (0 – 0) + (5 – 1) = 4 ms

Turnaround time(TAT) = Exit Process – Arrival

Tat(P0) = 3 – 2 = 1 ms

Tat(P1) = 5 – 1 = 4 ms

Tat(P2) = 9 – 0 = 9 ms

c) Calculate the CPU utilization

$$CPU\ Utilization = \frac{Total\ Waiting}{Total\ Time} \times 100\%$$
$$= \frac{0+1+4}{9} \times 100\%$$
$$= \frac{5}{9} \times 100\%$$