* Numerical - 1

Process	Burst Time	Priority
P1	7	5
P2	2	1
P3	3	3
P4	1	4
P5	9	2

⇒ Processes arrived in the order P1, P2, P3, P4, P5 at time 0

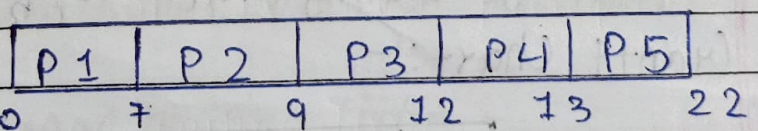
⇒ * FCFS (First Come First Serve):-

JoB	Arrival Time	Burst Time	Finish Time	Turnaround time	waiting time
P1	0	7	7	7	0
P2	0	2	9	9	7
P3	0	3	12	12	9
P4	0	1	13	13	12
P5	0	9	22	22	13

Average Turnaround Time = $\frac{63}{5}$ = **12.6**

Average Waiting Time = $\frac{41}{5}$ = **8.2**

⇒ Gantt Chart:→



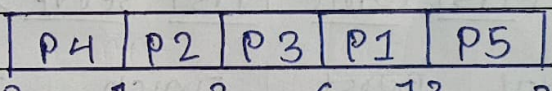
* Shortest Job First (SJF) (non-premptive) :-

Job	Arrival Time	Burst Time	Turnaround Time	Waiting Time	Finish Time
P1	0	7	13	6	13
P2	0	2	3	1	3
P3	0	3	6	3	6
P4	0	1	1	0	1
P5	0	9	22	13	22

Average Turnaround Time = $\frac{45}{5}$ = **9**

Average Waiting Time = $\frac{23}{5}$ = **4.6**

* Gantt Chart :-



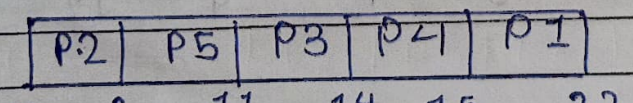
* non-premptive Priority :-

Job	Arrival Time	Burst Time	Finish Time	Turnaround Time	waiting Time
P1	0	7	22	22	15
P2	0	2	2	2	0
P3	0	3	14	14	11
P4	0	1	15	15	14
P5	0	9	11	11	2

Average Turnaround Time = $\frac{64}{5}$ = **12.8**

Average Waiting Time = 42/5 = **8.4**

* Gantt Chart :-



* Round Robin:-

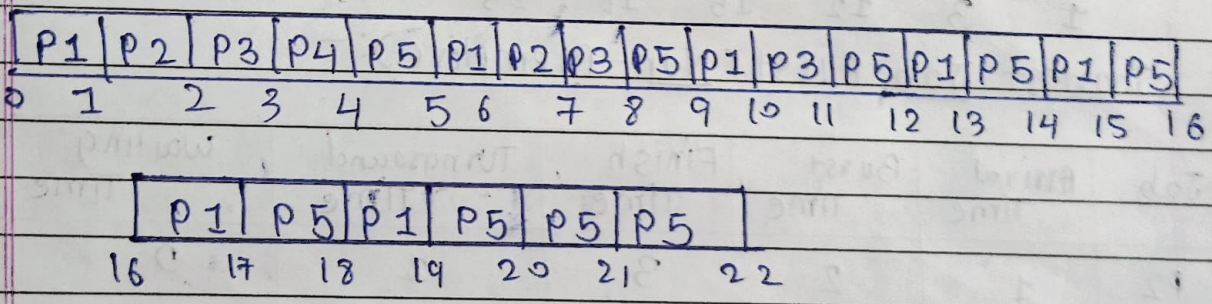
=> Time Quantum = 1.

JoB	Arrival Time	Burst Time	Turnaround Time	Waiting Time
P1	0	7	19	12
P2	0	2	7	5
P3	0	3	11	8
P4	0	1	4	3
P5	0	9	22	13

=> Average Turn Around Time = $\frac{63}{5}$ = **12.6**

=> Average Waiting Time = $\frac{41}{5}$ = **8.2**

* Gantt Chart:-



=> * Conclusion on Waiting Time:-

=> Out of all, Shortest JoB First (non-premptive) had minimal average waiting Time

* Numerical - 2 :-

* FCFS (First Come First Serve):-

Job	Arrival Time	Burst Time	Turnaround Time	Waiting Time
P2	1	2	2	0
P5	2	9	10	1
P3	3	3	12	9
P4	4	1	12	11
P1	5	7	18	11

Average Turnaround Time = $\frac{54}{5}$ = **10.8**

Average Waiting Time = $\frac{32}{5}$ = **6.4**

P2	P5	P3	P4	P1

1 3 12 15 16 23

* Shortest Job First (Non-Premptive):-

Job	Arrival Time	Burst Time	Finish Time	Turnaround Time	Waiting Time
P2	1	2	3	2	0
P5	2	9	23	21	12
P3	3	3	6	3	0
P4	4	1	7	3	2
P1	5	7	14	9	2

Average Turnaround Time = $^{38}/_{5}$ = **7.6**

Average Waiting Time = $^{16}/_{5}$ = **3.2**

~~P2 P5~~

P2	P3	P4	P1	P5

1 3 6 7 14 23

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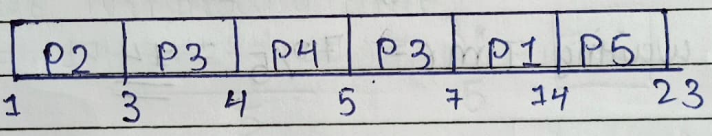
* SJF (Preemptive) :-

Job	Arrival Time	Burst Time	Finish Time	Turnaround Time	Waiting Time
P2	1	2	3	2	0
P5	2	9	23	21	12
P3	3	3	7	4	1
P4	4	1	5	1	0
P1	5	7	14	9	2

Average Turnaround Time = 37/5 = 7.4

Average waiting Time = 15/5 = 3



⇒ Out of all three FCFS, SJF (non-premptive) and SJF (Premptive), minimal average waiting time was in SJF (preemptive)

* Numerical-3:-

=> Priority

Job	Arrival Time	Burst Time	Turnaround Time	Waiting Time
P1	0	10	24	14
P2	0	2	26	24
P3	0	6	6	0
P4	0	8	14	6
P5	0	4	30	26

Average Turnaround Time in Priority

$= \frac{100}{5} = 20$

Average Waiting Time = $70/5 = 14$

* Round Robin with Time Quantum = 3 :-

Job	Arrival Time	Burst Time	Turn around Time	Waiting Time
P1	0	10	30	20
P2	0	2	5	3
P3	0	6	20	14
P4	0	8	29	21
P5	0	4	24	20

Average Turnaround Time = $\frac{108}{5} = 21.6$

Average Waiting Time = $78/5 = 15.6$

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* Numerical-4 :-

* => Round Robin with Time Quantum = 1sec

Job	Arrival Time	Burst Time	Finish Time	Turnaround Time	Waiting Time
A	1	8	18	17	9
C	2	2	5	3	1
B	4	1	6	2	1
D	5	1	8	3	2
E	6	5	17	11	6

Average Turnaround Time
$= \frac{17+3+2+3+11}{5} = \frac{36}{5} = \boxed{7.2}$

* Shortest Remaining Time First :-

Job	Arrival Time	Burst Time	Finish Time	Turnaround Time
A	1	8	18	17
C	2	2	4	2
B	4	1	5	1
D	5	1	6	1
E	6	5	11	5

Average Turnaround Time

$= \frac{17+2+1+1+5}{5} = \frac{26}{5} = \boxed{5.2}$

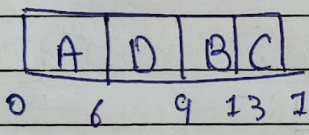
* Numerical-5

* SJF (non-preemptive):-

Job	Arrival Time	Burst Time	Finish Time	Turnaround Time	Waiting Time
A	0	6	6	6	0
B	1	4	13	12	8
C	3	5	18	15	10
D	5	3	9	4	1

Average Turnaround Time = $\frac{37}{4}$ = 9.25

Average Waiting Time = $\frac{19}{4}$ = 4.75

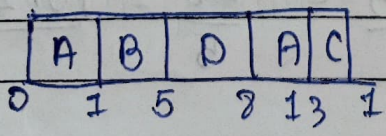


* SJF (preemptive):-

Job	Arrival Time	Burst Time	Finish Time	Turnaround Time	Waiting Time
A	0	6	13	13	7
B	1	4	5	4	0
C	3	5	18	15	10
D	5	3	8	3	0

Average Turnaround Time = 35/4 = 8.75

Average Waiting Time = 17/4 = 4.25



⇒ SJF (Preemptive) is better compared to SJF (non-preemptive) w.r.t. Turnaround Time

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* Numerical-6

* Shortest Job First (SJF) (Pre-emptive):-

Job	Arrival Time	Burst Time	Finish Time	Turnaround Time	Waiting Time
P1	0	9	32	32	23
P2	1	7	11	10	3
P3	2	6	17	15	9
P4	3	7	24	21	14
P5	4	3	7	3	0

Average Turnaround Time = $81/5 = 16.2$

Average Waiting Time = $49/5 = 9.8$

P1	P2	P5	P2	P3	P4	P1

* Round Robin with Time Quantum = 3ms

Job	Arrival Time	Burst Time	Finish Time	Turnaround Time	Waiting Time
P1	0	9	30	30	21
P2	1	7	31	30	23
P3	2	6	24	22	16
P4	3	7	32	29	22
P5	4	3	18	14	11

Average Turnaround Time = $\frac{125}{5} = 25$

Average Waiting Time = $93/5 = 18.6$

P1	P2	P3	P4	P1	P5	P2	P3	P4	P1	P2	P4

0 3 6 9 12 15 18 21 24 27 30 31 32

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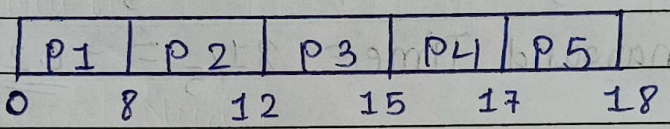
* Numerical-7

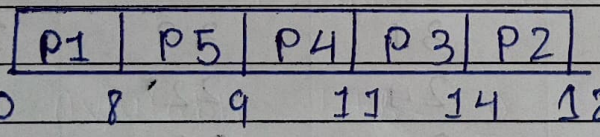
* First Come First Serve :-

Job	Arrival Time	Finish Time	Burst Time
P1	0	8	8
P2	1	12	4
P3	2	15	3
P4	3	17	2
P5	4	18	1



* Shortest Job First :-

Job	Arrival Time	Burst Time	Finish Time
P1	0	8	8
P2	1	4	18
P3	2	3	14
P4	3	2	11
P5	4	1	9



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* Round Robin with Time Quantum = 4

Job	Arrival Time	Burst Time	Finish Time	Turnaround Time	Waiting Time
P1	0	8	18	18	10
P2	1	4	8	7	3
P3	2	3	11	9	6
P4	3	2	13	10	8
P5	4	1	14	10	9

P1	P2	P3	P4	P5	P1

* Numerical - 8

* System - 1 :-

Process	Allocation	Max
1	5	6
2	4	7
3	2	6
4	0	2

Instances of Resource = 12
Available = 1

⇒ Need Matrix:-

Process	Need
P1	1
P2	3
P3	4
P4	2

⇒ Checking for deadlock:-

⇒ For P1 :→ Need ≤ AVAILABLE ⇒ 1 ≤ 1
∴ P1 will be executed

∴ Available = 1 + 5 = 6

⇒ Sequence = P1

⇒ For P2 :- Need ≤ Available ⇒ 3 ≤ 6
∴ Available = 6 + 4 = 10

⇒ Sequence = P1 → P2

⇒ For P3:- Need ≤ Available ⇒ 4 ≤ 10
∴ Available = 10 + 2 = 12
Sequence ⇒ P1 → P2 → P3

⇒ P4 is Remaining and 2 ≤ 12

∴ Sequence ⇒ P1 → P2 → P3 → P4

* System:2 :-

Process	Allocation	Max
1	5	8
2	3	9
3	4	8

Instances = 14
Available = 2

⇒ Need Matrix:-

Process	Need
1	3
2	6
3	4

* Checking for Deadlock:-

⇒ For P1 :→ Need ≥ Available ⇒ 3 ≥ 2

⇒ So, Resource cannot be allocated.

⇒ For P2 :→ Need ≥ Available ⇒ 6 ≥ 2
⇒ For P3 :→ Need ≥ Available ⇒ 4 ≥ 2

⇒ So, for all the processes, needed Resource is more than Available resource, so, deadlock will occur.

* Numerical-9 :-

Process	Allocation A B C D	Available A B C D	Max
P0	0 0 1 2	1 5 2 0	0 0 1 2
P1	1 0 0 0		1 7 5 0
P2	1 3 5 4		2 3 5 6
P3	0 6 3 2		0 6 5 2
P4	0 0 1 4		0 6 5 6

=> Need Matrix

Process	Need A B C D
P0	0 0 0 0
P1	0 7 5 0
P2	1 0 0 2
P3	0 0 2 0
P4	0 6 4 2

=> checking for deadlock :-

=> ~~Process P0 is alred~~

=> P0 is already executed as it does not need extra resources.

=> After P0, Process P3 will be executed.

=> Now, all other Processes will be executed because of surplus Resources Available.

=> So, System is in SAFE STATE.

=> For process P1 with (0,4,2) request; it will be granted if sequence => P0 -> P2 -> P3 -> P1 -> P4

* Numerical-10

=>

Process	Allocation	Max	Available
	A B C		A B C
			3 3 2
P0	0 1 0	7 5 3	
P1	2 0 0	3 2 2	
P2	3 0 2	9 0 2	
P3	2 1 1	2 2 2	
P4	0 0 2	4 3 3	

=> Need Matrix:-

Process	Need		
	A	B	C
P0	7	4	3
P1	1	2	2
P2	6	0	0
P3	0	1	1
P4	4	3	1

=> Checking for Deadlock:-

=> Process P0 will not be executed first as Available instances are less than Required

=> Proces P1:→ Need ≤ Available

∴ P1 will be granted resources.

Available Resources => ~~(3,3,2) + (3,2,2)~~

=> ~~(6, 5, 4)~~

=> (3,3,2) + (2,0,0) => (5,3,2)

Seqvence => P1

⇒ P2 will not be granted resources as Needed are more than available

⇒ For P3:→ Need ≤ Available
∴ P3 will be executed
Available = (5,3,2) + (2,1,1) = (7,4,3)

⇒ Sequence ⇒ P1 → P3

⇒ P4:→ Need ≤ Available
∴ P4 will be executed
∴ Available = (7,4,3) + (0,0,2) = (7,4,5)

⇒ Sequence ⇒ P1 → P3 → P4

⇒ Now, P0 and P2 will be executed as Available instances are greater than needed

⇒ Sequence ⇒

P1 → P3 → P4 → P0 → P2