

① Consider the following set of processes, with length of the CPU burst time given in milliseconds:

Process	Arrival Time	Burst Time	Priority
P1	0	10	3
P2	0	1	1
P3	3	2	3
P4	5	1	4
P5	10	5	2

- i) Draw four Gantt charts illustrating the execution of these processes using FCFS, SJF a non-preemptive priority and RR (Quantum=2) scheduling.
- ii) What is the turn around time of each process for each scheduling algorithm.
- iii) What is the waiting time for each process.

$$\text{Average turn around time} = \frac{\text{Sum of waiting time of individual process}}{\text{Number of processes}}$$

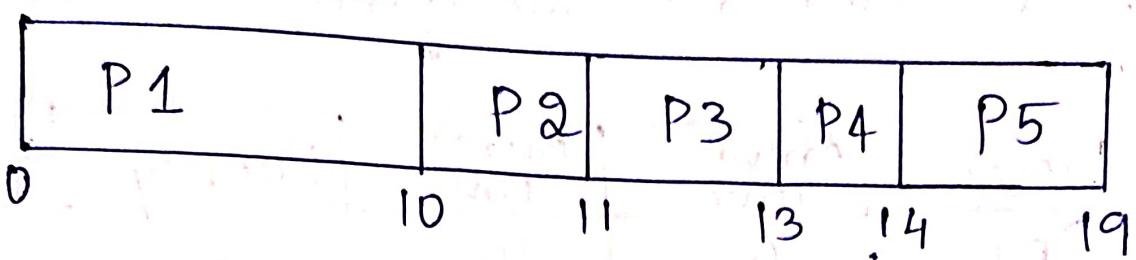
$$\text{Average waiting time} = \frac{\text{Sum of turn around time of individual process}}{\text{Number of processes.}}$$

$$TAT = CT - AT$$

$$WT = TAT - BT$$

i) FCFS

Gantt chart.



Process	Turn Around Time	Waiting Time
P1	$10 - 0 = 10$	$10 - 10 = 0$
P2	$11 - 0 = 11$	$11 - 1 = 10$
P3	$13 - 3 = 10$	$10 - 2 = 8$
P4	$14 - 5 = 9$	$9 - 1 = 8$
P5	$19 - 10 = 9$	$9 - 5 = 4$

$$\text{Avg TAT} = \frac{10 + 11 + 10 + 9 + 9}{5}$$

$$= \frac{49}{5} = 9.8 \text{ ms}$$

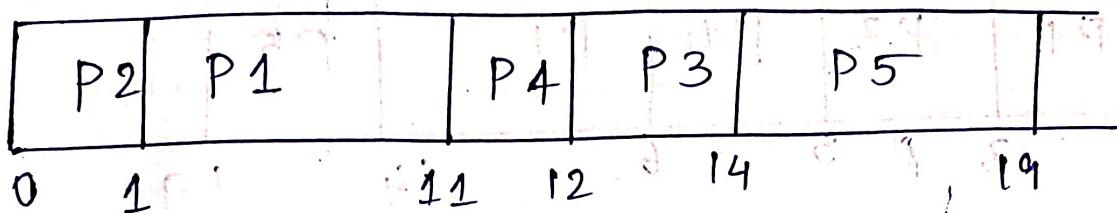
$$\text{Avg WT} = \frac{0 + 10 + 8 + 8 + 4}{5}$$

$$= \frac{30}{5} = 6 \text{ ms}$$

1) SJF

Non - Preemptive

Gantt chart



Process	Turn Around Time (TAT)	Waiting Time
P1	$11 - 0 = 11$	$11 - 10 = 1$
P2	$1 - 0 = 1$	$1 - 1 = 0$
P3	$14 - 3 = 11$	$11 - 2 = 9$
P4	$12 - 5 = 7$	$7 - 1 = 6$
P5	$19 - 10 = 9$	$9 - 5 = 4$

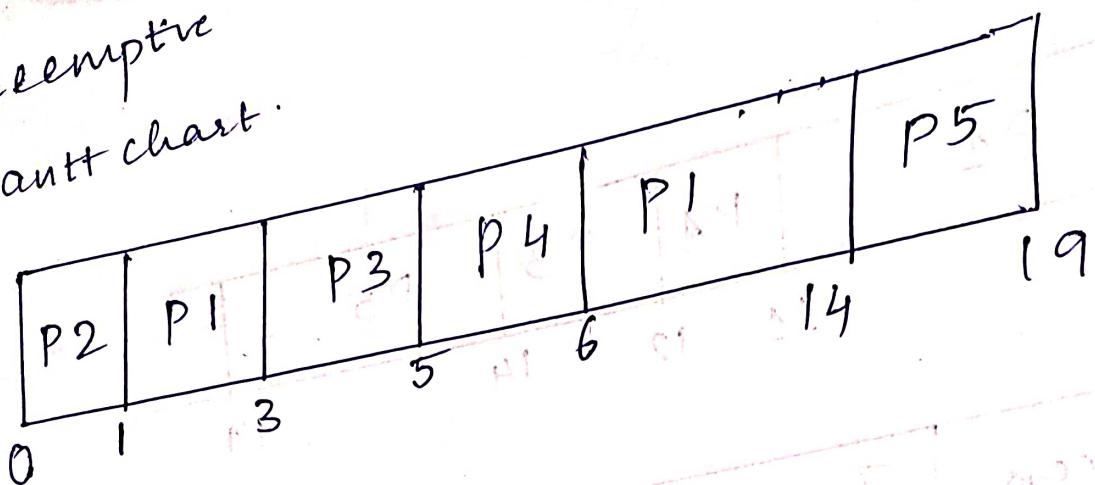
$$\text{Avg TAT} = \frac{11 + 1 + 11 + 7 + 9}{5}$$

$$= \frac{39}{5} = 7.8 \text{ ms.}$$

$$\text{Avg WT} = \frac{1 + 0 + 9 + 6 + 4}{5}$$

$$= \frac{20}{5} = 4 \text{ ms.}$$

Preemptive
Gantt chart:



$$TAT = (14 - 0) + (1 - 0)$$

Process	Turn Around Time (CTAT)	Waiting Time (WT)
P1	$14 - 0 = 14$	$14 - 10 = 4$
P2	$1 - 0 = 1$	$1 - 1 = 0$
P3	$5 - 3 = 2$	$2 - 2 = 0$
P4	$6 - 5 = 1$	$1 - 1 = 0$
P5	$19 - 10 = 9$	$9 - 5 = 4$

$$\text{Avg TAT} = \frac{14 + 1 + 2 + 1 + 9}{5}$$

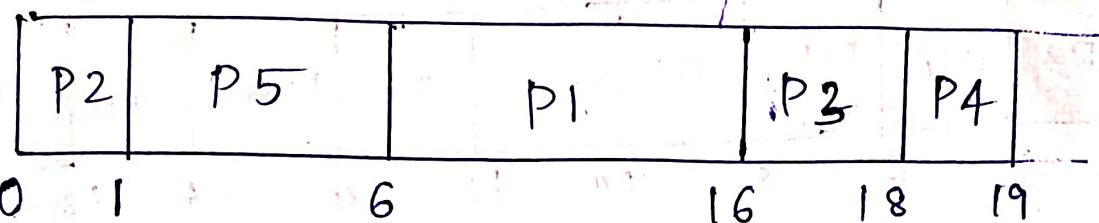
$$= \frac{27}{5} = 5.4 \text{ ms}$$

$$\text{Avg WT} = \frac{4 + 0 + 4}{5}$$

$$= \frac{8}{5} = 1.6 \text{ ms}$$

Non - Preemptive Priority Based.

Gantt chart



Process	Turn Around Time	Waiting Time
P1	$16 - 0 = 16$	$11 - 10 = 1$
P2	$1 - 0 = 1$	$1 - 1 = 0$
P3	$18 - 3 = 15$	$15 - 2 = 13$
P4	$19 - 5 = 14$	$14 - 1 = 13$
P5	$16 - 10 = 6$	$6 - 5 = 1$

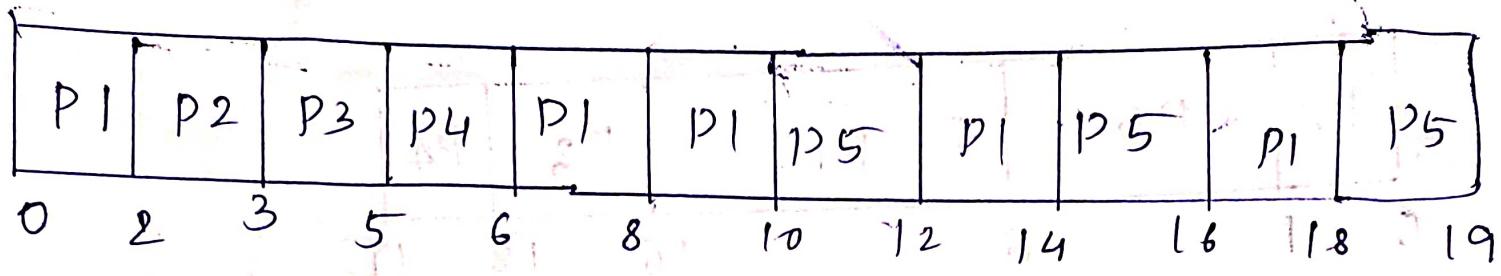
Avg TAT = $\frac{16 + 1 + 15 + 14 + 6}{5} = 10.4$

$$= \frac{47}{5} = 9.4 \text{ ms}$$

Avg WT = $\frac{1 + 0 + 13 + 13 + 1}{5} = 7.6$

$$\Rightarrow \frac{28}{5} = 5.6 \text{ ms}$$

Round Robin Scheduling



Process	Turn Around Time (TAT)	Waiting Time (WT)
P1	$18 - 0 = 18$	$18 - 10 = 8$
P2	$3 - 0 = 3$	$3 - 0 + 1 = 2$
P3	$5 - 3 = 2$	$2 - 2 = 0$
P4	$6 - 5 = 1$	$1 - 1 = 0$
P5	$19 - 10 = 9$	$9 - 5 = 4$

$$\text{Avg TAT} = \frac{18 + 3 + 2 + 1 + 9}{5}$$

$$= \frac{33}{5} = 6.6 \text{ ms}$$

$$\text{Avg WT} = \frac{8 + 2 + 0 + 4}{5}$$

$$\Rightarrow \frac{14}{5} = 2.8 \text{ ms.}$$

② Consider the following set of processes with arrival time.

- i) Draw gantt chart using FCFS, SJF preemptive and non-preemptive scheduling.
- ii) Calculate the average waiting and turn around time for each process of the scheduling algorithm..

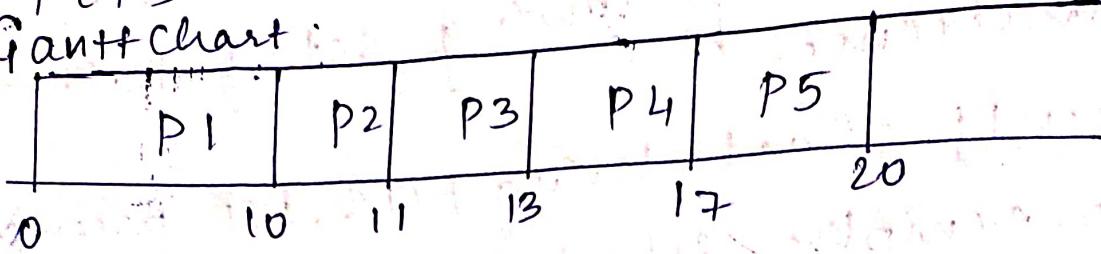
Process	Arrival Time	Burst Time
P1	0	10
P2	0	1
P3	1	2
P4	2	4
P5	2	3

$$\text{Average turn around time} = \frac{\text{Sum of waiting time for individual processes}}{\text{Number of processes}}$$

$$\text{Average waiting time} = \frac{\text{Sum of turn around time of individual processes}}{\text{Number of processes.}}$$

i) FCFS

Gantt Chart:



Process	Turn Around Time (TAT)	Waiting Time (WT)
P1	$10 - 0 = 10$	$10 - 10 = 0$
P2	$11 - 0 = 11$	$11 - 1 = 10$
P3	$13 - 1 = 12$	$12 - 2 = 10$
P4	$17 - 2 = 15$	$15 - 4 = 9$
P5	$20 - 2 = 18$	$18 - 3 = 15$

$$\text{Avg TAT} = \frac{10 + 11 + 12 + 15 + 18}{5}$$

$$= \frac{66}{5} = 13.2 \text{ ms.}$$

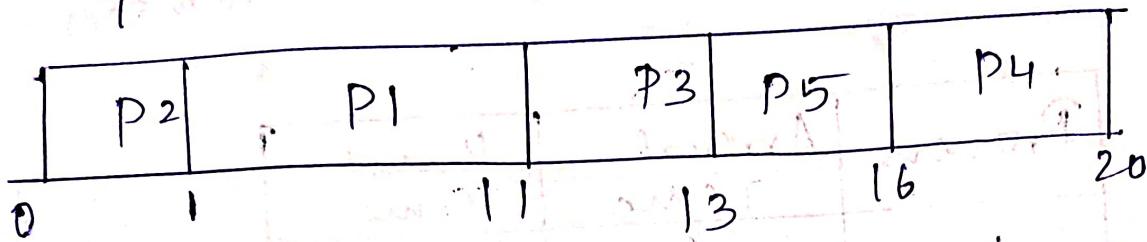
$$\text{Avg WT} = \frac{0 + 10 + 10 + 9 + 15}{5}$$

$$\text{Avg Turnaround time} = \frac{46}{5} = 9.2 \text{ ms.}$$

SJP

1) Non Preemptive

Gantt chart



Process	Turn Around Time (TAT)	Waiting Time (WT)
P1	$11 - 0 = 11$	$11 - 10 = 1$
P2	$1 - 0 = 1$	$1 - 1 = 0$
P3	$13 - 1 = 12$	$12 - 2 = 10$
P4	$20 - 2 = 18$	$18 - 4 = 14$
P5	$16 - 2 = 14$	$14 - 3 = 11$

$$\text{Avg TAT} = \frac{11 + 1 + 12 + 18 + 14}{5}$$

$$= \frac{56}{5} = 11.2 \text{ ms}$$

$$\text{Avg WT} = \frac{1 + 0 + 10 + 14 + 11}{5}$$

$$> \frac{36}{5} = 7.2 \text{ ms}$$

(3)

Consider the following set of processes with CPU burst time (in msec)

Process	Arrival Time	Burst Time
P0	0	6
P1	1	3
P2	2	1
P3	3	4

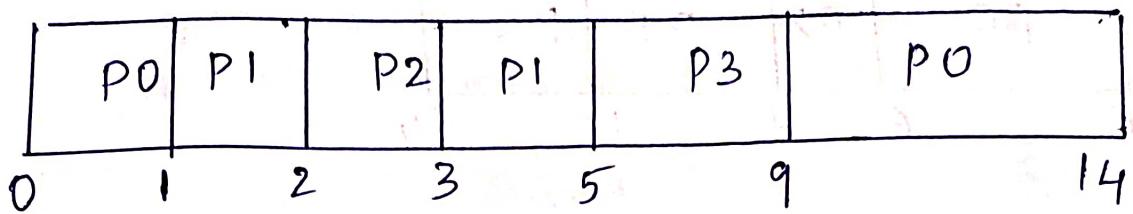
i) Draw Gantt chart illustrating the execution of above processes using SPT, SRTF and SJF. Hence show that SRTF is faster than SJF.

ii) Find the turnaround time of each process.

$$\text{Average turn around time} = \frac{\text{Sum of waiting time of individual processes}}{\text{Number of processes}}$$

$$\text{Average waiting time} = \frac{\text{Sum of turn around time of individual process}}{\text{Number of processes}}$$

STRF



Process	Turn Around time (TAT)	Waiting time (WT)
P0	$14 - 0 = 14$	$14 - 6 = 8$
P1	$5 - 1 = 4$	$5 - 3 = 2$
P2	$3 - 2 = 1$	$1 - 1 = 0$
P3	$9 - 3 = 6$	$6 - 4 = 2$

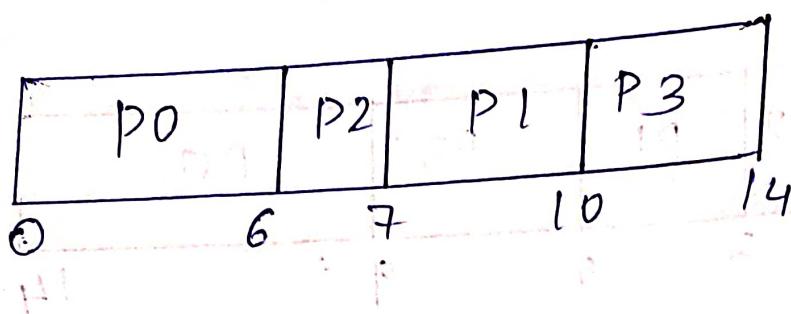
$$\text{Avg TAT} = \frac{14 + 4 + 1 + 6}{4}$$

$$= \frac{25}{4} = 6.25 \text{ ms}$$

$$\text{Avg WT} = \frac{8 + 2 + 0 + 2}{4}$$

$$= \frac{12}{4} = 3 \text{ ms.}$$

ii) Non Preemptive SJF



Process	Turn Around Time	Waiting Time
P0	$6 - 0 = 6$	$6 - 6 = 0$
P1	$10 - 1 = 9$	$9 - 3 = 6$
P2	$7 - 2 = 5$	$5 - 1 = 4$
P3	$14 - 3 = 11$	$11 - 4 = 7$

$$\text{Avg TAT} = \frac{6 + 9 + 5 + 11}{4}$$

$$= \frac{31}{4} = 7.75 \text{ ms}$$

$$\text{Avg WT} = \frac{0 + 6 + 4 + 7}{4}$$

$$= \frac{17}{4} = 4.25 \text{ ms.}$$

④ Consider following processes with CPU burst time given in milliseconds.

Process	Burst time	Priority
P1	10	3
P2	1	1
P3	2	3
P4	1	4
P5	5	2

Processes arrived in P1, P2, P3, P4, P5 order of all at time 0.

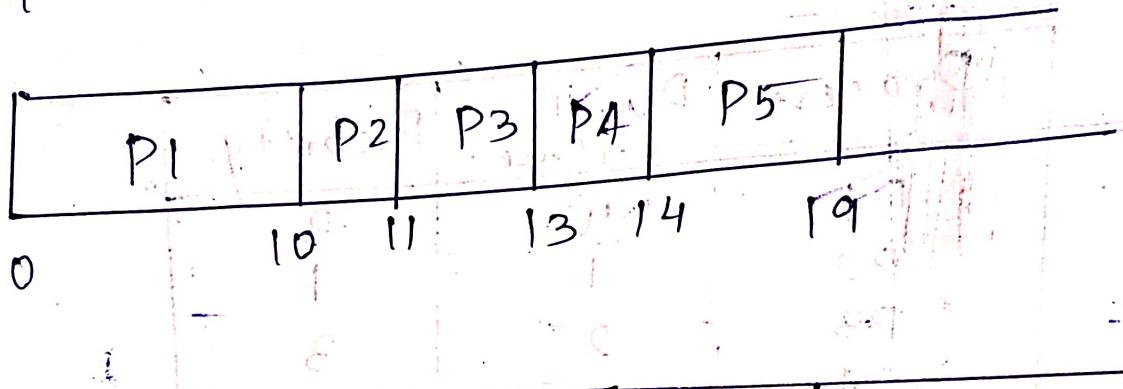
- i) Draw Gantt charts to show execution using FCFS, SJF, non preemptive priority and round robin (quantum = 1) scheduling.
- ii) Calculate turnaround time for each scheduling algorithm.
- iii) Calculate waiting time of each process for each one of the above scheduling algorithm.

$$\text{Average turn around time} = \frac{\text{Sum of waiting time of individual processes}}{\text{Number of processes}}$$

$$\text{Average waiting time} = \frac{\text{Sum of turn around time of individual processes}}{\text{Number of processes}}$$

1) FCFS

Gantt chart



Process	Turn Around Time	Waiting time
P1	$10 - 0 = 10$	$10 - 0 = 0$
P2	$11 - 0 = 11$	$11 - 1 = 10$
P3	$13 - 0 = 13$	$13 - 2 = 11$
P4	$14 - 0 = 14$	$14 - 1 = 13$
P5	$19 - 0 = 19$	$19 - 5 = 14$

$$\text{Avg TAT} = \frac{10 + 11 + 13 + 14 + 19}{5}$$

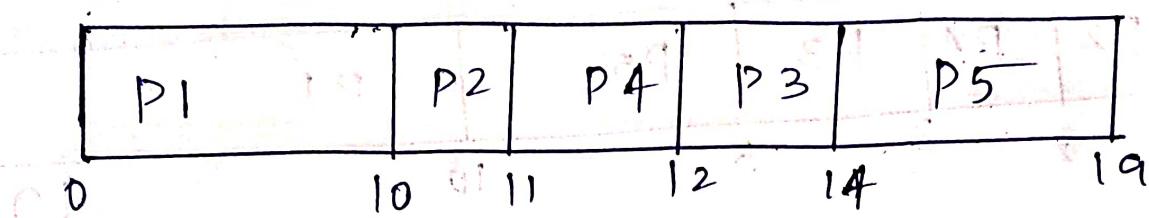
$$= \frac{67}{5} = 13.4 \text{ ms}$$

$$\text{Avg WT} = \frac{0 + 10 + 11 + 13 + 14}{5}$$

$$= \frac{48}{5} = 9.6 \text{ ms}$$

ii) SJF

Non Preemptive.



Process	Turn Around Time	Waiting time
P1	$10 - 0 = 10$	$10 - 0 = 0$
P2	$11 - 0 = 11$	$11 - 1 = 10$
P3	$12 - 0 = 12$	$12 - 1 = 11$
P4	$14 - 0 = 14$	$14 - 2 = 12$
P5	$19 - 0 = 19$	$19 - 5 = 14$

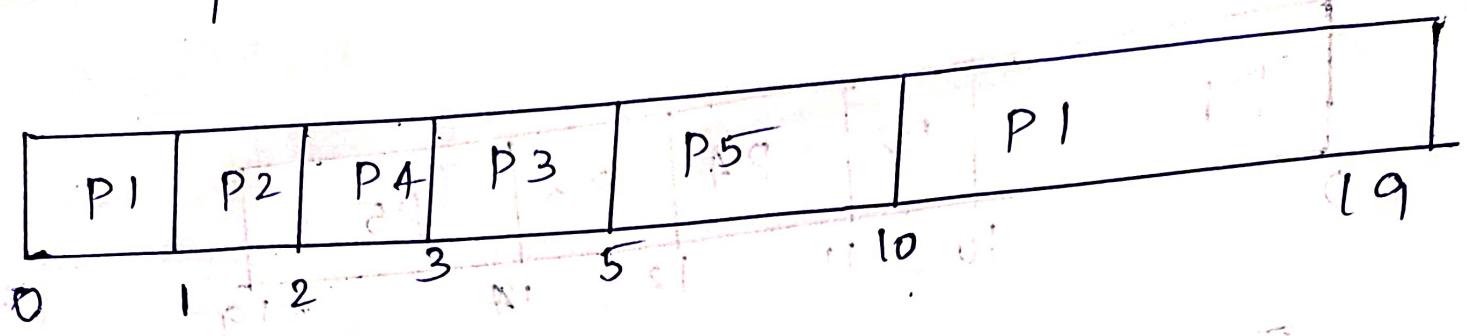
$$\text{Avg TAT} = \frac{10 + 11 + 12 + 14 + 19}{5}$$

$$= \frac{66}{5} = 13.2 \text{ ms}$$

$$\text{Avg WT} = \frac{0 + 10 + 11 + 12 + 14}{5}$$

$$= \frac{47}{5} = 9.4 \text{ ms}$$

Preemptive

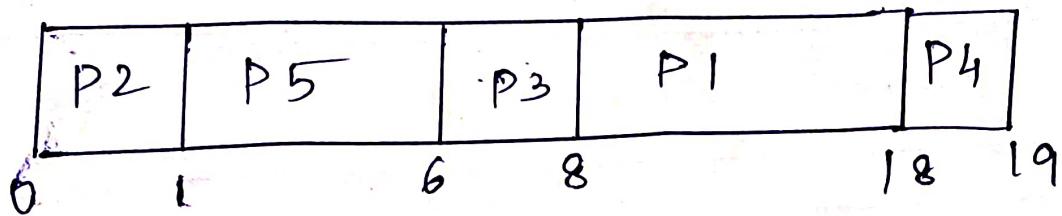


Process	Turn Around Time	Waiting Time
P1	19 - 0 = 19	19 - 10 = 9
P2	12 - 0 = 12	12 - 1 = 11
P3	5 - 0 = 5	5 - 2 = 3
P4	3 - 0 = 3	3 - 1 = 2
P5	10 - 0 = 10	10 - 5 = 5

$$\text{Avg TAT} = \frac{19 + 2 + 5 + 3 + 10}{5} = 7.8 \text{ ms}$$

$$\text{Avg WT} = \frac{9 + 1 + 3 + 2 + 5}{5} = 4 \text{ ms}$$

iii) Non Preemptive Priority



Process	Turn Around time	Waiting time
P1	$18 - 0 = 18$	$18 - 10 = 8$
P2	$1 - 0 = 1$	$1 - 1 = 0$
P3	$8 - 0 = 8$	$8 - 2 = 6$
P4	$19 - 0 = 19$	$19 - 1 = 18$
P5	$6 - 0 = 6$	$6 - 5 = 1$

$$\text{Avg TAT} = \frac{18 + 1 + 8 + 19 + 6}{5}$$

$$= \frac{52}{5} = 10.4 \text{ ms}$$

$$\text{Avg WT} = \frac{8 + 0 + 6 + 18 + 1}{5}$$

$$= \frac{33}{5} = 6.6 \text{ ms.}$$

⑤ Consider the following set of processes and find the average waiting time and average turnaround time using gantt chart for
 i) SJF ii) Priority Scheduling.

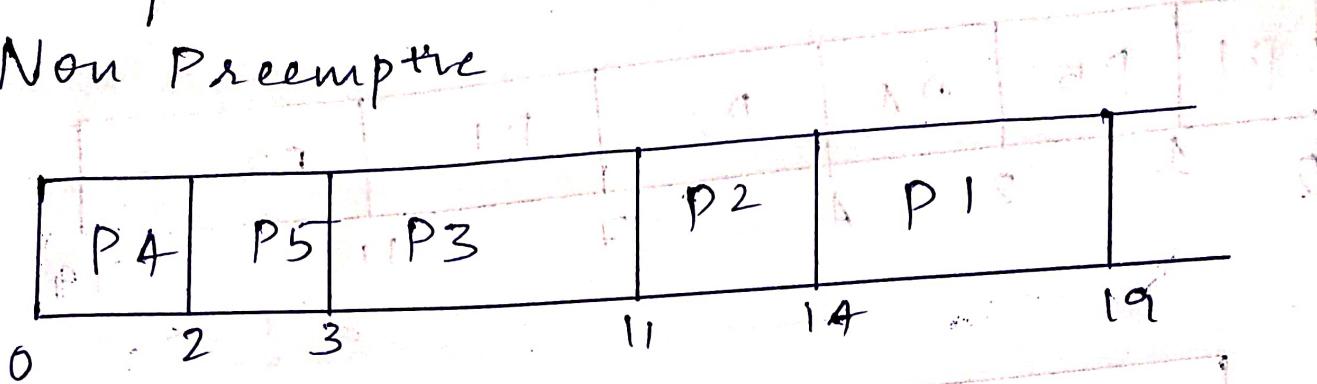
Process	Burst time	Priority
P1	5	5
P2	3	4
P3	8	3
P4	2	1
P5	1	2

$$\text{Avg Turn Around time} = \frac{\text{Sum of waiting time of individual processes}}{\text{Number of processes}}$$

$$\text{Avg Waiting time} = \frac{\text{Sum of turn around time of individual processes}}{\text{Number of processes}}$$

ii) Priority

Non Preemptive



Process	Turn Around Time	Waiting time
P1	19 - 0 = 19	19 - 5 = 14
P2	14 - 0 = 14	14 - 3 = 11
P3	11 - 0 = 11	11 - 8 = 3
P4	2 - 0 = 2	2 - 2 = 0
P5	3 - 0 = 3	3 - 1 = 2

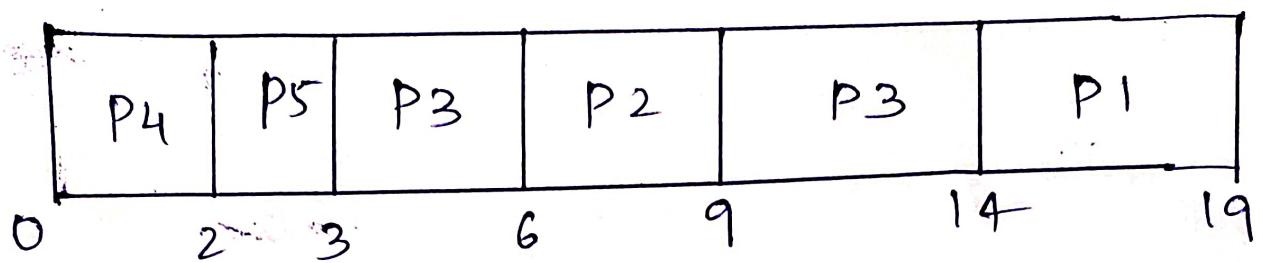
$$\text{Avg TAT} = \frac{19 + 14 + 11 + 2 + 3}{5}$$

$$= \frac{49}{5} = 9.8 \text{ ms}$$

$$\text{Avg WT} = \frac{14 + 11 + 3 + 0 + 2}{5}$$

$$= \frac{30}{5} = 6 \text{ ms}$$

Preemptive



Process	Turn Around Time	Waiting time
P1	19 - 0 = 19	19 - 5 = 14
P2	9 - 0 = 9	9 - 3 = 6
P3	14 - 0 = 14	14 - 8 = 6
P4	2 - 0 = 2	2 - 2 = 0
P5	3 - 0 = 3	3 - 1 = 2

$$\text{Avg TAT} = \frac{19 + 9 + 14 + 2 + 3}{5}$$

$$= \frac{47}{5} = 9.4 \text{ ms}$$

$$\text{Avg WT} = \frac{14 + 6 + 6 + 0 + 2}{5}$$

$$= \frac{28}{5} = 5.6 \text{ ms.}$$