P.S. Assignment - 2

Q1) Consider the set of processes with arrival time (in milliseconds), CPU burst time (in milliseconds), and priority (low number implies high priority) as shown below:

Process	Arrival time	Burst time	Priority
P_1	0	10	3
P2	0	1	1
P3	0	2	3
P4	0	1	4
P5	0	5	2

a) Find the average turnaround time, average waiting time and average response time for each of the following scheduling algorithms along with their Gantt chart illustrating the execution of these processes:

> FCFS, (consider the order specified in the table

> SJF (Non preemptive)

> SRTF

> Non preemptive, Priority based scheduling,

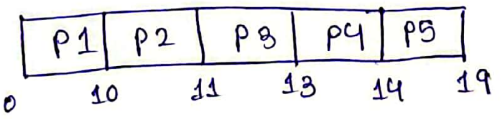
> Preemptive Priority based scheduling

> Round robin scheduling (quantum = 4 ms)

b) Which of the algorithms result in the minimum average waiting time over all processes?

(Ans) a) FCFS :-

Gantt chart →



Process	TAT	WT	RT
P1	10	0	0
P2	11	10	10
P3	13	11	11
P4	14	13	13
P5	19	14	14

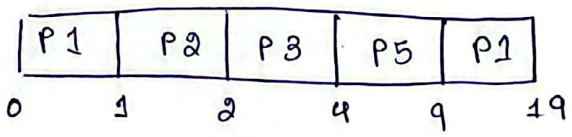
Avg. TAT = 67/5 = 13.4 ms

avg. WT = 48/5 = 9.6 ms

avg. RT = 48/5 = 9.6 ms

SJF (Non preemptive) :-

Gantt chart →



Process	TAT	WT	RT
P1	19	9	9
P2	1	0	0
P3	4	2	2
P4	2	1	1
P5	9	4	4

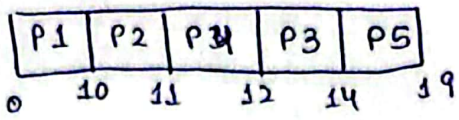
avg. TAT = 35/5 = 7 ms

avg. WT = 16/5 = 3.2 ms

avg. RT = 16/5 = 3.2 ms

SRTF :-

Gantt chart →



Process	WT	TAT	RT
P1	0	10	0
P2	10	11	10
P3	12	14	12
P4	11	12	11
P5	14	19	14

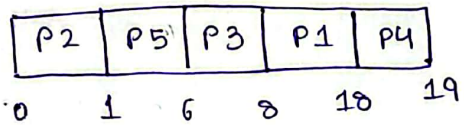
avg. WT = 47/5 = 9.4 ms

avg. TAT = 66/5 = 13.2 ms

avg. RT = 9.4 ms

Non-preemptive, Priority based scheduling :-

Gantt chard →



Process	TAT	WT	RT
P1	18	8	8
P2	1	0	0
P3	8	6	6
P4	19	18	18
P5	6	1	1

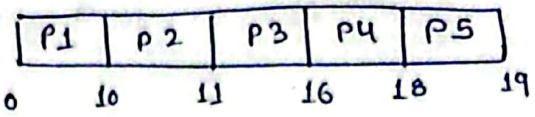
avg. TAT = 52/5 = 10.4 ms

avg. WT = 33/5 = 6.6 ms

avg. RT = 33/5 = 6.6 ms

Preemptive, Priority based scheduling :-

Gantt chart →



Process	TAT	WT	RT
P1	10	0	0
P2	11	10	10
P3	18	16	16
P4	19	18	18
P5	16	11	11

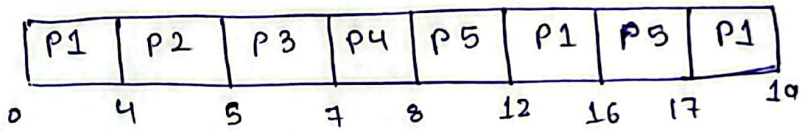
avg. TAT = 14.8 ms

avg. WT = 11 ms

avg. RT = 11 ms

Round robin scheduling (quantum = 5ms) :-

Gantt chart →



Process	BT	TAT	WT	RT
P1	~~10~~ 2	19	9	9
P2	~~10~~ 0	5	4	4
P3	~~8~~ 0	7	5	5
P4	~~7~~ 0	8	7	7
P5	~~5~~ 1	17	12	12

avg TAT = 11.2 ms

avg WT = 7.4 ms

avg. RT = 7.4 ms

b) SJF has the minimum average waiting time over all processes.

Q3) Consider the set of processes with arrival time (in milliseconds), CPU burst time (in milliseconds), and priority (low number implies high priority) as shown below.

Process	Arrival time	Burst time	Priority
P1	0	4	3
P2	0	2	1
P3	1	3	2
P4	2	2	4

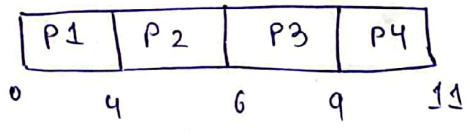
a) Find the average turnaround time, average waiting time and average response time for each of the following scheduling algorithm along with their gantt chart illustrating the execution of these processes:

- FCFS, (consider the order specified in the table)
- SJF (Non preemptive)
- SRTF
- Non preemptive, Priority based scheduling
- Preemptive priority based scheduling.
- Round robin scheduling (quantum = 2 ms)

b) which of the algorithms results in the minimum average waiting time over all processes?

(Ans) a) FCFS :-

gantt chart →



Process	TAT	WT	RT
P1	4	0	0
P2	6	4	4
P3	8	5	5
P4	9	7	7

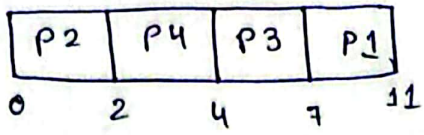
avg. TAT = 6.75 ms

avg. WT = 4 ms

avg. RT = 4 ms

SJF (non-preemptive) :-

Gantt chart →

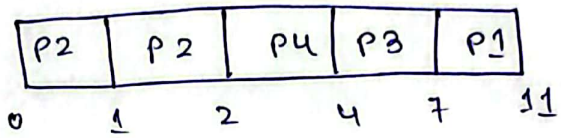


Process	TAT	WT	RT
P1	11	7	7
P2	2	0	0
P3	6	3	3
P4	2	0	0

avg TAT = 5.25ms
avg. WT = 2.5ms
avg. RT = 2.5ms

SRTF :-

Gantt chart →

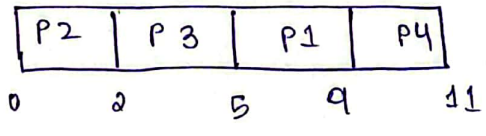


Process	BT	TAT	WT	RT
P1	~~4~~ 0	11	7	7
P2	~~2~~ 0	2	0	0
P3	~~6~~ 0	6	3	3
P4	~~2~~ 0	2	0	0

avg TAT = 5.25ms
avg WT = 2.5ms
avg RT = 2.5ms

Non-preemptive, priority based scheduling :-

Gantt chart →

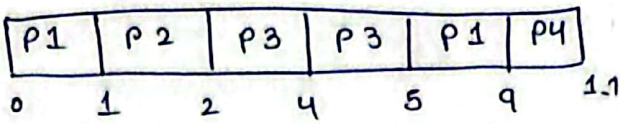


Process	CT	TAT	WT	RT
P1	9	9	5	5
P2	2	2	0	0
P3	5	4	1	1
P4	11	9	7	7

avg TAT = 6ms
avg WT = 3.25ms
avg. RT = 3.25ms

Preemptive, Priority based scheduling :-

Gantt chart →

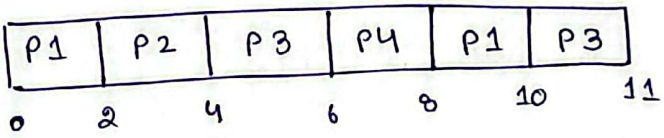


Process	BT	CT	TAT	WT	RT
P1	~~4~~ 0	9	9	5	5
P2	~~2~~ ~~1~~ 0	2	2	0	0
P3	~~3~~ 0	5	4	1	1
P4	~~1~~ 0	11	9	7	7

avg TAT = 6ms
avg WT = 3.25ms
avg RT = 3.25ms

Round robin scheduling :-

Gantt chart →



Process	BT	CT	TAT	WT	RT
P1	~~4~~ ~~2~~ 0	10	10	6	0
P2	~~2~~ 0	4	4	2	2
P3	~~3~~ ~~1~~ 0	11	10	7	3
P4	~~1~~ 0	8	6	4	4

avg TAT = 7.5ms
avg WT = 4.75ms
avg RT = 2.25ms

b) SJF & SRTF scheduling algorithms results in the minimum average waiting time over all processes.

Q3) consider the set of processes with arrival time (in miliseconds), CPU burst time (in miliseconds), and priority (high number implies high priority) as shown below :

Process	Arrival time	Burst time	Priority
P1	0	11	1
P2	0	8	0
P3	12	2	3
P4	2	6	2
P5	9	16	4

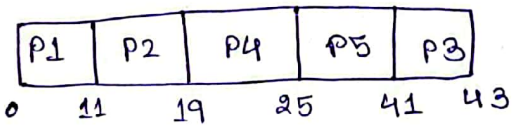
a) find the average turnaround time, average waiting time and average response time for each of the following scheduling algorithm along with their Gantt chart illustrating the execution of these processes:

- FCFS, (consider the order specified in the table)
- SJF (Non preemptive)
- SRTF
- Non preemptive, Priority based scheduling
- Preemptive, Priority based scheduling
- Round robin scheduling (quantum = 5ms)

b) which of the algorithms results in the minimum average waiting time over all process?

(Ans) a) FCFS:-

Gantt chart →



Process	CT	TAT	WT	RT
P1	11	11	0	0
P2	19	19	11	11
P3	43	31	29	29
P4	25	23	17	17
P5	41	32	16	16

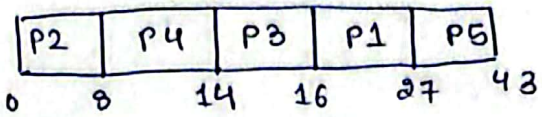
avg TAT = 23.2 ms

avg WT = 14.6 ms

avg RT = 14.6 ms

SJF (Non-preemptive) :-

Gantt chart →



Process	CT	TAT	WT	RT
P1	27	27	16	16
P2	8	8	0	0
P3	16	4	2	2
P4	14	12	6	6
P5	43	34	18	18

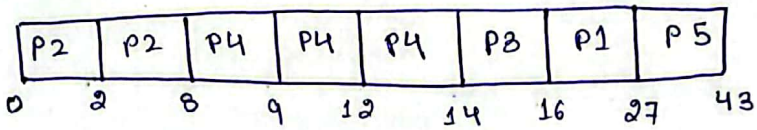
avg TAT = 17 ms

avg WT = 8.4 ms

avg RT = 8.4 ms

SRTF :-

Gantt chart →



Process	BT	CT	TAT	WT	RT
P1	~~11~~ 0	27	27	16	16
P2	~~8~~ ~~6~~ 0	8	8	0	0
P3	~~2~~ 0	16	4	2	2
P4	~~8~~ ~~8~~ ~~2~~ 0	14	12	6	6
P5	~~18~~ 0	43	34	18	18

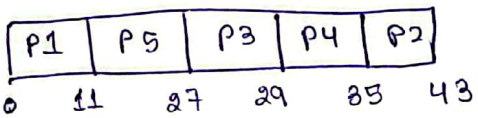
avg TAT = 17 ms

avg WT = 8.4 ms

avg RT = 8.4 ms

Non-preemptive priority based scheduling :-

Gantt chart →



Process	CT	TAT	WT	RT
P1	11	11	0	0
P2	43	43	35	35
P3	29	17	15	15
P4	35	33	27	27
P5	27	18	2	2

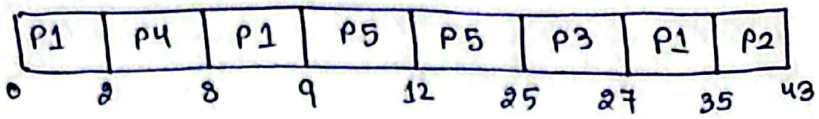
avg TAT = 24.4 ms

avg WT = 15.8 ms

avg RT = 15.8 ms

Preemptive priority based scheduling :-

Gantt chart →

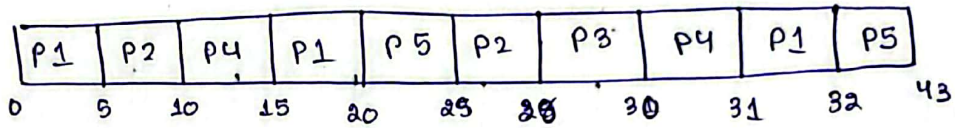


Process	CT	TAT	WT	RT
P1	35	35	24	0
P2	43	43	35	35
P3	27	15	13	13
P4	8	6	0	0
P5	25	16	0	0

avg TAT = 23ms
avg WT = 14.4ms
avg RT = 9.6ms

Round Robin scheduling :-

gantt chart →



Process	CT	TAT	WT	RT
P1	32	32	21	0
P2	28	28	20	5
P3	30	18	16	28
P4	31	29	23	10
P5	43	34	18	20

avg TAT = 28.8ms
avg WT = 19.6ms
avg RT = 12.6ms

b) Both SRTF & SJF have the minimum average waiting time over all processes.

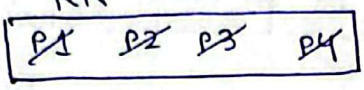
Q4) consider a multilevel feedback queue scheduling (MFLBQ) with three queues q1, q2 and q3. q1 and q2 use round-robin algorithm with time quantum equal to 3 and 5 miliseconds respectively. q3 uses first-come first-serve algorithm. Assume the arrival time of all processes as 0. A process entering the ready queue will put in queue 0. Processes in queue q1, q2 will be denoted to lower priority queue, if not

completed on specified time quantum. find the average waiting time. (A.W.T) and average turnaround time (A.T.A.T) for executing the following process ?

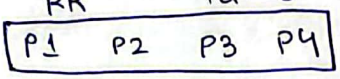
Processes	Burst time
P1	8
P2	22
P3	4
P4	12

(Ans)

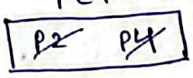
Q1 RR TQ = 3



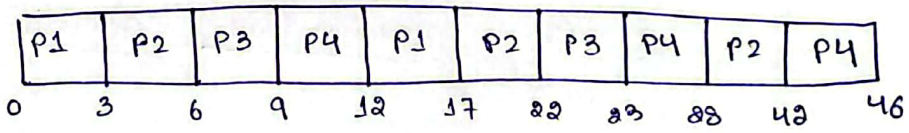
Q2 RR TQ = 5



Q3 FCFS



Gantt chart →



Process	AT	BT	CT	TAT	WT	RT
P1	0	8	17	17	9	0
P2	0	22	42	42	20	3
P3	0	4	23	23	19	6
P4	0	12	46	46	34	9

avg TAT = 29.5 ms

avg WT = 20.5 ms

avg RT = 4.5 ms

Q3) consider three CPU-intensive processes, which require 10, 20 and 30 time units and arrive at times 0, 2 and 6, respectively. How many

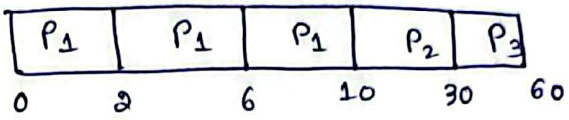
context switches are needed if the operating system implements a shortest remaining time first scheduling algorithm? Do not count the context switches at time zero and at the end..

(Ans)

Process	BT	AT
P1	10	0
P2	20	2
P3	30	6

SRTF (shortest remaining time first scheduling)

Gantt chart →



only two context switches are required i.e. P_1 to P_2 and P_2 to P_3

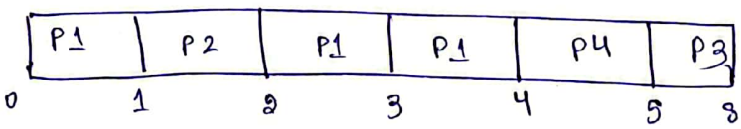
Q6) consider the following four processes with arrival times (in milliseconds) and their length of CPU bursts (in milliseconds) as shown below:

Process	Arrival time	Burst time
P1	0	3
P2	1	1
P3	3	3
P4	4	x

find the value of x, such that the average waiting time of the process is 1 millisecond, if the processes execute on a single processor using SRTF scheduling.

(Ans) Let x = 1

Gantt chart



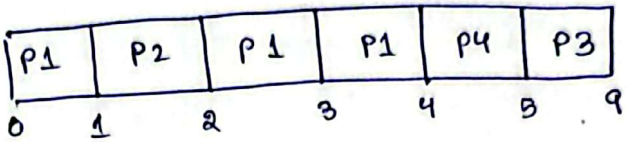
Process	AT	BT	CT	TAT	WT	RT
P1	0	3	4	4	1	0
P2	1	1	2	1	0	0
P3	3	3	8	5	2	2
P4	4	x=1	5	1	0	0

avg = $\frac{3}{4}$

= 0.75 ms

Let x = 2

Gantt chart →



Process	AT	BT	CT	TAT	WT	RT
P1	0	3	4	4	1	0
P2	1	1	2	1	0	0
P3	3	3	9	6	3	3
P4	4	x=2	6	2	0	0

avg = $\frac{4}{4}$

= 1 ms

when the value of x is 2, the average waiting time of the process is 1 millisecond.

Q7) How the base time quantum is related to the static priority? Find the base time quantum for the processes having highest, lowest and default static priority

(Ans) Base time quantum (in milliseconds) = $\begin{cases} (140 - \text{static priority}) \times 20 & \text{if } SP < 120 \\ (140 - \text{static priority}) \times 5 & \text{if } SP \geq 120 \end{cases}$

Base time quantum for highest priority

HP = 100

BTQ = (140 - (static priority)) × 20

= (140 - 100) × 20

= 40 × 20 = 800 ms

Base time quantum for lowest priority

LP = 139

BTQ = (140 - SP) × 5

= (140 - 139) × 5 = 5 ms

Base time quantum for default static priority

D.P. = 120

BTQ = (140 - 120) × 5

= 20 × 5 = 100 ms

Q8) what will be the dynamic priority of the following process?

Process	static priority	average sleep time
P1	110	250 ms
P2	120	700 ms
P3	132	15

(Ans)

Process	static priority	avg. sleep time	Bonus
P1	110	250 ms	2
P2	120	700 ms	7
P3	132	15	10

Dynamic priority,

P1 = max (100, min (static priority - bonus + 5, 139)

= max(100, min(110-8+5, 139))

= max(100, min(113, 139))

= max(100, 113)

$P_1 = 113$

P_2 = max(100, min(static priority - bonus + 5, 139))

= max(100, min(120 - 7 + 5, 139))

= max(100, min(118, 139))

= max(100, 118)

$P_2 = 118$

P_3 = max(100, min(132 - 10 + 5, 139))

= max(100, min(127, 139))

= max(100, 127)

$P_3 = 127$

Q9) What will be the minimum average sleep time for a process, so that the following processes will be considered as an interactive process by the scheduler in Linux system?

Process	static priority
P1	130
P2	108
P3	124
P4	132.

(Ans) A process is interactive if it satisfies the following condition.

bonus - 5 ≥ static priority / 4 - 28

P_1

bonus - 5 $\geq \frac{130}{4} - 28$

$\Rightarrow$ bonus $\geq \frac{130}{4} - 28 + 5$

$\Rightarrow$ bonus $\geq 33 - 23$

$\Rightarrow$ bonus ≥ 10

avg sleep time of P_1 is 1 sec

P_2

bonus $\geq \frac{108}{4} - 23$

$\Rightarrow$ bonus $\geq 27 - 23$

$\Rightarrow$ bonus ≥ 4

Average sleep time of P_2 is $\geq 400 < 500$ msec.

P_3

bonus $\geq \frac{124}{4} - 23$

$\Rightarrow$ bonus $\geq 31 - 23$

$\Rightarrow$ bonus ≥ 8

Average sleep time of P_3 is $\geq 800 < 900$ msec

P_4

bonus $\geq \frac{132}{4} - 23$

$\Rightarrow$ bonus $\geq 33 - 23$

$\Rightarrow$ bonus $\geq$ 10

So, avg. sleep time of P_4 is 1 sec.

Q10) which of the following process can not be considered as an interactive process scheduler in Linux system ?

Process	static priority
P1	136
P2	104
P3	116

(Ans) A process is interactive when the bonus is between 1 to 10.

P1

$$\text{bonus} - 5 \geq \frac{\text{static priority}}{4} - 28$$

$$\Rightarrow \text{bonus} \geq \frac{136}{4} - 28 + 5$$

$$\Rightarrow \text{bonus} \geq \frac{136}{4} - 23 \geq 11$$

$\therefore$ P_1 is not an interactive process.

P2

$$\text{bonus} \geq \frac{104}{4} - 28 + 5$$

$$\Rightarrow \text{bonus} \geq 26 - 23$$

$$\Rightarrow \text{bonus} \geq 3$$

$\therefore$ P_2 is an interactive process.

P_3

bones $\geq \frac{116}{4} - 28+5$

$\Rightarrow$ bones $\geq 29-23$

$\Rightarrow$ bones ≥ 6

$\therefore$ P_3 is an interactive process.