1 Consider the above set of processes that arrive at given times with certain priorities. The length of CPU burst time given in millisecond.

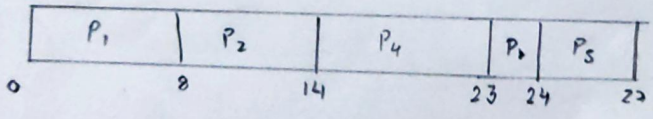
Process	Burst	Priority	Arrival Time
P_1	8	4	0
P_2	6	1	2
P_3	1	2	2
P_4	9	2	1
P_5	3	3	3

Apply the following CPU Scheduling to find the Average TA time, and Average Response time:

(a) Priority Scheduling
(b) SRTF
(c) RR (TQ = 2 ms)

A. (a) Priority Scheduling

Gantt Chart:



Avg. turnaround time = $\frac{(8-0)+(14-2)+(23-2)+(24-1)+(27-3)}{5}$

$= \frac{8+12+21+22+3}{5}$

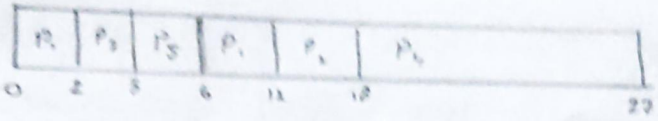
$= \frac{66}{5} = 13.4$ ms

Avg. response time = $\frac{(0-0)+(8-2)+(14-1)+(23-2)+(27-3)}{5}$

$= \frac{0+6+13+21+24}{5}$

$= 12.8$ ms

(b) Shortest Remaining Time First



Avg. Turnaround Time = $\frac{(12-0)+(18-2)+(3-2)+(27-18)+(16-3)}{5}$

$= \frac{12+16+1+9+3}{5}$

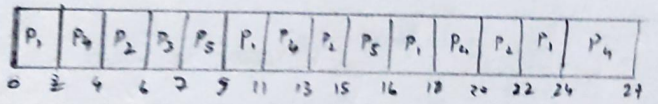
$= 8.2$ ms

Avg. Response Time = $\frac{(0-0)+(12-2)+(2-2)+(18-1)+(3-3)}{5}$

$= \frac{10+17}{5} = 5.4$ ms

(c) Round Robin

Time Quotent = 2 ms



Avg. Turnaround Time = $\frac{(24-0)+(22-2)+(7-2)+(27-1)+(16-3)}{5}$

$= \frac{24+20+5+26+13}{5}$

$= \frac{88}{5} = 17.6$ ms

Avg. Response Time = $\frac{(0-0)+(4-2)+(6-2)+(9-1)+(7-3)}{5}$

$= \frac{2+4+1+4}{5} = \frac{11}{5} = 2.2$ ms

2. Consider the following set of processes, with the length of the CPU burst given in milliseconds:

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

The processes are assumed to have arrived in the order P_1, P_2, P_3, P_4, P_5 at all time 0.

(a) Draw four Gantt charts that illustrate the execution of these processes using the following scheduling algorithms: FCFS, SJF, SRTF, non-preemptive priority (a smaller priority number implies a higher priority) and RR (quantum = 2)

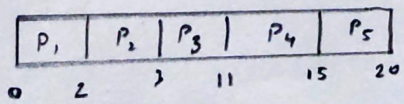
(b) What is the average waiting time of each process for each of the scheduling algorithms in part a?

(c) What is the average waiting time of each of these scheduling algorithms?

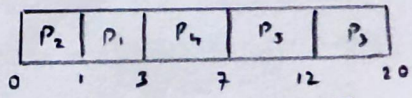
(d) Which of the algorithms results in the minimum average waiting time (overall processes)?

A.

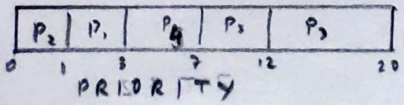
(a)



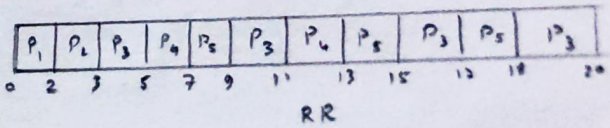
FCFS



SJF / SRTF



PRIORITY



RR

(d)

(b) Avg Turn around time

FCFS = $\frac{(2-0)+(3-0)+(11-0)+(15-0)+(20-0)}{5}$

= $\frac{2+3+11+15+20}{5} = \frac{51}{5} = 10.2$ ms

SJF = $\frac{(3-0)+(1-0)+(7-0)+(12-0)+(20-0)}{5}$

= $\frac{3+1+7+12+20}{5} = \frac{43}{5} = 8.6$ ms

PRIORITY = $[(3-0)+(1-0)+(7-0)+(12-0)+(20-0)]/5$

= $\frac{3+1+7+12+20}{5} = \frac{43}{5} = 8.6$ ms

RR = $\frac{(2-0)+(3-0)+(20-0)+(13-0)+(18-0)}{5}$

= $\frac{2+3+20+13+18}{5} = \frac{46}{5} = 9.2$ ms

(c) Avg Waiting time

FCFS = $\frac{(0-0)+(2-0)+(3-0)+(11-0)+(15-0)}{5}$

= $\frac{31}{5} = 6.2$ ms

SJF = $\frac{(0-0)+(1-0)+(3-0)+(7-0)+(12-0)}{5}$

= $\frac{23}{5} = 4.6$ ms

PRIORITY = $[(0-0)+(1-0)+(3-0)+(7-0)+(12-0)]/5$

= $\frac{23}{5} = 4.6$ ms

RR = $\frac{(0-0)+(2-0)+[(3-0)+(9-5)+(15-11)+(18-17)]+[(5-0)+(11-7)]+[(7-0)+(13-9)+(12-15)]}{5}$

= $\frac{2+(3+4+4+1)+(5+4)+(7+4+2)}{5} = \frac{2+12+9+13}{5}$

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

(d) 'Shortest Job First' (SJF) and Priority Scheduling had the minimum average waiting time considering overall processes

3. Consider the following set of threads with the length of the CPU Burst time given in milliseconds

Thread	Priority	Burst	Arrival
P_1	40	20	0
P_2	30	25	25
P_3	30	25	30
P_4	35	15	60
P_5	5	10	100
P_6	10	10	105

(a) Draw Gantt charts that illustrate the execution of these processes using the following scheduling algorithms: FCFS, SJF, SRTF, non-preemptive priority and RR (quantum = 4)

(b) What is the average turnaround time of each process for each of the scheduling algorithms in part a?

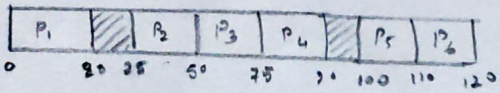
(c) What is the average waiting time of each process for each of these scheduling algorithms?

(d) What is the average response time for each process for each of the scheduling algorithms?

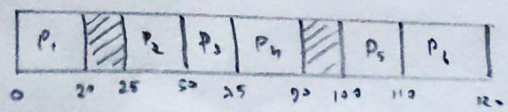
(e) Compare the performance of all the algorithms mentioned in part a for all three metrics in parts b, c, and d with tabular expression.

A.

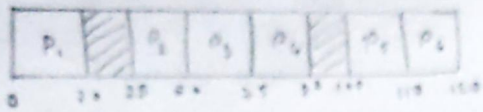
(a)



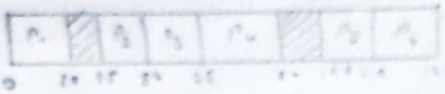
FCFS



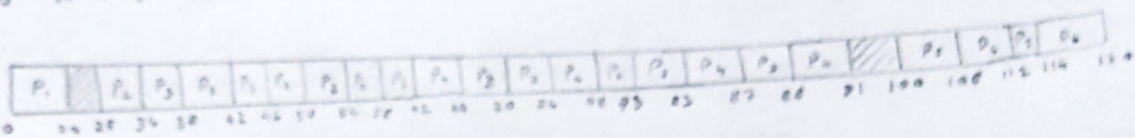
SJF



SRTF



PRIORITY



ROUND ROBIN

(b) For FCFS, SJF, SRTF and PRIORITY,

$$\text{Avg. Turnaround Time} = \frac{(20-0)+(50-25)+(75-30)+(90-60)+(120-100)+(120-105)}{6}$$

$$= \frac{20+25+45+30+10+15}{6}$$

$$= \frac{145}{6} = 24.17 \text{ ms}$$

For RR,

$$\text{Avg. Turnaround Time} = \frac{(20-0)+(73-25)+(88-30)+(91-60)+(114-100)+(120-105)}{6}$$

$$= \frac{20+48+58+31+14+15}{6}$$

$$= \frac{186}{6} = 31 \text{ ms}$$

(c) For FCFS, SJF, SRTF and PRIORITY,

$$\text{Avg. Waiting Time} = \frac{(0-0)+(25-25)+(50-30)+(75-60)+(100-100)+(110-105)}{6}$$

$$= \frac{20+15+5}{6} = \frac{40}{6} = 6.67 \text{ ms}$$

For RR,

Avg. Waiting Time = $\frac{(0-0) + [(25-25) + (38-34) + (46-42) + (54-50) + (66-58) + (78-70)] + [(34-30) + (42-38) + (70-46) + (98-54) + (120-62) + (134-74) + (82-82)] + [(62-60) + (74-66) + (88-78) + (114-114)] + [(100-100) + (112-108)] + [(108-105) + (117-117)]}{6}$

$= \frac{0 + [0+4+4+4+8+8] + [4+4+4+4+8+8+1] + [2+8+5+1]}{6} + [0+4] + [3+2]$

$= \frac{0 + 28 + 33 + 18 + 4 + 5}{6} = \frac{86}{6} = 14.33$ ms

(d) For FCFS, SJF, SRTF and PRIORITY,

Avg. Response Time = $\frac{(0-0) + (25-25) + (50-30) + (75-60) + (100-100) + (110-105)}{6}$

$= \frac{20+15+5}{6} = \frac{40}{6} = 6.67$ ms

For RR,

Avg. Response Time = $\frac{(0-0) + (25-25) + (34-30) + (62-60) + (100-100) + (108-105)}{6}$

$= \frac{0+0+4+2+0+3}{6} = \frac{9}{6} = 1.5$ ms

(e)

—	FCFS	SJF	SRTF	PRIORITY	RR
Avg. Turnaround Time (ms)	24.17	24.17	24.17	24.17	31.0
Avg. Waiting Time (ms)	6.67	6.67	6.67	6.67	14.33
Avg. Response Time (ms)	6.67	6.67	6.67	6.67	1.5

4 Five processes are competing for resources R1, R2, R3 [illegible] where (R1, R2, R3, R4) = (4, 4, 4, 2). The maximum claim of these processes and the initial resources allocated to these processes, are given in the following table:

PROCESS	MAX				ALLOCATION			
	R1	R2	R3	R4	R1	R2	R3	R4
P1	3	2	1	1	2	0	1	1
P2	1	2	0	2	1	1	0	0
P3	1	1	2	0	1	1	0	0
P4	3	2	1	0	1	1	1	0
P5	2	1	0	1	0	0	0	1

(a) Determine whether the system is in deadlock state or not, with the help of Banker's algorithm.

(b) If P2 requests two instances of R1, one instance of R3, and one instance of R4, check whether the system is still in safe state. If it is, find out the safe sequence of process execution.

A.

Process	Allocation				Max				Need			
	R_1	R_2	R_3	R_4	R_1	R_2	R_3	R_4	R_1	R_2	R_3	R_4
P_1	2	0	1	1	3	2	1	1	1	2	0	0
P_2	1	1	0	0	1	2	0	2	0	1	0	2
P_3	1	1	0	0	1	1	2	0	0	0	2	0
P_4	1	1	1	0	3	2	1	0	2	1	0	0
P_5	0	0	0	1	2	1	0	1	2	1	0	0

(c) Available

= (6, 4, 4, 2) - (5, 3, 2, 2)

= (1, 1, 2, 0)

1. Work = Available

= (1, 1, 2, 0)

Need[3] = (0, 0, 2, 0) < Work

P_3 request granted

Work = Work + (1, 1, 0, 0)

= (2, 2, 2, 0)

2. Need[4] = (2, 1, 0, 0) < Work

P_4 request granted

Work = Work + (1, 1, 1, 0)

= (3, 3, 3, 0)

3. Need[5] = (2, 1, 0, 0) < Work

P_5 request granted

Work = Work + (0, 0, 0, 1)

= (3, 3, 3, 1)

4. Need[1] = (1, 2, 0, 0) < Work

P_1 request granted

Work = Work + (2, 0, 1, 1)

= (5, 3, 4, 2)

5. Need[2] = (0, 1, 0, 2) < Work

P_2 request granted.

Work = Work + (1, 1, 0, 0)

= (6, 4, 4, 2)

Through Banker's Algorithm, we can confirm that the system is not in deadlock with a possible safe sequence of

$P_3 \rightarrow P_4 \rightarrow P_5 \rightarrow P_1 \rightarrow P_2$

(b) Process P2 requests resources,

$Req[2] = (2, 0, 1, 1)$

By Resource Request Algorithm,

$Available[2] = Available[2] - Req[2]$

$= (1, 1, 2, 0) - (2, 0, 1, 1)$

$= \phi$

∴ The system will be in deadlock

5 Consider a disk queue with I/O requests on the following cylinders in their arriving order:

67, 12, 15, 45, 48, 50, 109, 89, 56, 59, 34, 88, 13, 109, 22

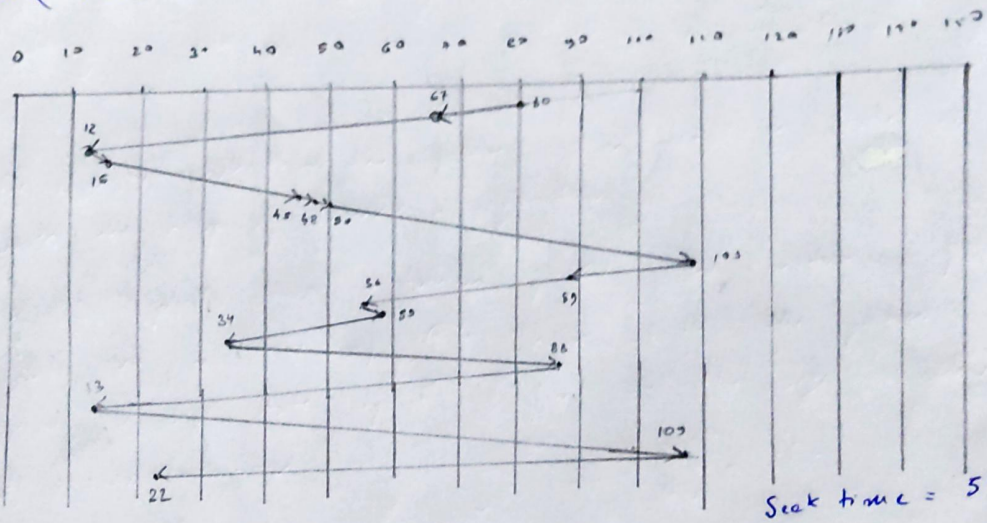
The disk head is assumed to be at cylinder 80 and the disk consists of total 150 cylinders. Compare the average seek length using FCFS, SSTF, SCAN and C-SCAN algorithms. Which one's performance is best and why!

A.

FCFS

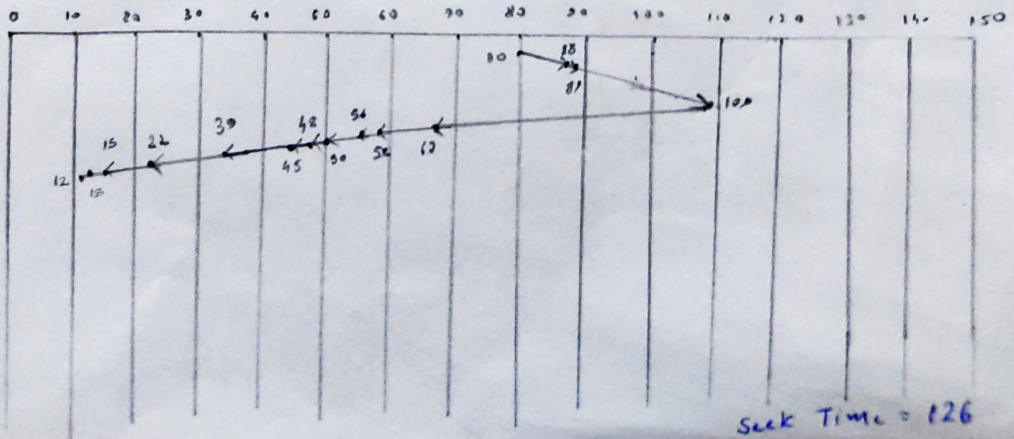
start = 80

Queue (0, 67, 12, 15, 45, 48, 50, 109, 89, 56, 59, 34, 88, 13, 109, 22, 150)



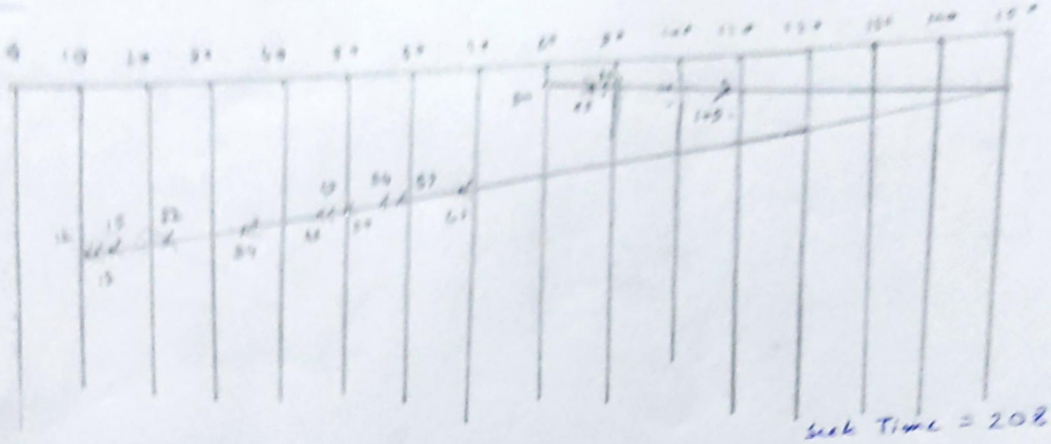
Seek time = 558

SSTF



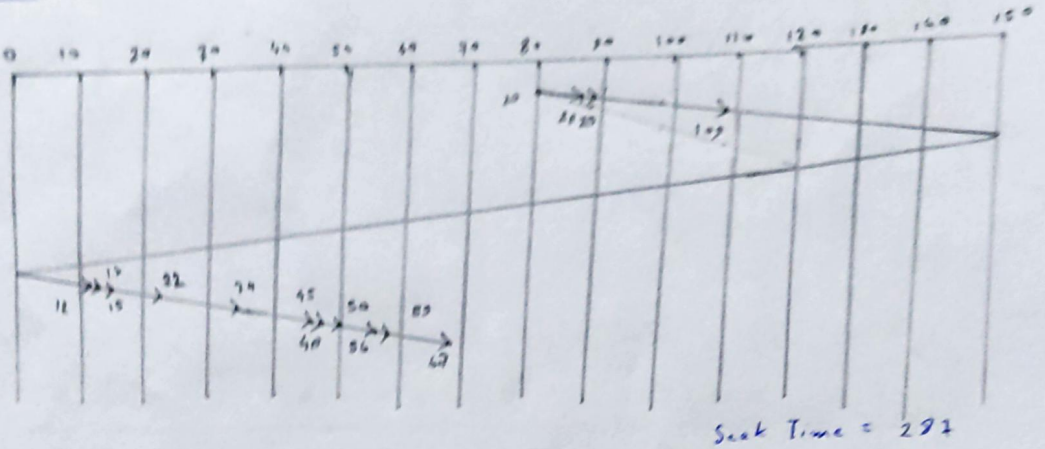
Seek Time = 126

SCAN



Seek Time = 208

C - SCAN



Seek Time = 291

6 Consider the virtual page reference string

5, 0, 2, 1, 0, 3, 0, 2, 4, 3, 0, 3, 2, 1, 3, 0, 1, 5, 3, 1, 2, 4, 5, 4, 0.

On a demand paged virtual memory system running on a computer system that main memory size of 3 page frames which are initially empty. Let LRU, FIFO and OPTIMAL denote the number of page faults under the corresponding page replacement policy. Examine their performance and sort them in ascending order.

A

LRU

	5	0	2	1	0	3	0	2	4	3	0	3	2	1	3	0	1	5	3	1	2	4	5	4	0
	5	5	5	1	1	1	2	2	2	0	0	0	1	1	1	1	1	1	1	1	1	1	5	5	5
		0	0	0	0	0	0	0	0	3	3	3	3	3	3	3	3	5	5	5	2	2	2	2	0
			2	2	2	3	3	3	4	4	4	4	2	2	2	0	0	0	3	3	3	4	4	4	4
PF:	✓	✓	✓	✓		✓		✓	✓	✓	✓		✓	✓		✓		✓	✓		✓	✓	✓		✓

Page Faults: 18

FIFO

	5	0	2	1	0	3	0	2	4	3	0	3	2	1	3	0	1	5	3	1	2	4	5	4	0
	5	5	5	0	0	2	1	3	0	2	4	4	3	0	2	1	1	3	3	0	5	1	2	2	4
		0	0	2	2	1	3	0	2	4	3	3	0	2	1	3	3	0	0	5	1	2	4	4	5
			2	1	1	3	0	2	4	3	0	0	2	1	3	0	0	5	5	1	2	4	5	5	0
PF:	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		✓		✓	✓	✓	✓		✓

Page Fault: 20

OPTIMAL

	5	0	2	1	0	3	0	2	4	3	0	3	2	1	3	0	1	5	3	1	2	4	5	4	0
	5	5	5	1	1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2	2	2
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	5	5	5	5	5	0
			2	2	2	2	2	2	4	4	4	4	2	1	1	1	1	1	1	1	1	4	4	4	4
	✓	✓	✓	✓		✓		✓			✓	✓			✓			✓			✓	✓			✓

Page Fault: 12

Performance in Ascending Order: OPTIMAL > LRU > FIFO