

ASSIGNMENT

1. Stacks: 7 2 3 1 2 5 3 4 6 7 7 1 0 5

3 Frames \rightarrow LRU, FIFO

Least Recently used:

7 2 3 1 2 5 3

7	7	7	1	1	1	3
	2	2	2	2	2	2
	3	3	3	3	5	5

Hit

4 6 7 7 1 0 5

3	3	7	7	7	7	5
4	4	9	9	9	1	1
5	6	6	6	6	0	0

Hit

Hit = 2

$$\text{Efficiency} = 2/14 = \underline{\underline{1/7}}$$

First In First Out

7 2 3 1 2 5 3

7	7	7	1	1	1	11
2	2	3	2	2	5	5
3			3	3	3	3

Hit

4 6 7 7 1 0 5

1	6	6	6	6	0	0
5	5	7	7	7	7	5
4	4	4	4	11	11	11

Hit

Hits = 3

Efficiency = $3/14$

∴ FIFO is more efficient than LRU as it has a better hit rate

3.

P	Burst Time	Priority
P ₁	10	3
P ₂	1	1
P ₃	2	3
P ₄	1	4
P ₅	5	2

i) Non preemptive SJF

P ₂	P ₄	P ₃	P ₅	P ₁
0	1	2	4	9

$$\text{Avg waiting time} = \frac{0+1+2+4+9}{5} = 3.2 \text{ ms}$$

$$\text{Avg turnaround time} = \frac{1+2+4+9+19}{5}$$

$$= 7 \text{ ms}$$

ii) Non preemptive priority

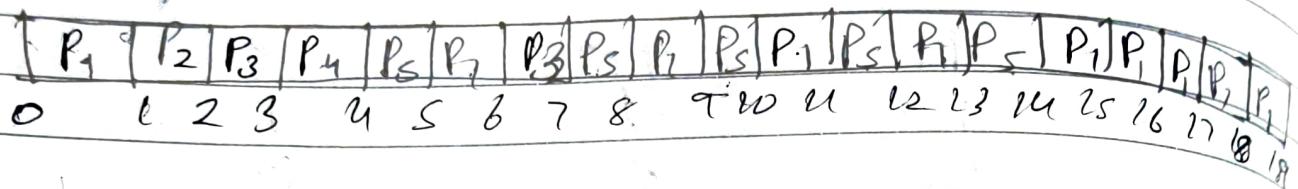
P ₂	P ₅	P ₁	P ₃	P ₄
0	1	6	16	18

$$\text{Avg waiting time} = \frac{0+1+6+16+18}{5} = 8.2 \text{ ms}$$

$$\text{Avg turnaround time} = \frac{1+6+16+18+19}{5} = 12 \text{ ms}$$

iii)

Round Robin Time quantum = 1 ms



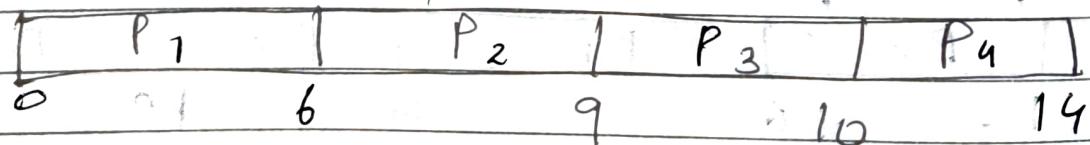
$$\text{Avg waiting time} = \frac{q + 1 + S + 3 + q}{S}$$
$$= \underline{\underline{5.4 \text{ ms}}}$$

$$\text{Avg turnaround time} = \frac{19 + 2 + 7 + 4 + 14}{S}$$
$$= \underline{\underline{9.2 \text{ ms}}}$$

2.

Process	Burst time	Arrival time
P1	6	0
P2	3	1
P3	1	2
P4	4	3

i) FCFS



$$\text{Avg waiting time} = \frac{0 + (6-1) + (9-2) + (10-3)}{4}$$
$$= \underline{\underline{4.75 \text{ ms}}}$$

$$\text{Avg turnaround time} = \frac{6 + (7-1) + (10-2) + (14-3)}{4}$$

$$= 8.25 \text{ ms}$$

ii) SRTF

P ₁	P ₂	P ₃	P ₄	P ₁
0	1	2	3	4

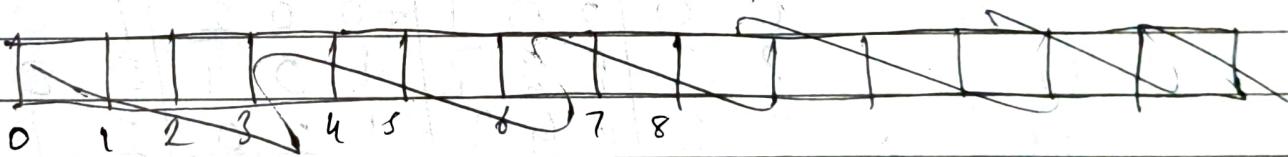
$$\text{Avg waiting time} = (9-1) + (1-1) + (2-2) + (3-2) + (5-3)$$

$$= 2.75 \text{ ms}$$

$$\text{Avg turnaround time} = \frac{14 + (5-1) + (3-2) + (9-3)}{4}$$

$$= 6.25 \text{ ms}$$

iii) RR (2ms)



P ₁	P ₂	P ₃	P ₄	P ₁	P ₂	P ₄	P ₁
0	2	4	5	7	9	10	12

$$\text{Avg waiting time} = \frac{(7-2+12-9)+(2-1+9-4)+(4-2)+(5-3+10-7)}{4}$$

$$= 5.25 \text{ ms}$$

$$\text{Avg. turnaround time} = 14 + \frac{(10-1)}{4} + \frac{(5-2)}{4}$$

$$+ \frac{(12-3)}{4}$$

$$= 8.75 \text{ ms}$$

4. Process	Allocation			Max	Available	
	A	B	C	A	B	C
P ₀	9	0	2	0	0	4
P ₁	1	0	0	2	0	1
P ₂	1	3	5	1	3	7
P ₃	6	3	2	8	4	2
P ₄	1	4	3	1	5	7

Process	Allocation			Max	Available	Need
	A	B	C	A	B	C
P ₀	0	0	2	0	0	4
P ₁	1	0	0	2	0	1
P ₂	1	3	5	1	3	7
P ₃	6	3	2	8	4	2
P ₄	1	4	3	1	5	7

+ 1 3 5

3 3 9

+ 6 3 2

9 6 11

+ 1 4 3

10 10 14

Safe sequence

= {P₀, P₁, P₂, P₃, P₄}

∴ Safe sequence exists, hence the system is in safe state.

Initially, $(1, 0, 2)$ is available and since $(0, 0, 2) < (1, 0, 2)$, the process P_2 's request can be granted.

5. string: 7 0 1 2 0 3 0 4 2 3 0 3 2 1 2 0 1 7 0 1

i) LRU ii) Optimal

i) LRU

7 0 1 2 0 3 0 4 2 3

7	7	7	2	2	2	2	4	4	9
0	0	0	0	0	0	0	0	0	3
1	1	1	3	3	3	3	2	2	2

Hit

Hit

0 3 2 1 2 0 1 7 0 1

0	0	0	1	1	1	1	1	1	1
3	3	3	3	3	0	0	0	0	0
2	2	2	2	2	2	2	7	7	7

Hit

Hit

Hit

Hit

Hit

Hit

No. of hits = 8

∴ No. of faults = 12

ii) Optimal

7	0	1	2	0	3	0	4	2
7	7	7	2	2	2	2	2	2
0	0	0	0	0	0	0	4	4
1	1	1	1	1	3	3	3	3
					Hit	Hit	Hit	Hit
0	3	2	1	2	0	1	7	0
2	2	2	2	2	2	2	7	7
0	0	0	0	0	0	0	0	0
3	3	3	1	1	1	1	1	1
				Hit	Hit	Hit	Hit	Hit

No. of hits = 11

No. of faults = 9

6. Process Arrival time Burst time Priority

P ₁	0	9	3
P ₂	1	4	2
P ₃	2	9	1
P ₄	3	5	4

FCFS, SRTF, RR (q = 2), Priority

i) FCFS

P ₁	P ₂	P ₃	P ₄
0	9	13	22

$$\text{Avg waiting time} = \frac{0 + (9-1) + (13-2) + (22-3)}{4}$$
$$= 9.5 \text{ ms}$$

$$\text{Avg turnaround time} = \frac{9 + (13-1) + (22-2) + (27-3)}{4}$$
$$= 16.25 \text{ ms}$$

ii) SRTF

P ₁	P ₂	P ₄	P ₁	P ₃
0	1	5	10	18

$$\text{Avg waiting time} = \frac{(10-1) + (1-1) + (18-2) + (5-3)}{4}$$
$$= 6.75 \text{ ms}$$

$$\text{Avg turnaround time} = \frac{18 + (5-1) + (27-2) + (10-3)}{4}$$
$$= 13.5 \text{ ms}$$

iii) RR (q = 2ms)

P ₁	P ₂	P ₃	P ₄	P ₁	P ₂	P ₃	P ₄	P ₁
0	2	4	6	8	10	12	14	16

P ₃	P ₄	P ₁	P ₂	P ₃	P ₁	P ₃
18	20	21	23	25	26	27

$$\begin{aligned}\text{Avg. waiting time} &= (6+6+3+2) + (2+6+1) \\ &\quad + (4+6+4+3+2) \cancel{+ (6+6+4)} \\ &= \frac{17+7+16+13}{4} \\ &= 13.25 \text{ ms}\end{aligned}$$

$$\begin{aligned}\text{Avg turnaround time} &= 26 + (2-1) + (27-2) \cancel{+ (2)} \\ &= 20 \text{ ms}\end{aligned}$$

iv) Priority

P ₃	P ₂	P ₁	P ₄
0	9	13	22

$$\text{Avg waiting time} = ($$

iv) Priority - (Preemptive)

P ₁	P ₂	P ₃	P ₂	P ₁	P ₄
0	1	2	11	14	22 27

$$\text{Avg waiting time} = \frac{(14-1) + (11-2-1) + (2-2)}{4}$$
$$= \underline{\underline{10 \text{ ms}}}$$

$$\text{Avg turnaround time} = \frac{(22-0) + (14-1) + (11-2) + (27-3)}{4}$$
$$= \underline{\underline{17 \text{ ms}}}$$

P70

7	Process	Allocation				Max.				Available				Need		
		A	B	C	D	A	B	C	D	A	B	C	D	A	B	C
P ₀		2	0	0	1	4	2	1	2	3	3	2	1	2	2	1
P ₁		3	1	2	1	5	2	5	2	2	0	0	1	2	1	3
P ₂		2	1	0	3	2	3	1	6	5	3	2	2	1	2	1
P ₃		1	3	1	2	1	4	2	4	1	3	1	2	0	1	1
P ₄		1	4	3	2	3	6	6	5	6	6	3	4	2	2	3
										1	4	3	2			
										7	10	6	6			

Safe sequence

$$= \{P_0, P_3, P_4, P_1, P_2\}$$

+3	1	2	1
10	11	8	7
+2	1	0	3
12	12	8	10

- i) Yes, the system is in safe state as a safe sequence exists.

Safe sequence = {P₀, P₃, P₄, P₁, P₂}

ii) P₂ = (0, 1, 1, 3),

No, if P₂ asks for (0, 1, 1, 3) it cannot be granted as D = 3 > 1 which is available, hence request is denied.

8. Process	Allocation			Maximum			Available			Need		
	A	B	C	A	B	C	A	B	C	A	B	C
P ₀	0	1	0	7	5	3	3	3	2	7	4	3
P ₁	2	0	0	3	2	2	2	2	0	1	2	2
P ₂	3	0	2	9	0	2	5	3	2	6	0	0
P ₃	2	1	1	2	2	2	2	1	1	0	1	1
P ₄	0	0	2	4	3	3	7	4	3	4	3	1
							0	0	2			
							7	4	5			

Need matrix

	A	B	C
=	7	4	3
	1	2	2
	6	0	0
	0	1	1
	4	3	1
			7
			5
			10

Safe sequence

$$= \{P_1, P_3, P_4, P_0, P_2\}$$

~~.....~~

9. String: 123412512345

PIPO for 2 frames

1 2 3 4 1 2

1	1	3	3	1	1
2	2	2	4	4	2

5 1 2 3 4 5

5	5	2	2	4	4
2	1	1	3	3	5

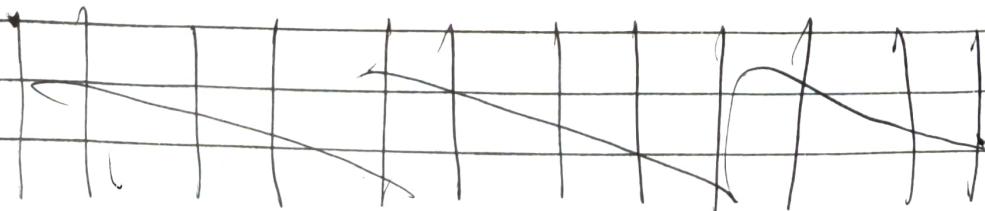
∴ There are no hit

No of faults = 12

FIFO with 3 frames :

1 2 3 4 1 2

1	1	1	4	4	4
2	2	2	2	1	1
3	3	3	3	3	2



5 1 2 8 M S

S	5	5	5	5	5	5	No of hits
1	1	1	3	3	3	3	= 3
2	2	2	2	4	4	4	
Hit	Hit	Hit					

4 frames

1	2	3	4	1	2
1	1	1	1	1	1
2	2	2	2	2	2
3	3	3	3	3	3
4	4	4	4	4	4
				Hit	Hit

S	1	2	3	4	S
S	S	S	S	9	9
2	1	1	1	1	1
3	3	2	2	2	2
4	4	4	3	3	3

~~No of hits = 2~~

PTO

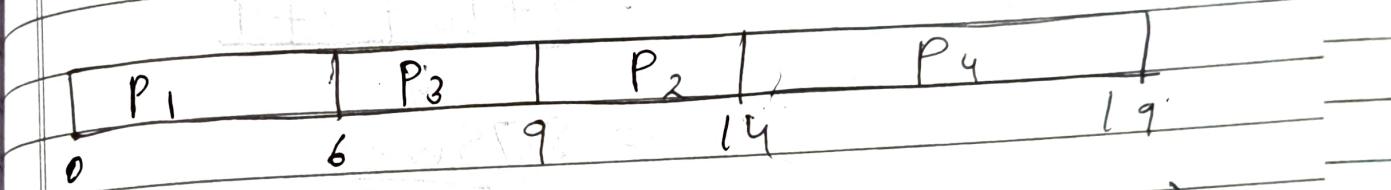
Belady's anomaly is a phenomenon in which the no of page faults increases as the no of frames increases.

Here, as seen, from no of frames increasing from 3 to 4, the page faults increase from 9 to 10.

∴ Belady's anomaly holds for FIFO.

<u>Process</u>	<u>Arrival time</u>	<u>Burst time</u>	<u>Priority</u>
P ₁	0	6	4
P ₂	3	5	2
P ₃	3	3	6
P ₄	5	15	3

- i) SJF pre-emptive i.e. R (q = 1)
- ii) SJF pre-emptive i.e. Shortest Job Remaining First



Avg Waiting time = $\frac{0 + (6-3) + (9-3) + (14-5)}{4}$

$$= \frac{3+6+9}{4}$$

$$= 4.5 \text{ ms}$$

Avg turnaround time = $\frac{(6-0) + (9-3) + (14-3) + (19-5)}{4}$

$$= \frac{6+6+11+14}{4}$$

$$= 11.75 \text{ ms}$$

ii) RR (q = 1ms)

P ₁	P ₂	P ₃	P ₄	P ₁	P ₂	P ₃	P ₄	P ₁	P ₂	P ₃	P ₄
0	3	4	5	6	7	8	9	10	11	12	13

P ₁	P ₂	P ₄	P ₂	P ₄
15	16	17	18	19

$$\begin{aligned}\text{Avg waiting time} &= (3+3+3)+(3+3+3+3+1-3) \\ &\quad + (4+3+3-3)+(5+3+3+2+1-3) \\ &= \frac{9+10+7+9}{4} \\ &= \underline{\underline{8.75 \text{ ms}}}\end{aligned}$$

$$\begin{aligned}\text{Avg turnaround time} &= (15-0)+(18-3) \\ &\quad + (13-3)+(19-5) \\ &= \frac{15+15+10+14}{4} \\ &= \underline{\underline{13.5 \text{ ms}}}\end{aligned}$$