

CS & IT ENGINEERING



Operating System

CPU Scheduling

Lecture -4

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Recap of Previous Lecture



Topic

Multilevel Queue Scheduling

Topic

Multilevel Feedback Queue Scheduling

Topic

Round Robin Scheduling

Topics to be Covered



Topic

Multilevel Queue Scheduling

Topic

Multilevel Feedback Queue Scheduling

Topic

Questions on Scheduling



Topic : Multilevel Queue Scheduling

Queue 1: RR with Q=3 $\Rightarrow \cancel{P1}, \cancel{P2}, \cancel{P4}, \cancel{P6}, \cancel{P7}$

P1	P2	P3	P4	P6	P4	P3	P7	P3	P5	P8
0	3	6	10	13	16	17	19	21	23	29

 $\Rightarrow P3, P5, P8$ 34

Queue 2: FCFS

Process	Arrival Time	Burst Time	Queue
P1	0	3	1
P2	0	3	1
P3	2	8 4 2	2
P4	<u>10</u>	4	<u>1</u>
P5	11	6	2
P6	11	3	1
P7	<u>19</u>	2	1
P8	13	5	2



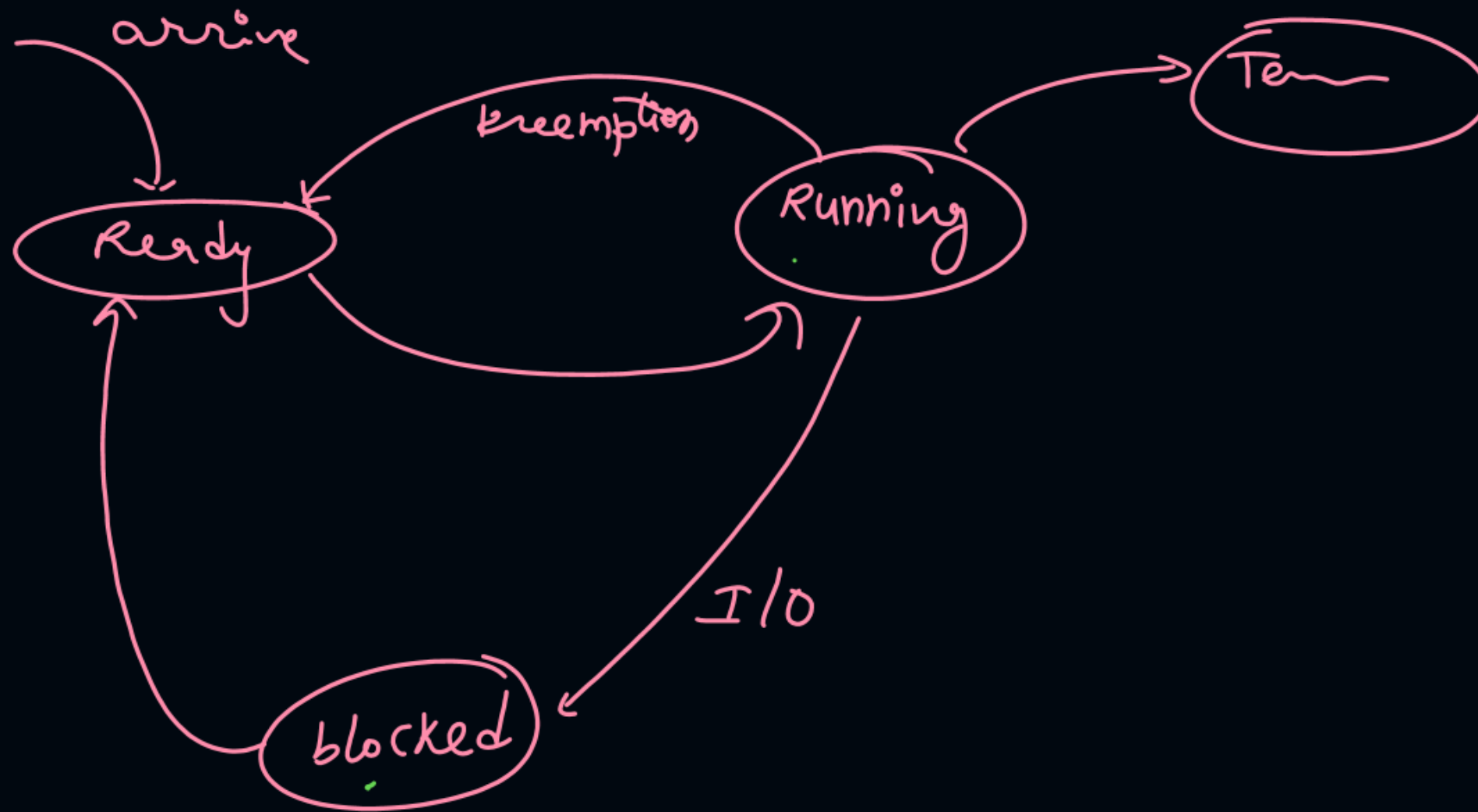
Topic : Analysis of Scheduling Algorithms

Basis of Analysis	Algorithm
Minimum average WT among non-preemptive	SJF avg WT in SJF \leq avg WT in any other non-preemptive algo
Minimum average WT among all algo ^s	SRTF
Non-preemptive always	FCFS, SJF, HRAN, non-preemptive priority algo, LJF
Preemptive always	None
SRTF behaves as SJF	1. when all processes arrive together 2. when later arriving processes do not have BT > Remaining time of current process
Preemptive Priority behaves as Non-Preemptive	1. when all processes arrive together 2. when later arriving processes do not have priority higher.



Topic : Analysis of Scheduling Algorithms

Basis of Analysis	Algorithm
RR behaves as Non-Preemptive	when $Q \geq \max(BT)$
Convoy Effect	FCFS, LJF
Starvation	SJF, SRTF, Priority, LJF, LRTF

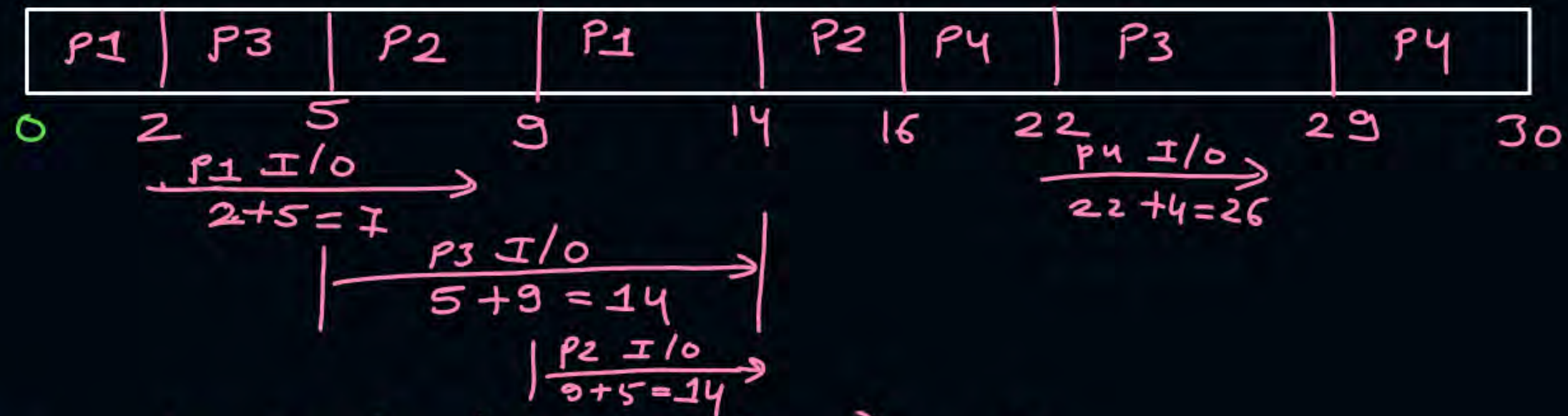


[MCQ]

#Q. Consider a process scenario in which each process executes first in CPU then goes for IO operation, then once again process needs a CPU bursts and then terminates. Following is given a process scenario in which for CPU execution system uses non preemptive SJF algorithm. Consider system has enough number of resources to carry out IO operations for all processes in parallel at a time. What is the average waiting time for the execution for the processes?

↳ in Ready state

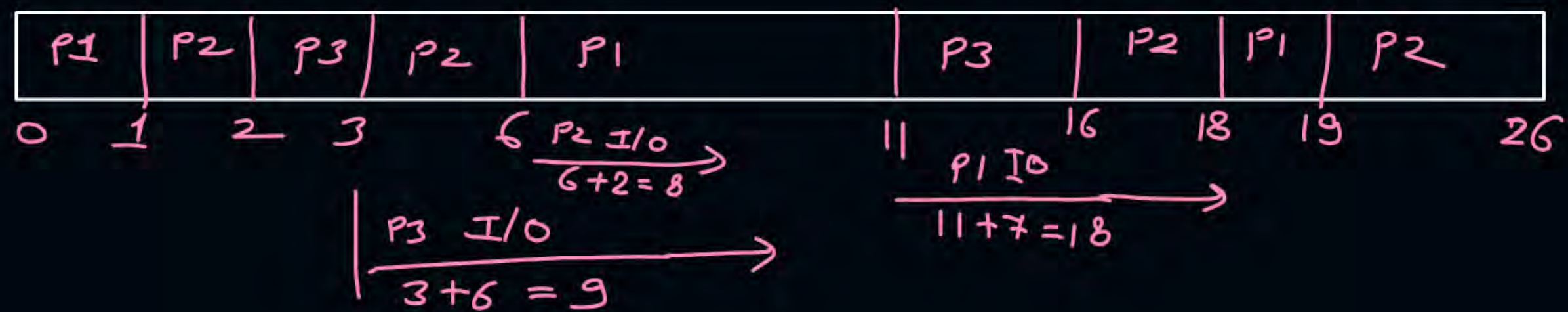
Process	Arrival Time	CPU Burst Time	IO Burst Time	CPU Burst Time	CT	TAT	WT = $TAT - \frac{\text{sum of all BT}}{4}$
P1	0	2	5	5	14	14	2
P2	0	4	5	2	16	16	5
P3	0	3	9	7	29	29	10
P4	0	6	4	1	30	30	19



R.Q. \Rightarrow ~~P1~~, ~~P2~~, ~~P3~~, ~~P4~~, ~~P1~~, ~~P2~~, ~~P3~~, P4

#Q. Consider a process scenario in which each process executes first in CPU then goes for IO operation, then once again process needs a CPU bursts and then terminates. Following is given a process scenario in which for CPU execution system uses preemptive SRTF algorithm. Consider system has enough number of resources to carry out IO operations for all processes in parallel at a time. What is the average waiting time for the execution for the processes?

Process	Arrival Time	CPU Burst Time	IO Burst Time	CPU Burst Time
P1	0	6	7	1
P2	1	4	2	9
P3	2	1	6	5



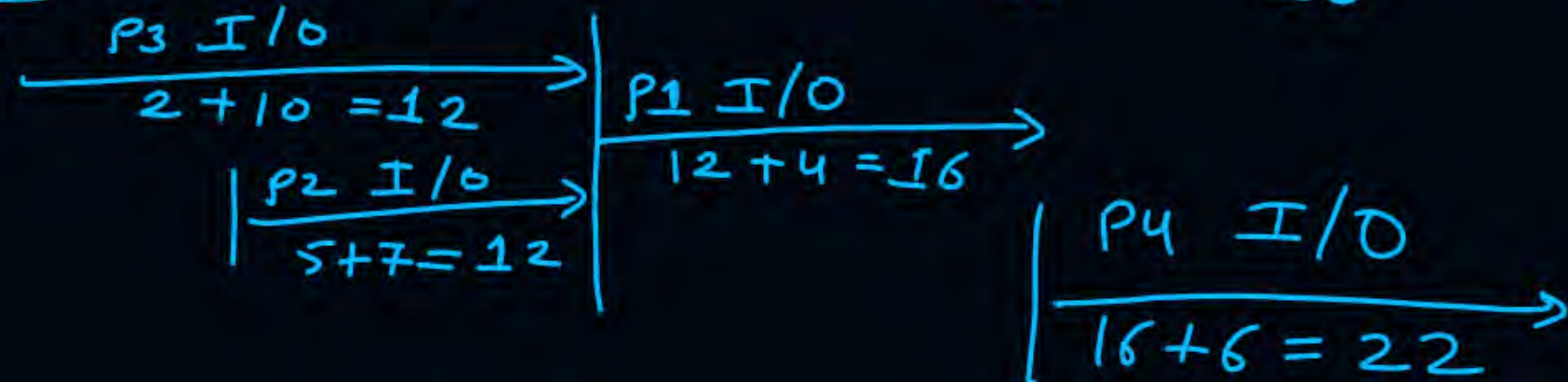
R.Q. = ~~P1~~, ~~P2~~, ~~P3~~, P2, ~~P3~~, P1

#Q. Consider a process scenario in which each process executes first in CPU then goes for IO operation, then once again process needs a CPU bursts and then terminates. Following is given a process scenario in which for CPU execution system uses non preemptive SJF algorithm. Consider system has only those number of resources to carry out IO operations for atmost 2 processes in parallel at a time. What is the average waiting time for the execution for the processes?

→ Ready Queue + device Queue

Process	Arrival Time	CPU Burst Time	IO Burst Time	CPU Burst Time	CT	TAT	WT
P1	0	5	4	5	25	25	11
P2	0	3	7	4	20	20	6
P3	0	2	10	7	33	33	14
P4	0	6	6	1	26	26	13

$$\text{avgT} = \frac{44}{4} = 11$$



R.Q. = ~~P1~~, ~~P2~~, ~~P3~~, ~~P4~~, ~~P1~~, ~~P2~~, P3, P4

- #Q. The arrival time, priority and duration of the CPU and I/O bursts for each of three processes P1, P2 and P3 are given in the table below. Each process has a CPU burst followed by an I.O burst followed by another CPU burst. Assume that each process has its own I/O resource.

Process	AT	Priority	BT (CPU)	BT(I/O)	BT(CPU)
P1	0	2	1	5	3
P2	2	3(lowest)	3	3	1
P3	3	1(highest)	2	3	1

The multi – programmed operating system uses preemptive priority scheduling. What are the finish times of the process P1, P2 and P3 ?

GATE - 2006

A 11, 15, 9

B 10, 15, 9

C 11, 16, 10

D 12, 17, 11

#Q. Multilevel Queue Scheduling, with fixed priority preemptive algorithm
Queue 1: RR with Q=2
Queue 2: SJF

Process	Arrival Time	Burst Time	Queue
P1	0	3	1
P2	1	3	2
P3	2	5	2
P4	1	4	1
P5	11	4	2
P6	15	3	1
P7	16	2	1



Topic : CPU Utilization



1. Without IO Operations

$$\text{CPU utilization} = 1 \Rightarrow 100\%$$

2. With IO Operations

Fraction of time a process goes for I/O = p

$$\text{for } n=1 \text{ process} \Rightarrow \text{CPU utilization} = 1 - p$$

$$\text{for } n=2 \text{ process} \Rightarrow \text{CPU utilization} = 1 - p^2$$

$$\text{for } n \text{ process} \Rightarrow \text{CPU utilization} = 1 - p^n$$

#Q. A computer system has degree of multiprogramming 10. And maximum I/O wait, that can be tolerated is 0.5. The CPU utilization is ____ %?

$$\begin{aligned} &= 1 - 0.5^{10} \\ &= 99.9\% \end{aligned}$$

[NAT]

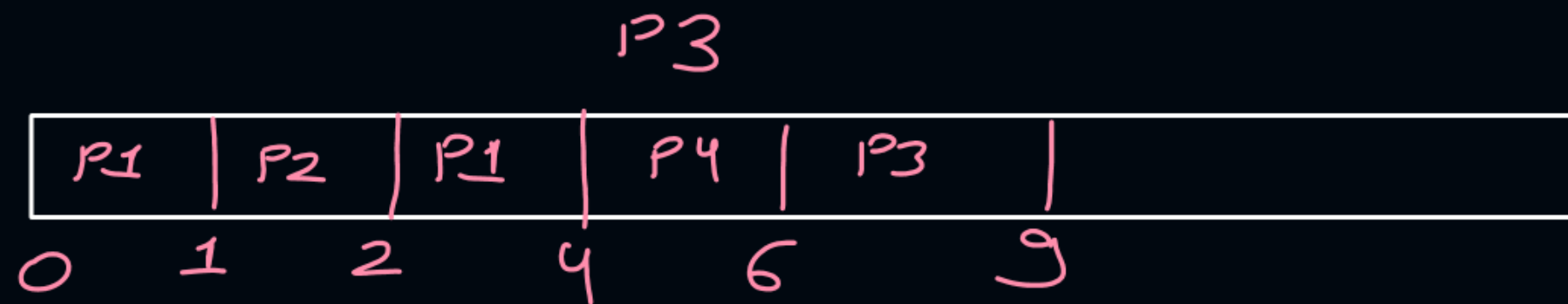
#Q. Consider the following four processes with arrival times (in milliseconds) and their length of CPU bursts (in milliseconds) as shown below:

Process	P1	P2	P3	P4
Arrival time	0	1	3	4
CPU burst Time	3 $\frac{2}{0}$	1	3	$Z = 2$

These processes are run on a single processor using preemptive Shortest Remaining Time First scheduling algorithm. If the average waiting time of the processes is 1 millisecond, then the value of Z is _____.

Gate - 2019

$$\text{avg } w_T = \frac{\text{sum of } w_T}{4} \Rightarrow \text{sum of } w_T = 4 \text{ ms}$$



	WT
P1	1
P2	0
P3	1+2=3
P4	0

	BT
P3	3
P4	2

$$Z \geq 3$$

$$Z < 3$$

[MCQ]

#Q. A uni-processor computer system only has two processes, both of which alternate 10 ms CPU bursts with 90 ms I/O bursts. Both the process were created at nearly the same time. The I/O of both processes ~~can~~ can proceed in parallel. Which of the following scheduling strategies will result in the least CPU utilization (over a long period of time) for this system ?

GATE - 2003

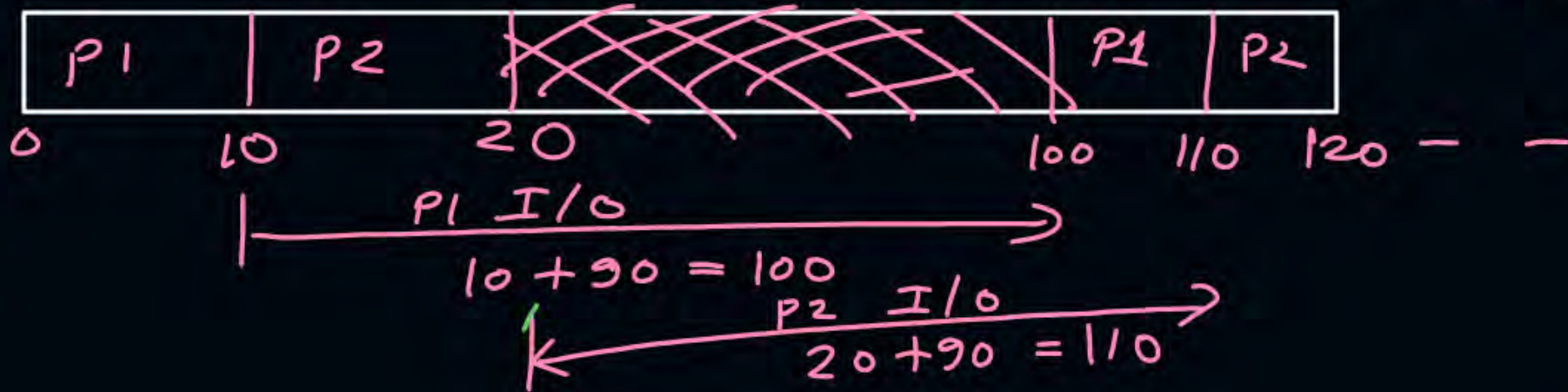
- A** First come first served scheduling
- B** Shortest remaining time first scheduling
- C** Static priority scheduling with different priorities for the two processes
- D** ✓ Round robin scheduling with a time quantum of 5 ms.

	CPU	I/O	CPU	I/O	-	-	-	-
P1	10	90	10	90				
P2	10	90	10	90	-	-	-	-

FCFS:-

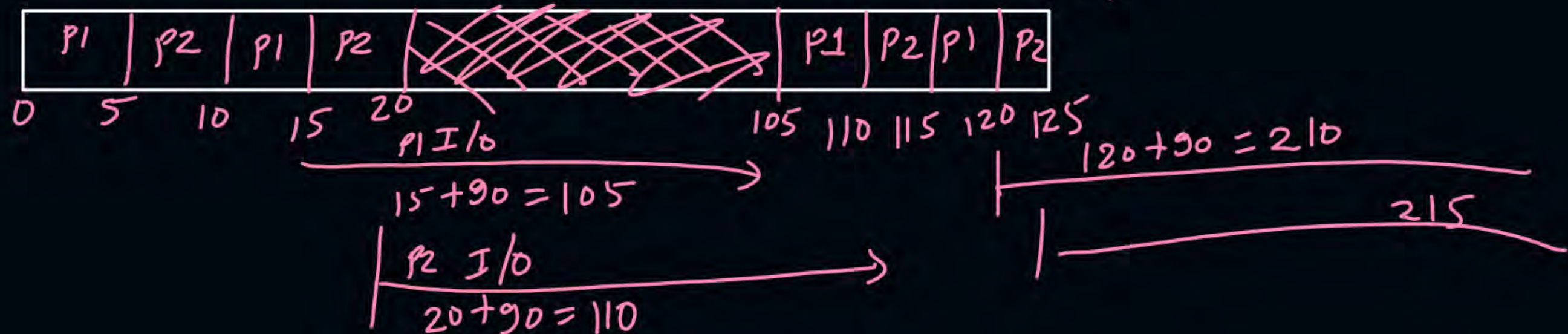
SRTF:-

Priority:-



$$\text{CPU utilization} = \frac{20}{100}$$

RR:-



$$= \frac{20}{105}$$

#Q. Consider three processes, all arriving at time zero, with total execution time of 10, 20 and 30 units, respectively. Each process spends the first 20% of execution time doing I/O, the next 70% of time doing computation, and the last 10% of time doing I/O again. The operating system uses a shortest remaining compute time first scheduling algorithm and schedules a new process either when the running process gets blocked on I/O or when the running process finishes its compute burst. Assume that all I/O operations can be overlapped as much as possible. For what percentage of time does the CPU remain idle?

GATE - 2006

0%



10.6%



30.0%



89.4%

[MCQ]

#Q. Consider four processes P, Q, R, and S scheduled on a CPU as per round-robin algorithm with a time quantum of 4 units. The processes arrive in the order P, Q, R, S, all at time $t = 0$. There is exactly one context switch from S to Q, exactly one context switch from R to Q, and exactly two context switches from Q to R. There is no context switch from S to P. Switching to a ready process after the termination of another process is also considered a context switch. Which one of the following is NOT possible as CPU burst time (in time units) of these processes?

GATE-2022

(A) $P = 4, Q = 10, R = 6, S = 2$

(B) $P = 2, Q = 9, R = 5, S = 1$

(C) $P = 4, Q = 12, R = 5, S = 4$

✓ (D) $P = 3, Q = 7, R = 7, S = 3$



$$\begin{array}{l|l}
 BT(P) \Rightarrow 1 \text{ to } 4 & BT(R) \Rightarrow 5 \text{ to } 8 \\
 BT(Q) \Rightarrow 9 \text{ to } 12 & BT(S) \Rightarrow 1 \text{ to } 4
 \end{array}$$



2 mins Summary

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Multilevel Queue Scheduling

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Multilevel Feedback Queue Scheduling

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Questions on Scheduling



Happy Learning

THANK - YOU

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