

CPU Scheduling

Practice Problems

By

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FCFS

Consider the set of 5 processes whose arrival time and burst time are given below:

Process ID	Arrival Time	Burst Time
P1	4	5
P2	6	4
P3	0	3
P4	6	2
P5	5	4

Calculate the average waiting time and average turnaround time,
if FCFS Scheduling Algorithm is followed.

Solution

Solution:

Process ID	Arrival Time	Burst Time
P1	4	5
P2	6	4
P3	0	3
P4	6	2
P5	5	4

Gantt Chart:



The shaded box represents the idle time of CPU

Turn Around time = Completion time - Arrival time

Waiting time = Turn Around time - Burst time

Process ID	Completion Time	Turnaround Time	Waiting Time
P1	9	9 - 4 = 5	5 - 5 = 0
P2	17	17 - 6 = 11	11 - 4 = 7
P3	3	3 - 0 = 3	3 - 3 = 0
P4	19	19 - 6 = 13	13 - 2 = 11
P5	13	13 - 5 = 8	8 - 4 = 4

Solution (Cont.)

Process ID	Completion Time	Turnaround Time	Waiting Time
P1	9	$9 - 4 = 5$	$5 - 5 = 0$
P2	17	$17 - 6 = 11$	$11 - 4 = 7$
P3	3	$3 - 0 = 3$	$3 - 3 = 0$
P4	19	$19 - 6 = 13$	$13 - 2 = 11$
P5	13	$13 - 5 = 8$	$8 - 4 = 4$

Now,

$$\begin{aligned}\text{Average Turn Around time} &= (5 + 11 + 3 + 13 + 8) / 5 \\ &= 40 / 5 \\ &= 8 \text{ units}\end{aligned}$$

$$\begin{aligned}\text{Average waiting time} &= (0 + 7 + 0 + 11 + 4) / 5 \\ &= 22 / 5 \\ &= 4.4 \text{ units}\end{aligned}$$

SRTF-1

An operating system uses shortest remaining time first scheduling algorithm for pre-emptive scheduling of processes. Consider the following set of processes with their arrival times and CPU burst times (in milliseconds):

Process ID	Arrival Time	Burst Time
P1	0	12
P2	2	4
P3	3	6
P4	8	5

The average waiting time (in milliseconds) of the processes is _____.

Solution

Process ID	Arrival Time	Burst Time
P1	0	12
P2	2	4
P3	3	6
P4	8	5

$$\text{Waiting Time for P1} = (17 - 2 - 0) = 15 \text{ ms}$$

$$\text{Waiting Time for P2} = (2 - 0 - 2) = 0 \text{ ms}$$

$$\text{Waiting Time for P3} = (6 - 0 - 3) = 3 \text{ ms}$$

$$\text{Waiting Time for P4} = (12 - 0 - 8) = 4 \text{ ms}$$

Solution:

Gantt Chart:



Average Waiting Time

$$= (15 + 0 + 3 + 4) / 4 = 5.5 \text{ ms}$$



Waiting Time = Total waiting Time - No. of milliseconds Process executed - Arrival Time

SRTF - 2

Consider the following processes, with the arrival time and the length of the CPU burst given in milliseconds. The scheduling algorithm used is preemptive shortest remaining-time first.

Process ID	Arrival Time	Burst Time
P1	0	10
P2	3	6
P3	7	1
P4	8	3

The average turn around time of these processes is _____ milliseconds.

Solution

Process ID	Arrival Time	Burst Time
P1	0	10 7
P2	3	6- 2
P3	7	1
P4	8	3

Turnaround Time for P1 = $(20 - 0) = 20 \text{ ms}$

Turnaround Time for P2 = $(10 - 3) = 7 \text{ ms}$

Turnaround Time for P3 = $(8 - 7) = 1 \text{ ms}$

Turnaround Time for P4 = $(13 - 8) = 5 \text{ ms}$

Solution:

Gantt Chart:



Average Turnaround Time

$$= (20 + 7 + 1 + 5)/4$$

$$= 33/4$$

$$= 8.25 \text{ ms}$$

Turn Around time = Completion time - Arrival time



Priority Scheduling - 1

Consider the set of processes with arrival time (in milliseconds), CPU burst time (in milliseconds), and priority (0 is the highest priority) shown below. None of the processes have I/O burst time.

Process ID	Arrival Time	Burst Time	Priority
P1	0	11	2
P2	5	28	0
P3	12	2	3
P4	2	10	1
P5	9	16	4

The average waiting time (in milliseconds) of all the processes using preemptive priority scheduling algorithm is_____.

Solution

Process ID	Arrival Time	Burst Time	Priority
P1	0	11 9-	2
P2	5	28	0
P3	12	2-	3
P4	2	10 7-	1
P5	9	16	4

$$\text{Waiting Time for P1} = (40 - 2 - 0) = 38 \text{ ms}$$

$$\text{Waiting Time for P2} = (5 - 0 - 5) = 0 \text{ ms}$$

$$\text{Waiting Time for P3} = (49 - 0 - 12) = 37 \text{ ms}$$

$$\text{Waiting Time for P4} = (33 - 3 - 2) = 28 \text{ ms}$$

$$\text{Waiting Time for P5} = (51 - 0 - 9) = 42 \text{ ms}$$

Average Waiting Time

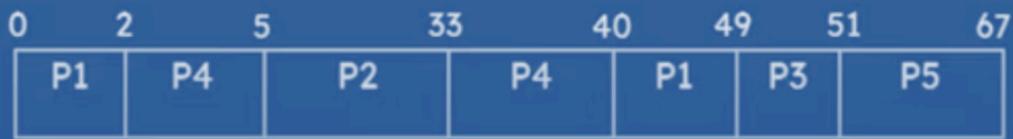
$$= (38 + 0 + 37 + 28 + 42) / 5$$

$$= 145/5 \text{ ms}$$

$$= 29 \text{ ms}$$

Solution:

Gantt Chart:



Priority Scheduling - 2

Consider the set of processes with arrival time (in milliseconds), CPU burst time (in milliseconds), and priority shown below: (Higher number represents higher priority)

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

If the CPU scheduling policy is priority non-preemptive, calculate the average waiting time and average turn around time.

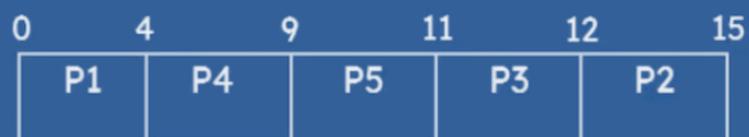
Solution

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

Process ID	Completion Time	Turnaround Time	Waiting Time
P1	4	4 - 0 = 4	4 - 4 = 0
P2	15	15 - 1 = 14	14 - 3 = 11
P3	12	12 - 2 = 10	10 - 1 = 9
P4	9	9 - 3 = 6	6 - 5 = 1
P5	11	11 - 4 = 7	7 - 2 = 5

Solution:

Gantt Chart:



$$\text{Turn Around time} = \text{Completion time} - \text{Arrival time}$$

$$\text{Waiting time} = \text{Turn Around time} - \text{Burst time}$$

Average Turn Around time

$$= (4 + 14 + 10 + 6 + 7) / 5 \\ = 41 / 5 = 8.2 \text{ ms}$$

Average waiting time

$$= (0 + 11 + 9 + 1 + 5) / 5 \\ = 26 / 5 = 5.2 \text{ ms}$$



Round Robin

Consider the set of 5 processes whose arrival time and burst time are given below:

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

If the CPU scheduling policy is Round Robin with time quantum = 2 units, calculate the average waiting time and average turn around time.

Solution

Turn Around time = Completion time - Arrival time

Waiting time = Turn Around time - Burst time

Process ID	Completion Time	Turnaround Time	Waiting Time
P1	13	$13 - 0 = 13$	$13 - 5 = 8$
P2	12	$12 - 1 = 11$	$11 - 3 = 8$
P3	5	$5 - 2 = 3$	$3 - 1 = 2$
P4	9	$9 - 3 = 6$	$6 - 2 = 4$
P5	14	$14 - 4 = 10$	$10 - 3 = 7$

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

Average Turn Around time

$$\begin{aligned} &= (13 + 11 + 3 + 6 + 10) / 5 \\ &= 43 / 5 = 8.6 \text{ units} \end{aligned}$$



Average waiting time

$$\begin{aligned} &= (8 + 8 + 2 + 4 + 7) / 5 \\ &= 29 / 5 = 5.8 \text{ units} \end{aligned}$$