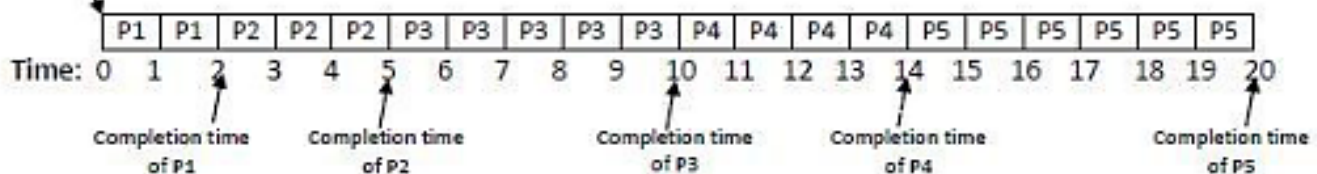# Example 1:

Q. Consider the following processes with burst time (CPU Execution time). Calculate the average waiting time and average turnaround time?

Process id	Arrival time	Burst time/CPU execution time
P1	0	2
P2	1	3
P3	2	5
P4	3	4
P5	4	6

Sol.

Gantt chart

P1	P1	P2	P2	P2	P3	P3	P3	P3	P3	P4	P4	P4	P4	P5	P5	P5	P5	P5	P5

Time: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

Completion time of P1   Completion time of P2   Completion time of P3   Completion time of P4   Completion time of P5

Turnaround time= Completion time – Arrival time

Waiting time= Turnaround time – Burst time

Process id	Arrival time	Burst time	Completion time	Turnaround time	Waiting time
P1	0	2	2	2-0=2	2-2=0
P2	1	3	5	5-1=4	4-3=1
P3	2	5	10	10-2=8	8-5=3
P4	3	4	14	14-3=11	11-4=7
P5	4	6	20	20-4=16	16-6=10

Average turnaround time= $\sum_{i=0}^{n}$ Turnaround time(i)/n   where, n= no. of process

Average waiting time= $\sum_{i=0}^{n}$ Wating time(i)/n   where, n= no. of process

Average turnaround time= 2+4+8+11+16/5 =41/5 =8.2

Average waiting time= 0+1+3+7+10/5 = 21/5 =4.2

#2

Consider the processes P1, P2, P3 given in the below table, arrives for execution in the same order, with Arrival Time 0, and given Burst Time,

PROCESS	ARRIVAL TIME	BURST TIME
P1	0	24
P2	0	3
P3	0	3

Gantt chart

P_1	P_2	P_3

0   24   27   30

PROCESS	WAIT TIME	TURN AROUND TIME
P1	0	24
P2	24	27
P3	27	30

Total Wait Time = 0 + 24 + 27 = 51 ms

Average Waiting Time = (Total Wait Time) / (Total number of processes) = 51/3 = 17 ms

Total Turn Around Time: 24 + 27 + 30 = 81 ms

Average Turn Around time = (Total Turn Around Time) / (Total number of processes) = 81 / 3 = 27 ms

Throughput = 3 jobs/30 sec = 0.1 jobs/sec

#3

Consider the processes P1, P2, P3, P4 given in the below table, arrives for execution in the same order, with given Arrival Time and Burst Time.

PROCESS	ARRIVAL TIME	BURST TIME
P1	0	8
P2	1	4
P3	2	9
P4	3	5

Gantt chart

P_1	P_2	P_3	P_4

0   8   12   21   26

PROCESS	WAIT TIME	TURN AROUND TIME
P1	0	8 – 0 = 8
P2	8 – 1 = 7	12 – 1 = 11
P3	12 – 2 = 10	21 – 2 = 19
P4	21 – 3 = 18	26 – 3 = 23

Total Wait Time:= 0 + 7 + 10 + 18 = 35 ms

Average Waiting Time = (Total Wait Time) / (Total number of processes)= 35/4 = 8.75 ms

Total Turn Around Time: 8 + 11 + 19 + 23 = 61 ms

Average Turn Around time = (Total Turn Around Time) / (Total number of processes)
61/4 = 15.25 ms

Throughput: 4 jobs/26 sec = 0.15385 jobs/sec

#4

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

Process Id	Arrival time	Burst time
P1	3	1
P2	1	4
P3	4	2
P4	0	6
P5	2	3

Solution-
If the CPU scheduling policy is SJF non-preemptive, calculate the average waiting time and average turnaround time.
Gantt Chart-

```
0      6      7      9      12      16

|  P4  |  P1  |  P3  |  P5  |  P2  |
```

Gantt Chart

Now, we know-
- Turn Around time = Exit time – Arrival time
- Waiting time = Turn Around time – Burst time

Process Id	Exit time	Turn Around time	Waiting time
P1	7	7 – 3 = 4	4 – 1 = 3
P2	16	16 – 1 = 15	15 – 4 = 11
P3	9	9 – 4 = 5	5 – 2 = 3
P4	6	6 – 0 = 6	6 – 6 = 0
P5	12	12 – 2 = 10	10 – 3 = 7

Now,
- Average Turn Around time = (4 + 15 + 5 + 6 + 10) / 5 = 40 / 5 = 8 unit
- Average waiting time = (3 + 11 + 3 + 0 + 7) / 5 = 24 / 5 = 4.8 unit

#5

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

Process Id	Arrival time	Burst time
P1	3	1
P2	1	4
P3	4	2
P4	0	6
P5	2	3

If the CPU scheduling policy is SJF pre-emptive, calculate the average waiting time and average turnaround time.

Solution-

Gantt Chart-

0	1	3	4	6	8	11	16
P4	P2	P1	P2	P3	P5	P4	

Gantt Chart

Process Id	Exit time	Turn Around time	Waiting time
P1	4	4 – 3 = 1	1 – 1 = 0
P2	6	6 – 1 = 5	5 – 4 = 1
P3	8	8 – 4 = 4	4 – 2 = 2
P4	16	16 – 0 = 16	16 – 6 = 10
P5	11	11 – 2 = 9	9 – 3 = 6

Now,

- Average Turn Around time = (1 + 5 + 4 + 16 + 9) / 5 = 35 / 5 = 7 unit
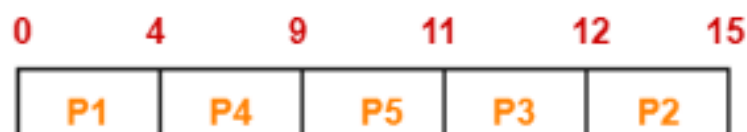- Average waiting time = (0 + 1 + 2 + 10 + 6) / 5 = 19 / 5 = 3.8 unit

#6

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

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 turnaround time. (*Higher number represents higher priority*)

Solution-
Gantt Chart-

```
0       4       9       11      12      15
+-------+-------+-------+-------+-------+
|  P1   |  P4   |  P5   |  P3   |  P2   |
+-------+-------+-------+-------+-------+
```

Now, we know-
- Turn Around time = Exit time – Arrival time
- Waiting time = Turn Around time – Burst time

Process Id	Exit time	Turn Around 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

Now,
- Average Turn Around time = (4 + 14 + 10 + 6 + 7) / 5 = 41 / 5 = 8.2 unit
- Average waiting time = (0 + 11 + 9 + 1 + 5) / 5 = 26 / 5 = 5.2 unit

Problem-03: Consider the set of 6 processes whose arrival time and burst time are given below-

Process Id	Arrival time	Burst time
P1	5	5
P2	4	6
P3	3	7
P4	1	9
P5	2	2
P6	6	3

If the CPU scheduling policy is Round Robin with time quantum = 3, calculate the average waiting time and average turnaround time.

Solution-

Ready Queue- **P3, P1, P4, P2, P3, P6, P1, P4, P2, P3, P5, P4**

Gantt chart-

0	1	4	6	9	12	15	18	21
■	P4	P5	P3	P2	P4	P1	P6	

21	24	27	30	32	33
P3	P2	P4	P1	P3	

Now, we know-
- Turn Around time = Exit time – Arrival time
- Waiting time = Turn Around time – Burst time

Process Id	Exit time	Turn Around time	Waiting time
P1	32	32 – 5 = 27	27 – 5 = 22
P2	27	27 – 4 = 23	23 – 6 = 17
P3	33	33 – 3 = 30	30 – 7 = 23
P4	30	30 – 1 = 29	29 – 9 = 20
P5	6	6 – 2 = 4	4 – 2 = 2
P6	21	21 – 6 = 15	15 – 3 = 12

Now,

- Average Turn Around time = (27 + 23 + 30 + 29 + 4 + 15) / 6 = 128 / 6 = 21.33 unit
- Average waiting time = (22 + 17 + 23 + 20 + 2 + 12) / 6 = 96 / 6 = 16 unit

Example-01:

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 unit, calculate the average waiting time and average turnaround time.

Solution-

Ready Queue-_____P5, P1, P2, P5, P4, P1, P3, P2, P1

Gantt Chart-

0	2	4	5	7	9	11	12	13	14
P1	P2	P3	P1	P4	P5	P2	P1	P5	

Now, we know-
- Turn Around time = Exit time – Arrival time
- Waiting time = Turn Around time – Burst time

Process Id	Exit time	Turn Around 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

Now,
- Average Turn Around time = (13 + 11 + 3 + 6 + 10) / 5 = 43 / 5 = 8.6 unit
- Average waiting time = (8 + 8 + 2 + 4 + 7) / 5 = 29 / 5 = 5.8 unit