FIRST COME FIRST SERVER (FCFS) – NON PREEMPTIVE

Process ID	Arrival Time	Burst Time
P1	4 ③	5
P2	6 ⑤	4
P3	0 ①	3
P4	6 ⑥	2
P5	5 ④	4

Gantt chart   *completion time*

```
      +5         +4          +4          +2         (plus BT)
0        3    4        9         13          17          19
|  P3  |■■■■|   P1    |   P5     |    P2     |    P4     |
```
→ *ascending AT*
if equal,
ascending
Process ID
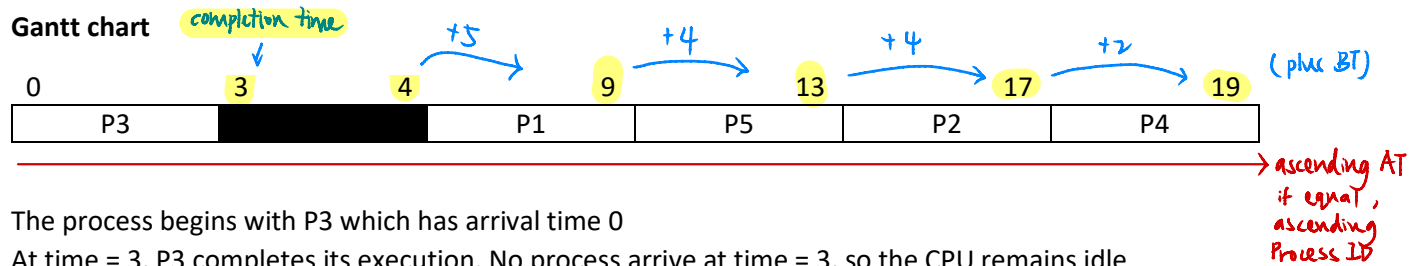
The process begins with P3 which has arrival time 0
At time = 3, P3 completes its execution. No process arrive at time = 3, so the CPU remains idle
The process continues with P1 which has arrival time 0
At time = 5, P5 arrives. P1 is still executing. Hence, P5 kept in a queue.

P5

At time = 6, P2 and P4 arrive. P1 is still executing. Hence, P2 and P4 kept in a queue.

P5	P2	P4

At time = 9, P1 process complete its execution.
At time = 9, P5 which is first in the queue, start execution. It has burst time of 4. It completes execution at time interval 13
At time = 13, P2 which is next in the queue, start execution. It has burst time of 4. It completes execution at time interval 17
At time = 17, P4 which is last in the queue, start execution. It has burst time of 2. It completes execution at time interval 19

Turnaround time = Completion Time – Arrival Time

Waiting Time = Turnaround Time – Burst Time

| Process ID	Completion Time	Turnaround Time	Waiting Time
		CT – AT	*TT – BT*
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

Average Turnaround Time = (5 + 11 + 3 + 13 + 8) / 5 = 40 / 5 = 8 units

Average Waiting Time = (0 + 7 + 0 + 11 + 4) / 5 = 22 / 5 = 4.4 unit

SHORTEST JOB FIRST (SJF) – NON PREEMPTIVE

Process ID	Arrival Time	Burst Time
P1	0 ①	10
P2	3	6 ④
P3	7	1 ✓
P4	8	3 ③

Gantt chart

*total of BT

arrival time 0,
then ascending
of BT,
If BT same
ascending of AT
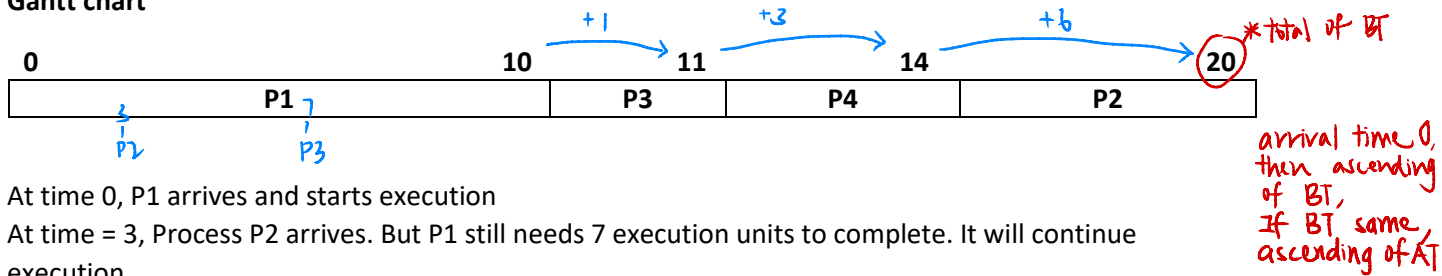
At time 0, P1 arrives and starts execution

At time = 3, Process P2 arrives. But P1 still needs 7 execution units to complete. It will continue execution.

P2

At time = 7 process P3 arrives and added to the waiting queue. P1 will continue execution.

P2	P3

At time = 8 process P4 arrives and added to the waiting queue. P1 will continue execution.

P2	P3	P4

At time = 10, process P1 will finish its execution. The burst time of P2, P3 and P4 is compared. Process P3 is executed because its burst time is the lowest.

P2	P4

At time = 11, process P3 will finish its execution. The burst time of P2 and P4 is compared. Process P4 is executed because its burst time is the lowest.

P2

At time = 14, process P4 will finish its execution. Process P2 is executed which is last in the queue

At time = 20, P2 finish its execution.

Turnaround time = Completion Time – Arrival Time

Waiting Time = Turnaround Time – Burst Time

Process ID	Completion Time	Turnaround Time	Waiting Time
P1	10	10 – 0 = 10	10 – 10 = 0
P2	20	20 – 3 = 17	17 – 6 = 11
P3	11	11 – 7 = 4	7 – 1 = 6
P4	14	14 – 8 = 6	6 – 3 = 3

Average Turnaround Time = (10 + 17 + 4 + 6) / 4 = 37 / 4 = 9.25 units

Average Waiting Time = (0 + 11 + 6 + 3) / 4 = 20 / 4 = 5 units

PRIORITY BASED (PREEMPTIVE)

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

Handwritten note (top right): WL: P1 P4

Gantt chart

```
0        2         5         33   ①  40    ②  49    ③  51    ④  67
   P1        P4        P2         P4        P1        P3        P5
```

Handwritten note: → ascending AT, if meet, smaller number of priority first.

At time = 0, Process P1 arrive. The execution begins with process P1, which has burst time 11

At time = 2, P4 arrives. P4 is at higher priority (1) compared to P1 having priority (2). P1 is preempted, and P4 begins its execution.

P1

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

At time = 5, P2 arrives. P2 is at higher priority (0) compared to P4 having priority (1). P4 is preempted, and P2 begins its execution.

P1	P4

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

At time = 9, P5 arrives. P2 has higher priority (0), so it continues its execution.

P1	P4	P5

At time = 12, P3 arrives. P2 has higher priority (0), so it continues its execution.

P1	P4	P5	P3

At time = 33, P2 completes its execution. P1, P3, P4 and P5 are in ready queue. P4 has higher priority (1). So P4 starts execution.

3

At time = 40, the process P4 has finished its execution. P1, P3 and P5 are in the waiting state. P1 has the highest priority (2) and starts execution.

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

At time = 49, the process P1 has finished its execution. P3 and P5 are in the waiting state. P3 has the highest priority (3) and starts execution.

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

At time = 51, the process P3 has finished its execution. P5 is the only process left. It starts execution.

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

At time = 67, P5 finish its execution.

Turnaround time = Completion Time – Arrival Time

Waiting Time = Turnaround Time – Burst Time

Process ID	Completion Time	Turnaround Time	Waiting Time
P1	49	49 – 0 = 49	49 – 11 = 38
P2	33	33 – 5 = 28	28 – 28 = 0
P3	51	51 – 12 = 39	39 – 2 = 37
P4	40	40 – 2 = 38	38 – 10 = 28
P5	67	67 – 9 = 58	58 – 16 = 42

Average Turnaround Time = (49 + 28 + 39 + 38 + 58) / 5 = 33 / 4 = 42.4 units

Average Waiting Time = (38 + 0 + 37 + 28 + 42) / 5 = 22 / 5 = 29 units

Process ID	Arrival Time	Burst Time
P1	0	10 3✓ 7
P2	3	6 4✓ 2
P3	7	1
P4	8	3

Gantt chart

0 3	3 4	7 1	8 ✓	10 3	13 7 20
P1	P2	P3	P2	P4	P1

At time = 0, P1 arrives and start execution.

At time = 3, Process P2 arrives with burst time = 6. P2 is executed because it has shorter burst time. Process P1 is preempted

P1

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

At time = 7, process P3 arrives with burst time = 1. P3 is executed because it has shorter burst time. Process P2 is preempted

P1	P2

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

At time = 8, P3 finishes its execution.

Process ID	Arrival Time	Burst Time
P1	0	7 out of 10 pending
P2	3	2 out of 6 pending
P3	7	0 pending
P4	8	3

At time = 8, process P4 arrives with burst time = 3. The burst time of P1, P2 and P4 are compared. Process P2 is executed because its burst time is lesser.

At time = 10, P2 finishes its execution. The burst time of P1 and P4 are compared. Process P4 is executed because its burst time is lesser.

Process ID	Arrival Time	Burst Time
P1	0	7 out of 10 pending
P2	3	0 pending
P3	7	0 pending
P4	8	3

At time = 13, P4 finishes its execution. Process P1 is executed which is the last in queue.

Process ID	Arrival Time	Burst Time
P1	0	7 out of 10 pending
P2	3	0 pending
P3	7	0 pending
P4	8	0 pending

At time = 20, P1 finishes its execution

Turnaround time = Completion Time – Arrival Time

Waiting Time = Turnaround Time – Burst Time

Process ID	Completion Time	Turnaround Time	Waiting Time
P1	20	20 – 0 = 20	20 – 10 = 10
P2	10	10 – 3 = 7	7 – 6 = 1
P3	8	8 – 7 = 1	1 – 1 = 0
P4	13	13 – 8 = 5	5 – 3 = 2

Average Turnaround Time = (20 + 7 + 1+ 5) / 4 = 33 / 4 = 8.25 units

Average Waiting Time = (10 + 1 + 0 + 2) / 4 = 13 / 4 = 3.25 units

ROUND ROBIN

Arrive at time = 0, Quantum = 4 millisecond

Process ID	Burst Time
P1	24
P2	3
P3	3

Gantt chart

0	4	7	10	14	18	22	26	30

P1	P2	P3	P1	P1	P1	P1	P1

The execution begins with process P1, which has burst time 24. Every process executed for 4 milliseconds.

P1	P2	P3

At time = 4, P1 is preempted and added to the end of the queue. The execution continue with P2, which has burst time 3. Because the burst time of P2 is less than 4 milliseconds, P2 will be execute until complete.

Process ID	Burst Time
P1	**20 out of 24 pending**
P2	3
P3	3

P3	P1

At time = 7, P2 finishes its execution. The execution continue with P3, which has burst time 3. Because the burst time of P3 is less than 4 milliseconds, P2 will be execute until complete.

P1

Process ID	Burst Time
P1	**20 out of 24 pending**
P2	**0 pending**
P3	3

At time = 10, P3 finishes its execution.

Process ID	Burst Time
P1	20 out of 24 pending
P2	0 pending
P3	0 pending

At time = 14 process P1 is executed which is the last in queue. Every process executed for 4 milliseconds.

Process ID	Burst Time
P1	16 out of 24 pending
P2	0 pending
P3	0 pending

At time = 18 process P1 is continue its execution.

Process ID	Burst Time
P1	12 out of 24 pending
P2	0 pending
P3	0 pending

At time = 22 process P1 is continue its execution.

Process ID	Burst Time
P1	8 out of 24 pending
P2	0 pending
P3	0 pending

At time = 26 process P1 is continue its execution.

Process ID	Burst Time
P1	4 out of 24 pending
P2	0 pending
P3	0 pending

At time = 30 P1 finishes its execution.

Turnaround time = Completion Time – Arrival Time

Waiting Time = Turnaround Time – Burst Time

Process ID	Completion Time	Turnaround Time	Waiting Time
P1	30	30 − 0 = 30	30 − 24 = 6
P2	7	7 − 0 = 7	7 − 3 = 4
P3	10	10 − 0 = 10	10 − 3 = 7

Average Turnaround Time = (30 + 7 + 10) / 3 = 54 / 5 = 15.66 units

Average Waiting Time = (6 + 4 + 7) / 5 = 17 / 3 = 5.66 units