Operating Systems Fundamentals

Processing scheduling
Exercises
and
Sample Solutions

Scheduling Criteria

Scheduling Criteria

are factors that affect the choice of Scheduling

Algorithm

- CPU Utilization
  - **CPU should be as busy as possible**
- Throughput
  - **Number of processes completed per unit time**
- Turnaround time
  - **Sum of time spent waiting, executing and doing I/O**
- Waiting time
  - **Sum of the time spent waiting in a ready queue**
- Response time
  - **A measure from time of submission to first response**

Optimisation Criteria

So Scheduler development should look to perform as best as possible on the following:

So which of below should be

maximised versus minimised

CPU utilization	Maximised
Throughput	Maximised
Turnaround time	Minimised
Waiting time	Minimised
Response time	Minimised

Scheduler Approaches Exercises

Different scheduler exercises include:

1. **First Come, First Served** **(FCFS)**
2. **Shortest Job First** **(SJF)**
3. **Shortest Remaining Job First** **(SJF)**
4. **Round Robin** **(RR)**

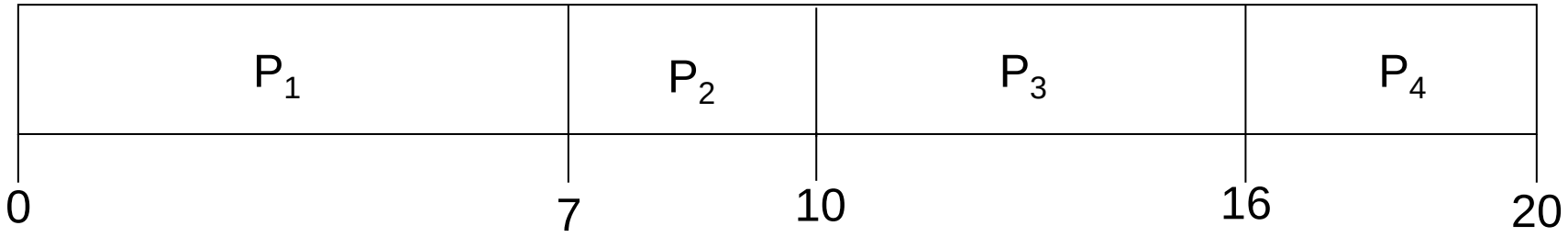
Exercise: First Come First Served

Process	Arrival Time	Burst Time
P1	0.0	7
P2	3.0	3
P3	8.0	6
P4	10.0	4

- Draw the Gantt chart
- Calculate wait times and average wait time
- Calculate turnaround time and average turnaround time.
- Calculate response time and average response time

Sample Solution: First Come First Served

Process	Arrival Time	Burst Time
P1	0.0	7
P2	3.0	3
P3	8.0	6
P4	10.0	4



- Waiting time: P1 = 0; P2 = 4; P3 = 2; P4 = 6
- Average waiting time: (0 + 4 + 2 + 6) / 4 = 3
- Turnaround time: P1 = 7; P2 = 7; P3 = 8; P4 = 10
- Average Turnaround time: (7 + 7 + 8 + 10) / 4 = 8
- Response Times: Same as waiting times [avg = 3]

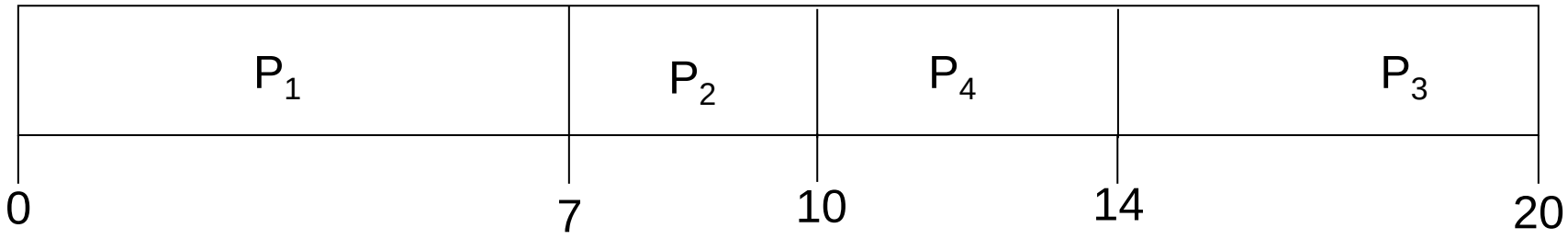
Exercise: Shortest Job First

Process	Arrival Time	Burst Time
P1	0.0	7
P2	3.0	3
P3	8.0	6
P4	10.0	4

- Draw the Gantt chart
- Calculate wait times and average wait time
- Calculate turnaround time and average turnaround time.
- Calculate response time and average response time

Sample Solution: Shortest Job First

Process	Arrival Time	Burst Time
P1	0.0	7
P2	3.0	3
P3	8.0	6
P4	10.0	4



- Waiting time: P1 = 0; P2 = 4; P3 = 6; P4 = 0
- Average waiting time: (0 + 4 + 6 + 0) / 4 = 2.5
- Turnaround time: P1 = 7; P2 = 7; P3 = 12; P4 = 4
- Average Turnaround time: (7 + 7 + 12 + 4) / 4 = 7.5
- Response Times: Same as waiting times [avg = 2.5]

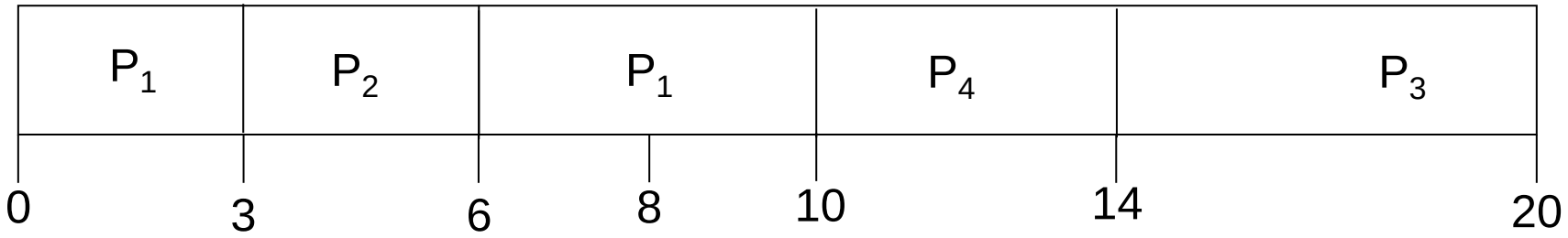
Exercise: Shortest Remaining Job First

Process	Arrival Time	Burst Time
P1	0.0	7
P2	3.0	3
P3	8.0	6
P4	10.0	4

- Draw the Gantt chart
- Calculate wait times and average wait time
- Calculate turnaround time and average turnaround time.
- Calculate response time and average response time

Sample Solution: Shortest Remaining Job First

Process	Arrival Time	Burst Time
P1	0.0	7
P2	3.0	3
P3	8.0	6
P4	10.0	4



- Waiting time: P1 = 3; P2 = 0; P3 = 6; P4 = 0
- Average waiting time: (3 + 0 + 6 + 0) / 4 = 2.25
- Turnaround time: P1 = 10; P2 = 3; P3 = 12; P4 = 4
- Average Turnaround time: (10 + 3 + 12 + 4) / 4 = 7.25
- Response Times: P1 = 0; P2 = 0; P3 = 6; P4 = 0 [avg=1.5]

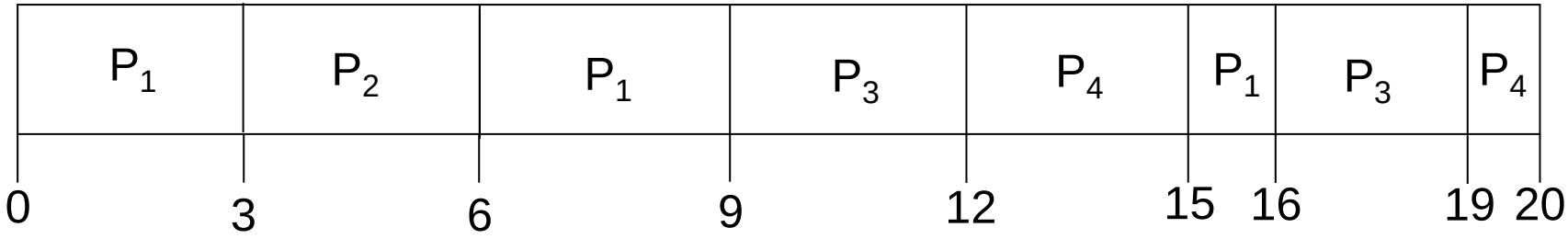
Exercise: Round Robin with Time Quantum = 3

Process	Arrival Time	Burst Time
P1	0.0	7
P2	3.0	3
P3	8.0	6
P4	10.0	4

- Draw the Gantt chart
- Calculate wait times and average wait time
- Calculate turnaround time and average turnaround time.
- Calculate response time and average response time

Solution: Round Robin with Time Quantum = 3

Process	Arrival Time	Burst Time
P1	0.0	7
P2	3.0	3
P3	8.0	6
P4	10.0	4



- Waiting time: P1 = 9; P2 = 0; P3 = 5; P4 = 6
- Average waiting time: (9 + 0 + 5 + 6) / 4 = 5
- Turnaround time: P1 = 16; P2 = 3; P3 = 11; P4 = 10
- Average Turnaround time: (16 + 3 + 11 + 10) / 4 = 10
- Response Times: P1 = 0; P2 = 0; P3 = 1; P4 = 2 [avg=0.75]

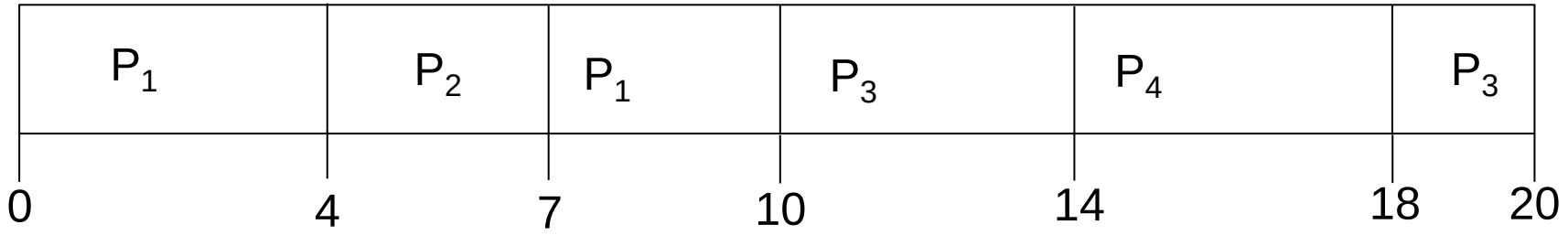
Solution: Round Robin with Time Quantum = 4

Process	Arrival Time	Burst Time
P1	0.0	7
P2	3.0	3
P3	8.0	6
P4	10.0	4

- Draw the Gantt chart
- Calculate wait times and average wait time
- Calculate turnaround time and average turnaround time.
- Calculate response time and average response time

Exercise: Round Robin with Time Quantum = 4

Process	Arrival Time	Burst Time
P1	0.0	7
P2	3.0	3
P3	8.0	6
P4	10.0	4



- Waiting time: P1 = 3; P2 = 1; P3 = 6; P4 = 4
- Average waiting time: (3 + 1 + 6 + 4) / 4 = 3.5
- Turnaround time: P1 = 10; P2 = 4; P3 = 12; P4 = 8
- Average Turnaround time: (10 + 4 + 12 + 8) / 4 = 8.5
- Response Times: P1 = 0; P2 = 1; P3 = 2; P4 = 4 [avg=1.75]