**ASSIGNMENT – 4**

Id – 2018ucp1505

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**Question 1: Fill the block by Exponential Averaging?**

1. **alpha = 0.4 and tou(n) = 8**

Answer:

By using formula:

tou(n+1) = alpha\*t(n) + (1 – alpha) \*tou(n)

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| N | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| t(n) | 6 | 10 | 11 | 7 | 4 | 6 | 9 | 3 | 7 | 5 |
| tou(n) | 8 | 7.2 | 8.32 | 9.39 | 8.43 | 6.66 | 7.8 | 8.28 | 6.17 | 6.5 |

1. **alpha = 0.6 and tou(n) = 8**

Answer:

By using formula:

tou(n+1) = alpha\*t(n) + (1 – alpha) \*tou(n)

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| N | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| t(n) | 6 | 10 | 11 | 7 | 4 | 6 | 9 | 3 | 7 | 5 |  |  |
| tou(n) | 8 | 6.8 | 8.72 | 10.09 | 8.24 | 5.7 | 5.88 | 7.75 | 4.9 | 6.16 |  |  |

**Question 2:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Process** | **Arrival Time** | **CPU Burst** | **I/O Burst** | **CPU Burst** |
| P1 | 0 | 4 | 3 | 5 |
| P2 | 0 | 5 | 4 | 2 |
| P3 | 0 | 3 | 2 | 3 |
| P4 | 0 | 2 | 1 | 4 |

Draw Gantt chart of CPU, process and I/O device and compute average turnaround time, waiting time and response time for following scheduling algorithms.

1. FCFS
2. SJF
3. Round Robin

Answer:

1. FCFS

Gantt chart:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| P1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P3 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Running CPU |  | Waiting CPU Queue |  | I/O Scheduled |  | Waiting I/O Queue |

Turnaround time = P1: 19-0 = 19 P2: 21-0 = 21 P3: 24-0 = 24 P4: 28-0 = 28

Average Turnaround time = 23

Response time = P1: 0-0 =0 P2: 4-0 =4 P3: 9-0 =9 P4: 12-0 =12

Average Response time = 6.25

Waiting time = P1: 19-4-5 =10 P2: 21-5-2 = 14 P3: 24-3-3 = 18 P4: 28-2-4 = 22

Average Waiting time = 16

1. SJF (Using pre-emptive scheduling)

Gantt Chart

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| P1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P3 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Running CPU |  | Waiting CPU Queue |  | I/O Scheduled |  | Waiting I/O Queue |

Turnaround time = P1: 26-0 = 26 P2: 28-0 = 28 P3: 12-0 = 12 P4: 16-0 = 16

Average turnaround time = 20.5

Response time = P1: 5-0 = 5 P2: 16-0 = 16 P3: 2-0 = 2 P4: 0-0 = 0

Average Response time = 5.75

Waiting time = P1: 26-4-5 = 17 P2: 28-5-2 = 21 P3: 12-3-3 = 6 P4: 16-2-4 = 10

Average Waiting time = 13.5

1. Round Robin

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| P1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P3 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Running CPU |  | Waiting CPU Queue |  | I/O Scheduled |  | Waiting I/O Queue |

Turnaround time: P1: 24-0 = 24 P2: 28-0 = 28 P3: 26-0 = 26 P4: 27-0 = 27

Average turnaround time: 26.25

Response time: P1: 0-0 = 0 P2: 1-0 = 1 P3: 2-0 = 2 P4: 3-0 = 3

Average Response time: 1.5

Waiting time: P1: 24-4-5 = 15 P2: 28-5-2 = 21 P3: 26-3-3 = 20 P4: 27-2-4 = 21

Average Waiting time = 19.25

**Question 3:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Process** | **Arrival Time** | **CPU Burst** | **I/O Burst** | **CPU Burst** | **Priority** |
| P1 | 0 | 4 | 3 | 5 | 4 |
| P2 | 1 | 5 | 4 | 2 | 2 |
| P3 | 2 | 3 | 2 | 3 | 3 |
| P4 | 3 | 2 | 1 | 4 | 1 |

Draw Gantt chart of CPU, process and I/O device and compute average turnaround time, waiting time and response time for following scheduling algorithms.

1. FCFS
2. SJF
3. SRTF
4. Priority (non-pre-emptive)
5. Priority (pre-emptive)
6. Round Robin

Answer:

1. FCFS

Gantt chart:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| P1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P3 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Running CPU |  | Waiting CPU Queue |  | I/O Scheduled |  | Waiting I/O Queue |

Turnaround time = P1: 19-0 = 19 P2: 21-1 = 20 P3: 24-2 = 22 P4: 28-3 = 25

Average Turnaround time = 21.5

Response time = P1: 0-0 = 0 P2: 4-1 = 3 P3: 9-2 = 7 P4: 12-3 = 9

Average Response time = 4.75

Waiting time = P1: 19-4-5 = 10 P2: 20-5-2 = 13 P3: 22-3-3 = 16 P4: 25-2-4 = 19

Average Waiting time = 14.5

1. SIF (Using pre-emptive scheduling)

Gantt chart:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| P1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P3 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Running CPU |  | Waiting CPU Queue |  | I/O Scheduled |  | Waiting I/O Queue |

Turnaround time: P1: 28-0 = 28 P2: 25-1 = 24 P3: 16-2 = 14 P4: 13-3 = 10

Average turnaround time: 19

Response time: P1: 0-0 = 0 P2: 16-1=15 P3: 6-2 = 4 P4: 4-3=1

Average response time: 5

Waiting time: P1: 28-4-5 = 19 P2: 24-5-2 =17 P3: 14-3-3 = 8 P4: 10-2-4 = 4

Average Waiting time: 12

1. SRTF

It will be same as SIF using pre-emptive scheduling as above because we don’t know alpha and history of Previous CPU burst.

1. Priority (Non pre-emptive)

Gantt chart:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| P1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P3 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Running CPU |  | Waiting CPU Queue |  | I/O Scheduled |  | Waiting I/O Queue |

Turnaround time: P1: 25-0 = 25 P2: 17-1 = 16 P3: 28-2 = 26 P4: 15-3 = 12

Average turnaround time: 19.75

Response time: P1: 0-0 = 0 P2: 6-1 = 5 P3: 17-2 = 15 P4: 4-3 = 1

Average response time: 5.25

Waiting time: P1: 25-4-5 = 16 P2: 16-5-2 = 9 P3: 26-3-3 = 20 P4: 12-2-4 = 6

Average Waiting time: 12.75

1. Priority (Pre-emptive)

Gantt chart:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| P1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P3 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Running CPU |  | Waiting CPU Queue |  | I/O Scheduled |  | Waiting I/O Queue |

Turnaround time: P1: 31-0 = 31 P2: 18-1 = 17 P3: 21-2 = 19 P4: 11-3 = 8

Average turnaround time: 18.75

Response time: P1: 0-0 = 0 P2: 1-1 = 0 P3: 12-2 = 10 P4: 4-3 = 1

Average response time: 2.75

Waiting time: P1: 31-4-5 = 22 P2: 17-5-2 = 10 P3: 19-3-3 = 13 P4: 8-2-4 = 2

Average Waiting time: 11.75

1. Round Robin

Gantt chart:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| P1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P3 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Running CPU |  | Waiting CPU Queue |  | I/O Scheduled |  | Waiting I/O Queue |

Turnaround time: P1: 28-0 = 28 P2: 27-1 = 26 P3: 22-2 = 20 P4: 25-3 = 22

Average turnaround time: 19

Response time: P1: 0-0 = 0 P2: 1-1 = 0 P3: 2-2 = 0 P4: 5-3 = 2

Average response time: 0.5

Waiting time: P1: 28-4-5 = 19 P2: 26-5-2 = 19 P3: 20-3-3 = 14 P4: 22-2-4 = 16

Average Waiting time: 17

**Question 4:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Process** | **Arrival Time** | **CPU Burst** | **I/O Burst** | **CPU Burst** | **Priority** |
| P1 | 0 | 5 | 2 | 3 | 2 |
| P2 | 2 | 3 | 6 | 2 | 4 |
| P3 | 3 | 7 | 3 | 1 | 1 |
| P4 | 7 | 1 | 4 | 5 | 3 |

Draw Gantt chart of CPU, process and I/O device and compute average turnaround time, waiting time and response time for following scheduling algorithms.

1. FCFS
2. SJF
3. SRTF
4. Priority (non-pre-emptive)
5. Priority (pre-emptive)
6. Round Robin

Answer:

1. FCFS

Gantt chart:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| P1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P3 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Running CPU |  | Waiting CPU Queue |  | I/O Scheduled |  | Waiting I/O Queue |

Turnaround time: P1: 19-0 = 19 P2: 21-2 = 19 P3: 22-3 = 19 P4: 27-7 = 20

Average turnaround time: 19.25

Response time: P1: 0-0 = 0 P2: 5-2 = 3 P3: 8-3 = 5 P4: 15-7 = 8

Average response time: 4

Waiting time: P1: 19-5-3 = 11 P2: 19-3-2 = 14 P3: 19-7-1 = 11 P4: 20-1-5 = 14

Average Waiting time: 12.5

1. SJF (Using Non-Pre-emptive scheduling)

Gantt chart:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
| P1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P3 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Running CPU |  | Waiting CPU Queue |  | I/O Scheduled |  | Waiting I/O Queue |

Turnaround time: P1: 18-0 = 18 P2: 15-2 = 13 P3: 32-3 = 29 P4: 23-7 = 16

Average turnaround time: 19

Response time: P1: 0-0 = 0 P2: 5-2 = 3 P3: 23-3 = 20 P4: 8-7 = 1

Average response time: 6

Waiting time: P1: 18-5-3 = 10 P2: 13-3-2 = 8 P3: 29-7-1 = 21 P4: 16-1-5 = 10

Average Waiting time: 12.25

1. SRTF

Same as that of above i.e., SJF as above because we don’t know alpha and history of Previous CPU burst.

1. Priority (non-pre-emptive)

Gantt chart:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 |
| P1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P3 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Running CPU |  | Waiting CPU Queue |  | I/O Scheduled |  | Waiting I/O Queue |

Turnaround time: P1: 15-0 = 15 P2: 29-2 = 27 P3: 16-3 = 13 P4: 26-7 = 19

Average turnaround time: 18.5

Response time: P1: 0-0 = 0 P2: 17-2 = 15 P3: 5-3 = 2 P4: 16-7 = 9

Average response time: 6.5

Waiting time: P1: 15-5-3 = 7 P2: 27-3-2 = 22 P3: 13-7-1 = 5 P4: 19-1-5 = 13

Average Waiting time: 14.25

1. Priority (pre-emptive)

Gantt chart:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 |
| P1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P3 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Running CPU |  | Waiting CPU Queue |  | I/O Scheduled |  | Waiting I/O Queue |

Turnaround time: P1: 18-0 = 18 P2: 34-2 = 32 P3: 14-3 = 11 P4: 24-7 = 17

Average turnaround time: 19.5

Response time: P1: 0-0 = 0 P2: 18-2 = 16 P3: 3-3 = 0 P4: 14-7 = 7

Average response time: 5.75

Waiting time: P1: 18-5-3 = 10 P2: 32-3-2 = 27 P3: 11-7-1 = 3 P4: 17-1-5 = 11

Average Waiting time: 12.75

1. Round Robin

Gantt chart:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
| P1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P3 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| P4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Running CPU |  | Waiting CPU Queue |  | I/O Scheduled |  | Waiting I/O Queue |

Turnaround time: P1: 25-0 = 25 P2: 21-2 = 19 P3: 22-3 = 19 P4: 26-7 = 19

Average turnaround time: 20.5

Response time: P1: 0-0 = 0 P2: 2-2 = 0 P3: 3-3 = 0 P4: 7-7 = 0

Average response time: 0

Waiting time: P1: 25-5-3 = 17 P2: 19-3-2 = 14 P3: 19-7-1 = 11 P4: 19-1-5 = 13

Average Waiting time: 13.75

**Question 5: What is Priority Inversion?**

**Answer:** Priority inversion is a operating system scenario in which a higher priority process is pre-empted by a lower priority process. This implies the inversion of the priorities of the two processes.

Problems due to Priority Inversion:

1. A system malfunction may occur if a high priority process is not provided the required resources.
2. Priority inversion may lead to implantation of the corrective measures. These may include the resetting of the entire system.
3. The performance of the system can be reducing due to priority inversion. This may happen because it is imperative for higher priority tasks to execute promptly.
4. System responsiveness decreases as high priority tasks may have strict time constraints or real time response guarantees.
5. Sometimes there is no harm caused by priority inversion as the late execution of the high priority process is not noticed by the system.

Solutions of Priority Inversion:

1. **Priority Ceiling**

All of the resources are assigned a priority that is equal to the highest priority of any task that may attempt to claim them. This helps in avoiding priority inversion.

1. **Disabling Interrupts**

There are only two priorities in this case i.e., interrupts disabled and preemptible. So, priority inversion is impossible as there is no third option.

1. **Priority Inheritance**

This solution temporarily elevates the priority of the low priority task that is executing to the highest priority task that needs the resource. This means that medium priority tasks cannot intervene and lead to priority inversion.

1. **No blocking**

Priority inversion can be avoided by avoiding blocking as the low priority task blocks the high priority task.

1. **Random boosting**

The priority of the ready tasks can be randomly boosted until they exit the critical section