

**Faculty of Engineering and Technology**

**Electrical and Computer Engineering Department**

**OPERATING SYSTEMS**

**ENCS3390**

**Answers of assignment 2**

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# Problem

**Consider the following set of processes:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Process** | **Arrival Time** | **Burst Time** | **Priority** |
| **P1** | **0** | **10** | **3** |
| **P2** | **1** | **8** | **2** |
| **P3** | **3** | **14** | **3** |
| **P4** | **4** | **7** | **1** |
| **P5** | **6** | **5** | **0** |
| **P6** | **7** | **4** | **1** |
| **P7** | **8** | **6** | **2** |

**For each of the following scheduling algorithms, show the Gantt chart, average**

**waiting time, and average turnaround time.**

**1- First Come First Served.**

**2- Shortest Job First.**

**3- Shortest Remaining Time First.**

**4- Round Robin, with q = 5**

**5- Priority Scheduling, with aging; where priority is decremented by 1 if the**

**process remains in the ready queue for 5 time units.**

## Part One: First Come First Served Scheduling.

First, we need to build the **Gantt chart** according to the above table:

**Gantt chart:**

0

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **P1**  10 | **P2**  18 | **P3**  32 | **P4**  39 | **P5**  44 | **P6**  48 | **P7**  54 |

Now we need to calculate **The Turn Around time** and **The Waiting time** for each process:

* To calculate **The Turn Around time,** we use the following formula:

**Turn Around time = Completion time – Arrival time**

* To calculate **The Waiting time,** we use the following formula:

**Waiting time = Turn Around time – Burst time**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Process** | **Arrival Time** | **Burst Time** | **Completion Time** | **Turn Around Time** | **Waiting Time** |
| **P1** | **0** | **10** | **10** | **10 - 0 = 10** | **10 – 10 = 0** |
| **P2** | **1** | **8** | **18** | **18 – 1 = 17** | **17 – 8 = 9** |
| **P3** | **3** | **14** | **32** | **32 – 3 = 29** | **29 – 14 = 15** |
| **P4** | **4** | **7** | **39** | **39 – 4 = 35** | **35 – 7 = 28** |
| **P5** | **6** | **5** | **44** | **44 – 6 = 38** | **38 – 5 = 33** |
| **P6** | **7** | **4** | **48** | **48 – 7 = 41** | **41 – 4 = 37** |
| **P7** | **8** | **6** | **54** | **54 – 8 = 46** | **46 – 6 = 40** |

Now, calculate **Average Waiting time**, and **Average Turnaround time**:

* **Average Waiting time** = (0+9+15+28+33+37+40)/7 = 162/7 = **23.14 units**
* **Average Turnaround time** = (10+17+29+35+38+41+46)/7 = 216/7 = **30.85 units**

## Part Two: Shortest Job First Scheduling.

First, we need to build the **Gantt chart** according to the above table:

**Gantt chart:**

40

19

0

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **P1**  10 | **P6**  14 | **P5** | **P7**  25 | **P4** | **P2**  32 | **P3**  54 |

Now we need to calculate **The Turn Around time** and **The Waiting time** for each process:

* To calculate **The Turn Around time,** we use the following formula:

**Turn Around time = Completion time – Arrival time**

* To calculate **The Waiting time,** we use the following formula:

**Waiting time = Turn Around time – Burst time**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Process** | **Arrival Time** | **Burst Time** | **Completion Time** | **Turn Around Time** | **Waiting Time** |
| **P1** | **0** | **10** | **10** | **10 - 0 = 10** | **10 – 10 = 0** |
| **P2** | **1** | **8** | **40** | **40 – 1 = 39** | **39 – 8 = 31** |
| **P3** | **3** | **14** | **54** | **54 – 3 = 51** | **51 – 14 = 37** |
| **P4** | **4** | **7** | **32** | **32 – 4 = 28** | **28 – 7 = 21** |
| **P5** | **6** | **5** | **19** | **19 – 6 = 13** | **13 – 5 = 8** |
| **P6** | **7** | **4** | **14** | **14 – 7 = 7** | **7 – 4 = 3** |
| **P7** | **8** | **6** | **25** | **25 – 8 = 17** | **17 – 6 = 11** |

Now, calculate **Average Waiting time**, and **Average Turnaround time**:

* **Average Waiting time** = (0+31+37+21+8+3+11)/7 = 111/7 = **15.85 units**
* **Average Turnaround time** = (10+39+51+28+13+7+17)/7 = 165/7 = **23.57 units**

## Part Three: Shortest Remaining Time First Scheduling.

First, we need to build the **Gantt chart** according to the above table:

**Gantt chart:**

54

40

31

18

9

1

0

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **P1** | **P2** | **P6**  13 | **P5** | **P7**  24 | **P4** | **P1** | **P3** |

Now we need to calculate **The Turn Around time** and **The Waiting time** for each process:

* To calculate **The Turn Around time,** we use the following formula:

**Turn Around time = Waiting time + Burst Time**

* To calculate **The Waiting time,** we use the following formula:

**Waiting time = Total waiting time – No. of units process executed – Arrival time**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Process** | **Arrival Time** | **Burst Time** | **Total waiting time** | **No. of units process executed** | **Waiting Time** |
| **P1** | **0** | **10** | **31** | **1** | **31 – 1 – 0 = 30** |
| **P2** | **1** | **8** | **1** | **0** | **1 – 0 – 1 = 0** |
| **P3** | **3** | **14** | **40** | **0** | **40 – 0 – 3 = 37** |
| **P4** | **4** | **7** | **24** | **0** | **24 – 0 – 4 = 20** |
| **P5** | **6** | **5** | **13** | **0** | **13 – 0 – 6 = 7** |
| **P6** | **7** | **4** | **9** | **0** | **9 – 0 – 7 = 2** |
| **P7** | **8** | **6** | **18** | **0** | **18 – 0 – 8 = 10** |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Process** | **Arrival Time** | **Burst Time** | **Waiting Time** | **Turn Around Time** |
| **P1** | **0** | **10** | **30** | **30 + 10 = 40** |
| **P2** | **1** | **8** | **0** | **0 + 8 = 8** |
| **P3** | **3** | **14** | **37** | **37 + 14 = 51** |
| **P4** | **4** | **7** | **20** | **20 + 7 = 27** |
| **P5** | **6** | **5** | **7** | **7 + 5 = 12** |
| **P6** | **7** | **4** | **2** | **2 + 4 = 6** |
| **P7** | **8** | **6** | **10** | **10 + 6 = 16** |

Now, calculate **Average Waiting time**, and **Average Turnaround time**:

* **Average Waiting time** = (30+0+37+20+7+2+10)/7 = 106/7 = **15.14 units**
* **Average Turnaround time** = (40+8+51+24+13+9+18)/7 = 160/7 = **22.85 units**

## Part Four: Round Robin Scheduling.

Note: q “Time Quantum” = 5 units.

First, we need to build the **Gantt chart** according to the above table:

**Gantt chart:**

54

42

30

20

0

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **P1**  5 | **P2** | **P3**  15  10 | **P4** | **P1**  25 | **P5** | **P6**  34 | **P7**  39 | **P2** | **P3**  47 | **P4**  49 | **P7**  50 | **P3** |

Now we need to calculate **The Turn Around time** and **The Waiting time** for each process:

* To calculate **The Turn Around time,** we use the following formula:

**Turn Around time = Waiting time + Burst Time**

* To calculate **The Waiting time,** we use the following formula:

**Waiting time = Total waiting time – No. of units process executed – Arrival time**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Process** | **Arrival Time** | **Burst Time** | **Total waiting time** | **No. of units process executed** | **Waiting Time** |
| **P1** | **0** | **10** | **20** | **5** | **20 – 5 – 0 = 15** |
| **P2** | **1** | **8** | **39** | **5** | **39 – 5 – 1 = 33** |
| **P3** | **3** | **14** | **50** | **10** | **50 – 10 – 3 = 37** |
| **P4** | **4** | **7** | **47** | **5** | **47 – 5 – 4 = 38** |
| **P5** | **6** | **5** | **25** | **0** | **25 – 0 – 6 = 19** |
| **P6** | **7** | **4** | **30** | **0** | **30 – 0 – 7 = 23** |
| **P7** | **8** | **6** | **49** | **5** | **49 – 5 – 8 = 36** |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Process** | **Arrival Time** | **Burst Time** | **Waiting Time** | **Turn Around Time** |
| **P1** | **0** | **10** | **15** | **15 + 10 = 25** |
| **P2** | **1** | **8** | **33** | **33 + 8 = 41** |
| **P3** | **3** | **14** | **37** | **37 + 14 = 51** |
| **P4** | **4** | **7** | **38** | **38 + 7 = 45** |
| **P5** | **6** | **5** | **19** | **19 + 5 = 24** |
| **P6** | **7** | **4** | **23** | **23 + 4 = 27** |
| **P7** | **8** | **6** | **36** | **36 + 6 = 42** |

Now, calculate **Average Waiting time**, and **Average Turnaround time**:

* **Average Waiting time** = (15+33+37+38+19+23+36)/7 = 201/7 = **28.71 units**
* **Average Turnaround time** = (25+41+51+45+24+27+42)/7 = 255/7 = **36.42 units**

## Part Five: Non-preemptive Priority Scheduling.

Note: priority is decremented by 1 if the process remains in the ready queue for 5 time units.

First, we need to build the **Gantt chart** according to the above table:

**Gantt chart:**

0

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **P1**  10 | **P4**  17 | **P2**  25 | **P3**  39 | **P5**  44 | **P6**  48 | **P7**  54 |

Now we need to calculate **The Turn Around time** and **The Waiting time** for each process:

* To calculate **The Turn Around time,** we use the following formula:

**Turn Around time = Completion time – Arrival time**

* To calculate **The Waiting time,** we use the following formula:

**Waiting time = Turn Around time – Burst time**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Process** | **Arrival Time** | **Burst Time** | **Priority** | **Completion Time** | **Turn Around Time** | **Waiting Time** |
| **P1** | **0** | **10** | **3** | **10** | **10 – 0 = 10** | **10 – 10 = 0** |
| **P2** | **1** | **8** | **2** | **25** | **25 – 1 = 24** | **24 – 8 = 16** |
| **P3** | **3** | **14** | **3** | **39** | **39 – 3 = 36** | **36 – 14 = 22** |
| **P4** | **4** | **7** | **1** | **17** | **17 – 4 = 13** | **13 – 7 = 6** |
| **P5** | **6** | **5** | **0** | **44** | **44 – 6 = 38** | **38 – 5 = 33** |
| **P6** | **7** | **4** | **1** | **48** | **48 – 7 = 41** | **41 – 4 = 37** |
| **P7** | **8** | **6** | **2** | **54** | **54 – 8 = 46** | **46 – 6 = 40** |

Now, calculate **Average Waiting time**, and **Average Turnaround time**:

* **Average Waiting time** = (0+16+22+6+33+37+40)/7 = 154/7 = **22 units**
* **Average Turnaround time** = (10+25+39+17+44+48+54)/7 = 208/7 = **29.71 units**