Operating System Mathematical problems

**Problem-01**:

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

|  |  |  |
| --- | --- | --- |
| **Process Id** | **Arrival time** | **Burst time** |
| P1 | 3 | 4 |
| P2 | 5 | 3 |
| P3 | 0 | 2 |
| P4 | 5 | 1 |
| P5 | 4 | 3 |

If the CPU scheduling policy is FCFS, calculate the average waiting time and average turnaround time.

Solution:

Gantt Chart:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| P3 |  | P1 | P5 | P2 | P4 |

0 2 3 7 10 13 14

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Process Id** | **Arrival time** | **Burst time** | waiting time | turnaround time |
| P1 | 3 | 4 | 0 | 4 |
| P2 | 5 | 3 | 5 | 8 |
| P3 | 0 | 2 | 0 | 2 |
| P4 | 5 | 1 | 8 | 9 |
| P5 | 4 | 3 | 3 | 6 |

We know that,

Waiting time = Starting time – Arrival time

Turnaround time = Burst time + Waiting time

So,

Average waiting time = (0+5+0+8+3)/5 = 3.2 ms

Average turnaround time = (4+8+2+9+6)/5 = 5.8 ms

## ****Problem-02:****

Consider the set of 3 processes whose arrival time and burst time are given below-

|  |  |  |
| --- | --- | --- |
| **Process Id** | **Arrival time** | **Burst time** |
| P1 | 0 | 2 |
| P2 | 3 | 1 |
| P3 | 5 | 6 |

If the CPU scheduling policy is FCFS, calculate the average waiting time and average turnaround time.

Solution:

Gantt Chart:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| P1 |  | P2 |  | P3 |

0 2 3 4 5 11

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Process Id** | **Arrival time** | **Burst time** | waiting time | turnaround time |
| P1 | 0 | 2 | 0 | 2 |
| P2 | 3 | 1 | 0 | 1 |
| P3 | 5 | 6 | 0 | 6 |

So,

Average waiting time = (0+0+0)/3 =0 ms

Average turnaround time = (2+1+6)/3 =3 ms

## ****Problem-03:****

Consider the set of 4 processes whose arrival time and burst time are given below-

|  |  |  |
| --- | --- | --- |
| **Process Id** | **Arrival time** | **Burst time** |
| P1 | 0 | 7 |
| P2 | 2 | 4 |
| P3 | 4 | 1 |
| P4 | 5 | 4 |

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

Solution:

Gantt Chart:

|  |  |  |  |
| --- | --- | --- | --- |
| P1 | P3 | P2 | P4 |

0 7 8 12 16

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Process Id** | **Arrival time** | **Burst time** | waiting time | turnaround time |
| P1 | 0 | 7 | 0 | 0 |
| P2 | 2 | 4 | 6 | 10 |
| P3 | 4 | 1 | 3 | 4 |
| P4 | 5 | 4 | 7 | 11 |

## **So,**

Average waiting time = (0+6+3+7)/4 = 4 ms

Average turnaround time = (0+10+4+11)/4 = 6.25 ms

## ****Problem-04:****

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 non-preemptive, calculate the average waiting time and average turnaround time.

Solution:

Gantt Chart:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| P4 | P1 | P3 | P5 | P2 |

0 6 7 9 12 16

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Process Id** | **Arrival time** | **Burst time** | waiting time | turnaround time |
| P1 | 3 | 1 | 3 | 4 |
| P2 | 1 | 4 | 11 | 15 |
| P3 | 4 | 2 | 3 | 5 |
| P4 | 0 | 6 | 0 | 6 |
| P5 | 2 | 3 | 7 | 10 |

## **So,**

Average waiting time = (3+11+3+0+7)/5 = 4.8 ms

Average turnaround time = (4+15+5+6+10)/5 = 8 ms

## ****Problem-05:****

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

|  |  |  |
| --- | --- | --- |
| **Process Id** | **Arrival time** | **Burst time** |
| P1 | 0 | 7 |
| P2 | 2 | 4 |
| P3 | 4 | 1 |
| P4 | 5 | 4 |
| P5 | 3 | 5 |

If the CPU scheduling policy is SJF preemptive, calculate the average waiting time and average turnaround time.

Solution:

Available process in the CPU: P1, p2, p5, p3, p4

Gantt Chart:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| P1 | P2 | P2 | P3 | P2 | P4 | P1 | P5 |

0 2 3 4 5 7 11 16 21

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Process Id** | **Arrival time** | **Burst time** | **Remaining time** | waiting time | turnaround time |
| P1 | 0 | 7 | 5,0 | 9 | 16 |
| P2 | 2 | 4 | 3,2,0 | 2 | 6 |
| P3 | 4 | 1 | 0 | 0 | 1 |
| P4 | 5 | 4 | 0 | 2 | 6 |
| P5 | 3 | 5 | 0 | 13 | 18 |

## **We know that,**

## **Waiting time =(Starting time -Arrival time) +(Starting time – last completion time)**

## **So,**

Average waiting time = (9+1+0+2+3)/5 = 5 ms

Average turnaround time = (16+6+1+6+18)/5 = 9.4 ms

## 

## ****Problem-06:****

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

|  |  |  |
| --- | --- | --- |
| **Process Id** | **Arrival time** | **Burst time** |
| P1 | 0 | 7 |
| P2 | 1 | 5 |
| P3 | 2 | 3 |
| P4 | 3 | 1` |
| P5 | 4 | 2 |
| P6 | 5 | 1 |

If the CPU scheduling policy is shortest remaining time first, calculate the average waiting time and average turnaround time.

Solution:

Available process in the CPU: P1, p2, p5, p3, p4

Gantt Chart:

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| P1 | P2 | P3 | P4 | P3 | P3 | P6 | P5 | P2 | P1 |

0 1 2 3 4 5 6 7 9 13 19

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Process Id** | **Arrival time** | **Burst time** | **Remaining time** | **Waiting time** | turnaround time |
| P1 | 0 | 7 | 6,0 | 12 | 19 |
| P2 | 1 | 5 | 4,0 | 7 | 12 |
| P3 | 2 | 3 | 2,1,0 | 1 | 4 |
| P4 | 3 | 1` | 0 | 0 | 1 |
| P5 | 4 | 2 | 0 | 3 | 5 |
| P6 | 5 | 1 | 0 | 1 | 2 |

## **So,**

Average waiting time = (12+7+1+0+3+1)/6 = 4 ms

Average turnaround time = (19+12+4+1+5+2)/6 = 7.17 ms

## ****Problem-07:****

Consider the set of 3 processes whose arrival time and burst time are given below-

|  |  |  |
| --- | --- | --- |
| **Process Id** | **Arrival time** | **Burst time** |
| P1 | 0 | 9 |
| P2 | 1 | 4 |
| P3 | 2 | 9 |

If the CPU scheduling policy is SRTF, calculate the average waiting time and average turnaround time.

Solution:

Available process in the CPU: P1, p2, p3

Gantt Chart:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| P1 | P2 | P2 | P1 | P3 |

0 1 2 5 13 22

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Process Id** | **Arrival time** | **Burst time** | **Remaining time** | **Waiting time** | turnaround time |
| P1 | 0 | 9 | 8,0 | 4 | 13 |
| P2 | 1 | 4 | 3,0 | 0 | 4 |
| P3 | 2 | 9 | 9 | 11 | 9 |

So,

Average waiting time = (4 + 0 + 11) / 3 = 15 / 3 = 5 ms

Average Turn Around time = (13 + 4 + 20) / 3 = 37 / 3 = 12.33 ms

## ****Problem-08:****

Consider the set of 4 processes whose arrival time and burst time are given below-

|  |  |  |
| --- | --- | --- |
| **Process Id** | **Arrival time** | **Burst time** |
| P1 | 0 | 20 |
| P2 | 15 | 25 |
| P3 | 30 | 10 |
| P4 | 45 | 15 |

If the CPU scheduling policy is SRTF, calculate the waiting time of process P2.

Solution:

Available process in the CPU: P1, p2, p3, p4

Gantt Chart:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **P1** | **P2** | **P3** | **P2** | **P5** |

## **0 20 30 40 55 70**

|  |  |  |  |
| --- | --- | --- | --- |
| **Process Id** | **Arrival time** | **Burst time** | **Remaining time** |
| P1 | 0 | 20 | 0 |
| P2 | 15 | 25 | 15, 0 |
| P3 | 30 | 10 | 0 |
| P4 | 45 | 15 | 0 |

## Waiting time of process P2 = (Starting time – Arrival time) + (Starting time – last completion time)

## **= (20 - 15) + (40 - 30)**

## **= 15 ms**

## ****Problem-09:****

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 = p1, p2, p3, p1, p4, p5, p2, p1, p5

Gantt Chart :

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| P1 | P2 | P3 | P1 | P4 | P5 | P2 | P1 | P5 |

0 2 4 5 7 9 11 12 13 14

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Process Id** | **Arrival time** | **Burst time** | **Remaining time** | **Waiting time** | turnaround time |
| P1 | 0 | 5 | 3,1,0 | 8 | 13 |
| P2 | 1 | 3 | 1,0 | 8 | 11 |
| P3 | 2 | 1 | 0 | 2 | 3 |
| P4 | 3 | 2 | 0 | 4 | 6 |
| P5 | 4 | 3 | 1,0 | 7 | 10 |

So,

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

## ****Problem-10:****

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 = p4, p5, p3, p2, p4, p1, p6, p3, p2, p4, p1, p3

Gantt Chart :

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | P4 | P5 | P3 | P2 | P4 | P1 | P6 | P3 | P2 |

0 1 4 6 9 12 15 18 21 24 27

|  |  |  |
| --- | --- | --- |
| P4 | P1 | P3 |

27 30 32 33

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Process Id** | **Arrival time** | **Burst time** | **Remaining time** | **Waiting time** | turnaround time |
| P1 | 5 | 5 | 2, 0 | 22 | 27 |
| P2 | 4 | 6 | 3, 0 | 17 | 23 |
| P3 | 3 | 7 | 4, 1 | 23 | 30 |
| P4 | 1 | 9 | 6, 3, 0 | 20 | 29 |
| P5 | 2 | 2 | 0 | 2 | 4 |
| P6 | 6 | 3 | 0 | 12 | 15 |

## **So,**

Average Turn Around time = (27 + 23 + 30 + 29 + 4 + 15) / 6 = 21.33 ms

Average waiting time = (22 + 17 + 23 + 20 + 2 + 12) / 6 = 16 ms

## ****Problem-11:****

Four jobs to be executed on a single processor system arrive at time 0 in the order A, B, C, D. Their burst CPU time requirements are 4, 1, 8, 1 time units respectively. The completion time of A under round robin scheduling with time slice of one time unit is-

[Draw a Gantt Chart]

Solution:

|  |  |  |
| --- | --- | --- |
| **Process Id** | **Arrival time** | **Burst time** |
| A | 0 | 4 |
| B | 0 | 1 |
| C | 0 | 8 |
| D | 0 | 1 |

Ready Queue = A, B, C, D, A, C, A, C, A, C

Gantt Chart :

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| A | B | C | D | A | C | A | C | A | C |

0 1 2 3 4 5 6 7 8 9 14

## Clearly, completion time of process A = 9 ms .

## ****Problem-12:****

Consider the set of 4 processes whose arrival time and burst time are given below-

|  |  |
| --- | --- |
| **Process Id** | **Burst time** |
| P1 | 3 |
| P2 | 4 |
| P3 | 1 |
| P4 | 6 |

If the CPU scheduling policy is Round Robin with time quantum = 2 unit, calculate the average waiting time and average turnaround time.

Solution:

Let , Arrival time = 0 ms

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Process Id** | **Burst time** | **Remaining time** | **Waiting time** | turnaround time |
| P1 | 3 | 1, 0 | 5 | 8 |
| P2 | 4 | 2, 0 | 6 | 10 |
| P3 | 1 | 0 | 4 | 5 |
| P4 | 6 | 4, 2, 2, 0 | 8 | 14 |

## Gantt Chart :

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| P1 | P2 | P3 | P4 | P1 | P2 | P4 |

## 0 2 4 5 7 8 10 14

## So,

## Average waiting time = (5+6+4+8)/4 = 5.75 ms

## Average turnaround time = (8+10+5+14)/4 = 9.25 ms

## ****Problem-13:****

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

|  |  |  |
| --- | --- | --- |
| **Process Id** | **Arrival time** | **Burst time** |
| P1 | 0 | 4 |
| P2 | 1 | 5 |
| P3 | 2 | 2 |
| P4 | 3 | 1 |
| P5 | 4 | 6 |
| P6 | 6 | 3 |

If the CPU scheduling policy is Round Robin with time quantum = 2, calculate the average waiting time and average turnaround time.

Solution:

## Ready Queue = p1, p2, p3, p1, p4, p5, p2, p6, p5, p2, p6, p5

## Gantt Chart :

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| P1 | P2 | P3 | P1 | P4 | P5 | P2 | P6 | P5 | P2 | P6 | P5 |

## 0 2 4 6 8 9 11 13 15 17 18 19 21

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Process Id** | **Arrival time** | **Burst time** | **Remaining time** | **Waiting time** | turnaround time |
| P1 | 0 | 4 | 2, 0 | 4 | 8 |
| P2 | 1 | 5 | 3, 1, 0 | 12 | 13 |
| P3 | 2 | 2 | 0 | 2 | 4 |
| P4 | 3 | 1 | 0 | 5 | 6 |
| P5 | 4 | 6 | 4, 2, 0 | 11 | 17 |
| P6 | 6 | 3 | 1, 0 | 10 | 13 |

## So,

## Average waiting time = (4+12+2+5+11+10)/6 = 7.67 ms

## Average turnaround time = (8+13+4+6+17+13)/6 = 10.17 ms

## ****Problem-14:****

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

|  |  |  |
| --- | --- | --- |
| **Process Id** | **Burst time** | **Priority** |
| P1 | 10 | 3 |
| P2 | 1 | 1 |
| P3 | 2 | 4 |
| P4 | 1 | 5 |
| P5 | 5 | 2 |

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 :

Arrival time = 0 ms

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| P2 | P5 | P1 | P3 | P4 |

0 1 6 16 18 19

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Process Id** | **Burst time** | **Priority** | **Waiting time** | turnaround time |
| P1 | 10 | 3 | 6 | 16 |
| P2 | 1 | 1 | 0 | 1 |
| P3 | 2 | 4 | 16 | 18 |
| P4 | 1 | 5 | 18 | 19 |
| P5 | 5 | 2 | 1 | 6 |

So,

Average waiting time = (6+0+16+18+1)/5 = 8.2 ms

Average turnaround time = (16+1+18+19+6)/5 = 12 ms

## ****Problem-15:****

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

|  |  |  |  |
| --- | --- | --- | --- |
| **Process Id** | **Arrival time** | **Burst time** | **Priority** |
| P1 | 1 | 4 | 2 |
| P2 | 2 | 3 | 3 |
| P3 | 3 | 1 | 4 |
| P4 | 4 | 5 | 5 |
| P5 | 5 | 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 :

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| P1 | P4 | P5 | P3 | P2 |

0 4 9 11 12 15

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Process Id** | **Arrival time** | **Burst time** | **Priority** | **Witting time** | turnaround time |
| P1 | 1 | 4 | 2 | 0 | 4 |
| P2 | 2 | 3 | 3 | 11 | 14 |
| P3 | 3 | 1 | 4 | 9 | 10 |
| P4 | 4 | 5 | 5 | 1 | 6 |
| P5 | 5 | 2 | 5 | 5 | 7 |

So,

Average waiting time = (0 + 11 + 9 + 1 + 5) / 5 = 26 / 5 = 5.2 ms

Average Turn Around time = (4 + 14 + 10 + 6 + 7) / 5 = 41 / 5 = 8.2 ms

## ****Problem-16:****

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

|  |  |  |  |
| --- | --- | --- | --- |
| **Process Id** | **Arrival time** | **Burst time** | **Priority** |
| P1 | 1 | 4 | 2 |
| P2 | 2 | 3 | 3 |
| P3 | 3 | 1 | 4 |
| P4 | 4 | 5 | 5 |
| P5 | 5 | 2 | 5 |

If the CPU scheduling policy is priority preemptive, calculate the average waiting time and average turnaround time. (Higher number represents higher priority).

Solution:

Gantt Chart :

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| P1 | P2 | P3 | P4 | P5 | P2 | P1 |

0 1 2 3 8 10 12 15

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Process Id** | **Arrival time** | **Burst time** | **Priority** | waiting time | turnaround time |
| P1 | 1 | 4 | 2 | 11 | 15 |
| P2 | 2 | 3 | 3 | 8 | 11 |
| P3 | 3 | 1 | 4 | 0 | 1 |
| P4 | 4 | 5 | 5 | 0 | 5 |
| P5 | 5 | 2 | 5 | 4 | 6 |

So,

Average Turn Around time = (15 + 11 + 1 + 5 + 6) / 5 = 38 / 5 = 7.6 ms

Average waiting time = (11 + 8 + 0 + 0 + 4) / 5 = 23 / 5 = 4.6 ms

## ****Problem-17:****

A system uses 3 page frames for storing process pages in main memory. It uses the First in First out (FIFO) page replacement policy. Assume that all the page frames are initially empty. What is the total number of page faults that will occur while processing the page reference string given below -

4, 7, 6, 1, 7, 6, 1, 2, 7, 2

Also calculate the hit ratio and miss ratio.

Solution:

FIFO page replacement policy

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 4 | 7 | 6 | 1 | 7 | 6 | 1 | 2 | 7 | 2 |
| F1 | 4 | 4 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| F2 |  | 7 | 7 | 7 | 7 | 7 | 7 | 2 | 2 | 2 |
| F3 |  |  | 6 | 6 | 6 | 6 | 6 | 6 | 7 | 7 |

H H H H

Total number of references = 10

Total number of Hit = 4

Hit ratio = (4/10)\*100 = 40%

Total number of miss = 10 – 4 = 6

Miss ratio = (6/10)\*100 = 60%

## ****Problem-18:****

A system uses 3 page frames for storing process pages in main memory. It uses the Least Recently Used (LRU) page replacement policy. Assume that all the page frames are initially empty. What is the total number of page faults that will occur while processing the page reference string given below -

4, 7, 6, 1, 7, 6, 1, 2, 7, 2

Also calculate the hit ratio and miss ratio.

Solution:

LRU page replacement policy

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 4 | 7 | 6 | 1 | 7 | 6 | 1 | 2 | 7 | 2 |
| F1 | 4 | 4 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| F2 |  | 7 | 7 | 7 | 7 | 7 | 7 | 2 | 2 | 2 |
| F3 |  |  | 6 | 6 | 6 | 6 | 6 | 6 | 7 | 7 |

H H H H

Total number of references = 10

Total number of Hit = 4

Hit ratio = (4/10)\*100 = 40%

Total number of miss = 10 – 4 = 6

Miss ratio = (6/10)\*100 = 60%

## ****Problem-19:****

A system uses 3 page frames for storing process pages in main memory. It uses the optimal page replacement policy. Assume that all the page frames are initially empty. What is the total number of page faults that will occur while processing the page reference string given below -

4, 7, 6, 1, 7, 6, 1, 2, 7, 1

Also calculate the hit ratio and miss ratio.

Solution:

Optimal page replacement policy

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 4 | 7 | 6 | 1 | 7 | 6 | 1 | 2 | 7 | 1 |
| F1 | 4 | 4 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| F2 |  | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 2 |
| F3 |  |  | 6 | 6 | 6 | 6 | 6 | 2 | 2 | 2 |

H H H H H

Total number of references = 10

Total number of Hit = 5

Hit ratio = (5/10)\*100 = 50%

Total number of miss = 10 – 5 = 5

Miss ratio = (5/10)\*100 = 50%

## ****Problem-19:****

A system uses 3 page frames for storing process pages in main memory. It uses the FIFO, LRU, Optimal page replacement policy. Assume that all the page frames are initially empty. What is the total number of page faults that will occur while processing the page reference string given below -

7, 0, 1, 2, 0, 3, 0, 4, 2, 3, 0, 3, 2, 1, 2, 0, 1, 7, 0, 1

Also calculate the hit ratio and miss ratio.

Solution:

FIFO page replacement policy

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 7 | 0 | 1 | 2 | 0 | 3 | 0 | 4 | 2 | 3 | 0 | 3 | 2 | 1 | 2 | 0 | 1 | 7 | 0 | 1 |
| F1 | 7 | 7 | 7 | 2 | 2 | 2 | 2 | 4 | 4 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 7 | 7 |
| F1 |  | 0 | 0 | 0 | 0 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| F3 |  |  | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 1 |

H H H H H

Total number of references = 20

Total number of Hit = 5

Hit ratio = (5/20)\*100 = 25%

Total number of miss = 20 – 5 = 15

Miss ratio = (15/20)\*100 = 75%

LRU page replacement policy

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 7 | 0 | 1 | 2 | 0 | 3 | 0 | 4 | 2 | 3 | 0 | 3 | 2 | 1 | 2 | 0 | 1 | 7 | 0 | 1 |
| F1 | 7 | 7 | 7 | 2 | 2 | 2 | 2 | 4 | 4 | 4 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| F1 |  | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 3 | 3 | 3 | 3 | 0 | 0 | 0 | 0 | 0 |
| F3 |  |  | 1 | 1 | 1 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 7 | 7 | 7 |

H H H H H H H H

Total number of references = 20

Total number of Hit = 8

Hit ratio = (8/20)\*100 = 40%

Total number of miss = 20 – 8 = 12

Miss ratio = (12/20)\*100 = 60%

Optimal page replacement policy

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 7 | 0 | 1 | 2 | 0 | 3 | 0 | 4 | 2 | 3 | 0 | 3 | 2 | 1 | 2 | 0 | 1 | 7 | 0 | 1 |
| F1 | 7 | 7 | 7 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 7 | 7 | 7 |
| F1 |  | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| F3 |  |  | 1 | 1 | 1 | 3 | 3 | 4 | 4 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

H H H H H H H H H H H

Total number of references = 20

Total number of Hit = 9

Hit ratio = (9/20)\*100 = 45%

Total number of miss = 20 – 9= 11

Miss ratio = (11/20)\*100 = 55%