**Question 1**

1. **Define a page-replacement algorithm using this basic idea. Specifically address these problems:**
2. The initial value of the counters is 0.
3. The counters will be increased when there is a new page coming to associate with the page frame.
4. The counters will be decreased when there is a page that associates with the page frame is not required.
5. - In *FIFO* algorithm, the earliest (first-in) page will be replaced.

* In *LRU* algorithm, the page will be replaced when it has not been used for the longest time.
* In *Optimal Page Replacement* algorithm, the page will be replaced when it will not be used for the longest time in the future.

1. **How many page faults for your algorithm for the following reference string, for four page frames?**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **1** | **2** | **3** | **4** | **5** | **3** | **4** | **1** | **6** | **7** | **8** | **7** | **8** | **9** | **7** | **8** | **9** | **5** | **4** | **5** | **4** | **2** |

*FIFO* algorithm:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 1 | 1 | 1 | 5 | 5 | 5 | 5 | 5 | 5 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 2 |
|  | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
|  |  | 3 | 3 | 3 | 3 | 3 | 3 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 5 | 5 | 5 | 5 | 5 |
|  |  |  | 4 | 4 | 4 | 4 | 4 | 4 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 4 | 4 | 4 | 4 |
| M | M | M | M | M | H | H | M | M | M | M | H | H | M | H | H | H | M | M | H | H | M |

So, there are 13 page faults when using *FIFO* algorithm.

*LRU* algorithm:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 1 | 1 | 1 | 5 | 5 | 5 | 5 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 5 | 5 | 5 | 5 | 5 |
|  | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
|  |  | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 4 | 4 | 4 | 4 |
|  |  |  | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 2 |
| M | M | M | M | M | H | H | M | M | M | M | H | H | M | H | H | H | M | M | H | H | M |

So, there also have 13 page faults when using *LRU* algorithm.

1. **What’s the minimum number of page faults for an optimal page replacement strategy for the reference string in part b with four page frames?**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **1** | **2** | **3** | **4** | **5** | **3** | **4** | **1** | **6** | **7** | **8** | **7** | **8** | **9** | **7** | **8** | **9** | **5** | **4** | **5** | **4** | **2** |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 6 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 2 |
|  | 2 | 2 | 2 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
|  |  | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 4 | 4 | 4 | 4 |
|  |  |  | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| M | M | M | M | M | H | H | H | M | M | M | H | H | M | H | H | H | H | M | H | H | M |

So, there are 11 page faults when using *optimal page replacement* algorithm.