

Question 1

a. Define a page-replacement algorithm using this basic idea. Specifically address these problems:

- The initial value of the counters is 0.
- The counters will be increased when there is a new page coming to associate with the page frame.
- The counters will be decreased when there is a page that associates with the page frame is no longer required, even in the remaining reference string.
- A page to be replaced is selected as the frame with the smallest counter, with a FIFO queue to break ties (the earliest (first-in) page will be replaced).

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

Notes:

F → page fault, NF → Not a page fault

■ → Page fault (new to memory frames), ■ → Already in memory frames

a. algorithm: **12 page faults**

time	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Reference string		1	2	3	4	5	3	4	1	6	7	8	7	8	9	7	8	9	5	4	5	4	2
Frame 0		1	1	1	1	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Frame 1			2	2	2	2	2	2	2	2	2	8	8	8	8	8	8	8	8	8	8	8	8
Frame 2				3	3	3	3	3	1	6	7	7	7	7	7	7	7	7	7	4	4	4	2
Frame 3					4	4	4	4	4	4	4	4	4	4	9	9	9	9	9	9	9	9	9
Status		F	F	F	F	F	NF	NF	F	F	F	F	NF	NF	F	NF	NF	NF	NF	F	NF	NF	F
Victim						1			3	1	6	2			4					7			4

c. 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?

time	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Reference string		1	2	3	4	5	3	4	1	6	7	8	7	8	9	7	8	9	5	4	5	4	2
Frame 0		1	1	1	1	1	1	1	1	6	6	8	8	8	8	8	8	8	8	8	8	8	8
Frame 1			2	2	2	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Frame 2				3	3	3	3	3	3	3	7	7	7	7	7	7	7	7	7	4	4	4	2
Frame 3					4	4	4	4	4	4	4	4	4	4	9	9	9	9	9	9	9	9	9
Status		F	F	F	F	F	NF	NF	NF	F	F	F	NF	NF	F	NF	NF	NF	NF	F	NF	NF	F
Victim						2				1	3	6			4					7			4

As a result, there are **11 page faults** when using the *optimal page replacement* algorithm. During a tie, the FIFO algorithm is used. Similarly, there are **11 page faults** when using the *optimal page replacement* algorithm, where the LRU algorithm is used during a tie.

time	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Reference string		1	2	3	4	5	3	4	1	6	7	8	7	8	9	7	8	9	5	4	5	4	2
Frame 0		1	1	1	1	1	1	1	1	7	7	7	7	7	7	7	7	7	7	4	4	4	4
Frame 1			2	2	2	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Frame 2				3	3	3	3	3	3	6	6	8	8	8	8	8	8	8	8	8	8	8	2
Frame 3					4	4	4	4	4	4	4	4	4	4	9	9	9	9	9	9	9	9	9
Status		F	F	F	F	F	NF	NF	NF	F	F	F	NF	NF	F	NF	NF	NF	NF	F	NF	NF	F
Victim						2				3	1	6			4					7			8