**9.21** Consider the following page reference string:

7, 2, 3, 1, 2, 5, 3, 4, 6, 7, 7, 1, 0, 5, 4, 6, 2, 3, 0 , 1.

Assuming demand paging with three frames, how many page faults

would occur for the following replacement algorithms?

• LRU replacement

• FIFO replacement

• Optimal replacement

1. LRU 18 page faults
2. FIFO 17 page faults
3. Optimal replacement 13 page faults

**9.30** A page-replacement algorithm should minimize the number of page

faults. We can achieve this minimization by distributing heavily used

pages evenly over all of memory, rather than having them compete for

a small number of page frames. We can associate with each page frame

a counter of the number of pages associated with that frame. Then,

to replace a page, we can search for the page frame with the smallest

counter.

a. Define a page-replacement algorithm using this basic idea. Specifically

address these problems:

i. What is the initial value of the counters?

ii. When are counters increased?

iii. When are counters decreased?

iv. How is the page to be replaced selected?

b. How many page faults occur for your algorithm for the following

reference string 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.

c. What is the minimum number of page faults for an optimal page replacement

strategy for the reference string in part b with four page frames?

a.

1. The initial value of counters is 0
2. Whenever a new page is associated with that page
3. Whenever one of pages associated with that frame is no longer required
4. Find a frame with the smallest counter. Use FIFO

b. 14 page faults

c. 11 page faults