Q1. Assume that the following section of main memory is used to store the page table for 3 different processes. The page-table base register values for process P1 is 1080, for P2 is 1085, and for P3 is 1090. Assume that the contests of memory below correspond to frame numbers. Also assume that frame size is 8192.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **contents** | **3** | **5** | **8** | **4** | **7** | **2** | **0** | **15** | **11** | **18** | **6** | **20** | **24** | **9** | **10** | **13** | **30** | **38** | **40** | **1** |
| **Memory addresses** | **1**  **0**  **7**  **6** | **1**  **0**  **7**  **7** | **1**  **0**  **7**  **8** | **1**  **0**  **7**  **9** | **1**  **0**  **8**  **0** | **1**  **0**  **8**  **1** | **1**  **0**  **8**  **2** | **1**  **0**  **8**  **3** | **1**  **0**  **8**  **4** | **1**  **0**  **8**  **5** | **1**  **0**  **8**  **6** | **1**  **0**  **8**  **7** | **1**  **0**  **8**  **8** | **1**  **0**  **8**  **9** | **1**  **0**  **9**  **0** | **1**  **0**  **9**  **1** | **1**  **0**  **9**  **2** | **1**  **0**  **9**  **3** | **1**  **0**  **9**  **4** | **1**  **0**  **9**  **5** |

To which physical memory address would the logical address (1, 1200) correspond to if generated by P1?

Answer:\_\_ **17584** \_\_\_\_\_\_\_\_\_\_\_\_\_

To which physical memory address would the logical address (3, 800) correspond to if generated by P2?

Answer:\_\_ **197408\_**\_\_\_\_\_\_\_\_\_\_\_\_

Assume that each process has 5 pages. To which process does the following physical address belong and which logical address corresponds to each physical address:

Physical address 57344 Process \_\_ **P1\_**\_\_\_\_\_\_Logical address \_\_\_\_**(0,0)\_**\_\_\_\_\_\_\_\_\_

Physical address 57343 Process \_\_\_\_\_ **P2**\_\_\_\_\_\_\_Logical address \_\_\_**(1,8191)**\_\_\_\_

Q2. (3 points) A paging system is experiencing a page fault rate of 1 in 1 million page references. When a page fault occurs, 30% of the time an empty frame is not available and frame replacement is needed. Assume that it takes 10 milliseconds to service a page fault needing no frame replacement. When frame replacement is needed, 40% of time the frame has been modified and it takes 20 milliseconds to service the page fault, in contrast it takes 12 milliseconds when the frame to be replaced has not been modified. It takes 100 nanoseconds to reference a physical memory location and we can neglect the time that it takes to access the page table.

Calculate the effective memory access time for this system under these conditions. Clearly indicate intermediate steps.

Answer: 111.56 nanoseconds

Q3.(3 points) Consider the following page reference string:

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

How many page faults would occur for the following replacement algorithms, assuming three and four frames? Remember that all frames are initially empty, so your first unique pages will cost one fault each.

* FIFO replacement
* Optimal replacement
* LRU replacement

Answer:

FIFO: 13, 12

Optimal: 9, 7

LRU: 13, 9

**Q1. (3 points)**

An OS designer wants to have a paged memory management system with no more than 15% increase in the memory access time. Assume that all pages are in the main memory and the paging system has a translation look-aside buffer (TLB) and a page table in main memory. Given the main memory cycle time is 1200ns and the cache access time is 100 ns what does the hit ratio need to be?

Solution: EAT = 1200\* 0.15+1200 = 1380

1380 = p\* (100 +1200) +(1-p) (2\*1200+100)

1380 =p\*1300 + (1-p)(2500)

1380 = 1300p-2500p+2500

1120 =1200p

p = 1120/1200= 93.33333%

**Q2. (2 points)**

Under what circumstances do page faults occur? Describe the actions taken by the operating system when page faults occur.

**Answer:**

1. Operating system looks at the table to decide:
   * Invalid reference ⇒ abort
   * Just not in memory
2. Get empty frame
3. Swap page into frame via scheduled disk operation
4. Reset tables to indicate page now in memory  
   Set validation bit = **v**
5. Restart the instruction that caused the page fault

**Q3. (3 points)**

Assume that in a paging system a process is given 2 frames. The frames are 200 words long. Assume that all of instruction for the process fit perfectly in the first frame. A 300 by 50 two-dimensional array, A, is declared by the process and the second frame is to be used when an array element is referenced. The elements of the array fit perfectly in the appropriate number of logical pages and no other data or instructions are included in these pages – only array elements. The array is stored in ROW MAJOR. Assume that it takes a word to store a value in each array position.

Consider the following loop that manipulates the array elements:

for j= 0 to 49 do

for i = 0 to 299 do

A[i][j] =0

How many total number of page faults will be generated by the statement A[i][j] = 0 in the loop above?

**Answer: \_\_50\*75=3750\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

How many total number of page faults will be generated by the statement A[i][j] = 0 in the loop above?

for i= 0 to 299 do

for j = 0 to 49 do

A[i][j] = 100

**Answer: \_\_\_75\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Q4. (1 point)** Clearly explain the relationship between the concept of “working set” and the concept “thrashing” in virtual memory system.

Answer:

In order for process to execute with a minimal number of page faults it must have its entire working set in main memory. A working set is a group of pages that actively referencing. As more and more processes are brought into main memory, fewer frames will be available per process. If the number for frames falls below the number of pages in the working set of a process then the number of page faults will increase. If many processes will be in this situation then the trashing will occur.

Q5. (1 point) Explain, succinctly but accurately, why it is that in order to protect memory in a pure segmentation system the displacement in the logical address needs to be checked against the length of the segment while in a paging system this check is not required.

Answer: Because the displacement value generated in a paging system cannot be greater than (page size). This is due to the fact that the number of bits allocated to the displacement value corresponds exactly to the page size of the system. Example: if the page size is 1024 then the numbers of bits allocated to the displacement value are 10.

**Q6. (1 point)** What type of memory fragmentation does a system that organizes real memory as multiple fixed partitions suffer from**?**

**Answer:**

Internal fragmentation

Q7. Describe the advantages of virtual memory system over a system that relies only on primary (real) memory.

**Answer:**

1. **Programs can be larger than main memory size**
2. **Higher degree of multiprogramming**
3. **Less main memory fragmentation because a process does not have to be in a contiguous address space.**