Homework 3

Due Date: November 21, 2008 **Points:** 90

Questions

1. (*10 points*) *Answer erroneously included on earlier version; please omit*

2. (*20 points*) Assume that we have a paged memory system with a cache to hold the most active page table entries. It takes 20ns to search the cache. If the page table is normally held in memory, and memory access time is 1μs, what is the effective access time if the hit ratio is 85%? What hit ratio will be necessary to reduce the effective memory access time to 1.1μs?

3. (*30 points*) Consider the following page reference string: $\omega = abcdabeabcde$. For the following, assume there are *no* pages in memory initially.
   (a) If the system uses the FIFO page replacement algorithm, with 3 frames available, how many page faults occur?
   (b) If the system uses the FIFO page replacement algorithm, with 4 frames available, how many page faults occur?
   (c) If the number of page faults differs in parts 3a and 3b, please explain the increase or decrease in the number of page faults.

4. (*20 points*) Consider the reference string $\omega = abcdebcdcbddbddd$. Assuming the working set replacement strategy, determine the minimum window size such that the string generates at most five page faults. Show which pages are in memory at each reference, as well as which pages are being brought into, and removed from, memory.

5. (*20 points*) A virtual memory has a page size of 1024 words, 8 virtual pages, and 4 physical page frames. The page table is as follows:

virtual page	*page frame*
0	3
1	1
2	not in main memory
3	not in main memory
4	2
5	not in main memory
6	0
7	not in main memory

   (a) Which virtual addresses will cause page faults?
   (b) What are the physical addresses for 0, 3728, 1023, 1024, 1025, 7800, and 4096?

Extra Credit

1. (*20 points*) Consider a memory in which contiguous segments $S_1, ..., S_n$ are placed strictly in their order of creation from one end of the store to the other. That is, when segment S_{n+1} is being created, it is placed immediately after segment S_n even though some of the segments $S_1, ..., S_n$ may have already been deleted. When the boundary between segments (in use or deleted) and the hole reaches the other end of the store, the segments in use are compacted. Let s and t denote the average length and lifetime of a segment (measured in words and memory references). Let f denote the fraction of the memory which is unused under equilibrium conditions. Show that the fraction of time F spent on compacting is constrained by $F \geq \frac{1f}{1+kf}$, where $k = \frac{t}{2s} - 1$.

   Hint: Find the average speed at which the boundary crosses the memory and assume that copying of a single word requires at least two memory references.