CSE 451 Homework Assignment #6: Virtual Memory
Due Date: Friday, December 3, 5pm

1. Suppose we are using the clock algorithm to decide page replacement. A crucial issue in the clock algorithm is how many page frames must be considered in order to find a page to replace. Assuming we have a sequence of F page faults in a system with P page frames, let C(F,P) be the number of pages considered for replacement in handling the F page faults (if the clock hand sweeps by a page frame multiple times, it is counted each time).

a. Give a formula for the minimum possible value of C(F,P).

b. Give a formula for the maximum possible value of C(F,P).

2. Suppose we have a computer with a simple single-level paged virtual memory system (with no segments), a software loaded TLB, and a physically addressed cache, give a symbolic formula for the average memory access time, as a function of the probability and cost of each event. Define any symbolic quantities you need. For example, you'll need
probability of a TLB miss, time to access memory, probability of page fault, time to access disk, etc.

3. Suppose a program that repeatedly scans through a very large array is running in virtual memory. In other words, if the array is 4 pages long, its page reference pattern is ABCDABCDABCD...

Sketch a graph showing the paging behavior, for each of the following page replacement algorithms. The y-axis of the graph is the number of page faults per referenced page, varying from 0 to 1; the x-axis is the size of the array being scanned, varying from smaller than physical memory to much larger than physical memory. Label any interesting points on the graph on both the x and y axes.

(a) LRU

(b) MIN

(c) Clock

4. Assuming perfect prefetching from a 10MB/s disk, what is the maximum percentage of references to new pages, in order to prevent a 500 MIP (million instruction per sec) CPU from stalling?