Assignment 5  
Memory Management  
CSCI 5103, Fall 2016  
Due November 4, 2016

This assignment must be done individually.

**Problem 1:** Chapter 3, Problem 4 (4th edition or the 3rd edition).
Consider a swapping system in which memory consists of the following hole sizes in memory order: 10 MB, 4 MB, 20 MB, 18 MB, 7 MB, 9 MB, 12 MB, and 15 MB. Which hole is taken for the successive segment requests of

(1) 12 MB  
(2) 10 MB  
(3) 9 MB

for first-fit? Now repeat the question for best-fit, worst-fit, and next-fit.

**Problem 2:** Chapter 3, Problem 11 from the text book (4th edition) or Problem 7 (3rd edition).
Consider the following C program:

```c
int X[N];
int step = M; /* M some predefined constant */
for (int i = 0; i < N; i += step ) X[i] = X[i] + 1;
```

(a) If this program is run on a machine with 4-KB page size and 64-entry TLB, what values of M and N will cause a TLB miss for every execution of the inner loop?  
(b) Would your answer in part (a) be different if the loop were repeated many times? Explain.

**Problem 3:** Chapter 3, Problem 14 (4th edition) or Problem 9 (3rd edition).
A machine has 32-bit address space and an 8-KB page. The page table is entirely in the hardware with 32-bit word per entry. When the process starts, the page table is copied to the hardware from memory, at one word every 100 nsec. If each process runs for 100 msec (including the time to load the page table), what fraction of the CPU time is devoted to loading the page tables?

**Problem 4:** Now suppose that this is demand paged virtual memory system. The page table is stored in the main memory. The memory access time is 100 nano seconds. This system uses a TLB, which takes 20 nanoseconds for searching. It takes 4 milliseconds to service a page fault if an empty frame is available or if the replaced page is not modified, and 8 milliseconds if the replaced page is modified.

Assume that the page to be replaced is modified 80% of the time. What is the maximum acceptable page-fault rate for an effective access time of no more than 200 nanoseconds?
Problem 5: Chapter 3, Problem 16 (4th edition)
You are given the following data for a virtual memory system:
   (a) The TLB can hold 1024 entries and can be accessed in 1 clock cycle (1 nsec).
   (b) The page table entry can be found in 100 clock cycles or 100 nsec.
   (c) The average page replacement time is 6 msec.
If page references are handled by the TLB 99% of the time, and only 0.01% lead to a page fault, what is the effective address-translation time?

Problem 6: (a) Consider a page reference string: (2 3 5 3 5 1 2). Given three page-frames, how many page replacements will happen with each of the LRU and FIFO algorithms?
(b) Extend the reference string in part (a) above with a small number of additional page references to yield an example in which LRU is better than FIFO for the case of three page frames.
(c) Now, extend this string in part (a) above with a different sequence of page references to yield an example in which FIFO is better than LRU.

Show the states of the page frames after each page fault in the above three cases.

Problem 7:
Please read Chapters 1 and 2 from the book O'Reilly book “Linux Device Drivers”, and answer the following question:

What is the utility of the following kernel functions?
   insmod
   lsmod
   module_init
   module_exit
   printk