Name:

Operating Systems
Fall 2011
Test 3
December 01, 2011

Closed books, notes, cell phones, PDAs, iPods, laptops, etc. No headphones, please. You may use a simple calculator (but you can do without).

You have 75 minutes to solve 7 problems. You get 10 points for writing your name on the top of this page. As with any exam, you should read through the questions first and start with those that you are most comfortable with. If you believe that you cannot answer a question without making some assumptions, state those assumptions in your answer.

Partial credit will be offered only for meaningful progress towards solving the problems.

Please read and sign below if you agree with the following statement:

In recognition of and in the spirit of the academic code of honor, I certify that I will neither give nor receive unpermitted aid on this exam.

Signature:_____

0	/10
1	/10
2	/15
3	/20
4	/10
5	/20
6	/15
Total	/100

1. (10 points) **Short Answer Questions**:

   a. Three methods of file allocation commonly used are: chained, indexed and _____.

   b. A _____ is a control structure that contains the key information needed by a Unix operating system for a particular file.

   c. The _____ shows the frame location for each page of the process.

   d. _____ in a computer system is organized as a linear, or one-dimensional, address space, consisting of a sequence of bytes or words.

   e. In the Dynamic Partitioning technique of memory management, the placement algorithm that scans memory from the location of the last placement and chooses the next available block that is large enough to satisfy the request is called _____.

   f. _____ is the range of memory addresses available to a process.

   g. _____ is transparent to the programmer and eliminates external fragmentation providing efficient use of main memory.

   h. The _____ page replacement policy results in the fewest number of page faults.

   i. _____ is a storage allocation scheme in which secondary memory can be addressed as though it were part of main memory.

   j. When the system spends most of its time swapping pieces rather than executing instructions it leads to a condition known as _____ .

2. (15 points) **Short attention span:**
    a. Once the operating system identifies a page to remove from memory, what must be done before the frame in which the page is stored can be reused?

    b. At one time, virtual memory system designers were advised to bias page replacement algorithms against modified pages in favor of those that have not been modified. The result of this suggestion was the unfortunate behavior of program code pages (which tend to be some of the only pages that are not modified) being kicked out of memory before other pages. Describe the rationale for the original suggestion of paging unmodified pages first.

    c. Consider a fixed partitioning scheme with equal-size partitions of 2^{16} bytes and a total main memory size of 2^{24} bytes. A process table is maintained that includes a pointer to a partition for each resident program. How many bits are required for the pointer? Justify your answer.

3. (20 points) A process has four page frames allocated to it. (All the following numbers are decimal, and everything is numbered starting from zero.) The time of the last loading of a page into each page frame, the last access to the page in each page frame, the virtual page number in each page frame, and the referenced (R) and modified (M) bits for each page frame are as shown (the times are in clock ticks from the process start at time 0 to the event).

Virtual Page Number	Frame	Time Loaded	Time Referenced	R Bit
20	0	60	161	0
22	1	130	160	1
24	2	10	162	1
31	3	20	163	1

A page fault to virtual page 23 has occurred at time 164. Which **frame** will have its contents replaced for each of the following memory management policies?

- FIFO (first-in-first-out)
- LRU (least recently used)
- Clock algorithm. Assume the clock arm moves circularly in increasing frame number and points to the frame immediately next the one that was most recently updated.
- Optimal. Use the reference string generated by the following program, considering the following parameters: the system has 256-byte pages. The program is located at address 1020, and its stack pointer is at 8190 (the stack grows toward 0). Each instruction occupies 4 bytes (1 word), and both instruction and data references count in the reference string.

```
Load word 6144 into register 0
Push register 0 onto the stack
Call a procedure at 5120, stacking the return address
Subtract the immediate constant 16 from the stack pointer
and place it in register RC
Compare the value in RC to the immediate constant 4
Jump if equal to 5152
```

Reference String:

Frame replaced by Optimal:

4. (10 points) In UNIX System V, the size of a block is 1KB, and each block can hold a total of 128 block addresses. Assume that there are 12 direct block pointers and a singly, doubly and triply indirect pointer in each inode.
    a. Using the inode scheme, what is the maximum size of a file?
    b. Assuming no information other than the file inode is already in main memory, how many disk accesses are required to access the byte in position 13,423,956? (Hint: If you don't have a calculator with you, this information might save you time: $2^{23} < 13{,}423{,}956 < 2^{24}$)

5. (20 points) Sketch rough graphs ("back of napkin") illustrating the relationships among the following quantities. Note any important assumptions underlying your analysis.
    a. Page fault rate as a function of page size. What page sizes are typical for current processors and operating systems?
    b. Disk access latency as a function of rotation speed.
    c. CPU utilization as a function of the degree of multiprogramming. Consider a uni-processor system.
    d. Memory fragmentation as a function of page size. Is that internal or external?

6. (15 points) Storage management:
    a. A computer has 512 GB of secondary storage and a block size of 512 bytes. How many KB are needed if a bitmap is used to keep track of free disk?

    b. Should the bitmap be kept in memory or on the disk? **Why**?

    c. For what performance objectives would you choose each of the following disk scheduling algorithms:

        FIFO
        SSTF
        CSCAN