CS 450 Exam 3 — Mon. 12/12/2016

Name: _____

Rules and Hints

- You may use one handwritten 8.5 × 11″ cheat sheet (front and back). This is the only additional resource you may consult during this exam. *No calculators.*
- Include step-by-step explanations and comments in your answers, and show as much of your work as possible, in order to maximize your partial credit.

Grade

	Your Score	**Max Score**
Problem 1: Short answer		22
Problem 2: Address translation and page tables		28
Problem 3: Page replacement		20
Problem 4: Filesystems		25
Problem 5: The last question		5
Total		**100**

Problem 1: Short Answer (22 points)

Part A (6 points)

What is the difference between internal and external fragmentation? Use a drawing to illustrate your answer.

Part B (4 points)

You are trying to read a memory location in a system with virtual memory. List the steps of a scenario in which this access requires *exactly one* off-chip access to RAM.

Part C (6 points)

Is there any reason to store contiguous virtual pages in contiguous physical RAM locations? What about contiguous blocks on a magnetic hard disk?

Part D (6 points)

What is DMA? How does it use (a) memory-mapped I/O and (b) interrupts?

Problem 2: Virtual memory (28 points)

Part A (4 points)

Consider the following sequence of operations:

1. Process A writes a value to address 0x1000.
2. Process B reads a value from address 0x1000.

Explain how the results of this operation will be different on a system with virtual memory from a system without it.

For the remaining parts of this problem, consider a hilariously tiny memory system with 16-bit virtual and physical addresses, and 256 (2^8) bytes per page. Process A currently has the following virtual-to-physical mappings, with no other valid virtual pages:

1. VPN 2 to PPN 40
2. VPN 3 to PPN 1
3. VPN 15 to PPN 9
4. VPN 31 to PPN 8

See the following pages for Parts B-D.

Part B (8 points)

Pick a valid virtual address for Process A, and translate it to its physical address (binary, decimal, or hex).

Part C (8 points)

Draw a flat page table for this process. Please note that you only need to show the fields that are relevant to address translation, and you can abbreviate long stretches of empty rows if applicable.

Part D (8 points)

Draw a 2-level page table for this process, assuming that the first-level and second-level page numbers are the same number of bits. Once again, you only need to show the relevant fields and can abbreviate large page tables.

Problem 3: Page replacement (20 points)

A process has 3 physical pages allocated to it (PPNs 1, 2, and 3). It then accesses a sequence of virtual pages, as shown in the table below:

After access to VPN:	PPN 1	PPN 2	PPN 3
Initial	–	–	–
33			
33			
44			
55			
66			
66			
55			
44			
33			

Part A (8 points)

If the OS uses optimal placement (that is, if it can predict the future), fill in the table above to show which virtual pages are mapped to each physical page after each access.

Part B (12 points)

In the table above, mark the first row (if any) where this policy deviates from:

- FIFO
- LRU
- LFU

Problem 4: Filesystems (25 points)

Part A (10 points)

Consider the following (invalid) file allocation table. Recall that 0 means that a block is available, and 0xff designates the last block in a file.

Block	Contents
0	reserved
1	reserved
2	3
3	6
4	5
5	6
6	7
7	0xff
8	0xff

Change as few blocks as possible to make the following condition true:
Exactly 2 files have information in disk blocks 2 through 8.

List the blocks in each file after your change:

Part B (5 points)

Sketch an inode for a file that has 16 data blocks.

Part C (10 points)

On your system, `/proc/cpuinfo` is an 8 KB text file. List, as specifically as you can, the sequence of inodes and disk blocks that are accessed in order to read the entire file. Assume that the root directory has inode # 2, and that disk blocks are 4 KB.

Problem 5: The last question (5 points)

What was the most interesting / useful thing you learned in this class?