CSSE 332 – Operating Systems
Rose-Hulman Institute of Technology
Computer Science and Software Engineering Department

Exam 2 — Paper Part

Name:_____ Section:_____ CM:_____

This exam consists of two parts. The first part is to be done on paper without using your computer. The second part of the exam is to be done on your computer. You have the full lab period (a total of three periods) to complete the entire exam.

Instructions: The paper part of the exam is closed book, open notes limited to one double-sided sheet of hand written notes, but **no computer or electronic devices** other than a calculator. Write all of your answers in the spaces provided.

When you complete the paper part of the exam, turn it in to an exam proctor. You may then begin using your computer. **Use of your computer before turning in the paper part of the exam will be considered academic dishonesty.**

To allow sufficient time to work on the computer part of the exam, we suggest using no more than 50 minutes for the paper part.

Please begin by putting your name on the first page and your initials on every page of the exam. We encourage you to skim the entire exam before answering any questions and show all your work to receive partial credit.

	Points available	Your Points
1	15	
2	10	
3	8	
4	4	
5	8	
6	5	
C	50	
Total	100	

Problem 1 (15 points) Consider a UNIX-like file system, where an i-node is used to hold the attributes of the file along with pointers to the data blocks. Assume that i-nodes, pointer blocks, data blocks, and disk sectors are all 4KB (2^{12} Bytes) in size. Each i-node contains 10 direct block pointers, 6 singly-indirect pointers, 8 doubly-indirect pointers, and 1 triply-indirect pointers. Disk block pointers are 64 bits (i.e. 8 Bytes).

Where appropriate, **express your answer in the form 2^n**.

(a) How many disk block pointers can be stored in each pointer block?

disk block pointers

(b) How many data blocks can be accessed using only direct pointers?

data blocks

(c) How many data blocks can be accessed using only single-indirect pointers?

data blocks

(d) How many data blocks can be accessed using only double-indirect pointers?

data blocks

(e) How many data blocks can be accessed using only the triple-indirect pointers?

data blocks

(f) If on average, the data content of a typical file occupies 7168 Bytes, determine what percent of the occupied disk space in Bytes is actually occupied by data.

percentage of Bytes storing data

(g) (3 points) Determine the number of disk accesses needed to read the $558,358,372,000^{\text{th}}$ Byte of a file using the three (chained, contiguous, and indexed) allocation schemes discussed in class. Assume that only the directory information is currently in memory.

Allocation	Disk Reads
Chained	
Contiguous	
Indexed	

Problem 2 (10 points) Consider a process with a 33-bit virtual address space and 8Kbyte (2^{13} Byte) pages. Each page table entry takes up 8 Bytes of storage. Suppose that the process occupies its entire virtual address space and that memory is byte addressable.

Assume that the processor's memory management unit uses a single-level page table scheme for mapping virtual addresses to physical addresses.

Where appropriate, **express your answer in the form 2^n**.

(a) How many pages are needed to hold the process?

Pages

(b) How many total page table entries are required in the process page table to reference each process page?

Entries

(c) How much memory is needed to store the process page table?

Bytes

(d) How many pages are needed to store the process page table?

Pages

(e) A TLB can be used to speed up memory access in a paging system. Suppose the TLB can be accessed in 6 ns and has a hit rate of 98%. If memory can be accessed in 50 ns, and no other penalty is incurred in servicing a TLB miss, what is the effective access time for a processor that uses a single-level page table scheme?

ns

Problem 3 (10 points) Part of the segment table for a process is shown below. All numbers are given in decimal form. **All addresses are Byte addresses**.

Segment number	Base Address	Length
0	219	430
1	2300	14
2	90	100
3	1327	580
4	1952	96
	⋮	

Determine if the following virtual addresses are valid. If possible, translate the virtual address to a physical address.

(a) 0, 600

(b) 1, 10

(c) 2, 500

(d) 3, 400

Problem 4 (4 points) Using the table below, indicate the page allocated to each frame when a page is referenced, using the Least Recently Used algorithm discussed in class. Assume that there are four frames that are candidates for replacement. In the space provided, indicate when a page fault occurs.

Consider the following page reference string:

7, 0, 1, 2, 0, 3, 0, 4, 2, 3, 0, 3, 2

Page	7	0	1	2	0	3	0	4	2	3	0	3	2
Frame 1													
Frame 2													
Frame 3													
Page Fault?													

Problem 5 (8 points) For each of the following disk scheduling policies and the set of pending requests for disk tracks, determine the sequence of tracks accessed and the number of tracks traversed. The requests are arranged in the order of arrival. There are 250 tracks (ranging from 0 to 249) and the disk head is currently at track 150 and moving toward the inside of the disk (i.e. track 0).

17, 199, 210, 226, 247, 14, 100, 97, 220, 0

(a) First-In, First-Out

Next track accessed	Tracks traversed
Total	

(b) N-step-LOOK (N = 3)

Next track accessed	Tracks traversed
Total	

Problem 6 (5 points) The following questions refer to the BareMetalOS project.

(a) Which scheduling algorithm did you use for your short term scheduler?

_____

(b) Select the memory management scheme used for loading processes into main memory.

i. Paging
ii. Segmentation
iii. Other

(c) (2 points) The directory sits at sector 2 of the disk and contains 16 entries. Briefly (in no more than one sentence) describe the makeup of each entry. Be specific in your description.

(d) Identify the mechanism used to manage free space.

i. Map
ii. Linked list
iii. Grouping