

Department of Computer Science and Engineering
National Sun Yat-sen University
Second Semester of 2021 PhD Qualifying Exam

Subject: **Operating Systems**

INSTRUCTIONS: *If any question is unclear or you believe some assumptions need to be made, state your assumptions clearly at the beginning of your answer.*

1. (10%; 5% each) Consider the two-dimensional array a:

```
double a[] [] = new double[250][250];
```

where each double occupies 8 bytes and a[0][0] is at location 200, in a paged system with pages of size 200 bytes. A small process is in page 0 (locations 0 to 199) for manipulating the matrix; thus, every instruction fetch will be from page 0. For three page frames, how many page faults are generated by the following array initialization loops, using LRU replacement and assuming (1) page frame 0 has the process in it, (2) the other two are initially empty, and (3) the array is stored in memory column-major. *Justify your answer for full credit.*

(a) for (int i = 0; i < 250; i++)
 for (int j = 0; j < 250; j++)
 a[i][j] = 0;

(b) for (int j = 0; j < 250; j++)
 for (int i = 0; i < 250; i++)
 a[i][j] = 0;

2. (10%; 5% each) A disk has 12000 cylinders, each with 8 tracks of 512 blocks. A seek takes 1 msec per cylinder moved. If no attempt is made to put the blocks of a file close to each other, two blocks that are logically consecutive (i.e., follow one another in the file) will require an average seek, which takes 5 msec. If, however, the operating system makes an attempt to cluster related blocks, the mean interblock distance can be reduced to 2 cylinders and the seek time reduced to 500 microsec per cylinder moved. How long does it take to read a 100 block file in both cases, if the rotational latency is 10 msec and the transfer time is 20 microsec per block? *Justify your answer for full credit.*
3. (10%) A machine has 64-bit virtual addresses and 32-bit physical addresses. Pages are 8 KB. How many entries are needed for the page table? *Justify your answer for full credit.*
4. (10%; 2% each) Consider a file currently consisting of 150 blocks. Assume that the file control block is already in memory. Calculate how many disk I/O operations are required for contiguous and linked allocation strategies, if, for one block, the following conditions hold. In the contiguous allocation case, assume that there is no room to grow in the beginning, but there is room to grow in the end. Assume that the block information to be added is stored in memory.
- (a) The block is removed from the beginning.
 - (b) The block is removed from the end.
 - (c) The block is added at the beginning.
 - (d) The block is added in the middle.
 - (e) The block is added at the end.

5. (10%) A computer whose processes have 4092 pages in their address spaces keeps its page tables in memory. The overhead required for reading a word from the page table is 500 nsec. To reduce this overhead, the computer has a TLB, which holds 32 (page, frame) pairs and can do a lookup in 50 nsec. What hit rate is needed to reduce the mean overhead to 200 nsec or less, *assuming that TLB is looked up first before the page table is read? Justify your answer for full credit.*
6. (10%) What would be the output of the following C program? (Note that the line numbers are for reference only.) *Justify your answer for full credit.*

```

1 #include <stdio.h>
2 #include <unistd.h>
3 #include <sys/types.h>
4 #include <sys/wait.h>
5 int main()
6 {
7     int status, fd[2];
8     pipe(fd);
9     pid_t pid = fork();
10    if (pid > 0) {
11        close(fd[1]);
12        close(0);
13        dup(fd[0]);
14        close(fd[0]);
15        waitpid(-1, &status, 0);
16        char buf[128];
17        int n = scanf("%s", buf);
18        printf("%d:%s\n", n, buf);
19    }
20    else if (pid == 0) {
21        close(fd[0]);
22        close(1);
23        dup(fd[1]);
24        close(fd[1]);
25        execl("/bin/echo", "echo", "how", "are", "you?", (void*) 0);
26    }
27    else {
28        return 1;
29    }
30    return 0;
31 }

```

7. (10%) What would be the output of the C program in Question 6 if the statements in lines 8 and 9 are swapped? *Justify your answer for full credit.*
8. (10%) Define in a single statement in C a pointer p to an array a of type int so that p[i] is an alias of a[i-n] where n is an offset to the index i. *Prove it for full credit.*
9. (20%; 5% each) Given an i-node with ten direct blocks and three levels of indirect blocks and assuming that the sizes of a pointer and a block are, respectively, 8 bytes and 8 Kbytes, answer the following questions. *Justify your answer for full credit.*
- What would be the size of the smallest file allowed in bytes?
 - What would be the size of the largest file allowed in bytes?
 - How many blocks are needed for the smallest file?
 - How many blocks are needed for the largest file?