

CS 3113 Introduction to Operating Systems  
Final Exam  
December 13, 2019

General instructions:

- Please wait to open this exam booklet until you are told to do so.
- This examination booklet has 13 pages. You also have been issued a bubble sheet.
- Write your name, university ID number and date, and sign your name below. Also, write your name and ID number on your bubble sheet, and fill in the bubbles for your ID.
- The exam is closed book, notes and electronic devices. The exception is that you may have one page of personal notes (double sided).
- The exam is worth a total of 137 points (and 15% of your final grade).
- You have 2 hours to complete the exam. Be a smart test taker: if you get stuck on one problem go on to the next.
- Use your bubble sheet to answer all multiple-choice questions. Make sure that the question number and the bubble row number match when you are answering each question. If you cannot effectively erase an incorrect answer, mark an 'X' over it.

On my honor, I affirm that I have neither given nor received inappropriate aid in the completion of this exam.

**Signature:** \_\_\_\_\_

**Name:** \_\_\_\_\_

**ID Number:** \_\_\_\_\_

**Date:** \_\_\_\_\_

Question	Points	Score
Files and File Systems	24	
Process Scheduling	40	
System Calls and Protection	9	
Processes and Threads	22	
Characters and Strings	8	
Resource Sharing	34	
Total:	137	

## Part I. Files and File Systems

- (2 points) True or False? When a process opens a file and then forks a child process, the two processes share the file offset.  
A. True   B. False
- (4 points) Assume the initial contents of file *myfile* and the execution of the following block of code. What are the final contents of *myfile*? Assume that there are no errors with permissions and that there are no newlines.

*myfile* initial contents:

```
pass
```

Code block:

```
FILE *fp = fopen("myfile", "a");  
  
if(fp == NULL){  
    printf("Error");  
    exit(-1);  
}  
  
fprintf(stdout, "_the exam");  
  
fclose(fp);
```

- A. pass   B. \_the exam   C. pass\_the exam   D. There is an error  
E. Answer not shown
- (4 points) Assume that a disk block stores  $I$  inodes and that there are multiple, sequential blocks that store inodes. Assume also that the first inode block is disk block  $K$ . Given that we would like to access inode  $j$ , which block and element of the block, respectively, must we access?  
A.  $I + j/K$  and  $j\%K$   
B.  $K + j/I$  and  $j\%I$   
C.  $I + j\%K$  and  $j/K$   
D.  $K + j\%I$  and  $j/I$   
E. Answer not shown

4. (4 points) Assume that a directory is deleted from the OUFSS; the directory's inode index is 18. Before the deletion, the first three entries of the inode allocation table are: *0xB4*, *0x3E* and *0xAC*. After a successful deletion, what is the new state of the inode allocation table (first 3 entries)?
- A. *0xB0*, *0x3E* and *0xAC*
  - B. *0xB4*, *0x1E* and *0xAC*
  - C. *0xB4*, *0x3E* and *0x8C*
  - D. *0xB4*, *0x3E* and *0xA8*
  - E. Answer not shown
5. (2 points) True or False? It is faster to sequentially access blocks on a hard disk that are contiguous than if they were randomly distributed on the disk.
- A. True    B. False
6. (4 points) Assume that a file of length 250 has been opened for reading and that the current offset is 223. What is the return value of the following `read()` call:

```
int ret = read(fd, buf, 37);
```

- A. 27    B. 37    C. 223    D. 250    E. Answer not shown
7. (4 points) Assume the initial contents of file *myfile2* and the execution of the following block of code. What are the final contents of *myfile2*? Assume that there are no errors.

myfile2 initial contents:

```
able-was-I-ere-I-saw-elba
```

Code block:

```
char buf[100];

int fd = open("myfile2", O_RDWR);

lseek(fd, 11, SEEK_SET);

read(fd, buf, 4);

buf[3] = 0;

printf("%s\n", buf);

close(fd);
```

- A. -ere    B. ere    C. ere-    D. re-    E. Answer not shown

Part II. Process Scheduling

8. (4 points) Consider the following processes, and arrival and burst times:

Process	Arrival Time	Burst Length
P1	0	8
P2	1	2
P3	2	6

According to the **shortest-time-remaining-first** algorithm, what is the average wait time for these processes?

- A. 3   B. 4   C. 5   D. 6   E. Answer not shown
9. (4 points) Assuming that the same set of processes are scheduled according to the **shortest-job-first** algorithm (i.e., non-preemptive), what is the average wait time?  
A. 3   B. 4   C. 5   D. 6   E. Answer not shown
10. (4 points) Assuming that the same set of processes are scheduled according to the **round robin** algorithm with a quantum of 5, what is the average wait time? Assume that newly arriving jobs are placed at the end of the round robin queue.  
A. 3   B. 4   C. 5   D. 6   E. Answer not shown
11. (4 points) Consider the following directory listing under a contiguous block allocation scheme with a block size of 8:

File	Start Block	N Blocks
index.html	23	2
project0.html	53	4
project1.html	41	8
project2.html	8	13

Which physical block is logical byte 27 of project1.html stored in?

- A. 41   B. 42   C. 43   D. 44   E. Answer not shown
12. (4 points) Which byte within the physical block is byte 27 of project1.html stored in?  
A. 2   B. 3   C. 5   D. 7   E. Answer not shown
13. (4 points) What is the logical byte that corresponds to physical block 11, byte 7?  
A. 23   B. 25   C. 27   D. 31   E. Answer not shown

14. (4 points) Consider a file system in which inodes contain a block index table, with one such table configured accordingly:

Index	Block
0	17
1	23
2	18
3	21

Assume a block size of 16. Which physical block is logical byte 45 of the file stored in?

- A. 17   B. 18   C. 21   D. 23   E. Answer not shown
15. (4 points) Which byte within the physical block is byte 45 stored in?  
A. 2   B. 3   C. 5   D. 13   E. Answer not shown
16. (4 points) Consider the following processes and burst times:

Process	Burst Length
P1	7
P2	4
P3	10

Assuming that all of the processes arrive at time zero, but in the following order: P1, P2, P3, what is the average wait time if the processes are scheduled according to the **first-come-first-served** algorithm?

- A. 5   B. 6   C. 7   D. 13   E. Answer not shown
17. (4 points) Assuming that the same set of processes are scheduled according to the **shortest-job-first** algorithm, what is the average wait time?  
A. 5   B. 6   C. 7   D. 13   E. Answer not shown

Part III. System Calls and Protection

18. (3 points) Which of the following is **not** a class of system call.
  - A. Process control
  - B. Memory management
  - C. Communication
  - D. Device management
  - E. All are classes of system calls
  
19. (2 points) True or False? The file system is always manipulated by code executing in a kernel mode.
  - A. True    B. False
  
20. (2 points) True or False? A system call allows the kernel to access user space code.
  - A. True    B. False
  
21. (2 points) True or False? *strcmp()* is a system call.
  - A. True    B. False

Part IV. Processes and Threads

22. (4 points) What number is printed by this program?

```
int main(int argc, char** argv)
{
    int p1[2];

    pipe(p1);

    int pid;
    int val = 42;

    if((pid = fork()) == -1) {
        fprintf(stderr, "Error forking\n");
        exit(-1);
    } else if(pid > 0){
        close(p1[0]);

        val = 7;
        write(p1[1], &val, sizeof(int));

        wait(NULL);
    } else{
        close(p1[1]);

        int val2 = 3;
        read(p1[0], &val2, sizeof(int));
        val2 += val;

        printf("%d\n", val2);
    }
}
```

A. 10   B. 45   C. 49   D. Answer not shown

23. (4 points) How many stars are output by this program?

```
int main(int argc, char** argv)
{
    for(int i = 0; i < 2; ++i) {
        int pid = fork();
        write(1, "*", 1);

        if(pid > 0) {
            wait(NULL);
        }
    }
}
```

A. 3   B. 4   C. 6   D. 8   E. Answer not shown

24. (2 points) True or False? Different threads of the same program have their own stacks.

A. True   B. False

25. (2 points) True or False? Creating a new thread is more expensive than creating a new process.  
A. True B. False
26. (3 points) In the many-user-threads to one-kernel-thread approach to thread management, scheduling of thread execution is typically done in:  
A. Kernel mode B. User mode C. Answer not shown
27. (4 points) Suppose that 75% of a computational task can be parallelized. According to Amdahl's law, with 100 processors, what is the effective speed-up?  
A. About 1.5 B. About 4 C. About 25 D. About 100  
E. Answer not shown
28. (3 points) In a thread library, what is the complement to *fork()*?  
A. `exit()` B. `join()` C. `return()` D. `spawn()` E. Answer not shown



Part V. Characters and Strings

29. (4 points) What is printed by the following block of code? (do not worry about spaces and newlines in your answer)

```
char str[100];  
  
strcpy(str, "IBM");  
strcpy(&str[2], "HAL");  
  
printf("%s\n", str);
```

- A. HAL   B. IBM   C. IBHAL   D. IBMHAL   E. Answer not shown

30. (4 points) What is output by the following block of code? (do not worry about spaces and newlines in your answer)

```
char str[100];  
  
strcpy(str, "Out: 1,5,27");  
  
int len = strlen(str);  
  
for(int i = 0; i < len; ++i) {  
    if(str[i] >= '0' && str[i] <= '9')  
        str[i] = (str[i] - '0' + 5)%10 + '0';  
}  
  
printf("%s\n", str);
```

- A. Out: 1,5,2  
B. Out: 1,5,27  
C. Out: 6,0,2  
D. Out: 6,0,72  
E. Answer not shown

Part VI. Resource Sharing

31. (4 points) Consider the following solution to the dining philosophers problem where the philosophers are:  $P_1, P_2, \dots, P_K$ , and the chopsticks are  $C_0, C_1, \dots$  (each is a binary semaphore initialized to state '1').

Each philosopher  $i$  uses the following algorithm:

```
while (true){
    think()
    wait(chopstick[i])
    wait(chopstick[i/2])
    eat()
    signal(chopstick[i/2])
    signal(chopstick[i])
}
```

Can deadlock happen?

- A. Yes    B. No
32. (2 points) True or False? **Deadlock** is a special case of **starvation**.  
A. True    B. False
33. (4 points) Assume that there is exactly one unit of each resource, and that the allocations and requests are as follows:
- P1: allocated R1 and requested R2
  - P2: requested R1 and R2

In this state, is the resource manager allowed to allocate resource R2 to either P1 or P2?

- A. P1: No; P2: No  
B. P1: No; P2: Yes  
C. P1: Yes; P2: No  
D. P1: Yes; P2: Yes (either P1 or P2, not both at the same time)

34. (4 points) True or False? According to the Banker's algorithm, the following system state is safe.

**Claim/Max Matrix**

	<b>Camera</b>	<b>Printer</b>	<b>Bluetooth</b>
Process A	2	1	2
Process B	5	5	3
Process C	5	4	4
Process D	1	0	2

**Current Allocation**

	<b>Camera</b>	<b>Printer</b>	<b>Bluetooth</b>
Process A	1	1	0
Process B	2	4	1
Process C	4	2	3
Process D	1	0	1

**Total Resources**

<b>Camera</b>	<b>Printer</b>	<b>Bluetooth</b>
8	7	6

A. True    B. False

35. (3 points) Which of the following is a hardware solution to the mutual exclusion problem?
- A. Binary semaphore
  - B. Counting semaphore
  - C. Mutex
  - D. Test-and-set
  - E. Answer not shown

36. (4 points) Assume that there is exactly one unit of each resource, and that the allocations and requests are as follows:

- P1: allocated R1 and R2
- P2: requested R1 and R3
- P3: requested R2 and allocated R3

Has deadlock occurred?

A. Yes    B. No

37. (3 points) Which condition of deadlock is prevented by requiring that all resource requests by a process are made simultaneously?  
 A. Hold and wait    B. No preemption    C. Exclusion    D. Circular wait
38. (4 points) True or False? According to the Banker's algorithm, the following system state is safe.

**Claim/Max Matrix**

	Camera	Printer	Bluetooth
Process A	7	5	4
Process B	7	2	3
Process C	3	2	5
Process D	4	0	2

**Need Matrix**

	Camera	Printer	Bluetooth
Process A	4	3	3
Process B	4	0	1
Process C	2	1	4
Process D	1	0	1

**Total Resources**

Camera	Printer	Bluetooth
11	5	6

- A. True    B. False

39. (4 points) Below is an implementation of a barber who can perform hair cuts on people, one at a time. Furthermore, there is a function that any number of people can call at any time (including at the same time) to get a hair cut. **customer** and **barber\_done** are counting semaphores.

```
barber()
{
    while(true){
        wait(customer);
        cut_hair();
        signal(barber_done);
    }
}

customer_get_hair_cut()
{
    signal(customer);
    wait(barber_done);
    pay();
}
```

How should the two semaphores be initialized before either of these functions is called? The barber cannot cut hair unless there is a customer and a customer cannot pay until the work is done.

- A.  $customer = 0; barber\_done = 0$
  - B.  $customer = 0; barber\_done = 1$
  - C.  $customer = 1; barber\_done = 0$
  - D.  $customer = 1; barber\_done = 1$
  - E. Answer not shown
40. (2 points) True or False? If the Banker's algorithm determines that a state is **unsafe**, then **deadlock** is guaranteed to happen.
- A. True
  - B. False