Introduction to Operating Systems, Fall 2020
Question Sheet

1. [Ch1+Ch13][9pts] Regarding IO operations
   a) What is the difference between synchronous IOs and asynchronous IOs?
   b) Is fread() synchronous or asynchronous by default?
   c) Is fwrite() synchronous or asynchronous by default?
2. [Ch1+Ch13][6pts] Describe the procedure of handing a timer interrupt, from that the timer generates an interrupt signal to the resumption of the interrupted program. Your answer must at least involve the following items: interrupt vector table, program counter, stack, and interrupt service routine.
3. [Ch2][10pts] Consider a user program that prompts the user for an input string, saves the string in a disk file, and terminates itself. List five different system calls that the program uses. You must also explain why the program uses these calls.
4. [Ch2][4pts] Regarding microkernel operating systems:
   a) They are considered more secure than monolithic kernels. Why?
   b) They suffer from poor performance for IO intensive applications. Why?
5. [Ch3][8pts] There are three possible states of a process: *running*, *ready*, and *waiting*. Now, consider a process that is currently running on the CPU. What is the next state of the process if
   a) the process is preempted by another high-priority process.
   b) the process initiates a synchronous IO operation and is then blocked.
6. [Ch3][5pts] Why context switch is implemented as an interrupt rather than a standard procedure call?
7. [Ch4][8pts] Threads in a process share almost everything, including the text, heap, and opened files, except the stack. Explain why it is necessary for concurrent threads to have their own stacks.
8. [Ch4][6pts] You are writing a CPU-bound program, which can be perfectly parallelized. The thread library that you use is based on the many-to-many thread model. Let the number of kernel-level threads allocated to the program be *K* and the number of physical CPU cores be *C*. Let the process contain *U* user-level threads. Discuss possible performance implications (in terms of the utilization of CPU cores) for the following cases:
   a) U=K>C
   b) U<K>C
9. [Ch5][24pts] CPU scheduling algorithms
   a) Shortest-Job-First (SJF) is the best in terms of the reduction of average process waiting time. However, SJF is not a good choice for CPU scheduling in

real systems. Give two reasons for that.

b) What is the problem when the time slice for Round-Robin (RR) is too small?

c) With multilevel feedback queue scheduling, IO-bound processes will be gradually promoted to upper-level queues, i.e., higher-priority queues. Explain the rationale of this design.

d) Many real-time operating systems implement Rate-Monotonic scheduling algorithm only but not Earliest-Deadline First scheduling. Explain why.

e) Process migration is necessary for load balancing among CPUs. However, it is always desirable to reduce the frequency of process migration. Explain why.

f) Why the virtual runtime approach in Linux CPU scheduling is free from starvation?

10. [Ch6][8pts] Why do modern operating systems use spinlocks as a synchronization mechanism only on multiprocessor systems and not on single-processor systems?

11. [Ch6][6pts] What is the potential problem of the following "solution" to the bounded-buffer problem? How it can be corrected?

semaphore empty=N,full=0,mutex=1; // N is the buffer size	
do {	do {
// produce an item	wait (mutex);
wait (mutex);	wait (full);
wait (empty);	// remove an item from buffer
// add the item to the buffer	signal (empty);
signal (full);	signal (mutex);
signal (mutex);	// consume the removed item
} while (true);	} while (true);
// producer process	// consumer process

12. [Ch6][6pts] There is only one restroom on the first floor of our building. The restroom is shared by all students, but it is made uni-sex with the following rules:

- Females and males cannot appear in the restroom at the same time, and
- there cannot be more than 3 people using the restroom

Write programs for males and females to solve this problem. Use as many semaphores as you wish. You don't have to worry about starvation.

*** Your answer must be specific and include necessary details. Giving a short answer without sufficient explanation will result in a score penalty.*