1. What is the difference between timesharing and multiprogramming systems?  
2. To use cache memory, main memory is divided into cache lines, typically 32 or 64  
bytes long. An entire cache line is cached at once. What is the advantage of caching an entire line instead of a single byte or word at a time?  
3. On early computers, every byte of data read or written was handled by the CPU (i.e., there was no DMA). What implications does this have for multiprogramming?  
4. Instructions related to accessing I/O devices are typically privileged instructions, that is, they can be executed in kernel mode but not in user mode. Give a reason why these instructions are privileged.  
5. A 255-GB disk has 65,536 cylinders with 255 sectors per track and 512 bytes per sector. How many platters and heads does this disk have? Assuming an average cylinder seek time of 11 ms, average rotational delay of 7 msec and reading rate of 100 MB/sec, calculate the average time it will take to read 400 KB from one sector.

**6.** Which of the following instructions should be allowed only in kernel mode?  
(a) Disable all interrupts.  
(b) Read the time-of-day clock.  
(c) Set the time-of-day clock.  
(d) Change the memory map.  
**7.** Consider a system that has two CPUs, each CPU having two threads (hyperthreading). Suppose three programs, *P0*, *P1*, and *P2*, are started with run times of 5, 10 and 20 msec, respectively. How long will it take to complete the execution of these programs? Assume that all three programs are 100% CPU bound, do not block during execution,  
and do not change CPUs once assigned.  
**8.** A computer has a pipeline with four stages. Each stage takes the same time to do its work, namely, 1 nsec. How many instructions per second can this machine execute?  
**9.** Consider a computer system that has cache memory, main memory (RAM) and disk, and an operating system that uses virtual memory. It takes 1 nsec to access a word from the cache, 10 nsec to access a word from the RAM, and 10 ms to access a word from the disk. If the cache hit rate is 95% and main memory hit rate (after a cache  
miss) is 99%, what is the average time to access a word?  
**10.** When a user program makes a system call to read or write a disk file, it provides an indication of which file it wants, a pointer to the data buffer, and the count. Control is then transferred to the operating system, which calls the appropriate driver. Suppose that the driver starts the disk and terminates until an interrupt occurs. In the case of reading from the disk, obviously the caller will have to be blocked (because there are no data for it). What about the case of writing to the disk? Need the caller be blocked awaiting completion of the disk transfer?  
**11.** What is a trap instruction? Explain its use in operating systems.  
**12.** Why is the process table needed in a timesharing system? Is it also needed in personal computer systems running UNIX or Windows with a single user?  
**13.** Is there any reason why you might want to mount a file system on a nonempty directory? If so, what is it?  
**14.** For each of the following system calls, give a condition that causes it to fail: fork, exec, and unlink.  
**15.** What type of multiplexing (time, space, or both) can be used for sharing the following resources: CPU, memory, disk, network card, printer, keyboard, and display?  
**16.** Can the count = write(fd, buffer, nbytes); call return any value in *count* other than *nbytes*? If so, why?  
**17.** A file whose file descriptor is *fd* contains the following sequence of bytes: 3, 1, 4, 1, 5, 9, 2, 6, 5, 3, 5. The following system calls are made:  
lseek(fd, 3, SEEK SET);  
read(fd, &buffer, 4);where the lseek call makes a seek to byte 3 of the file. What does *buffer* contain after the read has completed?  
**18.** Suppose that a 10-MB file is stored on a disk on the same track (track 50) in consecutive sectors. The disk arm is currently situated over track number 100. How long will it take to retrieve this file from the disk? Assume that it takes about 1 ms to move the arm from one cylinder to the next and about 5 ms for the sector where the beginning of  
the file is stored to rotate under the head. Also, assume that reading occurs at a rate of 200 MB/s.