Exercise 1

One reason GUIs were slow to be adopted was the cost of the hardware needed to support them. How much video RAM is needed to support a 25-line × 80-row character monochrome text screen? How much for a 1200 × 900-pixel 24-bit color bitmap? What was the cost of this RAM at 1980 prices ($5/KiB)? How much is it now?

Exercise 2

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.

Exercise 3

Consider a system that has two CPUs, each CPU having two threads (hyper-threading). Suppose three programs, P_1, P_2, P_3, P_4 and P_5, are started with run times of 10, 10, 15, 20 and 30 ms, 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.

Note: The logical processors in a hyper-threaded core share the execution resources.

Exercise 4

A 255 GiB 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 ms and reading rate of 100 MiB/s, calculate the average time it will take to read 400 KiB from one sector.

Exercise 5

Suppose that a 10 MiB file is stored on a disk on track 50 (all sectors which belong to the file are on the same track) 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 MiB/s.

Exercise 6

Consider a computer system that has cache memory, main memory (RAM) and disk, and an operating system that uses virtual memory. It takes 1 ns to access a word from the cache, 10 ns 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?

Note: A *word* is a fixed-sized piece of data handled as a unit by the processor. The number of bits in a word is a characteristic of a specific processor or computer architecture.

Exercise 7

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?

Exercise 8

Here are some questions for practicing unit conversions:

(a) How long is a nanoyear in seconds?
(b) Micrometers are often called microns. How long is a megamicron?
(c) How many bytes are there in a 1 PB memory? How about a 1 PiB memory?
(d) The mass of the earth is 6000 yottagrams. What is that in kilograms?