Assignment 1
CSC 4420 Computer Operating System
Chapter 1
Due: Jan. 27, 2025
50 Points

1. **What are the two main functions of an operating system? (5 points)**

   i. Providing abstractions to user programs.
   ii. Managing the computer's resources.

2. **What is multiprogramming? (5 points)**

   - Multiprogramming is the technique of partitioning memory into several pieces, each holding a different job, to ensure that the CPU remains actively utilized.

3. **There are several design goals in building an operating system, for example, resource utilization, timeliness, robustness, and so on. Give an example of two design goals that may contradict one another. (5 points)**

   - Performance vs Security:
   i. Optimizing an OS for maximum performance often involves minimizing the overhead associated with with security checks and controls. Leading the system more vulnerable to attacks.
   ii. On the other hand, implementing robust security measures can also lead to additional processing overhead, slowing down the system performance.

4. **What is the difference between kernel and user mode? Explain how having two distinct modes aids in designing an operating system. (5 points)**

   - **The most fundamental piece of software, runs in kernel mode for at least some of its functionality. In kernel mode, it has complete access to all the hardware and can execute any instruction the machine is capable of executing. It can execute any CPU instruction and interact directly with devices, memory, and the system's core functionality.**
   - **User mode is a restricted mode designed for running applications. In this mode, only a subset of machine instructions is accessible, and applications cannot directly access hardware or critical system resources.**

5. **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. (5 points)**

   - For the best case scenario assuming all three programs are 100% CPU bound, do not block during execution and do not change CPUs after being assigned, then all programs run in parallel in separate threads and the execution time will be 20msec

6. **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? (5 points)**

   - The machine will execute 1 second = 10^9nsec. Therefore, the machine will execute 1 billion instruction per second.

7. **What is the purpose of a system call in an operating system? (5 points)**

   - The purpose of system call is to enable user programs leveraging the capabilities of the operating system securely and efficiently. They abstract away the complexity of interacting directly with hardware (machine code) and provide a consistent programming interface for accessing system resources.

8. **Explain why file systems are almost always mounted on empty directories. (5 points)**

   - File systems are mounted on empty directories to prevent any file conflict between existing system and the mounted storage. Following this approach, ensures the mounted file systems to integrate cleanly into the file hierarchy with no disruption to existing data, handling a safe approach for external storage.

9. **What is the essential difference between a block special file and a character special file? (5 points)**

   i. Block special files represent devices that consist collection of randomly addressable blocks (like disks, SSDs, tapes.). Data is transferred in fixed size blocks. The program can read or write data in the specified block using system calls.

   ii. Character special files represent devices that communicate by streams of characters (printers, keyboards, mouse, modems.). Data is transferred as streams characters. The program interacts with the device one character at a time.

10. **Virtual machines have become very popular for a variety of reasons. Nevertheless, they have some downsides. Name one. (5 points)**

    - One downside of the virtual machines is that performance overhead, which involves multiple virtual machines running on a single physical machine leading to performance degradation due to the extra layer of abstraction and resource sharing. Early research projects improved performance over interpreters by translating blocks of code on the fly and storing them in a internal cache. Despite the improvements, the systems were still not fast enough for commercial environments.