**Name:**

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## CSCI 2310: Operating Systems
### Sample Midterm: Processes, Scheduling, and Synchronization

*General instructions*:

- This examination booklet has 10 pages.
- Don't forget to put down your name on the exam books.
- The exam is closed book and closed notes.
- Explain your answers clearly and be concise. Do not write long essays.
- You have 85 minutes to complete the exam. Be a smart test taker, if you get stuck on one problem go on to the next. Don't waste your time giving details that the question does not request.
- Show your work. Partial credit is possible, but only if you show intermediate steps.
- Good luck!

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1. **OS and Computer Structures** Answer the following questions briefly (15 points)

   (a) (6pts) What is a trap? Explain the key steps performed by the OS to handle a trap.

(b) (6pts) Explain how a system call is different from a regular function call. Why are system calls needed?

(c) (3pts) What is the primary disadvantage of the micro-kernel architecture for designing an OS kernel?

2. **Processes and Threads** (20 points)

(a) (3pts) What is a process? Draw a state transition diagram that shows the various states that a process can be in and the various transitions it can make between these states.

(b) (8 pts) What steps must be performed by an OS kernel upon a context switch? Explain why the context switch overhead influences the length of the time slice used by a CPU scheduling policy.

(c) (9 pts) Using the *fork()*, *exec* and *waitpid()* system calls, write a program in pseudo-code in which a parent forks two child processes. Each child prints "My process id is X, my parent's id is Y". The two children then execute the Firefox and the Google Chrome browser programs, respectively. The parent waits for both children to complete before it exits. Assume that the *getpid()* system call tells you your own process id.

3. **CPU Scheduling** (25 points)

(a) (6pts) What scheduling algorithm would you choose if you wanted to minimize the waiting time of a process? List the disadvantages, if any, of this scheduling algorithm.

(b) (9 pts) Consider a scheduling algorithm that chooses a process that has used up the least processor time in the recent past. Why will this algorithm favor I/O-bound processes and yet not permanently starve CPU-bound processes?

(c) (10pts) Assuming FCFS and round robin scheduling algorithms, construct an example job mix with at least three jobs, such that all jobs have the same completion times. Your example should precisely state the arrival times of each job, their lengths, and the duration of the time slice for the round robin scheduler. Assume that the context switch overhead is zero.

4. **Deadlocks** (20 points)

(a) (5 pts) What are the necessary conditions in order for deadlock to occur?

(b) (7 pts) Explain how deadlock can occur in the naive version of the Dining Philosophers problem, then describe how we can modify the problem to prevent deadlock. Pseudocode is not necessary but you should clearly describe the steps involved.

(c) (8 pts) Consider the following system state for four processes $P_0$, $P_1$, $P_2$ and $P_3$, and three resources $A$, $B$ and $C$. Using Bankers algorithm, determine whether the following state is safe or unsafe. Explain your answer.

| | Max | | | Allocation | | | Available | | |
|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | A | B | C | A | B | C |
| $P_0$ | 0 | 0 | 2 | 0 | 0 | 0 | | | |
| $P_1$ | 1 | 7 | 5 | 1 | 0 | 0 | | | |
| $P_2$ | 2 | 3 | 5 | 1 | 3 | 5 | | | |
| $P_3$ | 0 | 6 | 5 | 0 | 6 | 3 | | | |
| total | | | | 2 | 9 | 8 | 1 | 5 | 2 |

5. **Synchronization** (20 points)

(a) (20 pts) You are given a game with 3 players and 3 colors (red, blue, green). You must ensure that the players only move pieces in the order: red, blue, green, red, blue, green, etc. Write three routines using **semaphores** for the players to call: MoveRed, MoveBlue, and MoveGreen. Remember to write the initialization routines, and you may assume red always starts. You can use pseudo-code for your solution.

(overflow sheet for your answers)