1(a). What mechanism is commonly supported, in a CPU, for implementing system calls (invoking functions provided by the operating system)? (5%)

1(b). Why the mechanism for implementing user-program subprogram calls (e.g., stack push and pop) cannot be used to implement system calls? (5%)

2. Suppose that the processes arrive for execution at the times indicated below. Each process will run the listed amount of time.

Process	Arrival Time	Burst Time
P1	0.0	6
P2	0.5	4
P3	1.0	3

(a) What is the average waiting time for these processes when the FCFS scheduling algorithm is adopted? (6%)

(b) What is the average waiting time for these processes when the Round-Robin scheduling algorithm is adopted and the time quantum, 2, is used? (9%)

3(a). "spin-lock" is one type of semaphore implementation for process synchronization. Explain why spin-lock is not appropriate for uniprocessor systems. (8%)

3(b). The system calls, wait() and signal(), are provided by operating systems for semaphore processing. A basic requirement is these two functions must be atomically executed. If the computer hardware supports no special synchronization instructions (e.g., test-and-set), how can "atomic execution" be implemented? (7%)

4. A page-replacement algorithm should minimize the number of page faults. What is the number of page faults for the LRU (least recently used) page replacement strategy for the page reference sequence below with four page frames? (10%)
   1, 3, 4, 2, 5, 4, 2, 1, 6, 7, 8, 7, 8, 9, 7, 8, 9, 5, 2, 5, 2, 3

5. Please explain the following terminologies. (12%)
   (a) Convoy effect
   (b) Belady's anomaly
   (c) Thrashing
   (d) Read-modified-write

6. Constant linear velocity (CLV) and constant angular velocity (CAV) are two well-known disk physical structure techniques. What does CLV mean? What does CAV mean? Which method is used in CD-ROM and DVD-ROM drives? Which method is used in hard disks? (10%)

7. Please list two common interprocess communication mechanisms and compare their differences. (10%)

8. Numerous schemes provide redundancy at lower cost by using the idea of disk striping combined with "parity" bits. These schemes have different cost-performance tradeoffs and are classified into levels called **RAID levels**. Please explain the basic idea of these schemes from RAID 1 to RAID 6. (18%)