1. What is the purpose of interrupts? What are the differences between a trap and an interrupt? Can traps be generated intentionally by a user program? If so, for what purpose? (10%)

2. Discuss, with examples, how the problem of maintaining coherence of cached data manifests itself in the following processing environments: (10%)
   a) Single-processor systems   b) Multiprocessor systems

3. Define the essential properties of the following types of operating systems: (10%)
   a) Time sharing   b) Parallel

4. Describe three general methods for passing parameters to the operating system. (10%)

5. Describe the actions taken by a kernel to context-switch between processes. (10%)

6. Explain the following terms: multiprogramming, multiprocessing, and multithreading. (10%)

7. Consider a multiprocessor system and a multithreaded program written using the many-to-many threading model. Let the number of user-level threads in the program be more than the number of processors in the system. Discuss the performance implications of the following scenarios. (10%)
   a. The number of kernel threads allocated to the program is less than the number of processors.
   b. The number of kernel threads allocated to the program is equal to the number of processors.

8. Consider a system running ten I/O-bound tasks and one CPU-bound task. Assume that the I/O-bound tasks issue an I/O operation once for every millisecond of CPU computing and that each I/O operation takes 10 milliseconds to complete. Also assume that the context switching overhead is 0.1 millisecond and that all processes are long-running tasks. What is the CPU utilization for a round-robin scheduler when: (10%)
9. Consider the following set of processes, with the length of the CPU-burst time given in milliseconds: (10%)

<table>
<thead>
<tr>
<th>Process</th>
<th>Burst Time</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>P2</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>P3</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

The processes are assumed to have arrived in the order $P1$, $P2$, $P3$, all at time 0.

a. Draw two Gantt charts illustrating the execution of these processes using SJF and a nonpreemptive priority (a smaller priority number implies a higher priority), and RR (quantum = 1) scheduling.

b. What is the turnaround time of each process for each of the scheduling algorithms in part a?

10. We can evaluate the performance of an algorithm through deterministic modeling, queuing model, simulations, and implementations. Please describe the advantages and disadvantages of the above four evaluation methods. (10%)