1. The following is a sequence of undo-log records written by two transactions $T$ and $U$:

$$<\text{START } T>; <T, A, 10>; <\text{START } U>; <U, B, 20>; <T, C, 30>; <U, A, 40>; <\text{COMMIT } U>; <T, E, 50>; <\text{COMMIT } T>$$

(a) What is the effect on the disk value of $A$ if there is a crash at some point during the sequence of events?

(b) What does this example say about the ability of logging by itself to preserve the atomicity of transactions?

(c) What property of histories ensure that such situations do not occur?

2. Consider the execution shown in Figure 1 and answer the following questions.

(a) What is done during Analysis? (Be precise about the points at which Analysis begins and ends and describe the contents of any tables constructed in this phase.)

(b) What is done during Redo? (Be precise about the points at which Redo begins and ends.)

(c) What is done during Undo? (Be precise about the points at which Undo begins and ends.)

3. Consider the execution shown in Figure 2 and answer the following questions.

(a) Extend the figure to show $prevLSN$ and $undonextLSN$ values.

(b) Describe the actions taken to rollback transaction $T2$. 

1
Figure 1: Figure for Question 2.

(c) Show the log after T2 is rolled back, including all \(\text{prevLSN}\) and \(\text{undonextLSN}\) values.

4. Briefly answer the following questions.

(a) How is checkpointing done in ARIES?

(b) Checkpointing can also be done as follows: Quiesce the system so that only checkpointing activity can be in progress, write out copies of all dirty pages, and include the dirty page table and transaction table in the checkpoint record. What are the pros and cons of this approach versus the checkpointing approach of ARIES?

(c) What happens if a second \text{begin_checkpoint} record is encountered during the Analysis phase?

(d) Can a second \text{end_checkpoint} record be encountered during the Analysis phase?

5. Consider the three conditions under which a redo is unnecessary in the ARIES algorithm.

(a) Why is it cheaper to test the first two conditions?

(b) Describe an execution that illustrates the use of the first condition.

(c) Describe an execution that illustrates the use of the second condition.
<table>
<thead>
<tr>
<th>LSN</th>
<th>LOG</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>update: T1 writes P2</td>
</tr>
<tr>
<td>10</td>
<td>update: T1 writes P1</td>
</tr>
<tr>
<td>20</td>
<td>update: T2 writes P5</td>
</tr>
<tr>
<td>30</td>
<td>update: T3 writes P3</td>
</tr>
<tr>
<td>40</td>
<td>T3 commit</td>
</tr>
<tr>
<td>50</td>
<td>update: T2 writes P5</td>
</tr>
<tr>
<td>60</td>
<td>update: T2 writes P3</td>
</tr>
<tr>
<td>70</td>
<td>T2 abort</td>
</tr>
</tbody>
</table>

Figure 2: Figure for Question 3.