1.

(a) With immediate modification, modified buffer blocks can be written to the disk even if the transactions that made those modifications have not all committed. Is there any drawback if this is not allowed?

- It may not work with transactions that perform a large number of updates, since the disk buffer may get filled with updated buffer blocks that cannot be evicted to disk and the transactions cannot proceed.

(b) With immediate modification, a transaction is allowed to commit even if it has modified some buffer blocks that have not yet been written to disk. Is there any drawback if this is not allowed?

- The commit of transactions might be slowed down until all its modified blocks have been output to the disk.
- It may incur more output operations because frequently updated buffer blocks are output multiple times, once for each transaction.

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2. Suppose we do not log actions taken during transaction rollback using undo operation and the following log records are generated in which a rollback actually happened to T_1 between steps 2 and 3 (but there are no log records reflecting the occurrence of the rollback).

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1. <T_1 start>
2. <T_1, A, 1000, 900>
3. <T_2 start>
4. <T_2, A, 1000, 2000>
5. <T_2 commit>

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(a) When recovering from a system crash, show how actions taken during recovery could result in an incorrect database state.

(b) What would be the correct sequence of logs?

(a) Since the log contains neither <T_1 commit> nor <T_1 abort>, T_1 would be undone and A takes the value 1000. The update made by T_2, though committed, is lost.

(b) The correct sequence of logs is as follows:

1. <T_1 start>
2. <T_1, A, 1000, 900>
3. <T_1, A, 1000>
4. <T_1 abort>
5. <T_2 start>
6. <T_2, A, 1000, 2000>
7. <T_2 commit>

This would make sure that T_1 would not get added to the undo-list in the redo phase.

3. Consider the following log. Suppose there is a crash ***after*** the last log record is written out.

(a) Show all possible values of all data items on disk after the crash but before recovery?

(b) Show the steps in time sequence during recovery.

<T_0 start>
<T_0, B, 2000, 2050>
<T_1 start>
<checkpoint {T_0, T_1}>
<T_1, C, 700, 600>
<T_1 commit>
<T_2 start>
<T_2, A, 500, 400>
<T_0, B, 2000>

(a) A = 500 or 400, B = 2000 or 2050, C = 700, 600.

(b) Recovery would happen as follows:

Redo phase:

a. Undo-List = {T_0, T_1}
b. Start from the checkpoint entry and perform the redo operation.
c. C = 600
d. T_1 is removed from the Undo-list, Undo-List = {T_0}
e. T_2 is added to the Undo list, Undo-List = {T_0, T_2}
f. A = 400
g. B = 2000

Undo phase:

a. Undo-List = {T_0, T_2}
b. Scan the log backwards from the end.
c. output the redo-only record < T_2, A, 500 >; A = 500
d. output < T_2 abort >; T_2 is removed from the Undo list, Undo-List = {T_0}
e. output the redo-only record < T_0, B, 2000 >; B = 2000
f. output < T_0 abort >; T_0 is removed from the Undo list; Undo-List = { }

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