Each question is worth 10 points. You may work with one partner and sign both of your names to your paper.

1. The Undo, No Redo algorithm has the following description: Transactions First transfer before-images of each page to the audit trail and then put the after-images in the database.
   Suppose we changed it so that we transfer the after-image to the database before putting the before-image to the audit trail. Will this be correct? Prove your answer.

2. Suppose that a transaction manager has done the following steps in the two phase commit protocol for a transaction T:
   (a) It has asked all servers whether they are willing to commit and they all responded affirmatively.
   (b) It has told all servers to commit, but has not waited for a response.
   Does the transaction manager still need to keep a record of transaction T? If not, why not? If so, for how long?

3. Suppose we are trying to decide whether to put a non-clustering index on attribute B for relation R to support equality selections on B. The relation has 10 million records. Each page can store 10 records. There are 10,000 different values of B. A sequential scan will fetch 10 pages per read. Explain why you would or would not want to include a non-clustering index.

4. Suppose that each of relations R, S, T, V, W has A as its only key. Which of the following queries may output a different number of records if DISTINCT is removed? Prove your answer.

   a. SELECT DISTINCT R.A, S.A
      FROM R, S
      WHERE R.B = S.C

   b. SELECT DISTINCT R.A
      FROM R, S
      WHERE R.B = S.C

   c. SELECT DISTINCT R.A
      FROM R, S
      WHERE R.B = S.A

   d. SELECT DISTINCT R.A
      FROM R, S, T, V, W
      WHERE R.B = S.A
      AND R.D = T.D
      AND R.C = V.A
      AND T.A = S.B
      AND W.A = S.D

   e. SELECT DISTINCT R.A
      FROM R, S, T
      WHERE R.B = T.A
      AND R.B = S.C
5. Suppose that the following four transactions are the only ones that execute during some interval (R stands for read, W for write, and different letter arguments represent different data items).

T1: R(A) W(B) R(C) W(D)
T2: W(A) W(C)
T3: R(D) R(B)
T4: R(A) R(E)

a. What is the finest chopping of T1 assuming that its reads and writes cannot be reordered? Show the chopping.

b. What is the finest chopping of T1 assuming that its reads and writes can be reordered? Show the reordering, then the chopping.

c. Can any other transactions be chopped?