NATIONAL UNIVERSITY OF SINGAPORE

CS3223 – DATABASE SYSTEMS IMPLEMENTATION
(Semester 2: AY2016/17)

Time Allowed: 2 Hours

INSTRUCTIONS TO CANDIDATES

1. This assessment paper consists of **TWO** Sections and comprises **TWELVE (12)** printed pages. Section **A** has **THREE (3)** questions, and Section **B** has **EIGHT (8)** questions. The maximum score is **FORTY** (40).
2. Answer **ALL** questions. Write your answers within the **space provided** in this booklet.
3. This is an **OPEN BOOK** assessment.
4. You are allowed to use an authorized calculator.
5. Please write your **Student Number** below. Do not write your name.

Student Number:												

EXAMINER'S USE ONLY	
Questions	**Marks**
Section A (32 marks)	
Q1 (12 marks)	
Q2 (8 marks)	
Q3 (12 marks)	
Section B (8 marks)	
Total (40 marks)	

Section A (32 marks)

1. **(12 marks)** Consider a database with three relations: R(a, b, c), S(c, b, d) and T(d, b, e). The primary keys of relations R, S and T are attributes a, c and d respectively. Suppose R has 500 tuples, S has 500 tuples and T has 1,000 tuples. Let the number of distinct values of b be 100, i.e., V(R,b) = V(S, b) = V(T, b) = 100. Moreover, assume that the b values are integers ranging from 0 to 99. Suppose every attribute is of the same size, and each page can hold 10 tuples of R. Suppose the database maintains histograms for attribute b by keeping **ONLY** the frequency of the **THREE** most common values, as tabulated below (the other values are not maintained and are assumed to be uniformly distributed):

	0	**1**	**2**	**3**	**4**	**Others**
R.b	72	30	10			388
S.b		40	16	250		194
T.b	100		10		17	873

a) Draw a plan tree for the following query. You should push down as many operations as possible. You should join R and S first, then join the intermediate result with T.

```
SELECT a, b+e → x
FROM   R, S, T
WHERE  R.b = S.b AND S.b = T.b
```

b) Estimate the size of the query result in terms of pages and tuples.

c) Suppose the database only supports sort-merge join. What is the cost of performing the query (in terms of I/O counts) assuming you can run all join operations in two passes (using the plan in part (a))? You should write out the intermediate join results to disk. Ignore the cost to write out the final join result.

2. **(8 marks)** Consider the following sequences of actions, listed in the order in which they are submitted to the DBMS:

T1	T2	T3
R(X)		
	W(X)	
	W(Y)	
		W(Y)
W(Y)		
Commit		
	Commit	
		Commit

a) Suppose the database adopt the Strict 2PL lock-based concurrency control mechanism with the Wait-die policy as the deadlock prevention mechanism. Assume that the timestamp of transaction Ti is i. Describe the sequence of events that happen in the following table (1 line per event; note that there may be fewer or more than 10 events). For example, if T1 acquires a shared lock on an item X, then write "T1 acquires shared lock on X"; if T1 waits for T2 for item X, then write "T1 waits for X from T2", and so on. If a transaction is blocked, assume that all of its actions are queued until it is resumed; the DBMS continues with the next action (according to the listed sequence) of an unblocked transaction. If a transaction is aborted, it should restart only after other running transactions are completed. Transactions are restarted based on the order in which they are aborted.

Event No.	Event
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

b) Suppose we adopt a deadlock detection approach using the wait-for-graph. Is there a deadlock for the above schedule. What can you say about the two different approaches (wait-die prevention vs wait-for-graph detection) to handling deadlocks?

3. **(12 marks)** Suppose you are given the following log file under the ARIES recovery mechanism.

LSN	TID	PrevLSN	Type	PageID	Data	OldValue	NewValue
1	1	NULL	Start				
2	1	1	Update	1	A	oldA	newA
3	2	NULL	Start				
4	2	3	Update	2	B	oldB	newB
5	1	2	Update	3	C	oldC	newC
6			Checkpoint Start				
7			Checkpoint End				
8	3	NULL	Start				
9	2	4	Update	4	D	oldD	newD
10	3	8	Update	5	E	oldE	newE
11	1	5	Commit				
12	2	9	Update	2	B	oldB	newB

********** C R A S H **********

a) After the recovery, which transactions will be committed and which will be aborted?

Committed:

Aborted:

b) Suppose the dirty page table in the Checkpoint record has only pages 1 and 2 in it. At what LSN will the REDO pass of recovery begin? Explain why. Why do you think page 3 is not in the dirty page.

c) Suppose the dirty page table in the Checkpoint record has only pages 1 and 2 in it. List the pages that may be written during the REDO pass of recovery and the corresponding LSN number? Justify your answer.

d) Suppose the dirty page table in the Checkpoint record has only pages 1 and 2 in it. Complete the log as part of the recovery process. What pages may be written during the UNDO pass of recovery (list the corresponding LSN for each page)?