Write your answers in the boxes provided only. Do not write on the back or outside the box.

Database Systems — CSci 4380
Final Exam
May 19, 2016

RCS ID: _____ @rpi.edu **Name:** _____

RIN # : _____

Rules. The exam is 120 minutes for a total of 100 points. Open book and notes. Do not use any electronic tools including your computer. Work alone. You **cannot** talk to anyone in class, or share notes or thoughts. With the exception of queries, you must explain your answers and show your computations. No explanation, no points.

Question 1 (10 points). You are given the schedule below. List all conflicts. Draw the conflict graph. Discuss whether it is serializable or not. If it is serializable, write down one serial order equivalent to this schedule.

$$r_1(W)\ r_2(X)\ r_2(Y)\ r_1(X)\ w_2(Z)\ r_3(Z)\ w_3(Z)\ w_1(X)\ w_3(X)\ r_3(Y)\ w_3(Y)$$

Question 2 (6 points). You are given the following log and data page entries found on disk after a crash. Based on this information, answer the following questions and give an explanation for all your answers.

(a) Can you conclude whether this DBMS uses FORCE or NO FORCE? Why?

(b) Can you conclude whether this DBMS uses STEAL or NO STEAL? Why?

LSN	Log Entry	PrevLSN
1	Update T2 P1	-
2	Update T1 P3	-
3	Update T3 P2	-
4	Update T2 P4	1
5	Update T3 P5	3
6	Commit T2	4
7	Update T1 P4	2
8	Commit T1	7

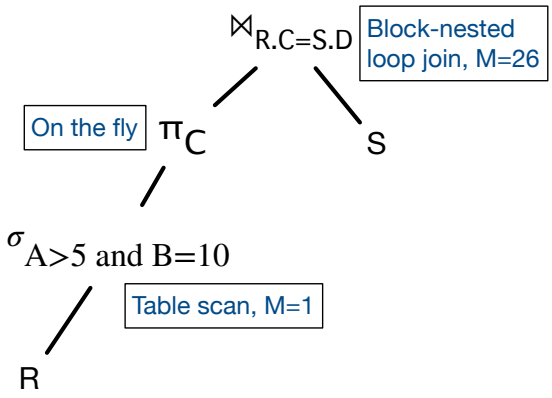
pageLSN	Data Page
1	P1
3	P2
2	P3
7	P4
5	P5

Question 3 (18 points). You are given the following query tree and the following statistics. Answer the following and show your work with detailed computations.

TUPLES(R)=60,000	TUPLES(S)=100,000	VALUES(R.A)=3,000	VALUES(R.B)=20
PAGES(R)=8,000	PAGES(S)=5,000	VALUES(R.C)=20,000	VALUES(S.D)=8,000

(a) Find the cost of this operation in terms of number of pages. You can assume that after projection on attribute C, you can store about 20 tuples of R in a single memory block. Show your work.

(b) Propose at least one good index for this query and discuss why this is a good index. An index without explanation will get no points.



Question 4 (18 points). Suppose you are given a relation Proj(EmpNo, DeptNo, ProjNo, Name, Desc) with the following information:

- TUPLES(Proj)=60,000, PAGES(Proj)=12,000
- There are 500 employees (EmpNo), 200 projects (ProjNo) and 100 departments (DeptNo) in this relation. Assume employees are uniformly distributed across departments and projects, and you can use the usual cardinality estimation methods.
- Index I1 is on Proj(ProjNo, DeptNo) with height 2 (root, internal level and leaf) and 250 leaf nodes (with 240 pointers to tuples at each leaf node).

Find the cost of the following queries by using this index. Explain your answers in detail.

```
Q1: SELECT Name, Desc FROM Proj WHERE ProjNo=12 AND DeptNo=5;
Q2: SELECT ProjNo     FROM Proj WHERE DeptNo>3;
Q3: SELECT Name, Desc FROM Proj WHERE ProjNo=5 AND EmpNo=5;
```

For questions 5 and 6, use the data model below representing the leadership positions held by students in the Student Union of a large technological university. Go student leadership!

`Students(studid, fname, lname, email, address)`
This table contains all students (current and past) with their current email and address.

`Offices(oid, name, studtype, duration)`
Available officer positions in the union, `studtype` is the type of student for this office (either `grad` or `undergrad`), and `duration` is the length of the office.

`HeldOffices(hid, studid, oid, fromyear, toyear)`
Stores the offices held by a student. If the student is currently in office, `toyear` is `null`.
A student may only hold one office in any given year.
Each office can be held by at most one student in a calendar year.
These constraints are managed by separate application rules.

Question 5 (18 points). Find students who have held (i.e. in the past) at least two different `undergrad` offices (`Offices.studtype`) and held the same undergrad office at least twice. Return the first name, last name and email of the student, and total duration of time the student served (using `fromyear, toyear` attributes).

Note that a student who served from 2015 to 2015 would have served for 1 year, and 2015 to 2016 for 2 years. We only count past offices held, not the current one if any.

```
Students(studid, fname, lname, email, address)
Offices(oid, name, studtype, duration)
HeldOffices(hid, studid, oid, fromyear, toyear)
```

Question 6 (18 points). Find all offices that have been vacant since 2014. These offices currently have no officer and the last officer for this office finished her term in 2014 (term ended on `Heldoffices.toyear`). Return id, name and duration (i.e. `Offices.duration`) for the offices.

Question 7 (12 points). Suppose you decide to change the data model from Questions 5 and 6 and store more information for each student. For each student, you will store which years she attended the university and which degrees she obtained. You will also store the various emails and addresses she has used in the past. As a result, the Students relation will change to the following:

`Students(studid, fname, lname, email, address, from, to, degree, major)`

with the following functional dependencies:

`studid` $\rightarrow$ `fname lname`
`studid from to` $\rightarrow$ `degree major`

(a) Put the above relation in BCNF using BCNF decomposition. Show your work by finding the keys of resulting relations and showing that the relation is in BCNF. (We will also accept 3NF decomposition here but check whether the resulting relations are in BCNF or not and mark the keys.)

(b) Using the relations found in part (a) above, check if each relation is in 4NF based on the multi-valued dependencies given below. If it is not, use 4NF decomposition to put them in 4NF.

`studid` $\twoheadrightarrow$ `email`
`studid` $\twoheadrightarrow$ `address`

This page is left blank for scratch work, random thoughts and pictures!
Congratulations, DBS is done.
Let me know if you wish to be a mentor for DBS next semester. It is a great learning experience.
Also, have a great summer.