PLEASE HAND IN

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UNIVERSITY OF TORONTO
Faculty of Arts and Science

APRIL 2018 EXAMINATIONS

CSC 343
Duration — 3 hours

Aids Allowed: None

Student Number: |_|_|_|_|_|_|_|_|_|_|

Family Name(s): _____

Given Name(s): _____

In the SQL questions, you are welcome to use views. Comments are not required, although they may help us mark your answers.

There are blank pages at the end for rough work.

A mark of at least 50 out of 100 on this exam is required in order to pass the course.

It's been a real pleasure teaching you this term. Good luck!

# 1:	_____/ 12
# 2:	_____/ 12
# 3:	_____/ 18
# 4:	_____/ 5
# 5:	_____/ 8
# 6:	_____/ 6
# 7:	_____/ 6
# 8:	_____/ 10
# 9:	_____/ 6
# 10:	_____/ 7
# 11:	_____/ 10
TOTAL:	_____/100

Good Luck!

CONT'D...

Question 1. [12 MARKS]

Consider this relational schema. Keys are underlined and null values are not allowed. The only constraints that hold are the listed integrity constraints and the indicated key constraints.

No partial marks. Explanations must be correct and legible.

Relations

One(a, b, c)
Two(e, f)
Three(h, i, j)
Four(m, n, o)

Integrity constraints

(I.1) One[a] $\subseteq$ Three[h]
(I.2) Two[e] $\subseteq$ Three[i]
(I.3) Four[n,o] $\subseteq$ Three[h, i]

Part (a) [2 MARKS]

Suppose $|\Pi_a(One)| = 2$. What are possible values for $|\Pi_{h,i,j}(Three)|$?

Circle all possible answers.

0 1 2 4 100

Part (b) [2 MARKS]

Suppose $|\Pi_h(Three)| = 2$. What are possible values for $|\Pi_m(Four)|$?

Circle all possible answers.

0 1 2 4 100

Part (c) [2 MARKS]

Suppose *One* contains a single tuple, *Two* contains two tuples and *Four* contains four tuples. How many tuples can *Three* contain?

Circle all possible answers.

0 1 2 4 100

Part (d) [2 MARKS]

Will the following queries return the same answers on all databases in which *Four* contains 4 tuples. If yes, explain. If no, give an example instance on which they differ that is as small as possible.

(i) $\Pi_j(Three)$ (ii) $\Pi_j(Three \bowtie_{h=n} Four)$

Answer: YES NO

Explanation:

Part (e) [2 MARKS]

Is the following a valid instance of the relational schema? If not, list all constraints that are violated.

One

a	b	c
1	1	1

Two

e	f
2	2

Three

h	i	j
1	1	1
2	1	2
1	2	1

Four

m	n	o
1	1	1
2	2	2

Part (f) [2 MARKS]

Is the following a valid instance of the relational schema? If not, list all constraints that are violated.

One

a	b	c
1	1	1
2	2	1

Two

e	f
2	1
2	2

Three

h	i	j
1	1	1
1	2	1
3	2	2
3	4	4

Four

m	n	o
1	1	1
2	3	2

Question 2. [12 MARKS]

Consider this relational schema. Keys are underlined and null values are not allowed. The only constraints that hold are the listed integrity constraints and the indicated key constraints.

Write the following queries or constraints in relational algebra. No partial marks will be given for answers in any other language including SQL.

Relations

User(uid, name, lastSeen)
Every user has a unique identifier, `uid`, a name, and time when they were last seen in the system (`lastSeen`).

Message(mid, from, to, content, sentTime)
Indicates that the message `mid` was sent by the user `from` to the user `to` at time `sentTime`. The attribute `content` includes the body (content) of the message.

Delivered(mid, uid, deliveryTime)

Integrity constraints

(M.1) Message[from] $\subseteq$ User[uid]
(M.2) Message[to] $\subseteq$ User[uid]
(M.3) Delivered[mid, uid] $\subseteq$ Message[mid, to]

Part (a) [2 MARKS]

Does the schema enforce the constraint that if a message is delivered, it must be delivered strictly **after** the time is sent. If so, explain how. If not, write a constraint to enforce this.

Part (b) [2 MARKS]

Does the schema enforce the constraint that a message can only be sent to exactly one user (not less than one and not more than one)? If so, explain how. If not, write a constraint to enforce this.

Part (c) [3 MARKS]

Return the names of all users who have never sent a message.

Part (d) [5 MARKS]

Find users (their user ids) who have sent at least one message to every other user. The user may or may not have sent a message to herself, but must have sent a message to all other users.

Question 3. [18 MARKS]

Recall the schema below, which we have used in the course this term. Note we have changed the `term` attribute to a `year` attribute to permit easier comparison.

Student(sID, surName, firstName, campus, email, cgpa)

Course(dept, cNum, name, breadth)

Offering(oID, dept, cNum, year, instructor)

Took(sID, oID, grade)

Offering[dept, cNum] $\subseteq$ Course[dept, cNum]

Took[sID] $\subseteq$ Student[sID]

Took[oID] $\subseteq$ Offering[oID]

Part (a) [5 MARKS]

Return any campus for which no student on that campus has taken any course.

Part (b) [6 MARKS]

For every student, return his or her cgpa, the average of all the grades recorded for the student in the database (as avgGrade), and the number of departments she has taken courses from (as numDept). Only include students who have been assigned a campus (meaning their campus value is not null). For example, if Mary got a 4.0 in CSC 343, a 4.0 in CSC 369, and a 1.0 in French 101, then return her sid, her cpga along with an avgGrade of 3.0 and numDept of 2. Hint: Don't forget to include students that exist but have not taken any courses.

Part (c) [7 MARKS]

Write a query in SQL that finds courses (their dept, cNum and name) that have been offered at least ten times since the year 2000 and have always had an enrollment over 100 (in every offering since 2000). For the question, *since 2000* means *year* $>$ 2000. As an example, a course that has been offered 20 times since 2000, but one of those offerings had an enrollment of only 90, would not qualify and should not be returned.

Question 4. [5 MARKS]

Consider the existence of a table myCourses in your PostgreSQL database schema university. Write server side code (java/jdbc) that connects to the database, and submits SQL queries in order to determine whether the table myCourses is populated with some tuples. If there are tuples in myCourses then your code should delete all tuples. Once the tuples are deleted (or if the original table was already empty) your code should drop the table myCourses from the database. The script finally closes the database connection.

Notes: Your code should work correctly for any database instance.
Marking will be tolerant on java syntax errors, so its fine if you miss the exact name of a java method.

Question 5. [8 MARKS]

Consider the following schema:

```
DROP SCHEMA IF EXISTS rp CASCADE;
CREATE SCHEMA rp;
SET SEARCH_PATH TO rp;

CREATE TABLE One (
   c INT PRIMARY KEY,
   d INT UNIQUE
);

CREATE TABLE Two (
   e INT,
   f INT,
   PRIMARY KEY (e, f),
   FOREIGN KEY (e) REFERENCES One ON UPDATE CASCADE ON DELETE CASCADE
);

CREATE TABLE Three (
   g INT CHECK ( g > 0 ),
   h INT not null,
   i INT UNIQUE,
   j INT,
   FOREIGN KEY (i, j) REFERENCES Two ON UPDATE SET NULL ON DELETE CASCADE
);
```

Part (a) [3 MARKS]

Suppose the tables have been populated as shown below. Show all changes that would be done to the database if the following update were issued. If the update produces an error state what the error is and why it is produced.

```
update one set c = c+1;
```

```
One
 c | d
---+---
 2 | 1
 1 | 2
```

```
Two:
 e | f
---+---
 1 | 1
 2 | 2
 1 | 2
 2 | 1
```

```
Three:
 g | h | i | j
---+---+---+---
 1 | 1 | 1 | 1
 2 | 2 | 2 | 2
```

Part (b) [2 MARKS]

Would your answer change if the table definition for Three where changed to:

```
FOREIGN KEY (i, j) REFERENCES Two ON UPDATE RESTRICT ON DELETE SET NULL
```

Explain.

Part (c) [3 MARKS]

Starting with the original database and schema show all changes that would be done to the database if the following commands were issued. If any produces an error state what the error is and why it is produced. Assume the others execute correctly.
Hint: syntax on first command is same as "insert into one values (3, null);"

```
insert into one values (3);
delete from one where c < 2;
insert into three values (1, 2, 3, 4);
```

```
One
 c | d
---+---
 2 | 1
 1 | 2
```

```
Two:
 e | f
---+---
 1 | 1
 2 | 2
 1 | 2
 2 | 1
```

```
Three:
 g | h | i | j
---+---+---+---
 1 | 1 | 1 | 1
 2 | 2 | 2 | 2
```

Question 6. [6 MARKS]

Consider the relation $R(J, K, L, M, N, P, Q)$ with the following functional dependencies:

$$\{ MP \to N,\ \ JN \to QM,\ \ NQ \to Q,\ \ LM \to J, N \to L \}.$$

Part (a) [1 MARK]

What is the closure of LMP?

Part (b) [1 MARK]

Do M and N together form a superkey for R? Circle one answer and explain.

YES NO

Explain:

Part (c) [1 MARK]

Give a minimal key for R in the box below.

Minimal key: [ ]

Part (d) [3 MARKS]

Justify why you know that this is a minimal key.

Question 7. [6 MARKS]

Consider relation $R(A, B, C, D, E, F)$ with the following FDs.

$$S = \{ E \to F,\ A \to CE,\ BD \to A,\ DF \to E \ \}$$

Suppose you want to decompose R into BCNF. For each FD, indicate whether it violates BCNF. If it does, give the attributes that would be in R1 and R2 if you decomposed R into R1 and R2 based on that FD.

Dependency	Violates BCNF?	R1 attributes	R2 attributes
$E \to F$	YES NO		
$A \to CE$	YES NO		
$BD \to A$	YES NO		
$DF \to E$	YES NO		

Question 8. [10 MARKS]

Consider relation $R(H, I, J, K, L, M)$ with functional dependencies:

$$S = \{\ HML \to MKL,\ \ IK \to HL,\ \ LM \to MK,\ \ H \to L, L \to K, I \to J\ \}$$

In this question you will perform 3NF synthesis on R.

Part (a) [6 MARKS]

Give a minimal basis for S. Write your rough work (which will not be marked) below, and put the minimal basis in the box on the next page. If S already comprises a minimal basis, just state this.

A minimal basis is:

Part (b) [2 MARKS]

List the relations generated based only on the FDs in the minimal basis. (We will do the final step of the 3NF synthesis algorithm in the next question.)

Part (c) [2 MARKS]

Do we need to add an extra relation? Circle one: YES NO

If you answered yes, list the attributes of one acceptable extra relation inside the box that we could add to finish the 3NF synthesis. If you answered no, justify your answer.

Question 9. [6 MARKS]

Consider the relation $T(A, B, C, D, E, F)$ with functional dependencies

$$S = \{\ BD \to AB,\ \ E \to DB,\ \ F \to E,\ \ A \to F\ \}$$

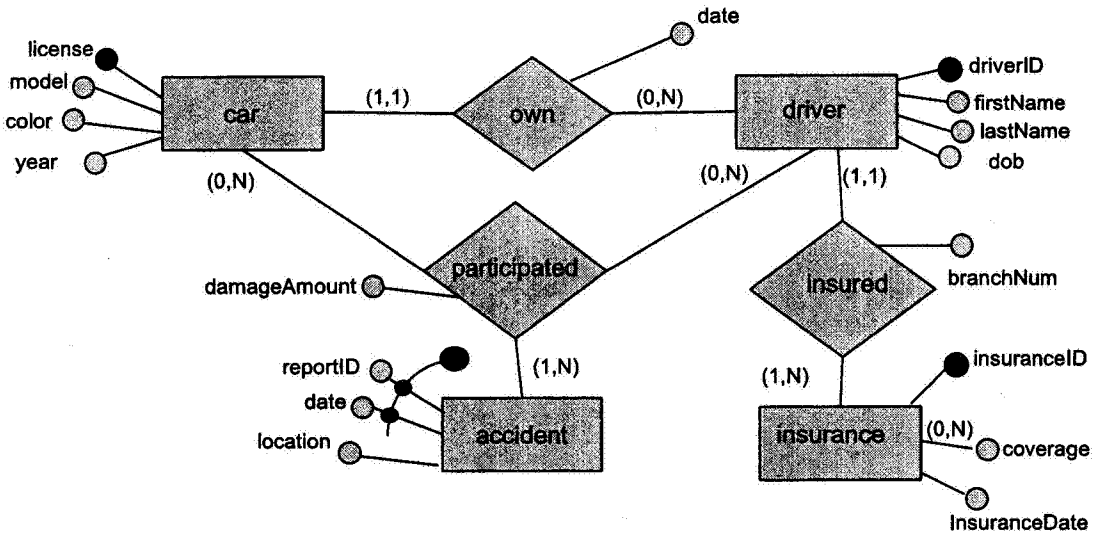
Calculate the projection of S onto the attributes $\{B, D, E, F\}$. Show your work and put your final set of FD's in the box.

Question 10. [7 MARKS]

A university registrars office maintains data about the following entities: (a) courses, including number (which is unique), and attributes title, credits, syllabus, and prerequisites (a possible empty set of prerequisites); (b) instructors, including a unique identification number, along with other attributes name, department, and title. (c) course offerings, including course number (which must be a valid course), year, semester, section number, instructor(s) (a set of one or more instructors which must all be valid instructors), hours, and classroom – for a single course, the offering year, semester and section number together must be unique; and (d) students, including a unique student-id, along with name, and program. Students may be enrolled in many different offerings (even none) and an offering may have many (or no) students. Each enrollment has a grade. A student may not enroll in the same offering more than once. Construct an E-R diagram for the registrars office. All attributes are single-valued unless specified otherwise. Do not change anything in the specification or impose additional constraints that are not mentioned (for example, you should permit a student to enroll in many different offerings of the same course even if you don't feel this is realistic).

Question 11. [10 MARKS]

Below is an Entity-Relationship diagram about car insurance. Translate this Entity-Relationship diagram into a relational schema. For each relation, provide its name, attributes and keys. To indicate a key, underline all attributes that are part of the key using a single line. To define referential integrity constraints, use relational notation (that is, use $\subseteq$ notation, not SQL notation). If there are constraints in the ER diagram that cannot be expressed in the relational model, state what they are and why they cannot be expressed. In your design try to avoid creating a model where any of the attributes could be null. If this is not possible, explain why and what attributes would have to permit null values



Use this page for rough work. If you want work on this page to be marked, please indicate this clearly *at the location of the original question.*

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Total Marks = 100