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UNIVERSITY OF TORONTO
Faculty of Arts and Science

DECEMBER 2016 EXAMINATIONS

CSC 343 H1F
Instructor: Miller and Horton

Duration — 3 hours

Examination Aids: None

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

Family Name(s): ____________________

Given Name(s): ____________________

# 1:	______/ 13
# 2:	______/ 12
# 3:	______/ 13
# 4:	______/ 6
# 5:	______/ 8
# 6:	______/ 4
# 7:	______/ 6
# 8:	______/ 6
# 9:	______/ 4
# 10:	______/ 6
# 11:	______/ 6
# 12:	______/ 6
# 13:	______/ 10
TOTAL:	______/100

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

There is a blank page at the end for rough work.

A mark of at least 40 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!

Question 1. [13 MARKS]

Consider the following schema for a hair salon.

Relations

- Clients(<u>CID</u>, name, phone).
  CID is the ID of a client, *name* and *phone* are their name and phone number.
- Staff(<u>SID</u>, name).
  SID is the ID of a staff member and *name* is their name.
- Appointments(<u>CID, date, time</u>, service, SID)
  CID is the ID of the client whose appointment it is, *date* and *time* indicate when the appointment happens, *service* is the name of the service they have at this appointment, and *SID* is the ID of the staff member providing the service for this apppointment.

Integrity Constraints

- Appointments[CID] $\subseteq$ Clients[CID].
- Appointments[SID] $\subseteq$ Staff[SID].

Recall that no nulls are permitted in the relational model.

Part (a) [5 MARKS]

Create an ER diagram that represents this data well.

Part (b) [8 MARKS]

Which of the following statements are enforced by the relational schema we provided? **Circle one answer** for each. If the statement is enforced, say what part of the schema enforces it. If it is not enforced, write an integrity constraint in relational algebra that would enforce it. Marks will only be given if your explaination is correct.

1. A client can't have a haircut and a manicure at the same date and time.

   Enforced This part of the schema enforces it:

   Not enforced This new integrity constraint would enforce it:

2. The same phone number can't be associated with two different clients.

   Enforced This part of the schema enforces it:

   Not enforced This new integrity constraint would enforce it:

3. A client can't have two phone numbers.

   Enforced This part of the schema enforces it:

   Not enforced This new integrity constraint would enforce it:

4. Every client has at least one appointment.

   Enforced This part of the schema enforces it:

   Not enforced This new integrity constraint would enforce it:

Question 2. [12 MARKS]

Below is a slightly simplified version of a schema we used in lecture. A course's cName attribute gives its full name, such as "Introduction to Databases", while dept has a value such as "CSC" and cNum has a value such as 343.

Student(<u>sID</u>, surName, firstName)
Course(<u>dept, cNum</u>, cName)
Offering(<u>oID</u>, dept, cNum, term, instructor)
Took(<u>sID, oID</u>, grade)

Offering[dept, cNum] $\subseteq$ Course[dept, cNum]
Took[sID] $\subseteq$ Student[sID]
Took[oID] $\subseteq$ Offering[oID]

Write a query in relational algebra that finds the SID and surname of each student who has a passing grade in every first-year course ever offered by department 'BIO', but never took a course offered by department 'CHE'. A first-year course is one whose cNum is between 100 and 199 inclusive. A passing grade is a grade over 50. Use only the basic operators $\Pi, \sigma, \bowtie, \times, \cap, \cup, -, \rho, :=$. Continue your answer on the next page if needed.

Hint: As a first step, write the left-hand sides of a series of assignment statements; use good names for the intermediate relations. This will help you solve the question, and also to earn part marks if you make a mistake.

Continue your answer here if needed.

Question 3. [13 MARKS]

Part (a) [4 MARKS]

Here is the schema for table Took expressed in SQL:

```
create table Took(
      sID integer,
      oID integer,
      grade integer,
      primary key (sID, oID),
      foreign key (sID) references Student,
      foreign key (oID) references Offering);
```

For each pair of SQL queries below, circle one answer to indicate whether the queries return the same result on all database instances ("**equivalent**"), return same result on this one instance (from Part (b) on next page), but not on all instances ("**same on this instance**"), or neither of the above ("**neither**").

1. A) `select sid from took;`

   B) `select t1.sid as sid from took t1, took t2;`

   Circle one: equivalent same on this instance neither

2. A) `select avg(grade) from took;`

   B) `select avg(t1.grade) from took t1, took t2;`

   Circle one: equivalent same on this instance neither

3. A) `select distinct sid from took;`

   B) `(select sid from took) union (select sid from took where grade =90);`

   Circle one: equivalent same on this instance neither

4. A) `select distinct sid from took;`

   B) `select distinct oid as sid from took where grade > 86;`

   Circle one: equivalent same on this instance neither

Part (b) [9 marks]

Consider the following valid instance of Took. (Assume the foreign key relationships are satisfied by appropriate rows in the other tables.)

sID	oID	grade
1	1	90
1	2	100
2	1	90
2	3	80
2	4	85

For each SQL query below, circle one answer to indicate whether or not it is legal. If legal, show the output. If not, explain the error. Your output or explanation must be correct to receive any marks.

1. ```
   select *
   from took
   group by sid;
   ```

   Circle one: Legal Illegal

   Output or explanation:

2. ```
   select min(grade), count(*), count(distinct oid), sid
   from took
   group by sid;
   ```

   Circle one: Legal Illegal

   Output or explanation:

3.
```
select *
from took t1
where not exists (
      select * from took t2
      where t2.oid = t1.oid and t1.sid <> t2.sid and t2.grade >= t1.grade);
```

Circle one: Legal Illegal

Output or explanation:

4.
```
(select sid from took) except all (select sid from took where grade < 90);
```

Circle one: Legal Illegal

Output or explanation:

5.
```
select *
from took t1 left join took t2 on t1.grade> t2.grade and t1.sid <> t2.sid
order by t1.sid, t1.oid;
```

Circle one: Legal Illegal

Output or explanation:

Question 4. [6 MARKS]

Consider the following schema. Primary keys are underlined.

Sailor(<u>**SID**</u>, Sname)

Reserve(<u>**SID, BID, Date**</u>) Reserve[SID] $\subseteq$ Sailor[SID] Reserve[BID] $\subseteq$ Boat[BID]

Boat(<u>**BID**</u>, Color)

The following syntactically correct queries in SQL and relational algebra attempt to return the set (*i.e.*, with no duplicates) of all SIDs of all Sailors who have never reserved a red boat. For each, circle one answer to indicate whether it is correct or incorrect. Note that the symbol <> means "not equal to" or $\neq$.

1.
```
select  S.SID
from    Sailor S
where   S.SID not in ( select  R.SID
                       from    Reserve R, Boat B
                       where   B.Color = 'red')
```
Circle one: correct incorrect

2.
```
select  distinct S.SID
from    Sailor S, Reserve R, Boat B
where   S.SID = R.SID and R.BID = B.BID and B.Color <> 'red'
```
Circle one: correct incorrect

3.
```
select  S.SID
from    Sailor S
where   not exists (  select  R.SID
                      from    Reserve R, Boat B
                      where   S.SID = R.SID and R.BID = B.BID and B.Color = 'red' )
```
Circle one: correct incorrect

4.
```
select      distinct R.SID
from        Reserve R, Boat B
where       R. BID = B.BID and B.color = 'red'
group by    R.SID
having      count(*) < 1
```
Circle one: correct incorrect

5. $\Pi_{SID}(Sailor) - \Pi_{SID}(\sigma_{Color='red'}(Reserve \bowtie Boat))$

Circle one: correct incorrect

6. $\Pi_{SID}(\Pi_{SID,BID}(Sailor \bowtie Reserve) - \Pi_{SID,BID}(\sigma_{Color='red'}(Sailor \bowtie Reserve \bowtie Boat)))$

Circle one: correct incorrect

Question 5. [8 MARKS]

Consider the following SQL definitions:

```
create table Treatment (
    PhysicianID   int not null,
    PatientID     int not null,
    Date          date not null,
    Diagnosis     varchar(30),
    Location      char(5) references Location
                      on delete cascade on update cascade,
    primary key(PhysicianID,PatientID,Date),
    check (PatientID <> PhysicianID) );
```

```
create table Location (
    id    char(5) primary key,
    head  int );
```

Which of the following are valid (legal) instances of table Treatment that satisfy all constraints. If illegal, circle the problem data and write a short explanation of the problem.

Assume that table Location contains three tuples { (Yonge, 1), (Bloor, 2), (Maine, 1) }.

1. Circle one: Legal Illegal

PhysicianID	PatientID	Date	Diagnosis	Location
1	3	1/1/02	Chicken Pox	Bloor
2	1	1/1/02	Measles	Bloor
3	2	1/1/02	Chicken Pox	Bloor
3	1	1/1/02	Null	Bloor

2. Circle one: Legal Illegal

PhysicianID	PatientID	Date	Diagnosis	Location
5	1	1/1/02	Null	Bloor
2	1	1/1/02	Measles	Yonge
7	1	1/1/02	Chicken Pox	Null
4	1	1/1/02	Null	Null

3. Circle one: Legal Illegal

PhysicianID	PatientID	Date	Diagnosis	Location
1	1	3/3/02	Chicken Pox	Yonge
1	2	1/1/02	Flu	Null
1	3	2/2/02	Measles	Yonge

4. Circle one: Legal Illegal

PhysicianID	PatientID	Date	Diagnosis	Location
2	1	3/3/02	Flu	Yonge
3	2	3/3/02	Measles	Yonge
2	1	3/3/02	Chicken Pox	Yonge

5. Consider the following instance of Treatment and again assume that Location contains three tuples { (Yonge, 1), (Bloor, 2), (Maine, 1) }.

PhysicianID	PatientID	Date	Diagnosis	Location
1	2	1/1/02	Glaucoma	Bloor
2	1	1/1/02	Flu	Maine
3	4	2/2/02	Chicken Pox	Yonge
4	3	3/3/02	Flu	Bloor

Show the contents of tables Treatment and Location after the following update.

```
delete from Treatment
where Location = 'Bloor';
```

6. Consider the following instance of Treatment and again assume that Location contains three tuples { (Yonge, 1), (Bloor, 2), (Maine, 1) }.

PhysicianID	PatientID	Date	Diagnosis	Location
1	2	1/1/02	Glaucoma	Bloor
2	1	1/1/02	Flu	Maine
3	4	2/2/02	Chicken Pox	Yonge
4	3	3/3/02	Flu	Bloor

Show the contents of tables Treatment and Location after the following update.

```
update location
set id = 'Queen'
where head = (select max(head) from location);
```

Question 6. [4 MARKS]

Consider the relation R on attributes $ABCDEFG$, with the following functional dependencies:

$$A \to BEF, \quad G \to BC, \quad CD \to G.$$

Throughout this question, we use the term "key" in the sense of "minimal key".

Part (a) [1 MARK]

Is AD part of a key for R? Yes No

Explain:

Part (b) [1 MARK]

Is AB part of a key for R? Yes No

Explain:

Part (c) [1 MARK]

Is ADCE a key (not part of a key, *is* a key) for R? Yes No

Explain:

Part (d) [1 MARK]

Is ADG a key (not part of a key, *is* a key) for R? Yes No

Explain:

Question 7. [6 MARKS]

Consider the relation R on attributes $LMNOPQ$, with the following functional dependencies:

$$P \to OM, \quad MP \to N, \quad L \to NO, \quad ON \to LM, \quad OP \to L.$$

Part (a) [2 MARKS]

Create a valid instance of R that satisfies the functional dependencies, has two tuples, and contains redundancy.

State exactly what data in this instance is redundant and explain what makes it redundant.

Part (b) [2 MARKS]

What important property does BCNF decomposition guarantee that 3NF synthesis does not guarantee?

What important property does 3NF synthesis guarantee that BCNF decompositon does not guarantee?

Part (c) [2 MARKS]

Consider this set of relations and their functional dependencies:

$R1(A, B, C)$	$R2(C, D, E)$	$R3(E, F, G)$
$A \to B$	*none*	$EF \to G$
$C \to AB$		

Could these relations be the result of the BCNF decomposition algorithm? Yes No

Explain:

Question 8. [6 MARKS]

Consider relation $R(A, B, C, D, E, F)$ with functional dependencies S.

$$S = \{AD \to BC, \quad ABD \to E, \quad BE \to CDF, \quad CD \to A, \quad BF \to C\}$$

Compute a minimal basis for S. Explain all steps and show your rough work. There will be no marks for a correct answer without this. Put your final answer where shown on the next page.

Write your minimal basis for S below. Merge the RHSs of the functional dependencies, and present the functional dependencies in alphabetical order as you did on Assignment 3.

Question 9. [4 MARKS]

Suppose we are employing the 3NF synthesis algorithm on a relation $R(A, B, C, D, E, F)$, and we already have the following minimal basis:

$$S = \{CD \to A, \quad CEF \to AB, \quad D \to E\}$$

Use the 3NF synthesis algorithm to obtain a set of relations that are in 3NF. Explain all steps in your answer. There will be no marks for a correct answer without a good explanation of the steps.

Question 10. [6 marks]

Consider the relation R(A, B, C, D, E) with the following functional dependencies:

$$A \rightarrow B, \quad C \rightarrow DE, \quad E \rightarrow AD$$

Part (a) [3 marks]

Suppose we are considering a decomposition of this relation into two relations $R1(A, D, E)$ and $R2(B, C, D)$. Use a technique such as the chase test to check whether this is not a lossless join decomposition. Show your reasoning.

Circle your conclusion: Lossless Lossy

Part (b) [3 marks]

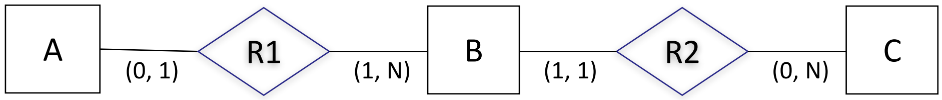
Suppose instead we are considering a decomposition of this relation into the relations $R1(A, B)$, $R2(C, D)$ and R3(A, C, E). Use a technique such as the chase test to check whether this is not a lossless join decomposition. Show your reasoning.

Circle your conclusion: Lossless Lossy

r

Question 11. [6 marks]

Consider the ER diagram below.



In this question you will think about how the number of entities in one entity set relates to the number of entities in the other entity sets. When asked for a maximum, if there is no limit write "no limit".

Part (a) [2 marks]

Suppose $|A|$ is 50.

Minimum value of $|B|$: ____________________ Maximum value of $|B|$: ____________________

Minimum value of $|C|$: ____________________ Maximum value of $|C|$: ____________________

Part (b) [2 marks]

Suppose $|B|$ is 100.

Minimum value of $|A|$: ____________________ Maximum value of $|A|$: ____________________

Minimum value of $|C|$: ____________________ Maximum value of $|C|$: ____________________

Part (c) [2 marks]

Suppose $|C|$ is 80.

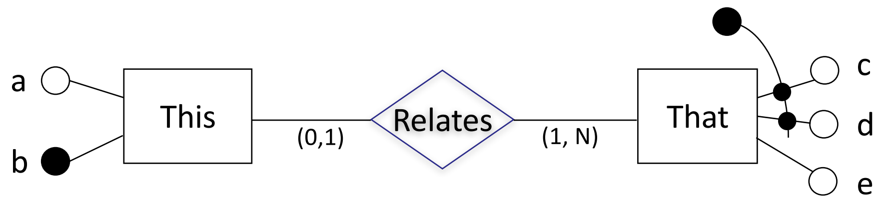
Minimum value of $|B|$: ____________________ Maximum value of $|B|$: ____________________

Minimum value of $|A|$: ____________________ Maximum value of $|A|$: ____________________

Question 12. [6 MARKS]

Part (a) [3 MARKS]

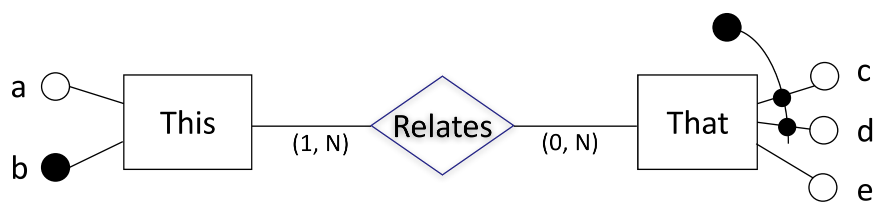
Consider the ER diagram below.



Translate this ER diagram into a relational schema. Use underlining to express the key of each relation, and subset notation to express all foreign keys.

Part (b) [3 MARKS]

Here is nearly the same ER diagram. The cardinalities have been changed.



Translate this ER diagram into a relational schema. Use underlining to express the key of each relation, and subset notation to express all foreign keys.

Question 13. [10 MARKS]

Closets, Closets, Closets would like to start mining information about its online reputation. They have gathered a set of tweets that mention the hashtag #ClosetsClosetsClosets. For each tweet, they have the tweeter's Twitter account (meaning the identifier or handle for the account), the date tweeted, and the contents of the tweet. For each Twitter account they also track the number of followers. A Twitter account can produce mutiple tweets on the same date so each Tweet has a unique TweetID. Of course, each Tweet is produced by exactly one Twitter account. They also record the set of all hashtags mentioned in each tweet (excluding #ClosetsClosetsClosets, which is mentioned in all the tweets they gathered). They have hired a social media consulting firm that has provided them with further data: the facebook account (at most one) for many of the Twitter Accounts (but not for all Twitter Accounts, since they don't all an identifiable facebook account). A facebook account has a unique id and a count (which may be zero or more) of the number of times the facebook account has liked a product produced by Closets, Closets, Closets. Some facebook accounts may be associated with multiple twitter accounts.

Design an ER Diagram to represent this information. Your solution should not have redundancy.

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.*

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.*

Total Marks = 100