CS348: INTRODUCTION TO DATABASE SYSTEMS
(Midterm Examination (makeup), Fall 2013)

TIME: 80 minutes

NAME AND ID HERE: _____

NOTE 1: This is a closed book examination. For example, class text, copies of overhead slides and printed notes may not be used. There are 11 pages. The last page, only, may be separated and used as an easy reference for the second question. Answer all questions in the space provided.

NOTE 2: Some of the questions in this examination are open ended; however, they can be answered to the level discussed in class by short organized answers. It is recommended that you spend part of your time organizing your answer, rather than writing down ideas in the order they occur to you. The conciseness and organization of your answers will be taken into consideration in the grading.

NOTE 3: There are 100 marks in total. As a guide to managing your time, the marks awarded for each question are indicated in parenthesis at the start of the question.

NOTE 4: You are also being tested on your ability to understand the questions. In the case of a perceived ambiguity, state a clear assumption and proceed to answer the question.

NOTE 5: Cheating is an academic offence. Your signature below indicates that you understand and agree to the University's policies regarding cheating on exams.

PLEASE SIGN HERE: _____

I. (34 marks; continued on next two pages) General questions about database systems and the relational model. Answer each of the following using no more than a few sentences in each case.

(a) Explain how logical data independence can reduce the cost of developing and maintaining an information system.

(b) Explain each of the following terms.

1. conceptual level

2. atomicity

3. relational devision

(c) Describe four kinds of tasks that are the responsibility of database administration.

(d) Consider the relational operators: (a) reference, (b) selection, (c) projection, and (d) natural join. Is this collection of operators relationally complete? If not, list a minimal collection of additional operators that can be added to yield a relationally complete query language.

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(e) Assuming a relation R has attributes $\{A, B, C\}$ and a relation S has attributes $\{D, E\}$, answer each of the following

1. Rewrite the following relational algebra query to an equivalent query with at most three occurrences of unary or binary operators.

$$\pi_A(\sigma_{B=D}(\sigma_{A=3}(R) \times \pi_C(\sigma_{E=1}(S))))$$

2. Can the following SQL query be expressed in the relational algebra? Justify your answer.

```
select A from R
group by A
having count(*) < A and max(B) < 10
```

II.(45 marks; continued on next three pages) Consider the following relational database schema for maintaining customer rental information for a hypothetical car rental agency. (NOTE: this schema is reproduced on the final page of the exam.)

```
CREATE TABLE customer
   (  cnum             INTEGER NOT NULL,
      cname            VARCHAR(20) NOT NULL,
      city             VARCHAR(20) NOT NULL,
   PRIMARY KEY (cnum) );

CREATE TABLE car
   (  license          INTEGER NOT NULL,
      make             VARCHAR(20) NOT NULL,
      model            VARCHAR(20) NOT NULL,
      year             INTEGER NOT NULL,
   PRIMAY KEY (licence) );

CREATE TABLE pickup
   (  rnum             INTEGER NOT NULL,
      cnum             INTEGER NOT NULL,
      license          INTEGER NOT NULL,
      fee              INTEGER NOT NULL,
   PRIMARY KEY (rnum),
   FOREIGN KEY (cnum) REFERENCES customer,
   FOREIGN KEY (license) REFERENCES car );

CREATE TABLE dropoff
   (  rnum             INTEGER NOT NULL,
   PRIMARY KEY (rnum),
   FOREIGN KEY (rnum) REFERENCES pickup );
```

The database schema reflects two main events relating to car rentals: (a) a customer takes posession of a car at the start of a rental agreement (in this case, a tuple is added to the `pickup` table), and (b) a customer returns the car at the end of a rental agreement and pays the agreed rental fee (in this case, a tuple is added to the `dropoff` table). Thus, the database records information about both past and ongoing car rentals.

Write each of the following queries *in both the relational algebra and in SQL.*

(a) The numbers and names of all customers who have rented cars at least twice in the past.

(b) The numbers and names of all customers in Waterloo who are currently renting a car for a fee exceeding 100.

Write the following query in SQL only.

(c) The models of cars that generate the highest revenue, that is, for which the total rental fees for both past and ongoing rentals of cars of these models is the highest.

III.(21 marks; continued on next page) Questions on the SQL standard and application development. Answer each of the following using no more than a few sentences in each case.

(a) Is it true that, once defined, a SQL view can be used exactly like a SQL table? Justify your answer.

(b) Should a null value for an attribute A in SQL always be interpreted as indicating that the value of A is unknown? Justify your answer.

(c) Explain the conditions that must be satisfied by an application in order that it can be encoded using C, SQL and the static embedded SQL protocol.

(d) Explain the purpose served by each of the following.

1. the event component of a trigger

2. a host variable

3. an indicator variable

The following is reproduced from Question II. You may detach this page to assist composing your answers to Question II. NOTE: do not write on this page.

```
CREATE TABLE customer
   (  cnum             INTEGER NOT NULL,
      cname            VARCHAR(20) NOT NULL,
      city             VARCHAR(20) NOT NULL,
   PRIMARY KEY (cnum) );

CREATE TABLE car
   (  license          INTEGER NOT NULL,
      make             VARCHAR(20) NOT NULL,
      model            VARCHAR(20) NOT NULL,
      year             INTEGER NOT NULL,
   PRIMAY KEY (licence) );

CREATE TABLE pickup
   (  rnum             INTEGER NOT NULL,
      cnum             INTEGER NOT NULL,
      license          INTEGER NOT NULL,
      fee              INTEGER NOT NULL,
   PRIMARY KEY (rnum),
   FOREIGN KEY (cnum) REFERENCES customer,
   FOREIGN KEY (license) REFERENCES car );

CREATE TABLE dropoff
   (  rnum             INTEGER NOT NULL,
   PRIMARY KEY (rnum),
   FOREIGN KEY (rnum) REFERENCES pickup );
```