Subset of CMPS 180 Database Systems I
Winter 2016
Final Exam
March 16, 2016

This is a subset of the questions from the Winter 2016 CMPS 180 Final that was taught by another instructor. This Final covered only the material presented in the second half of the quarter, unlike my CMPS 180 Final, which may cover material from the entire quarter, focusing more on the second half. Notes that I inserted, such as this one, are in red.

There is material (much of which I deleted) in the Winter 2016 CMPS 180 course that we didn't discuss in our class. There's also a lot of material that we discussed in our course that was not included in the Winter 2016 CMPS 180 course. You are responsible for whatever we did in our CMPS 180 course, **whether or not** it's in this Final, or in the previous CMPS 182 Final that I've also posted on Piazza.

I've also deleted most of the blank space that appeared after problems, since (unlike the students who took the Final) you don't have to answer the questions in the space provided.

Instructions: Answer all questions *concisely* in the space provided.

PART 1: Circle the correct answer.

a. A primary key of a relation schema can consist of multiple attributes.
   i. YES ii. NO

b. If A is a key for $R(A,B)$ and A is also a key for $S(A,B)$, then A is also a key for $R \cup S$.
   i. YES ii. NO

c. The natural join of two relations R and S, denoted as $R \bowtie S$, can be expressed using the basic relational algebra operators σ, π, x, ∪, -, (selection, projection, cartesian product, union, and difference operators).
   i. YES ii. NO

d. Let $R(A,B,C,D)$ be a relation schema, where A is the only key for this relation and the only other functional dependency for this relation is $BC \rightarrow D$. Is R in Boyce-Codd Normal Form (BCNF)?
   i. YES ii. NO

e. Let $R(A,B,C,D)$ be a relation schema, where A is the only key for this relation and the only other functional dependency for this relation is $BC \rightarrow D$. Is R in Third Normal Form (3NF)?
   i. YES ii. NO

f. Every relation in Third Normal Form (3NF) is also in Boyce-Codd Normal Form (BCNF).
   i. YES ii. NO

g. Every relation schema with only one attribute is in Boyce-Codd Normal Form (BCNF).
   i. YES ii. NO

h. Every relation schema with only two attributes is in Boyce-Codd Normal Form (BCNF).
   i. YES ii. NO

i. Let $\mathcal{F}$ be the following set of functional dependencies:
   $\{AB \rightarrow C, CD \rightarrow A, CD \rightarrow E\}$

   Which of the following is in $\mathcal{F}^+$ (i.e., the closure of $\mathcal{F}$)?
   i. $AB \rightarrow B$
   ii. $AE \rightarrow F$
   iii. $CD \rightarrow B$
   iv. $C \rightarrow A$

j. Let $\mathcal{F}$ be the following set of functional dependencies
$\{B \rightarrow CD, D \rightarrow AB, A \rightarrow EF\}$

Which of the following is correct? (Recall that AB^+ denotes the closure of the set of attributes $\{A,B\}$.)

i. $AB^+ = \{A,B,C,D\}$
ii. $BF^+ = \{A,B,C,D\}$
iii. $CD^+ = \{A,B,C,D,E,F\}$
iv. $F^+ = \{\}$

k. Given the relation schemas $R(A,B)$ and $S(B,C)$, is the following equivalence true or false?

$$\sigma_{B=3}(R \bowtie S) = \sigma_{B=3}(R) \bowtie \sigma_{B=3}(S)$$

i. TRUE ii. FALSE

l. Let R(A,B) and S(C,D) be two relation schemas, and suppose let R contain m distinct tuples and S contains n distinct tuples. What is the total number of tuples in $R \bowtie S$?

i. m ii. n iii. m * n iv. m+n
v. greater than or equal to min(m,n) but less than or equal to max(m,n)

m. The relation schema $R(A,B,C,D)$ can be losslessly-decomposed into the following two relations $R1(A,B,C)$ and $R2(A,C,D)$ with respect to the following set o functional dependencies $\{ A \rightarrow B, BC \rightarrow D \}$.

i. YES ii. NO

PART 2: Assume that you have the following database schema:

Student(sid, name, age, major, GPA, deptid),
Dept(deptid, chairid)
Faculty(facultyid, name)
ResearchInterest(facultyid, research)

You may assume that sid, deptid, and facultyid are keys for the relations Student, Dept, and Faculty, respectively. The key for ResearchInterest consists of both attributes facultyid and research. Furthermore, deptid of Student is a foreign key of deptid of Dept. This means that for every tuple t in the Student relation, t.deptid occurs as the deptid of some tuple in the Dept relation. Similarly, chair of Dept is a foreign key of facultyid of Faculty.

(Hint: Except for question 2(a) and 2(c), a solution to every question requires only a simple SELECT ... FROM ... WHERE ... GROUPBY ... HAVING query. You may or may not need GROUPBY or HAVING in your answers. NO points will be awarded for queries that involve multiple SELECT ... FROM ... WHERE ... GROUPBY ... HAVING clauses.)

EXTRA SPACE WAS PROVIDED FOR ANSWERS IN THIS AND FOLLOWING PARTS OF THE EXAM, BUT I DELETED THAT EXTRA SPACE FROM THIS PRACTICE VERSION OF THE EXAM.

a. Write a statement to insert the tuple (123, "John Smith", 20, "TM", 3.9, "TM") into the Student relation.

b. Write a SQL query to retrieve the major of all students whose age is less than 20 or whose GPA is greater than 3.0.
(*No points will be awarded if more than one SELECT…FROM... WHERE… GROUP BY… HAVING… statement is used in your answer*.)

c. Express the above query in relational algebra.

d. Write a SQL query to retrieve the facultyids of faculty whose research interests do not overlap with the research interests of any other faculty. (*Hint: You may want to consider using an EXCEPT keyword in your SQL query; take the difference between all facultyids of faculty and facultyids of faculty with at least one common research interest with another faculty. NO points will be awarded if subqueries are involved.*)

e. Express the above query in relational algebra.

f. Write a SQL query to compute the average GPA of students whose major is "Technology Management" or "Computer Science".

g. Write a SQL query to retrieve the names of each faculty with more than 4 research interests.

PART 3: In the following questions, assume you have three relation schemas $R(A,B)$, $S(A,B)$, and $T(B,C)$.

i. The five basic relational operators are operators, select (σ), project (Π), cartesian product (X), union($\cup$) and difference (-).
State CONCISELY the meaning of the phrase "the five basic operators are independent of one another."

ii. Express $R \cap S$ in terms of the basic relational algebra operators. Note that you need not use every basic relational algebra operator in your answer.

iii. Express $R \bowtie T$ in terms of the basic relational algebra operators.

PART 4:

Let $R(A,B,C,D,E)$ be a relational schema and $\mathcal{F}$ be the following set of functional dependencies { $AB \rightarrow DE$, $CE \rightarrow B$, $D \rightarrow A$ $C \rightarrow A$ }.

a. Show that $CE \rightarrow D$ by computing the attribute closure of *CE*. *Explain your steps clearly in order to obtain full credit.*

b. (**3 pts**.) Show that $CE \rightarrow D$ using Armstrong's axioms. *Explain your steps clearly in order to obtain full credit.*

c. (**2 pts**.) List all the candidate keys for *R*. *Explain your steps clearly in order to obtain full credit.*

d. (**2 pts**.) Is R in Boyce-Codd Normal Form (BCNF)? *Answer YES or NO and justify your answer.*

e. (**2 pts**.) Is R in Third Normal Form (3NF)? *Answer YES or NO and justify your answer.*

f. (**2 pts**.) Is the decomposition of *R* into *R1*(*A,B,C*) and *R2*(*A,B,C,D*) a lossless-join decomposition? *Answer YES or NO and justify your answer.*

g. (**2 pts**.) Is the decomposition of *R* into *R1(A,B,C)* and *R2(C,D,E)* a lossless-join decomposition ? *Answer YES or NO and justify your answer.*

h. (**5 pts.**) The figure below shows a partial instance of the relation schema R(A,B,C,D,E,F,G). Given that this relation satisfies the following functional dependencies

$$\{B \rightarrow C,\ E \rightarrow DF,\ A \rightarrow D,\ C \rightarrow F\},$$

fill in the missing values in the relation so that the resulting relation satisfies the functional dependencies. *You are NOT allowed to use nulls to fill in the missing values.*

A	**B**	**C**	**D**	**E**	**F**	**G**
1		3				3
1	2	3	4	5	6	3
	2			5		
4	3	4	2	8	1	

PART 5:

We will be discussing XML and JSON during the last week of class, probably including problem i. of Part 5, but probably not including problem ii.

i. The following XML document is not well-formed. List two reasons why it is not well-formed.

```
<CMPS180>
  <student studentid=”245” studentname=”Anna”>
      <homeworks grade=”10” grade=”8”>
  </student1>
  <student studentid=”112”>
      <studentname>John</studentname>
      <labs>
         <lab1>100</lab1>
         <lab2>95</lab2>
      </labs>
  </student>
</CMPS180>
```

ii. Complete the following document type descriptor (DTD) to specify that a every student has an attribute `studentid` whose type is `ID`, and every student has as subelements, `name`, followed by zero or more `homework` or `lab` assignments. The types of these subelements are `PCDATA`.

```
<!DOCTYPE CMS180 [
   <!ELEMENT   CMPS180   (student+)>
   <!ELEMENT   student




]>
```