CS4604 Midterm Exam

October 13, 1999

Please enter the following information:

- **Name:**

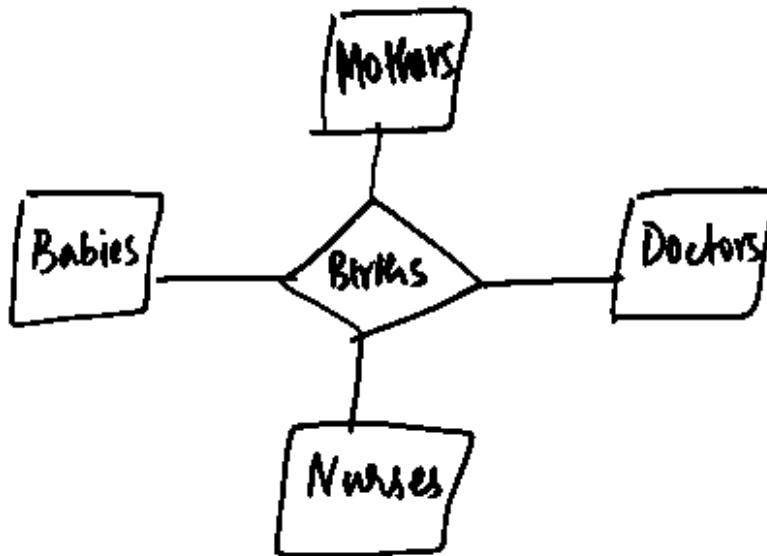- **ID:**

GOOD LUCK!
Do not write below this line

Problem	Max Score	Score
1	20	
2	15	
3	15	
4	10	
5	10	
6	20	
7	5	
8	5	

1. (20 points) Consider the following four-way relation **Births** between *Babies*, *Mothers*, *Nurses* and *Doctors*.

For each of the three parts below, redraw the above E/R diagram to model the additional constraint(s) presented. Your answer will consist of three separate E/R diagrams, one for each of the cases outlined below. Each of the three parts is independent of the others.

(a) (5 points) For every baby, there is a unique mother.

(b) (5 points) For every combination of baby, nurse and doctor, there is a unique mother. This might sound like a strange contraint, but you should assume that it holds and give an E/R diagram. "I don't think this is correct" will fetch you zero points.

(c) (10 points) Every baby is the result of a unique birth, but a birth can involve more than one baby born to the same mother (example, twins). A birth cannot involve more than one mother. Every baby, thus, has a unique mother.

2. (15 points) Suppose we decompose relation $R(A, B, C, D, E)$ into relation $S(A, B, C)$ and some other relations. Give the FDs that hold in S if the dependencies in R are: $\{AB \to D, AC \to E, BC \to D, D \to A, E \to B\ \}$.

The FDs that hold in $S(A,B,C)$ are obtained by projecting F onto $\{A,B,C\}$:

- $A^+ = \{A\}$, $B^+ = \{B\}$, $C^+ = \{C\}$
- $AB^+ = \{A,B,D\}$ → within ABC: nothing new
- $AC^+ = \{A,C,E,B\}$ → $AC \to B$
- $BC^+ = \{B,C,D,A\}$ → $BC \to A$

So the FDs that hold in S are:

$$AC \to B, \quad BC \to A$$

3. (15 points) Consider the following badly-conceived E/R diagram where the entity sets
have their usual interpretations: The idea is that each course can have different sections
and many TAs. Assume we would like, in addition, to enforce the following constraints:

- A TA cannot be shared jointly by two or more courses or two or more sections of
  the same course.

- Every TA *must* serve for *a* section of some course.

- Course names are unique but Section numbers are unique only within a course.

Redraw the E/R diagram to take into account all of these factors. Your answer will
consist of one single E/R diagram that models all of the above constraints.
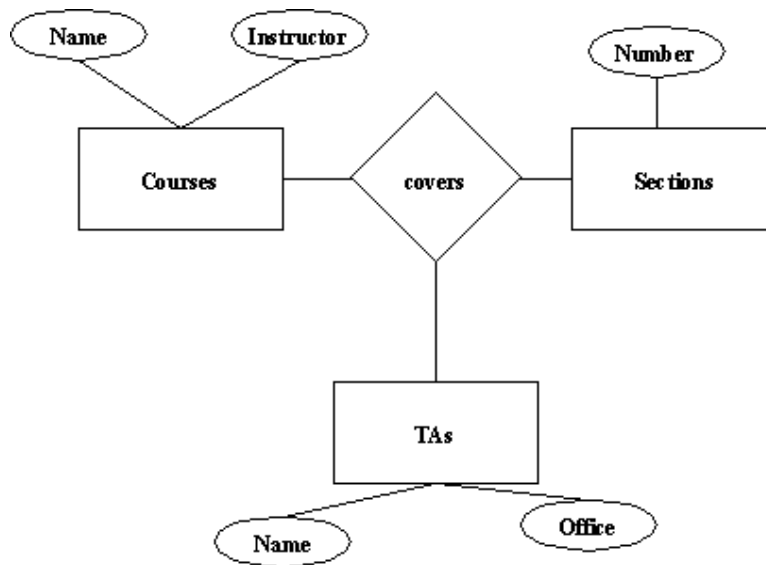
4. (10 points) List all (we need all, even those that derive from others) the non-trivial MDs (and *only* the non-trivial MDs) satisfied by a relation $R(A, B, C)$ that has (only) the following tuples:

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(a1,b1,c1)
(a1,b1,c2)
(a2,b1,c1)
(a2,b2,c3)
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Listing trivial MDs will make you lose points.

5. (10 points) A set of attributes is said to be *closed*, if its closure (with respect to a given set of FDs) is itself. Consider a relation with schema $R(A, B, C, D)$ and an unknown set of FDs. If we are told which sets of attributes are closed, we can do some nifty reverse-engineering, and figure out what the FDs could be.

- (5 points) What are the FDs if all 16 subsets of the four attributes are closed?

- (5 points) What are the FDs if the only closed sets are $\{\}$, $\{A, B\}$, and $\{A, B, C, D\}$?

6. (20 points) Provide an E/R diagram for the following situation: We wish to model universities, colleges (which are administrative units within a university), departments (which are administrative units within a college) and buildings. For example, the 'McBryde Hall' building houses the 'Computer Science' department which functions under the 'Arts and Sciences' college of the 'Virginia Polytechnic Institute and State University.' For universities, we wish to record the name and the year it was founded. For colleges, we wish to record its name and the university it functions under. For departments, we wish to record its name, and the college under which it functions. Names of universities are unique. Names of colleges are unique only within a university and names of departments are likewise unique only within a college (For example, many colleges have an 'information services' department). Buildings are unique within only an university. A department could be located in more than one building and a single building can house many departments (like McBryde Hall). If there is any aspect of the problem not modeled by your E/R diagram, explain them in the "Notes" section. Failing to write "Notes" implies that your E/R diagram is *exact*.

7. (5 points) Prove that every two-column relation is in BCNF.

8. (5 points) In the relation $R(A_1, A_2, A_3, A_4, ..., A_n)$, each of the n attributes is a key. Determine the number of superkeys for R.