Exam I
Computer Science 420
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City University of New York
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NAME (Printed) ______________________________
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Exam Rules

- **Show all your work. Your grade will be based on the work shown.**
- **The exam is closed book and closed notes.**
- **When taking the exam, you may have with you pens or pencils, and an 8 1/2" x 11" piece of paper filled with notes, programs, etc.**
- **You may not use a computer or calculator.**
- **All books and bags must be left at the front of the classroom during this exam.**
- **Do not open this exams until instructed to do so.**

Question 1	
Question 2	
Question 3	
Question 4	
Question 5	
Question 6	
Question 7	
Question 8	
Question 9	
Question 10	
TOTAL	

1. True or False:

   (a) ___ All database management systems are relational.

   (b) ___ Every set is a bag.

   (c) ___ Relationships cannot have attributes in E/R diagrams.

   (d) ___ Relationships in E/R diagrams connect one or more entity sets.

   (e) ___ In ODL, every relationship must have an inverse.

   (f) ___ Every key is a superkey.

   (g) ___ Every superkey is a key.

   (h) ___ Attributes that are keys cannot appear in functional dependencies.

   (i) ___ If X is a key for the relation R, then there is functional dependency for R with $X \rightarrow$ all attributes.

   (j) ___ Every functional dependency is a multivalued dependency.

2. Answer in two sentences or less the following:

   (a) Why are there no "weak classes" in ODL (but there are weak entity sets in E/R diagrams)?

   (b) What is an anomaly? Give an example.

3. Consider the relation $R(A, B, C, D, E)$ with the function dependencies:

$$A \rightarrow B, B \rightarrow C, C \rightarrow A, D \rightarrow E, \text{ and } E \rightarrow D$$

   (a) What are the keys of R?

   (b) How many superkeys are there of R? Justify your answer.

4. Draw an E/R diagram for the following situations. Indicate any keys, weak entity sets, or subclasses.

   (a) Entity sets *Courses* and *Departments*. A course is given by a unique department, but its only attribute is its number. Different departments can offer courses with the same number. Each department has a unique name.

   (b) Entity sets *Computers*, *Laptops*, and *Owners*. A computer has a manufacturer, CPU speed, and a unique name. Laptops, have all the properties of computers, as well as their weight and battery life. Owners are identified by their names. Every computer has at most one owner, but owners can have several computers.

5. Give an ODL design for a database recording information about teams, players, and their fans, including:

   (a) For each team, its name, its players, its team captain (one its players), and the colors of its uniform.

   (b) For each player, his/her name.

   (c) For each fan, his/her name, favorite teams, favorite players, and favorite color.

6. For each of the following types of relationships, give an example and draws its E/R diagram:

   (a) one-one:

   (b) many-one:

   (c) many-many:

7. (a) Consider a relation $R(A, B)$ with two tuples: $R = \{(4, 1), (4, 2)\}$.

      i. Does $A \to B$ hold for this instance of R?
         Circle one: YES NO

      ii. Does $A \twoheadrightarrow B$ hold for this instance of R?
         Circle one: YES NO

   (b) Now consider a relation $R(A, B, C)$ with two tuples: $R = \{(3, 2, 1), (4, 2, 6)\}$.

      i. Does $A \to B$ hold for this instance of R?
         Circle one: YES NO

      ii. Does $B \to C$ hold for this instance of R?
         Circle one: YES NO

      iii. Does $A \twoheadrightarrow C$ hold for this instance of R?
         Circle one: YES NO

8. Convert the following ODL description of a schema to a relational database schema. Remember that `Course` objects have an "object identity," and you may invent an attribute representing this OID, e.g. `CourseID`.

```
interface Course {
    attribute integer number;
    attribute string room;
    relationship Dept deptOf inverse Dept::coursesOf;
};

interface LabCourse : Course {
    attribute integer computerAlloc;
};

interface Dept (key name) {
    attribute string name;
    attribute string chair;
    relationship Set<Course> coursesOf
         inverse Dept::deptOf;
};
```

9. (a) Define Boyce-Codd Normal Form (BCNF):

(b) Define Third Normal Form (3NF):

(c) Define Fourth Normal Form (4NF):

(d) Is every relation in Third Normal Form also in Boyce Codd Normal Form? If yes, explain why. If no, give an example that shows why this is not true.

(e) Is every relation in Fourth Normal Form also in Boyce Codd Normal Form? If yes, explain why. If no, give an example that shows why this is not true.

10. Given the relation schema $R(A, B, C, D)$ with the functional dependencies

$$\begin{aligned} AB &\rightarrow C \\ BC &\rightarrow D \\ CD &\rightarrow A \\ AD &\rightarrow B \end{aligned}$$

(a) Indicate all the Boyce Codd Normal Form violations. Do not forget to consider dependencies that are not in the given set, but follow from them. However, it is not necessary to give violations that have more than one attribute on the right side.

(b) Decompose the relations, as necessary, into a collection of relations that are in Boyce Codd Normal Form.