Answer Key for Exam I
Computer Science 420
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1. True or False:

   (a) F All database management systems are relational.
   (b) F Only relationships can have attributes in E/R diagrams.
   (c) F Every bag is a set.
   (d) T Every key is a superkey.
   (e) F Every superkey is a key.
   (f) F Attributes that are keys cannot appear in functional dependencies.
   (g) F If for a relation R, $X \to$ all attributes, then X is a key for the relation R.
   (h) T Every functional dependency is a multivalued dependency.
   (i) F You cannot embed a query inside another query.
   (j) T Views can queried as if they were tables.

2. Answer the following in two sentences or less:

   (a) What is a constraint?
   `A constraint is a condition or assertion that are required to hold in the database. Some examples of constraints include uniqueness and key constraints.`
   (b) What is the difference between a bag and a set?
   `A set allows elements to appear at most once. In a bag, elements can occur multiple times.`

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

$$B \to C \text{ and } B \to D$$

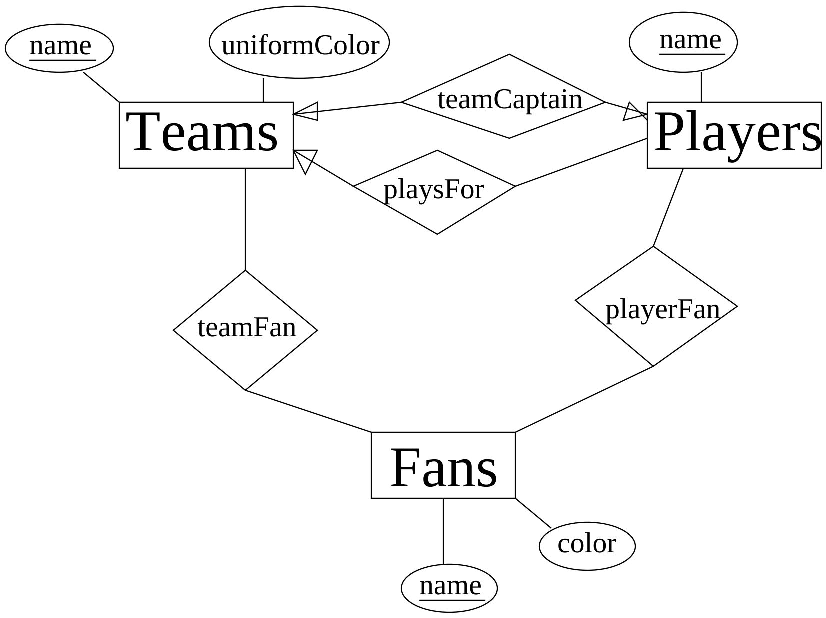
   (a) What are the keys of R?
   `First, the closures are: A+ = A, B+ = BCD, C+ = C, D+ = D. In fact, since A does not occur on the right hand side of any functional dependency, it must be part of any key. Further, any key must also contain B, since it is the only attribute on the left hand side of the functional dependencies. Using this reasoning, we see AB must be part of any key. AB is minimal, so, is a key. Also, any other 2 element set is not a key (or even a superkey), since it doesn't contain AB. It follows that all three and four element sets that contain AB are superkeys, those who don't are not superkeys. Thus, AB is the only key.`

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

`The superkeys are all sets containing AB: AB,ABC,ABD,ABCD. So, the number of superkeys is 4.`

`You can also get this answer by noticing that there are` $2^2 = 4$ `ways to form sets from` $\{C, D\}$ `(the attributes not in the key).`

4. (a) Draw an E/R diagram for the following situations. Indicate any keys, weak entity sets, or subclasses:
Entity sets *Teams*, *Players* and *Fans*. A team has its name, its players, its team captain (one its players), and the colors of its uniform. For each player, you should keep track of his/her name. And, for each fan, we have his/her name, favorite teams, favorite players, and favorite color.



(b) Translate your E/R diagram into a relation schema. Indicate keys for each relation as well as any functional dependencies that hold about each relation.

`First, make a relation for each entity set:`

- `Teams(name)`
- `Players(name)`
- `Fans(name, color)`

`Then for each relationship:`

- `PlaysFor(teamName, playerName)`
- `CaptainOf(teamName, playerName)`
- `TeamFanOf(fanName,teamName)`
- `PlayerrFanOf(fanName,playerName)`

Eliminate any redundant tables to give the database schema:
PlaysFor(teamName, playerName), CaptainOf(teamName, playerName)
[playerName is also a key for CaptainOf], TeamFanOf(fanName,teamName),
PlayerrFanOf(fanName,playerName), Fans(name, color)

The functional dependencies are:

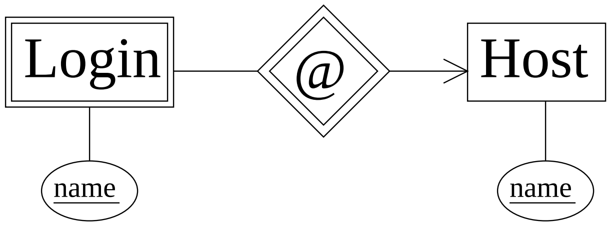
- PlaysFor: playerName$\rightarrow$teamName
- CaptainOf: playerName$\rightarrow$teamName teamName$\rightarrow$playerName
- TeamFanOf: none
- PlayerrFanOf: none
- Fans: name$\rightarrow$color

(Note: another way to do this problem is to add an extra entity set for Color.)

5. For each of the following types of situations, give an example **and** draws its E/R diagram:

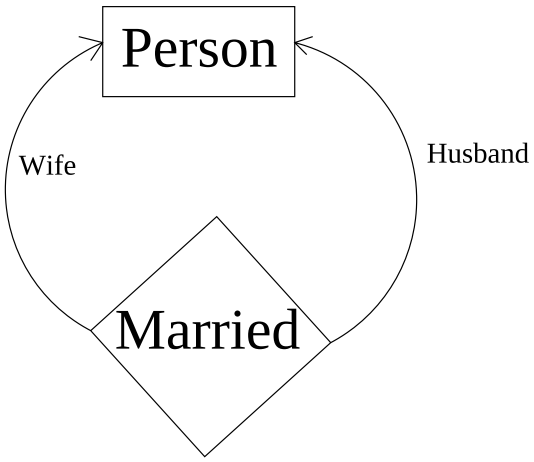
   (a) a weak entity set:

   Login is a weak entity set:



   (b) a relationship with roles:

   Husband and wife are the roles for the relationship Married:



6. (a) Consider a relation $R(A, B)$ with two tuples: $R = \{(1, 2), (2, 3)\}$.

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

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

(b) Now consider a relation $R(A, B, C)$ with two tuples: $R = \{(5, 2, 1), (7, 2, 6)\}$.

i. Does $A \rightarrow B$ hold for this instance of R?
Circle one: <u>YES</u> NO

ii. Does $B \rightarrow C$ hold for this instance of R?
Circle one: YES <u>NO</u>

iii. Does $AB \twoheadrightarrow C$ hold for this instance of R?
Circle one: <u>YES</u> NO

7. Given the relation schema:

```
Movie(title, year, length, inColor, studioName)
```

(a) Write a query that lists all movies made after 1990:

```
SELECT *
FROM Movie
WHERE year > 1990;
```

(b) Write a query that lists all movies with "Star" in the title:

```
SELECT *
FROM Movie
WHERE title LIKE '%Star%'
```

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

$$A \rightarrow B$$
$$B \rightarrow C$$
$$C \rightarrow A$$
$$A \rightarrow D$$

(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.

`Each of the attributes on the left hand side of a functional dependency is a key. That is, A+ = B+ = C+ = D+ = all attributes.`

`So, there are no BCNF violations.`

(b) Indicate all the Third 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.

`Every functional dependency that is in BCNF is in 3NF, so there are no 3NF violations.`

(c) Decompose the relations, as necessary, into a collection of relations that are in **Third Normal Form**.

`The relation R(A,B,C,D) is in 3NF, so, no decomposition is necessary.`

9. Given the relation schema:

```
Employee(ID, Name, Address, Phone, YearHired)
```

where `ID` is the employee's company identification number and the key for relation. `Name`, `Address`, and `Phone` are the employee's name, address, and phone number. The year the employee was hired is stored in `YearHired`.

(a) Write the SQL statement that will create the table above. Remember to include the types of the data as well as any keys. Include the constraints that the `Name` must not be `NULL` and the default value for `Address` is `‘‘1600 Pennsylvania Avenue’’`.

```
CREATE TABLE Employee (
    ID INTEGER PRIMARY KEY,
    name CHAR(30) NOT NULL,
    address VARCHAR(255) DEFAULT '1600 Pennsylvania Avenue,
    phone CHAR(12),
    yearHired INTEGER
);
```

(b) Write the SQL statements that will add the following employees to the table:

```
Abraham Lincoln, employee number 16, no known phone, hired: 1861
George W. Bush, employee number 42, 202-456-1414, hired: 2001
Bill Clinton, employee number 43, address: 55 W 125 Street, NY, NY,
              hired: 1993
```

[You do not need to worry about information not provided above. You only need to insert into the table the data provided.]

```
INSERT INTO Employee(name, ID, yearHired)
   VALUES('Abraham Lincoln', 16, 1861);
INSERT INTO Employee(name, ID, phone, yearHired)
   VALUES('George W. Bush', 42, '202-456-1414', 2001);
INSERT INTO Employee(name, ID, address, yearHired)
   VALUES('Bill Clinton', 43, '55 W 125 Street, NY, NY', 1993);
```

(c) What is the result of the following query on your database:

```
SELECT name, address, phone
FROM Employee;
```

```
Abraham Lincoln    1600 Pennsylvania Avenue   NULL
George W. Bush     1600 Pennsylvania Avenue   202-456-1414
Bill Clinton       55 W 125 Street, NY, NY    NULL
```

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

    A relation R is in BCNF iff whenever there is a nontrivial functional dependency X->B, then X is a superkey for R.

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

    A relation R is in 3NF iff whenever there is a nontrivial functional dependency X->B, then either X is a superkey for R or B is the member of some key.

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

    A relation R is in 4NF iff whenever there is a nontrivial multivalued dependency X->>B, then X is a superkey for R.

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

    ```
    No, 3NF is weaker than 4NF. For example, the relation R(name, street,
    city, title, year) with the MVD's:
    name->>street city
    name->>title year
    and the only functional dependency:
    name street city title year -> name street city title year
    Note that the R is in BCNF and thus 3NF, but not in 4NF.
    ```

    (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.

    Yes, if a relation is in 4NF, then every nontrivial MVD is really a FD with a superkey on the left. This gives that every nontrivial FD has a superkey on the left, so, the relation is in BCNF.