Quiz: Functional Dependency & Normalization Solutions

[Part A: Functional Dependency Quiz]

1. _____ refers to an attribute or group of attributes mentioned in the *left-hand side* of the arrow in a Functional Dependency (FD).
   a) Discriminator
   b) Determinant
   c) Multivalued attribute
   d) All of the above

Solution: **Determinant.**

2. In a functional dependency X --> Y, if Y is functionally dependent on X, but not on X's proper subsets, then we would call the functional dependency as:
   a) Full Functional Dependency
   b) Partial Functional Dependency
   c) Multivalued Functional Dependency
   d) None of the above

Solution: **Full Functional Dependency. Example: {SSN, PID} → Hours. The 'Hours' is only *fully* dependent on *both* 'SSN' and 'PID' (project ID) attributes.**

3. Which of the following is the result of bad database design?
   a) Repetition of Information
   b) Inability to represent some information
   c) Inconsistent database state due to some transaction
   d) All of the above

Solution: **All of the above**

4. If X --> {Y, Z} then X --> Y and X --> Z is
   a) Composition Rule
   b) Reflexivity Rule
   c) Union Rule
   d) Decomposition Rule

Solution: **Decomposition Rule. Example: SSN →{Name, Salary} then SSN → Name and SSN → Salary**

5. If X --> Y is a functional dependency and X and Y are sets of attributes, what is the relationship between X and Y?
   a) One-to-Many
   b) Many-to-One
   c) One-to-One
   d) Many-to-Many

Solution: **One-to-One**

6. For a functional dependency X --> Y, it is said to be _____ if Y is the subset or equal to X.
   a) Total
   b) Trivial
   c) Non-trivial
   d) Partial

Solution: **Trivial. Example: {SSN, Name} → SSN and {SSN, Name} → {SSN, Name} are both *trivial* FDs.**

7. Which of the following functional dependencies are held in the given table?

RegNo	*Name*	*Gen*	*Edu*	*Phone*	*Manager*
R1	Sundar	M	BTech	9898786756	Kumar
R2	Ram	M	MS	9897786776	Kumar
R3	Karthik	M	MCA	8798987867	Steve
R4	John	M	BSc	7898886756	Badrinath
R5	Priya	F	MS	9809780967	Kumar
R6	Ram	M	MTech	9876887909	Jagdeesh

   a) RegNo --> {Name, Gen, Edu}
   b) RegNo --> {Phone}
   c) {Manager, Name} --> RegNo
   d) All of the above

Solution**: All of the above. All FDs hold true.**

8. Consider the FDs: RegNo --> {Name, Gen, Edu, Phone, Manager}, Phone --> {RegNo, Name, Gen, Edu, Manager} and Edu --> Manager. If these are the functional dependencies of the given relation, which of the following is the Primary key? (it may be more than one option)
   a) RegNo
   b) Phone
   c) {RegNo, Phone}
   d) {RegNo, Edu}

Solution: **RegNo or Phone; both options are correct. (c) is incorrect, since it is not the minimum super key (it consists of two candidate keys), while (d) it is just a superkey.**

9. Let the relation R(A, B, C, D, E). If {A, B}, {A, B, E}, and {C, D, E} can uniquely identify any tuple in the relation, which of the following would be the Primary key?
   a) ABE
   b) CDE
   c) AB
   d) None of the above

Solution**: The minimum super key, i.e., the set with the minimum number of attributes tha can uniquely identify any tuples in R is the set {AB}.**

10. Consider the relation R(B, O, I, S, Q, D). If S --> D, I --> B, {IS} --> Q, and B --> O, then which is the candidate key?
   a) IS
   b) IB
   c) BO
   d) SD

Solution: **The set {IS} can determine all the other attributes. I determines B, and via transitivity of B → O, I determines both {B, O}. S determines D and both {IS} determine Q. Hence, {IS} determine {Q, D}. That is, IS can determine B, O (from I), D (from S), Q (from IS), i.e., IS → {B, O, D, Q}.**

11. If A --> B, B --> C, and C --> D, then which of the following is true?
    a) A --> C
    b) B --> D
    c) A --> D
    d) All of the above

Solution**: All of the above. (a) A → via transitivity (A → B, B → C), (b) B → D via transitivity (B → C, C → D), and (c) A → D via all the above: A → B, B → C, C → D.**

12. Which of the following in a relation schema R *fully* functionally determines *all* the attributes of R?
    a) Primary Key
    b) Candidate Key
    c) Both Primary and Candidate Key
    d) Neither Primary Key nor Candidate Key

Solution**: Both Primary and Candidate Key.**

13. Let the candidate keys for the relation R(A,B,C,D,E) be {A,B}, {A,C}, {C,D}, and assume that {A,B} is chosen as the Primary key for R. Which of the following is true?
    a) A is non-prime attribute
    b) C is a prime attribute
    c) E is prime attribute
    d) None of the above

Solution: **C is a prime attribute.**

14. Assume that a **Bank** associates every **Customer** with the home **Branch,** in which the customer maintains an account. Which of the following is true?
    a) Branch --> Branch
    b) Customer --> Branch
    c) Customer --> Customer
    d) All of the above

Solution**: All of the above**

15. In a relational schema R(A, B, C) with functional dependencies A --> B, B --> C, and A --> C, which of the functional dependencies is redundant?
    a) A --> C
    b) A --> B
    c) B --> C
    d) None of the above

Solution**: A → C, since this can be inferred by the transitivity: A→B and B → C.**

[Part B: Normal Forms Quiz]

1. Assume that a relation R has the following properties. What is the normal form of R?

Properties: *No multi-valued attributes, no partial functional dependencies with the primary key.*

a) First Normal Form
b) Second Normal Form
c) Third Normal Form
d) Boyce-Codd Normal Form

2. Assume that a relation R has the following properties. What is the normal form of R?

Properties: *Has no partial functional dependencies, has multi-valued attributes*

(a) First Normal Form
(b) Second Normal Form
(c) Third Normal Form
(d) None of the above

3. Assume that a relation R has the following properties. What is the normal form of R?

Properties: *Has no multi-valued attributes, has no partial functional dependencies, has attributes with atomic domains, has transitive dependencies.*

(a) 1NF & 2NF
(b) 1NF, 2NF, & 3NF
(c) 1NF & 3NF
(d) BCNF

4. Consider a relation R with the following functional dependencies:
{A → B, C → D, AC → E, D → F}.

How many keys does R have and what are they?
(a) 1, {(AC)}
(b) 2, {(AC), (AD)}
(c) 3, {(AC), (BC), (ABD)}
(d) 2, {(AC), (ABD)}

5. Consider the relation below. Select one of the following FDs that would violate the 3NF property?
Student (StudentID, StudentName, StudentPhone, CourseID, CourseName)

(a) StudentID → StudentName
(b) CourseID → CourseName
(c) StudentID → StudentPhone
(d) StudentID → CourseID

Explanation: The CourseID causes a transitive FD between CourseName and StudentID. That is, StudentID determines CourseID and, due to the FD CourseID → CourseName, then StudentID determines CourseName (via the non-prime attribute CourseID).

6. Consider the R(A, B, C, D), assume that A is the Primary Key and assume the FDs:
{A → B, A → C, AB → C, C → D}.
Which of the following would violate the 3NF rule?

(a) AB → C
(b) C → D
(c) A → BCD
(d) None of the above

Explanation: In 3NF we have that "no non-prime attribute should depend on another non-prime attribute" (i.e, no transitive dependency). The non-prime attribute D is fully functionally dependent on another non-prime attribute C. Hence, this violates 3NF.

7. Consider the relation R(A, B, C) with {A → B, C → B}. Assume that we decompose R into R1 (A, B) and R2 (A, C). Which of the following is true for this case?

(a) R1 and R2 are in BCNF
(b) Dependency preserving decomposition
(c) R1 and R2 are in 3NF
(d) All of the above

Explanation: If we have a relation with just two attributes, we cannot look for partial functional dependencies, transitive functional dependency, or multiple candidate keys. Hence, the relations R1 and R2 are in 3NF and BCNF. The decomposition given above is not a dependency preserving decomposition. Because the decomposition results in elimination of C → B.

8. Propose a set of FDs for the relation R(A, B, C, D) with primary key {AB} such that R is in 1NF but not in 2NF.

Solution: Consider the set of FDs: AB → CD and B → C. {AB} is the PK for this relation since AB → CD which also implies that AB → ABCD. Moreover, the FD: B → C violates 2NF since:

- **B is not a super key**
- **C is not part of some candidate key of R**
- **B is a *subset* of the primary key {AB} (partial functional dependency)**

9. Propose a set of FDs for the relation R(A,B,C,D) with primary key {AB} such that R is in 2NF but not in 3NF.

Solution: Consider the set of FDs: AB → CD and C → D. {AB} is obviously the primary key for this relation since AB → CD implies also that AB → ABCD. Moreover, the FD: C → D violates 3NF but not 2NF since:

- **C is not a super key**
- **D is not part of some key of R**
- **D is transitively dependent of the primary key {AB} via the non-prime attribute C.**

10. Consider the relation R(A, B, C) with the FD: B → C. If A is a candidate key for R, is it possible for R to be in BCNF? If so, under what conditions? If not, explain why not.

Solution: The only way R could be in BCNF is if B is a super key for R.