COMPUTER SCIENCE & INFORMATION TECHNOLOGY

Databases

Comprehensive Theory
with Solved Examples *and* Practice Questions

MADE EASY PUBLICATIONS

www.madeeasypublications.org

MADE EASY Publications Pvt. Ltd.
Corporate Office: 44-A/4, Kalu Sarai (Near Hauz Khas Metro Station), New Delhi-110016 | **Ph. :** 9021300500
Email : infomep@madeeasy.in | **Web :** www.madeeasypublications.org

Databases

EDITIONS

First Edition : 2015
Second Edition : 2016
Third Edition : 2017
Fourth Edition : 2018
Fifth Edition : 2019
Sixth Edition : 2020
Seventh Edition : 2021
Eighth Edition : 2022
Ninth Edition : 2023

Tenth Edition : 2024

CONTENTS

Databases

Databases

Goal of the Subject

The main goal of Data Base management System is to make it possible for users to create, edit and update data in database files. Once created, the DBMS makes it possible to store and retrieve data from those database files.

More specifically, a DBMS provides the following functions:

- Concurrency: concurrent access (meaning ‘at the same time’) to the same database by multiple users
- Security: security rules to determine access rights of users
- Backup and recovery: processes to back-up the data regularly and recover data if a problem occurs
- Integrity: database structure and rules improve the integrity of the data
- Data descriptions: a data dictionary provides a description of the data

Databases

INTRODUCTION

Very often the subject *Data Base management System* is discussed vastly. But in this book we tried to keep it around the GATE syllabus. Each topic required for GATE is crisply covered with illustrative examples and each chapter is provided with Student Assignment at the end of each chapter so that the students get the thorough revision of the topics that he/she had studied. This subject is carefully divided into seven chapters as described below.

1. **The Relational Model**: In this chapter we discuss ER model and its constraints, types of relationships and we also the minimization of ER diagrams.
2. **Database design and Normalization: In** this chapter we discuss the types of keys in relational model , integrity constraints , functional dependencies of attributes and their properties, decomposition of relationship into 2NF, 3NF, BCNF etc.
3. **Relational Algebra**: In this chapter we discuss the Operators of relational algebra, operations on the set of records and finally we discuss the Tuple Relational Calculus (TRC).
4. **SQL**: In this chapter we discuss the basic form of SQL Query, operator, types of queries, group by and having clauses and finally we discuss the special properties of NULL value.
5. **Transaction**: In this chapter we discuss the ACID properties of a transaction, problem of concurrent execution, serializability etc.
6. **Concurrency Control Techniques**: In this chapter we discuss the various protocols used to achieve concurrent execution with any of the problem discussed in the previous chapter.
7. **File Organization and Indexing:** in this chapter we discuss concept of file organization, indexing techniques and B, B+ trees which form backbone of indexing techniques.

■■■■

CHAPTER 1

The Relational Model

1.1 INTRODUCTION

Entity relationships (ER) model is high level database design allows us to describe the data involved in real-world enterprise in terms of objects and their relationships and is widely used to develop initial database design. In overall design process, the ER model is used in a phase called conceptual database design.

1.2 DATABASE DESIGN AND ER DIAGRAMS

The database design process can be divided into six steps. The ER model is most relevant to the first three steps.

Requirements Analysis

The very first step in designing a database application is to understand what data is to be stored in the database, what applications must be built on top of it, and what operations are most frequent and subject to performance requirements. In other words, we must find out what the users want from the database. This is usually an informal process that involves discussions with user groups, a study of the current operating environment and how it is expected to change, analysis of any available documentation on existing applications that are expected to be replaced or complemented by the database, and so on.

Conceptual Database Design

The information gathered in the requirements analysis step is used to develop a high-level description of the data to be stored in the database, along with the constraints known to hold over this data. This step is often carried out using the ER model and is discussed in the rest of this chapter. The ER model is one of several high-level, or semantic, data models used in database design. The goal is to create a simple description of the data that closely matches how users and developers think of the data

Logical Database Design

We must choose a DBMS to implement our database design, and convert the conceptual database design into a database schema in the data model of the chosen DBMS. We will consider only relational DBMSs, and therefore, the task in the logical design step is to convert an ER schema into a relational database schema.

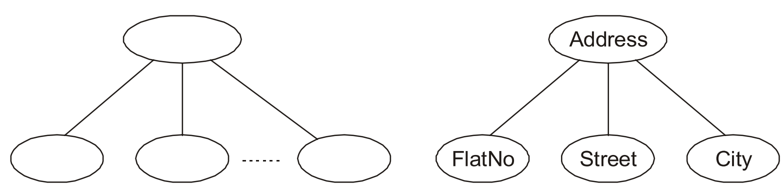
1.3 ENTITY, ATTRIBUTES, ENTITY SET

- Entity is an object that exist and is distinguishable from other objects. For example a person with give UID is an entity as he can be uniquely identified as one particular person.
- An entity may be concrete (person) or abstract (job). It is represented by rechange.
- An entity set is a collection of similar entities. (All persons having an account at a bank)
- Entity sets need not be disjoint. For example, the entity set employee (all employees of a bank) and entity set customer (all customers of the bank) may have members (Entity) in common.
- An entity is described using a set of attributes, all entities in a given entity set have same attributes, this is what we mean by similar.
- For each attribute associated with an entity set, we must identify domain of attribute which is the set of permitted values (e.g. if a company rates employees on a scale of 1 to 10 and stores rating in a field called rating, the associated domain consist of integers 1 through 10)
- Attribute is represented by an oval.
- Types of attributes and their representations:
  1. **Key attribute:** The attribute which uniquely identifies each entity in the entity set is called key attribute. For example, account number of customer.

     Represented as

  2. **Composite attribute:** An attribute composed of many other attributes is called as composite attribute. For example, address of employee.

     Represented as

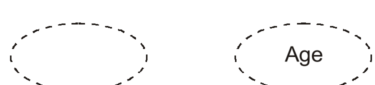


  3. **Multivalued attributed:** An attribute consisting more than one value for a given entity. For example, phone number of bank employee.

     Represented as

  4. **Derived attribute:** An attribute which can be derived from other attributes of the entity type is known as derived attribute. For example, age of employee (as it can be derived from date of birth).

     Represented as



1.4 RELATIONSHIP AND RELATIONSHIP SETS

- Relationship is association between two or more entities.
- Relationship set is a set of relationships of same type i.e. relate two or more entity sets.

A relationship set can be thought of as a set of *n*-tuples: $\{(e_1,\ldots,e_n) \mid e_1 \in E_1,\ldots, e_n \in E_n\}$

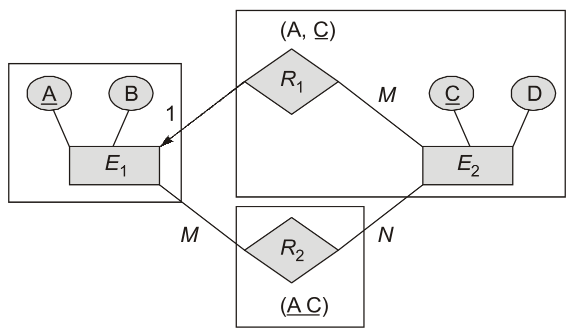
Each n-tuple denotes a relationship involving *n* entities e_1 through e_n, where entity e_i is in entity set E_i. In figure, we show the relationship set Works_In, in which each relationship indicates a department in which an

For $M : M$ mapping, minimization is performed by maintaining separates tables for E_1, E_2, R. R can't be combined with E_1 or E_2 as it has key <u>AC</u>.
Minimum number of tables for $M : M$ mapping = 3.

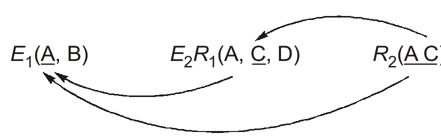
Example 1.1 E_1 and E_2 are entity sets and R_1 and R_2 are relationship sets related between E_1 and E_2 with 1 : M and M : N mapping respectively. How many minimum relations are required to represent this database instance?

(a) 2
(b) 3
(c) 4
(d) 5

Solution: (b)



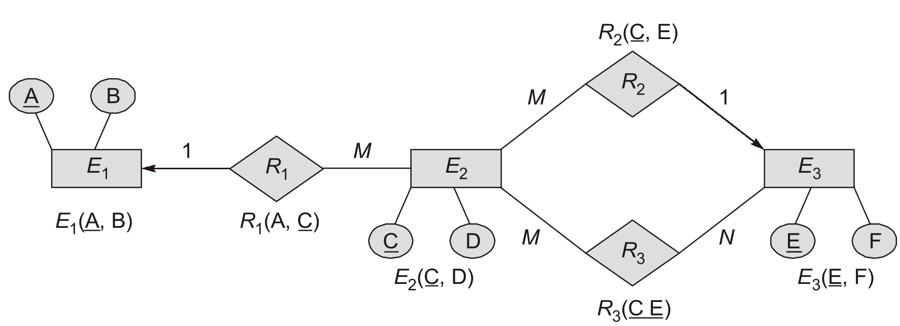
Since R_1 has 1 : M mapping, R_1 can be combined to E_2, so we get



Hence, we have 3 relation and 3 foreign key.

Example 1.2 E_1, E_2, E_3, entity set. R_1 relationship set between E_1 and E_2 with 1 : M mapping R_2, R_3 relationship set between E_2, E_3 with M : 1 and M : M mapping respectively. How many minimum relational table for given ERD?

Solution:



R_1 is in 1 : M mapping, hence R_1 and E_2 can be combined.
E_1(<u>A</u>, B) and R_1 E_2(A, <u>C</u>, D)
also R_2 has M : 1 mapping, hence R_2 and E_2R, can be combined
E_3(<u>E</u>, F) and R_2 E_2 R_1(<u>C</u>, E, A, D)

Summary

In this chapter we presented the modeling concepts of a high-level conceptual data model, the Entity-Relationship (ER) model. We started by discussing the role that a high-level data model plays in the database design process, we defined the basic ER model concepts of entities and their attributes. Which can be nested arbitrarily to produce complex attributes:

- Simple or atomic
- Composite
- Multivalued
- Derived

We also briefly discussed stored versus derived attributes. Then we discussed the ER model concepts at the schema or "intension" level:

- Entity types and their corresponding entity sets
- Key attributes of entity types
- Value sets (domains) of attributes
- Relationship types and their corresponding relationship sets
- Participation roles of entity types in relationship types

We presented two methods for specifying the structural constraints on relationship types. The first method distinguished two types of structural constraints:

- Cardinality ratios (1:1, 1:N, M:N for binary relationships)
- Participation constraints (total, partial)

We discussed weak entity types and the related concepts of owner entity types, identifying relationship types, and partial key attributes.

The ER modeling concepts we have presented thus far—entity types, relationship types, attributes, keys, and structural constraints—can model many database applications. However, more complex applications—such as engineering design, medical information systems, and telecommunications—require additional concepts if we want to model them with greater accuracy.

Student's Assignment

Q.1 Which of the following statement above ER models is/are correct?

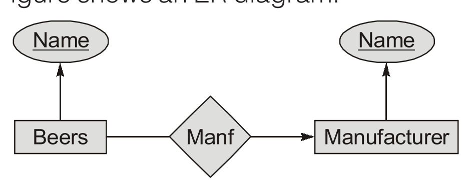
I. Many-many relationships cannot be representation ERD.

II. Relationship sets can have attributes of their own.

III. All many to one relationships are represented by the relationships between a weak and a non weak entity set.

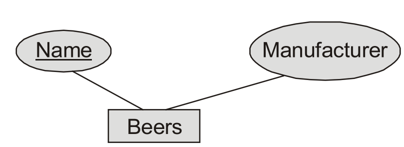
(a) II only (b) III only
(c) II and III only (d) I and II only

Q.2 Figure shows an ER diagram:

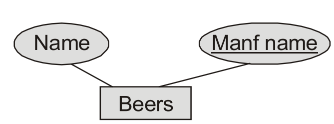


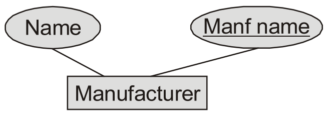
Which of the following best describes the above ER diagram?

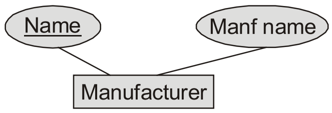
(a)



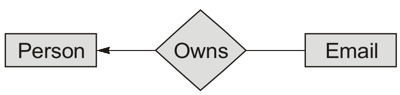
(b)

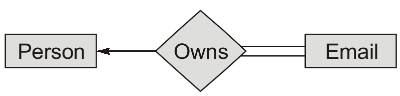


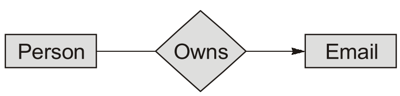
(c) 

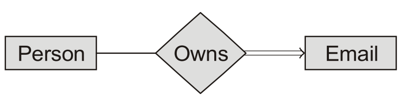
(d) 

Q.3 Suppose we have two entity sets person, E-mail and use a relationship Owns. A person own atmost one E-mail account but an email account can be owned by multiple persons. Which of the following is an ER diagram based on above description.

(a) 

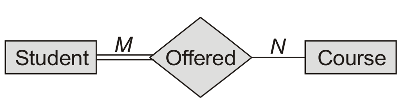
(b) 

(c) 

(d) 

Q.4 A student can take one or more courses and courses can be offered to any number of students. Which of the following represents given scenario in ER-model

(a) 

(b) 

(c) 

(d) 

Q.5 R is relationship, with 1 : 1 cardinality 30% participation at E_1 end 70% participation at E_2 end which is the best possible design?
(a) E_1 and E_2 kept separate with foreign key at E_1 end
(b) E_1 and E_2 kept separate with foreign key at E_2 end
(c) E_1 and E_2 kept separate with foreign key at E_1 as well as E_2
(d) E_1 and E_2 merges into a single table with no foreign key

Q.6 For weak entity set to be meaningful it must be part of
(a) one to one relationship
(b) one to many relationship
(c) many to one relationship
(d) All of the above

Q.7 In an E-R diagram, Y is the dominant entity and X is a subordinate entity. Then which of the following is incorrect:
(a) Operationally, if Y is deleted, so X is also deleted
(b) X existence is dependent on Y
(c) Operationally, if X is deleted, so Y is also deleted
(d) Operationally, if X is deleted, Y remains the same

Q.8 Map the following statements with True (T)/False (F)
S_1 : Participation of the weak entity set in identifying relationship must be total.
S_2 : Multivalued attributes in E-R diagram require separate tables when converted into relational model with satisfy 2NF.
(a) F T (b) T F
(c) F F (d) T T

Answers Key:

1. (a) **2.** (a) **3.** (c) **4.** (b) **5.** (b)
6. (b) **7.** (c) **8.** (d)

Student's Assignments — Explanations

2. (a)

Manufacturer is a name and it is at the 'one' end of any relationship. Hence it should not be an entity set it can be a attribute of Beer entity option (a) is correct.

CHAPTER

2

Database Design and Normalization

2.1 DEFINITION OF KEYS AND ATTRIBUTES PARTICIPATING IN KEYS

Primary Key and Candidate Key

Key (primary key) of a relation schema is the minimal set of attributes that uniquely identifies each tuple (row) in the relation. Primary key contain unique, non-null value.

Example:

Student

(Sid,	Sname,	age)
S_1	A	20
S_2	B	20
S_3	C	22

Here sid contains unique, non-null value hence, it is the primary key. Two students can have same name or age, that is why, they can't be considered for primary key.

If a relation schema has more than one key, each is called candidate key. One of the candidate key is designated to be primary key and others are called **secondary keys (Alternate keys)**. Alternate keys allowed NULL values.

Candidate key: An attribute or set or attributes 'X' in R is candidate key of R iff

(*i*) No two rows in R have same value for X. (i.e., unique value for X).

(*ii*) No proper subset of 'X' can differentiate rows uniquely (i.e., X is minimal attribute set).

Example:

BankEmp

(Eid,	Ename,	DOB,	PANId,	PFNo,	Bank,	AccNo)
E_1	X	–	X_1	P_4	SBI	101
E_2	Y	–	X_2	Null	SBI	102
E_3	Z	–	X_5	P_3	ICICI	103

Candidate keys for BankEmp are:

{Eid, PanId, PFNo, Bank, AccNo}

Here Eid is primary key, rest are alternate keys.

{Bank, AccNo} is combined key because there can be no two records with same bank and accNo. Either the Bank would be different or the AccNo.

Primary Attributes

Prime attributes are those attributes that belong to any candidate key of relation. They are also called key attributes.

Example: for above relation BankEmp: Eid, PanId, PFNo, Bank, AccNo are prime attribute.

Non Prime Attributes

Non prime attributes are those attributes which do not belong to any candidate key.

Example: for above relation BankEmp: Ename, DOB are nonprime attributes.

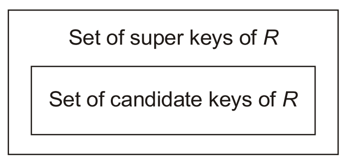
Super Key

A super key of a relational schema R is a set of attributes $S \subseteq R$ which can differentiate records of the relation uniquely and this set S may not be the minimal attribute set.

Example: Student (Sid, Sname, age)

{<u>Sid</u>}: Candidate key

{<u>Sid</u>, <u>SidSname</u>, <u>Sidage</u>, <u>SidSnameage</u>}: Super key



To find number of super keys in R when candidate keys are given

(Number of super key among prime attribute of R) $\times 2^{(\text{Number of non prime attributes})}$

Example 2.1 Let $R(A, B, C, D, E)$ be a relation with candidate key $\{A, B\}$. Find the number of super keys in R.

Solution:

(i) Calculate number of super key among prime attribute of R: A, B, AB (3)

(ii) Number of non prime attributes C, D, E (3)

$$\text{Number of super keys} = 3 \times 2^3 = 24$$

Example 2.2 Consider a relation $R(A_1, A_2, A_3, \ldots A_n)$. Find super key of R if each attribute of relation is candidate key.

Solution:

(i) Number of super key among prime attributes (i.e., $A_1, A_2, \ldots A_n$) of R: $2^n - 1$

(ii) Number of non prime attribute 0

$$\text{Number of super keys} = (2^n - 1) - 2^0$$
$$= 2^n - 1$$

Example 2.3 Consider relation R (A_1, A_2, ... A_n) with A_1 as primary key. How many super keys are possible?

Solution:

(i) Number of super keys among prime attributes (i.e. A_1) of R = 1 (A_1)

(ii) Number of non prime attributes = $n - 1$ (A_2, A_3, ..., A_n)

Number of super keys = $1 \times 2^{n-1} = 2^n - 1$

Foreign Key

Foreign key is the set of attribute references to the primary key or alternate key of same table or some other table.

Student

(Sid	Sname	age)
S_1	A	20
S_2	B	22
S_3	B	20
S_4	C	21
S_5	B	22

Enroll

(Sid,	Cid	Fee)
S_1	C_1	
S_1	C_2	
S_3	C_2	
S_5	C_3	

Here student is referenced relation and enroll is referencing relation sid of enroll foreign key references sid of student. That i.e., every value present in sid of enroll should be from the set of values present in sid of student.

But, sid of enroll can be null if it is not the primary key of the relation.

- Each record of referencing relation can relate to atmost 1 record of referenced relation.
- Each record of referenced relation can relate to any (0 or more) records of referencing relation i.e. referenced relation $1 \rightarrow m$ referencing relation.

  Example: Foreign key referencing same relation.

R

(A	B	C)
2	11	Null
4	12	2
5	13	2
6	14	4
7	14	6

2.2 INTEGRITY CONSTRAINTS

An Integrity Constrains (IC) is a condition specified on a database schema and restricts the data that can be stored in an instance of the database. If a database instance satisfies all the integrity constrains specified on the database schema it is legal instance. A DBMS enforces IC, in that it permits only legal instances to be stored in the database.

Integrity constrains are specified and enforces at different times.

(*i*) When a DBA or end user defines a database schema, he or she specifies the ICs that must hold on any instance of this database.

Example 2.5 Given a relation R (A, B, C, D, E, F) with FDs

$$AB \rightarrow C$$
$$B \rightarrow D$$
$$AD \rightarrow E$$

Compute $(AB)^+$

Solution:

Add A, B to S

$S = \{A, B\}$

- Attributes that can be derived from A — None
- Attributes that can be derived from B — D ($B \rightarrow D$)
  Add D to S
  $S = \{A, B, D]$
- Attributes that can be derived from D — None
- Attributes that can be derived from AB — C ($AB \rightarrow C$)
  Add C to S
  $S = \{A, B, D, C]$
  Attributes that can be derived from AD — E (Since $AD \rightarrow E$)
  Add E to S
  $S = \{A, B, C, D, E]$
  Checking until there is no change is S or if all attributes of R have been added to S.
  $\therefore \quad (AB)^+ = \{A, B, C, D, E\}$

Example 2.6 Find attribute closure of B with given for relation R (A, B, C, D, E)

$$\{AB \rightarrow C, B \rightarrow D, C \rightarrow E, D \rightarrow A\}$$

Solution:

Let S represent attribute closure set for B.

$S = \{B\}$

$S = \{B, D\}$ since $B \rightarrow D$, so added D

$S = \{B, D, A\}$ since $D \rightarrow A$, so added A

$S = \{B, D, A, C\}$ since $AB \rightarrow C$, so added C

$S = \{B, D, A, C, E\}$ since $C \rightarrow E$, so added E

$\therefore \quad B^+ = \{A, B, C, D, E\}$

2.5 MEMBERSHIP TEST

If we just want to check whether a given dependency $X \rightarrow Y$ is in the closure of set F of FDs. We can do so efficiently without computing F^+, by using closure of X (finding X^+). If X^+ contains Y then $X \rightarrow Y$ is a member of functional dependency set F i.e. $X \rightarrow Y$ is logically implied in F or $F \Rightarrow X \rightarrow Y$.

Example 2.7 Prove or disprove the following inference rule for functional dependency using (*i*) Armstrong's Axioms (*ii*) Attribute closure

$$\{X \rightarrow Y, XY \rightarrow Z\} \Rightarrow \{X \rightarrow Z\}$$

Solution:

(*i*) Armstrong's Axioms:

$X \to X$ (trivial) and $X \to Y$ (given) so by union rule $X \to XY$ ...(1)

$X \to XY$ (from(1)) and $XY \to Z$ (given) by transitivity $X \to Z$

(*ii*) Attribute closure: If closure of X determines Z in the given FD set, then $X \to Z$ is logically implies in the given FD. $X^+ \to XY\underline{Z}$

Since X^+ contains Z, $X \to Z$ implies in the given FDs.

2.6 CLOSURE OF SET OF FUNCTIONAL DEPENDENCIES AND EQUIVALENCE OF SETS OF FUNCTIONAL DEPENDENCIES

A closure of a set of FDs is the set of all possible FDs that can be derived from a given set of FDs. It is also referred to as complete set of FDs.

If F is used to denote the set of FDs for relation R, then a closure of a set of FDs implied by F is denoted by F^+.

$F = \{A \to B, B \to C\}$

$F^+ = \{A \to A$ (Trivial FD) ...(1)

$A \to B$ (Given) ...(2)

$A \to C$ (Transitivity rule) ...(3)

$A \to AB$ (Union rule, merging (1) and (2)) ...(4)

$A \to AC$ (Union rule, merging (1) and (3)) ...(5)

$A \to BC$ (Union rule, merging (2) and (3)) ...(6)

$A \to ABC$ (Union rule, merging (1), (2) and (3))

$B \to B$ (Union rule, merging (1), (2) and (3))

$B \to B$ (Trivial FD) ...(7)

$B \to C$ (Given) ...(8)

$B \to BC$ (Union rule, merging (4) and (8))

$C \to C$ (Trivial FD) ...(9)

$AB \to AB$ (Trivial FD) ...(10)

$AB \to A$ (Decomposition rule) ...(11)

$AB \to B$ (Decomposition rule) ...(12)

$AB \to AC$ (Transitive rule since $AB \to A$ and $A \to AC$)

$AB \to BC$ (Transitive rule since $AB \to A$ and $A \to BC$)

$AB \to C$ (Transitive rule since $AB \to A$ and $A \to C$)

$AB \to ABC$ (Transitive rule since $AB \to A$ and $A \to ABC$)

$BC \to BC$ (Trivial FD)

$AC \to AC$ (Trivial FD)

$AC \to ABC$ (Transitive rule since $AC \to A$ and $A \to ABC$)

$AC \to A$, $AC \to C$ {Trivial FD}

$BC \to B$, $BC \to C$ {Trivial FD}

$ABC \to ABC$ (Transitive FD)

}

Student's Assignment

Q.1 Consider the following in the given table:

A	B	C
a_1	b_1	c_1
a_1	b_1	c_2
a_2	b_1	c_1
a_2	b_1	c_3

What is the number of functional dependencies in the canonical cover of this instance?

Q.2 Consider relation $r(P, Q, R, S)$ with functional dependencies

$PQ \rightarrow R$
$PQ \rightarrow S$
$R \rightarrow P$
$S \rightarrow Q$

Find the number of candidate keys in relation.

Q.3 Given a relation R with four attributes A, B, C, D. The following FDs holds for R

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

Identify the best normal form that R satisfies?
(a) 1NF (b) 2NF
(c) 3NF (d) BCNF

Q.4 Find the highest normal form of the relation $R(A, B, C, D)$ that holds following FDs.

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

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

Q.5 F and G are two FDs sets

F:	G:
$P \rightarrow Q$	$P \rightarrow R$
$R \rightarrow P$	$R \rightarrow Q$
$PQ \rightarrow R$	$QR \rightarrow P$

Which of the following is correct?
(a) F covers G but G does not cover F
(b) G cover F but F does not cover G
(c) F covers G and G covers F
(d) None of these

Q.6 A relation $R(A, B, C, D, E, F)$ holds following FDs.

$AB \rightarrow C$
$C \rightarrow D$
$D \rightarrow EA$
$E \rightarrow F$
$F \rightarrow B$

Find the number of candidate keys of R.

Q.7 Given $R(A, B, C, D)$ with FDs $F = \{AB \rightarrow CD, C \rightarrow A, B \rightarrow D\}$ is decomposed into $R_1(A, B, C)$ and $R_2(B, C, D)$ then which of the following statement is true about decomposition of R?
(a) lossless and dependency preserve decomposition
(b) lossless and not dependency preserve decomposition
(c) lossy and dependency preserve decomposition
(d) lossy and not dependency preserve decomposition

Q.8 A relation $R(A, B, C, D, E, F, G)$ holds following FDs.

$B \rightarrow ACD$
$BD \rightarrow E$
$EFG \rightarrow H$
$F \rightarrow GH$

Which of the following FD can be removed without altering the key of the relation R?
(a) $B \rightarrow ACD$ (b) $BD \rightarrow E$
(c) $EFG \rightarrow H$ (d) $F \rightarrow GH$

Q.9 Consider the following relational schema R(P, Q, R, S, T) with FD set {P → QR, RS → T, Q → S, T → P} if the relation decomposed into R_1(P, Q, R) R_2(P, S, T). Which of the following true for given decomposition?
(a) Lossless join decomposition and dependency preserving decomposition.

(b) Lossless join decomposition but not dependency preserving decomposition.
(c) Dependency preserving decomposition but not lossless join.
(d) Not dependency preserving and not lossless join decomposition.

Q.10 Consider the following relational schema:
R(ABCDE) with FD set $\{A \to B, C \to D, BD \to E, E \to C\}$
How many of given FD's violate 3NF?

Q.11 Consider a relation $R(A, B, C, D)$ with FDs $A \to B$ and $C \to D$ then the decomposition of R into $R_1(A, B)$ and $R_2(C, D)$ is
(a) Dependency preserving and lossless join
(b) lossless but *NOT* dependency preserving
(c) Dependency preserving but not lossless join
(d) Not dependency preserving and not lossless join

Q.12 Given a relation $R(A, B, C)$ with FDs set $\{A \to B, B \to C, C \to B\}$
(i) Lossless decomposition is always possible for R
(ii) Dependency preserving decomposition is always possible for R.
Assume decomposition includes all the attributes of R.
(a) Both (i) and (ii) true
(b) (i) is true and (ii) is false
(c) (i) is false and (ii) is true
(d) Both (i) and (ii) are false

Q.13 Consider the following statement
P : Canonical cover may not be unique.
Q : $F = \{AB \to C, A \to B, B \to A\}$. Canonical cover of F is unique
Which of the above statement is true?
(a) Both P and Q true
(b) P is true and Q is false
(c) P is false and Q is true
(d) Both P and Q are false

Q.14 Consider a relation $R(A, B, C, D, E)$ holds FDs. $F = \{AB \to C, C \to D, B \to E\}$ is decomposed into $R_1(A, B, C)$ and $R_2(C, D)$ then this decomposition
(a) Lossless and dependency preserving
(b) Dependency preserving and not lossless
(c) Lossless and not dependency preserving
(d) Not dependency preserving and not lossless

Q.15 Consider the following FD set on $R(A, B, C)$
$F = \{A \to BC, B \to C, A \to B, AB \to C\}$
The canonical cover of this set is
(a) $A \to B$ and $B \to C$
(b) $A \to BC$ and $B \to C$
(c) $A \to BC$ and $A \to B$
(d) $B \to BC$ and $AB \to C$

Q.16 Consider a relation $R(A, B, C, D, E)$ holds FDs $AC \to B$, $BD \to C$, $CE \to D$, $DA \to E$, $EB \to A$. Find number of keys that contain attribute A.

Q.17 Consider the following statements:
1. Prime attribute transitively determined by super key is allowed by 3NF.
2. Non prime attribute transitively determined by super key is allowed by 3NF.
3. Every partial dependency is transitive dependency.
4. Candidate key is only determined by functional dependencies not by MVD's.

Which of the above statements are true?
(a) 1, 2 and 4 only
(b) 1, 3 and 4 only
(c) 1, 2 and 3 only
(d) All of these

Q.18 How many superkeys in the following relation $R(A\ B\ C\ D\ E)$ $(AB \to C, BC \to D, CD \to A, AD \to B)$
(a) 11
(b) 8
(c) 10
(d) 9

Q.19 If every non key attribute is functionally dependent on primary key, then the relation will always be in
(a) 1NF
(b) 2NF
(c) 3NF
(d) BCNF

Q.20 Consider the following schema:
$R(\underline{C}, D)$, $Q(\underline{B}, C)$, $P(\underline{A}, B)$
C is foreign key in Q referencing $R(C)$ on delete cascade B is foreign key in P referencing $Q(B)$ on delete set null suppose current content of P, Q, R as follows:

	A	B
P	a	a
	b	b

	B	C
Q	a	a
	b	a

	C	D
R	a	a
	b	a

After executing **delete from** *R*. What tuples *P* will contain?
(a) (*a*, NULL) and (*b*, *b*)
(b) (*a*, NULL) and (*b*, NULL)
(c) (*b*, *b*) only
(d) *P* will not be changed

Q.21 In most general case, if table *R* has foreign key constraint referencing table *S* then
(a) Each tuple in *R* is related to one or more tuples in *S*.
(b) Each tuple in *R* is related to exactly one tuple in *S*
(c) Each tuple in *R* is related to zero or one tuple in *S*
(d) Each tuple in *R* is related to zero or more tuples in *S*.

Q.22 Consider the following statements:
(*i*) An entity integrity constraint states that no primary key value can be null
(*ii*) A referential integrity constraint is specified between two relations.
(*iii*) A foreign key can't be used to refer to it's own relation
Identify which of the above statements are correct?
(a) Only (*i*) and (*iii*)
(b) Only (*ii*) and (*iii*)
(c) Only (*i*) and (*ii*)
(d) All of these

Q.23 If both the functional dependencies $X \rightarrow Y$ and $Y \rightarrow X$ hold for two attributes X and Y then the relationship between X and Y is
(a) 1 : 1
(b) M : 1
(c) 1 : M
(d) None of these

Q.24 *R*(*A*, *B*, *C*, *D*) is a relation. Which of the following does not have a lossless join dependency preserving BCNF decomposition.
(a) $A \rightarrow B, B \rightarrow CD$
(b) $A \rightarrow B, B \rightarrow C, C \rightarrow D$
(c) $AB \rightarrow C, C \rightarrow AD$
(d) $A \rightarrow BCD$

Q.25 A functional dependency of the form $x \rightarrow y$ is trivial if
(a) $y \subseteq x$
(b) $y \subset x$
(c) $x \subseteq y$
(d) $x \subset y$

Q.26 A relation *R*(*ABC*) has no non-trivial functional dependencies, and then what should be the set of candidate keys for the relation?
(a) {*ABC*}
(b) {*A*, *B*, *C*}
(c) {*AB*, *BC*, *CA*}
(d) None of these

Q.27 If a relation is in BCNF, then which of the following statement is always true?
(a) The relation does not have any type of data redundancy
(b) The relation does not have data redundancy (which is due to functional dependency)
(c) The relation may have data redundancy (which is due to functional dependency)
(d) None of these

Q.28 Assume a table *P* has only one candidate key then which of the following is always true about *P*?
(a) *P* is in both 3NF and BCNF
(b) *P* is in 3NF but may not be in BCNF
(c) *P* is in 2NF but may not be in 3NF
(d) None of these

Answer Key:

1. (2)	**2.** (4)	**3.** (c)	**4.** (a)	**5.** (c)
6. (3)	**7.** (a)	**8.** (c)	**9.** (b)	**10.** (1)
11. (c)	**12.** (b)	**13.** (b)	**14.** (d)	**15.** (a)
16. (3)	**17.** (b)	**18.** (d)	**19.** (b)	**20.** (b)
21. (b)	**22.** (c)	**23.** (a)	**24.** (c)	**25.** (a)
26. (a)	**27.** (b)	**28.** (d)		

Student's Assignments Explanations

1. (2)

The relation has following FDs:

$$A \to B$$
$$C \to B$$
$$AC \to B$$

Finding minimal cover of R.

FD $AC \to B$ has extraneous attribute C because $A \to B$ is already a FD, so C not required to imply B.

$$A \to B$$
$$C \to B$$
$$A \to B$$

$A \to B$ is redundant FD.

Minimal cover: $\{A \to B, C \to B\}$.

2. (4)

$$(PQ)^+ \to PQRS$$

Look the FDs where right hand side is P or Q.

$R \to P \Rightarrow RQ$ is the key (replace P).

$S \to Q \Rightarrow RS$ is the key (replace both P and Q) and PS is the key (replace Q).

3. (c)

$$(AB)^+ = \{A, B, C, D\}$$
$$(CD)^+ = \{C, D, A, B\}$$

Candidate key = $\{AB, CD\}$

Prime attributes = $\{A, B, C, D\}$

Since all attributes of R are prime. R is in 3NF.

Check for BCNF:

$$\left.\begin{array}{l} AB \to C \\ AB \to D \end{array}\right\} \text{Satisfy BCNF since } AB \text{ is superkey}$$

$$C \to D$$
$$\downarrow$$
Not superkey

R not in BCNF.

4. (a)

Keys = A, BC

Non prime attributes: D

$$B \to D$$

Partial dependency exist so the relation is not in 2NF. It is in 1NF.

5. (c)

Check if F covers G:

FD of G: $\{P \to R, R \to Q, QR \to P\}$

$P \to R$

In F, $P^+ = \{P, Q, R\}$

$R \to Q$

In F, $R^+ = \{R, P, Q\}$

$QR \to P$

In F, $(QR)^+ = \{Q, R, P\}$

Hence F covers G.

Check if G covers F:

FD of F: $\{P \to Q, R \to P, PQ \to R\}$

$P \to Q$

In G, $(P)^+ = \{P, R, Q\}$

$R \to P$

In G, $(R)^+ = \{R, Q, P\}$

$PQ \to R$

In G, $(PQ)^+ = \{P, Q, R\}$

Hence G covers F.

6. (3)

$$(AB)^+ = \{A, B, C, D, E, F\}$$

AB is one candidate key.

Now, take these FDs where right hand side is A or B.

- $F \to B$ Replace B with F in above candidate key AF is the key.
- $E \to S$ Replace E with F in above candidate key. AE is the key.

$D \to AE$

So D is also a candidate key.

$C \to D$

So C is another candidate key.

CK of $R = \{AB, AE, AF, C, D\}$

7. (a)

$R_1(A, B, C)$ $R_2(B, C, D)$

For lossless join decomposition

$$R_1 \cap R_2 = AB$$
$$(AB)^+ = \{C, D, A, B\}$$

Common attribute in R_1 and R_2 determines both R_1 and R_2.

Hence lossless join