KARPAGAM ACADEMY OF HIGHER EDUCATION
(Deemed to be University)
(Established Under Section 3 of UGC Act 1956)
Pollachi Main Road, Eachanari Post, Coimbatore - 641021
(For the candidates admitted from 2016 onwards)

DEPARTMENT OF COMMERCE (CA)

Semester IV

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16CCU402 **DATABASE MANAGEMENT SYSTEMS**

Course Objective: Database Management System enables to students to understand the basis of data structures, query language, Relational Models and SQL. This helps to understand the database management and storage in the phase of software development.

Learning Outcomes:

- To enable the students to learn the data base operations and process
- On success understand management and implementation issues pertinent to databases in public and private organizations
- Understand the database development process and technology
- Understand structured query languages (SQL)

UNIT-I

Purpose of Database - Overall System Structure - Entity Relationship Model -Mapping Constraints - Keys - E-R Diagrams.

UNIT- II

Relational Model - Structure - Formal Query Language - Relational Algebra - Tuple and Domain Relational Calculus.

UNIT- III

Structured Query Language - Basic Structure - Set Operations - Aggregate Functions - Date, Numeric, and Character Functions - Nested Sub queries -Modification Of Databases - Joined Relations-DDL - Embedded SQL.

UNIT- IV

Relational Database Design - Pitfalls - Normalization Using Functional Dependencies - First Normal Form-Second Normal Form-Third Normal Form-Fourth Normal Form And BCNF.

UNIT- V

Oracle - Introduction - SQL (DDL,DML, DCL Commands) - Integrity Constraints - PL/SQL - PL/SQL Block - procedure, function - Cursor management - Triggers - Exception Handling.

Suggested Readings:

Text Book

1. Abraham Silber Sehatz, Henry F. Korth & S. Sudharasan. (2010) , *Database System Concepts*[6th Edition]. New Delhi, Tata McGraw Hill Mc Graw Hill Publication.

Reference Books

1. Singh. (2011) *Database systems: Concepts, Design & Applications*, [2nd Edition]. New Delhi, Pearson Education.
2. Gerald V.Post. (2011). *DBMS-Designing And Business Applications [5th* Edition] New Delhi, Tata McGraw Hill
3. Michael Abbey And Michael.J.Core.(2008). *Oracle- A Beginners guide* [4th Edition] New Delhi, Tata McGraw Hill.

Website

1. www.tutorialpoint.com
2. www.w3school.in
3. www.javapoint.com/sql-tutorial
4. www.tutorialspoinexamples.com/SQL

KARPAGAM ACADEMY OF HIGHER EDUCATION

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Coimbatore – 641 021.

LECTURE PLAN

DEPARTMENT Of COMMERCE WITH COMPUTER APPLICATION

STAFF NAME: SARANYA.W SEMESTER: IV

SUBJECT NAME: DATABASE MANAGEMENT SYSTEM

SUB.CODE: 16CCP402 CLASS: II B.Com CA

S. No.	Lecture Duration (Hr)	Topics to be covered	Support Material
Unit - I			
1.	1	Database system application	T1: 1-2
2	1	Purpose of Database	T1:2-4
3	1	Overall System Structure	T1:16-18
4	1	Entity Relationship Model	T1: 23-28
5	1	Mapping Constraints	T1:30-34
6	1	Keys	T1:34-36
7	1	E-R Diagrams symbols	T1: 36-37
8	1	Components • Entity ○ Sets and keys	W1
9	1	• Attributes ○ Types of attributes	W1
10	1	Relationship • Types of relationship	W1
11	1	Recapitulation And Important Questions Discussion	
Total Number of Hours Planned for Unit – I			11
Unit – II			
S No.	**Lecture Duration (Hr)**	**Topics to be covered**	**Support Material**
1.	1	Relational Model	

		• Introduction	T1:63-64
2	1	Structure	T1:64-71
3	1	Formal Query Language • Procedural query language	T1: 71 W1
4	1	• Non Procedural query language	W2
5	1	Relational Algebra • Select • Project • Cartesian product	T1: 71-86
6	1	• Rename • Union • Set intersection • Set difference	W2
7	1	• Assignment • division • Join ❖ Left ❖ Right ❖ Outer	W2
8	1	Tuple and Domain	T1: 86-90
9	1	Relational Calculus • Tuple relational calculus	T1: 90-92
10	1	• Domain relational calculus	T1:92-94
11	1	Recapitulation And Important Questions Discussion	
Total Number of Hours Planned for Unit – I			11 HOURS
Unit - III			
S. No.	**Lecture Duration (Hr)**	**Topics to be covered**	**Support Material**
1.	1	Structured Query Language	T1: 111-113
2	1	Basic Structure	T1: 113-120
3	1	Set Operations	T1:120-122
4	1	Aggregate Functions	T1:122-124
5	1	Date	W1

6	1	Numeric	W1
7	1	Character Functions	W1
8	1	Nested Sub queries	T1:125-129
9	1	Modification Of Databases	T1:131-136
10	1	Joined Relations	T1:136-146
11	1	DDL	T1:140-145
12	1	Embedded SQL.	T1: 145-148
13	1	Recapitulation And Important Questions Discussion	
Total Number of Hours Planned for Unit – I			13 HOURS
Unit – IV			
S. No.	**Lecture Duration (Hr)**	**Topics to be covered**	**Support Material**
1.	1	Relational Database Design	T1:215
2	1	Pitfalls	T1: 215-217
3	1	Normal forms	W1
4	1	Normalization Using Functional Dependencies	W2
5	1	First Normal Form	W1
6	1	Second Normal Form	W1
7	1	Third Normal Form	T1: 228-231
8	1	Fourth Normal Form	T1:235-236
9	1	BCNF	T1:237-238

10	1	Integrity rules	W2
11	1	Recapitulation And Important Questions Discussion	
Total Number of Hours Planned for Unit – I			11
Unit – V			
S. No.	**Lecture Duration (Hr)**	**Topics to be covered**	**Supporrt Material**
1.	1	Oracle • Introduction	R2:3-15
2	1	SQL • DDL, • DML • DCL (Commands)	R3: 184-186
3	1	Integrity Constraints	W3
4	1	PL/SQL	R3:227-235
5	1	PL/SQL Block	W3
6	1	procedure	W3
7	1	function	W2
8	1	Cursor management	W4
9	1	Triggers	W4
10	1	Exception Handling	W4
11	1	Recapitulation And Important Questions Discussion	
12	1	Previous ESE question paper discussion	
13	1	Previous ESE question paper discussion	
14	1	Previous ESE question paper discussion	
Total Number of Hours Planned for Unit – I			14 HOURS

Suggested Readings:

Text Book

1. Abraham Silber Sehatz, Henry F. Korth & S. Sudharasan. (2010) , *Database System Concepts*[6th Edition]. New Delhi, Tata McGraw Hill Mc Graw Hill Publication.

Reference Books

1. Singh. (2011) *Database systems: Concepts, Design & Applications*, [2nd Edition]. New Delhi, Pearson Education.
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3. Michael Abbey And Michael.J.Core.(2008). *Oracle- A Beginners guide* [4th Edition] New Delhi, Tata McGraw Hill.

Websites

1. www.tutorialspoint.com
2. www.w3schools.in
3. www.javatpoint.com/sql-tutorial
4. http://tutorialspointexamples.com/sql-tutorial-beginners/

UNIT I

SYLLABUS

Purpose of Database - Overall System Structure - Entity Relationship Model - Mapping Constraints - Keys - E-R Diagrams.

INTRODUCTION TO DATABASE SYSTEMS:

Data

- The raw facts are called as data.
- The word "raw" indicates that they have not been processed.

  Ex: For example 89 is the data.

Information

- The processed data is known as information.

  Ex: Marks: 89; then it becomes information.

Knowledge

- Knowledge refers to the practical use of information.
- Knowledge necessarily involves a experience.

DATA/INFORMATION PROCESSING:

The process of converting the data (raw facts) into meaningful information is called as data/information processing.

DIFFERENCE BETWEEN DATA AND INFORMATION:

S.No	DATA	INFORMATION
1	Raw facts	Processed data
2	It is in unorganized form	It is in organized form
3	Data doesn't helpin decision making process	Information helps in decision making process

DATABASE

- A database is a collection of inter-related data.
- A database is a collection of information that is organized so that it can be easily accessed, managed and updated.

For example,

Consider data of bank accounts. Here, all the data - id, name, address, and contact no - interrelated. So, they represent some particular customer.

Applications of Database Systems

The following are the various kinds of applications/organizations uses databases for their business processing activities in their day-to-day life.

They are:

1. Banking: For customer information, accounts, and loans, and banking transactions.
2. Airlines: For reservations and schedule information. Airlines were among the first to use databases in a geographically distributed manner—terminals situated around the world accessed the central database system through phone lines and other data networks.
3. Universities: For student information, course registrations, and grades.

4. Credit Card Transactions: For purchases on credit cards and generation of monthly statements.
5. Telecommunication: For keeping records of calls made, generating monthly bills, maintaining balances on prepaid calling cards, and storing information about the communication networks.
6. Finance: For storing information about holdings, sales, and purchases of financial instruments such as stocks and bonds.
7. Sales: For customer, product, and purchase information.
8. Manufacturing: For management of supply chain and for tracking production of items in factories, inventories of items in warehouses/stores, and orders for items.
9. Human resources: For information about employees, salaries, payroll taxes and benefits, and for generation of paychecks.
10. Railway Reservation Systems: For reservations and schedule information.
11. Web: For access the Back accounts and to get the balance amount.
12. E –Commerce: For Buying a book or music CD and browse for things like watches, mobiles from the Internet.

DATABASE MANAGEMENT SYSTEM

- A database management system (DBMS) is a collection of inter-related data and a set of programs to manipulate those data.
- Database management system (DBMS) stores data in such a way that it becomes easier to retrieve, manipulate, and produce information.
- Data manipulation consist various operation like store data, modify data, remove data, retrieve that data.

- So, DBMS = Database + Set of programs
- It also provides security or safety against system crashes.

Goals of DBMS

The primary goal of a DBMS is to provide a way to store and retrieve database information that is both convenient and efficient.

- Manage large bodies of information.
- Provide convenient and efficient ways to store and access information.
- Secure information against system failure or corrupt.
- Permit data to be shared among multiple users.

PURPOSE OF DATABASE SYSTEM

The typical file processing system is supported by a conventional operating system. Permanent records are stored in various files and a number of different application programs are written to extract records from and add records to the appropriate files.

DISADVANTAGES OF FILE PROCESSING SYSTEM:

The following are the disadvantages of File Processing System:

Data Redundancy:

- The same information may be duplicated in several places with different format. This redundancy leads to higher storage and access cost.
- Data Inconsistency:
- Because of data redundancy, it is possible that data may not be in consistent state.

Difficulty in Accessing Data:

- Accessing data is not convenient and efficient in file processing system.

Data Isolation Or Limited Data Sharing::

- Data are scattered in various files.
- Also different files may have different formats and these files may be stored in different folders may be of different departments.
- So, due to this data isolation, it is difficult to share data among different applications.

Integrity Problems:

- Data integrity means that the data contained in the database in both correct and consistent.
- For this purpose the data stored in database must satisfy correct and constraints.

Atomicity Problems:

- Any operation on database must be atomic.
- This means, it must happen in its entirely or not at all.

Concurrent Access Anomalies:

- Multiple users are allowed to access data simultaneously. This is for the sake of better performance and faster response.

Security Problems:

- Database should be accessible to users in limited way.
- Each user should be allowed to access data concerning his requirements only.

For Example

Consider part of a savings-bank enterprise that keeps information about all customers and savings accounts. One way to keep the information on a computer is to store it in operating system files. To allow users to manipulate the

information, the system has a number of application programs that manipulate the files, including:

- A program to debit or credit an account
- A program to add a new account
- A program to find the balance of an account
- A program to generate monthly statements

Programmers wrote these application programs to meet the needs of the bank. New application programs are added to the system as the need arises.

For example, suppose that the savings bank decides to offer checking accounts.

As a result, the bank creates new permanent files that contain information about all the checking accounts maintained in the bank, and it may have to write new application programs to deal with situations that do not arise in savings accounts, such as overdrafts.

Thus, as time goes by, the system acquires more files and more application programs.

The system stores permanent records in various files, and it needs different application programs to extract records from, and add records to, the appropriate files.

Before database management systems (DBMS) came along, organizations usually stored information in file-processing system.

Organizational information in a file-processing system has a number of major disadvantages:

Data Redundancy and Inconsistency:

The address and telephone number of a particular customer may appear in a file that consists of savings-account records and in a file that consists of checking-account records. This redundancy leads to higher storage and access cost. In, it

may lead to data inconsistency; that is, the various copies of the same data may no longer agree. For example, a changed customer address may be reflected in savings-account records but not elsewhere in the system.

Difficulty in Accessing Data:

Suppose that one of the bank officers needs to find out the names of all customers who live within a particular postal-code area. The officer asks the data-processing department to generate such a list. Because there is no application program to generate that. The bank officer has now two choices: either obtain the list of all customers and extract the needed information manually or ask a system programmer to write the necessary application program. Both alternatives are obviously unsatisfactory.

Data Isolation:

Because data are scattered in various files and files may be in different formats, writing new application programs to retrieve the appropriate data is difficult.

Integrity Problems:

The balance of a bank account may never fall below a prescribed amount (say, $25). Developers enforce these constraints in the system by adding appropriate code in the various application programs. However, when new constraints are added, it is difficult to change the programs to enforce them. The problem is compounded when constraints involve several data items from different files.

Atomicity Problems:

A computer system, like any other mechanical or electrical device, is subject to failure. In many applications, it is crucial that, if a failure occurs, the data be restored to the consistent state that existed prior to the failure. Consider a

program to transfer $50 from account A to account B. If a system failure occurs during the execution of the program, it is possible that the
$50 was removed from account A but was not credited to account B, resulting in an inconsistent database state. Clearly, it is essential to database consistency that either both the credit and debit occur, or that neither occur. That is, the funds transfer must be atomic—it must happen in its entirety or not at all. It is difficult to ensure atomicity in a conventional file-processing system.

Concurrent-Access Anomalies:

For the sake of overall performance of the system and faster response, many systems allow multiple users to update the data simultaneously. In such an environment, interaction of concurrent updates may result in inconsistent data. Consider bank account A, containing $500. If two customers withdraw funds (say $50 and $100 respectively) from account A at about the same time, the result of the concurrent executions may leave the account in an incorrect (or inconsistent) state. Suppose that the programs executing on behalf of each withdrawal read the old balance, reduce that value by the amount being withdrawn, and write the result back. If the two programs run concurrently, they may both read the value $500, and write back $450 and$400, respectively. Depending on which one writes the value last, the account may contain $450 or $400, rather than the correct value of $350. To guard against this possibility, the system must maintain some form of supervision. But supervision is difficult to provide because data may be accessed by many different application programs that have not been coordinated previously.

Security Problems:

Not every user of the database system should be able to access all the data. For example, in a banking system, payroll personnel need to see only that part of the

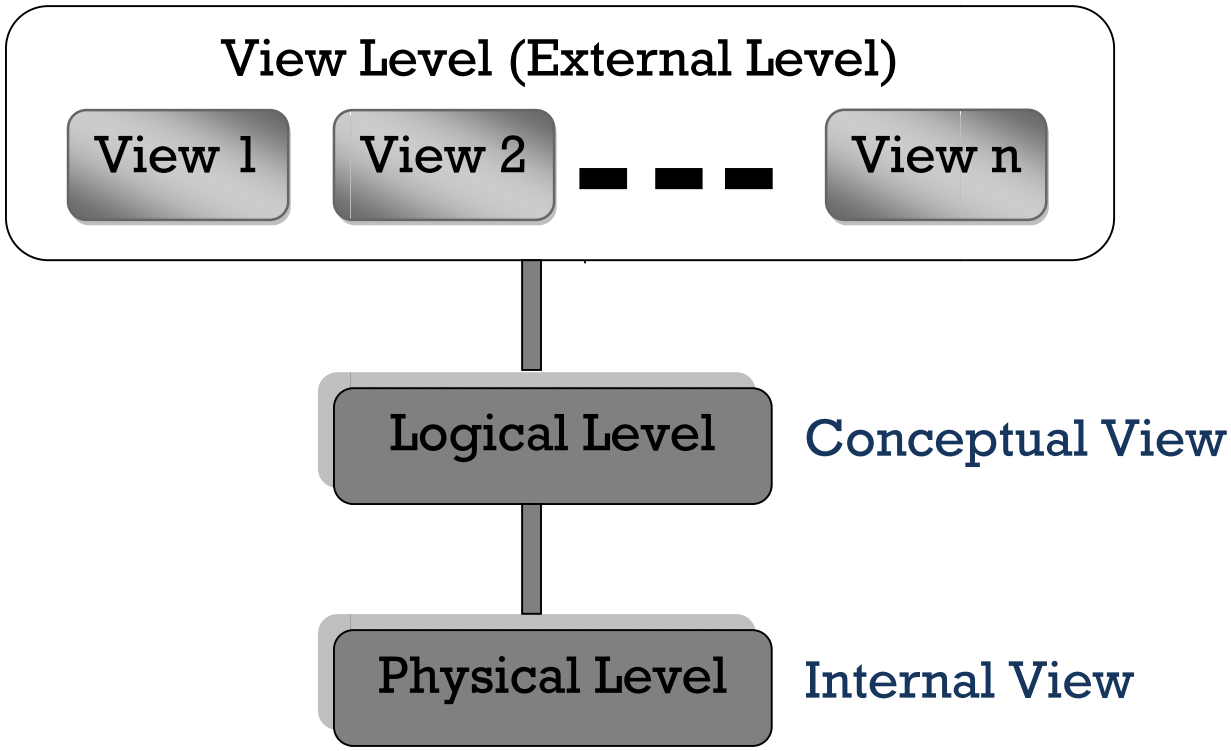
database that has information about the various bank employees. They do not need access to information about customer accounts. But, since application programs are added to the system in an ad hoc manner, enforcing such security constraints is difficult. These difficulties, among others, prompted the development of database systems.

VIEW OF DATA

- A DBMS is a collection of interrelated files and a set of programs that allow users to access and modify these files.
- A major purpose of a database system is to provide users with an abstract view of the data.
- i.e., the system hides certain details of how the data are stored and maintained.
- To understand the view of data, we must have a basic knowledge of
  i) Data Abstraction and ii) Instance & Schema.

Data Abstraction

- The major purpose of a database system is to provide users with an **abstract view** of the system.
- The system hides certain details of how data is stored and created and maintained
- Complexity should be hidden from database users.



1. Physical Level or Internal View:

- This is the lowest level of data abstraction.
- It describes how the data (e.g., Customer) are actually stored on storage devices (for example words or bytes).
- It is also known as physical level.
- It provides internal view of physical storage of data.
- It deals with complex low level data structures, file structures and access methods in detail.
- It also deals with Data Compression and Encryption techniques, if used.

2. Logical Level or Conceptual View:

- This is the next higher level than internal level of data abstraction.
- It describes what data are stored in the database and what relationships exist among those data.

```
type customer = record
    name : string; street : string; city
    : integer;
end;
```

- It is also known as logical level.
- It hides low level complexities of physical storage.
- Database administrator and designers work at this level to determine what data to keep in database.
- Application developers also work on this level.

3. View Level or External Level:

- This is the highest level of data abstraction.
- It describes only part of the entire database that an end user concern.
- It is also known as a view level.
- End users need to access only part of the database rather than entire database.
- Different user needs different views of database. And so, there can be many view level abstractions of the same database.

  For example, tellers in a bank see only part of the information on customer accounts; they cannot access information concerning salaries of employees.

Instances and Schemas

- Schema – the logical structure of the database (e.g., set of customers and accounts and the relationship between them)
- Instance: The collection of information stored in the database at a particular moment.

The difference between Schema and Instance are given in below table.

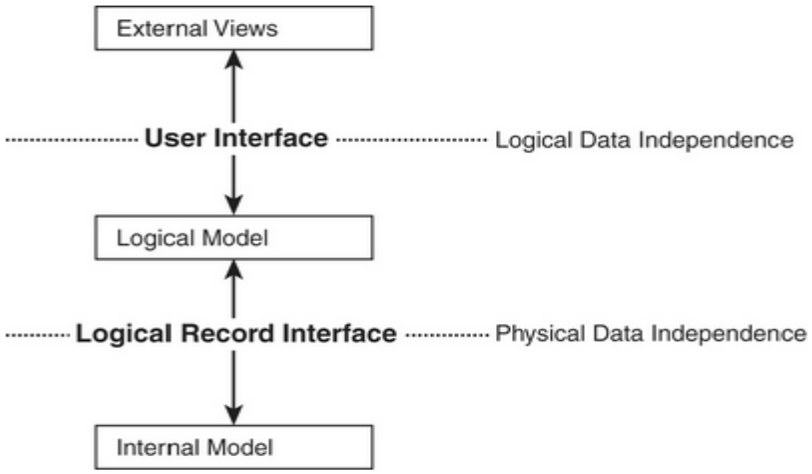
	Schema	**Instance**
Definition	The overall logical design of the database.	The collection of information stored in the database at a particular moment.
Includes	Table names, column names, data types, and size of columns, various constraint at logical level.	Actual data or information stored in tables in form of different records.
Change	Changes infrequently.	Changes frequently.
Cause of change	Insertion of tables or columns and change in datatype,size or constraints on any column.	insert, delete or update operation on data stored in database.
Analogy	variable declaration	value of the variable

Data Independence

- Data independence is ability to modify a schema definition in one level without affecting a schema definition in the next higher level.

There are two levels of data independence:

1. Physical Data Independence
2. Logical Data Independence



Physical Data Independence

- It is the ability to modify the physical schema without requiring any change in application programs.
- Modifications at the internal levels are occasionally necessary to improve performance.
- Possible modifications at internal levels are change in file structures, compression techniques, hashing algorithms, storage devices, etc.
- Physical data independence separates conceptual levels from the internal levels.
- This allows providing a logical description of the database without the need to specify physical structures.
- Comparatively, it is easy to achieve physical data independence.

Logical Data Independence

- It is ability to modify the conceptual schema without requiring any change in application programs.
- Modifications at the logical levels are necessary whenever the logical structure of the database is altered.
- Logical data independence separates external level from the conceptual

view.

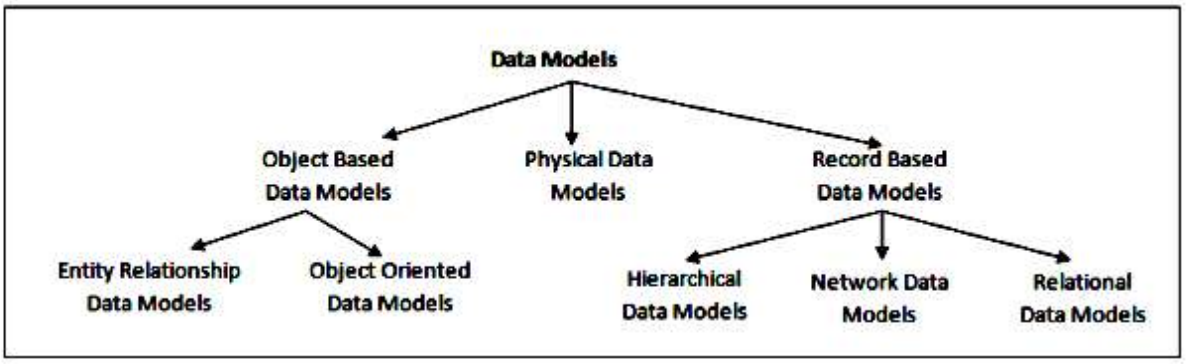
- Comparatively it is difficult to achieve logical data independence.
- Application programs are heavily dependent on logical structures of the data they access. So any change in logical structure also requires programs to change.

Difference between Logical Data Independence & Physical Data Independence

Logical Data Independence	**Physical Data Independence**
It is concerned with the structure of the data or changing the data definition.	It is concerned with storage of the data.
It is very difficult as the retrieving of data are heavily dependent on logical	It is easy to retrieve.
Application program need not be changed if new fields are added or deleted from the database.	Physical database is concerned with the change of the storage device.
It is concerned with the conceptual schema.	It is concerned with the internal schema.

DATA MODELS

- The structure of the database is called the data models.
- A Collection of conceptual tools for describing data, data relationship, data semantic and consistency constraint.



Object based Data Models

- It is designed using the entities in the real world, attributes of each entity and their relationship.
- It picks up each thing/object in the real world which is involved in the requirement.

There are two types of object based data Models

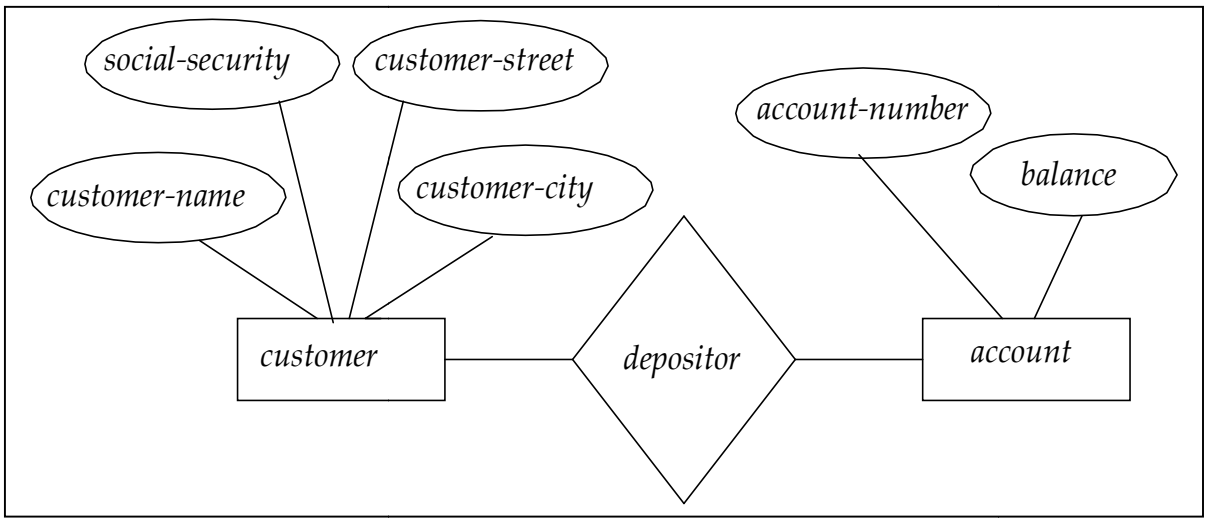
- Entity Relationship Model
- Object oriented data model.

ER data model is one of the important data model which forms the basis for the all the designs in the database world. It defines the mapping between the entities in the database. Object oriented data model, along with the mapping between the entities, describes the state of each entity and the tasks performed by them.

Entity-Relationship Model

- The entity-relationship model is based on a perception of the world as consisting of a collection of basic objects (entities) and relationships among these objects.
- An entity is a distinguishable object that exists.
- Each entity has associated with it a set of attributes describing it.

- E.g. number and balance for an account entity.
- A relationship is an association among several entities.
- E.g. depositor relationship associates a customer with each account he or she has.
- The set of all entities or relationships of the same type is called the entity set or relationship set.
- Another essential element of the E-R diagram is the mapping cardinalities, which express the number of entities to which another entity can be associated via a relationship set.
- The overall logical structure of a database can be expressed graphically by an E-R diagram:
  - Rectangles: represent entity sets.
  - Ellipses: represent attributes.
  - Diamonds: represent relationships among entity sets.
  - Lines: link attributes to entity sets and entity sets to relationships.

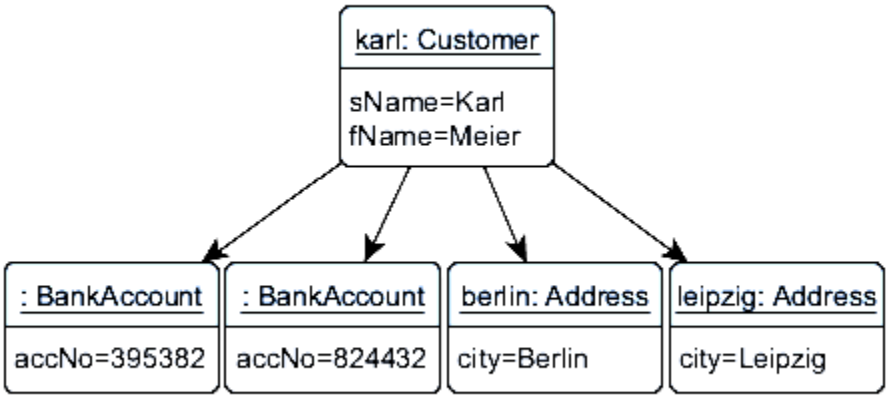


Object-Oriented Database Model

- In the object oriented data model the (OODM). Both data and their relationship are contained in a single structure known us an object.
- An object includes information about relationship between the facts within the object, as well as information about its relationship with other objects.
- It is said to be "SEMANTIC DATA MODEL"

Object Oriented Data model components

- An object is the abstraction of the real- world entity. An object represents only one occurrence of entity.
- Attributes describe the property of an object.
- Objects that are similar in characteristics are grouped in class.
- **Class:** is a collection of similar objects with shared structure (attributes) and behavior (method)
- **Method**: represents a real word action such as finding a selected person's name, changing person's name or printing a person's address.
- Classes are organized in class hierarchy. The class hierarchy resembles an upside down tree in which each class has only one parent.
- Inheritance is the ability of an object within the class hierarchy to inherit the attributes and methods of the class.



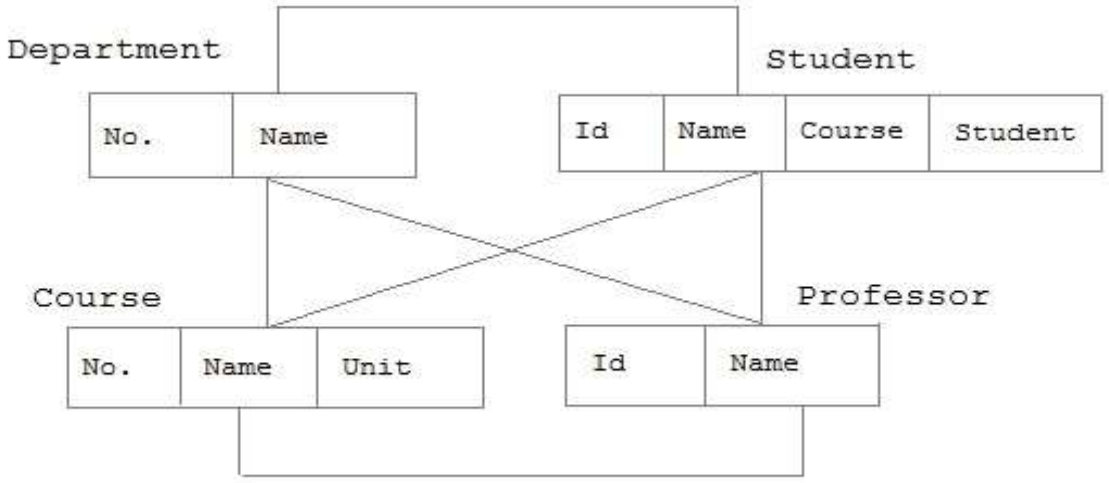
Relational Model

- The relational model uses a collection of tables to represent both data and the relationships among those data.
- Each table has multiple columns, and each column has unique name.

Customer name	Social security	Customer street	Customer city	Account number
Johnson	192-83-7465	Alma	Palo Alto	A-101
Smith	019-28-3746	North	Rye	A-215
Johnson	192-83-7465	Alma	Palo Alto	A-201
Jones	321-12-3123	Main	Harrison	A-217
Smith	019-28-3746	North	Rye	A-201

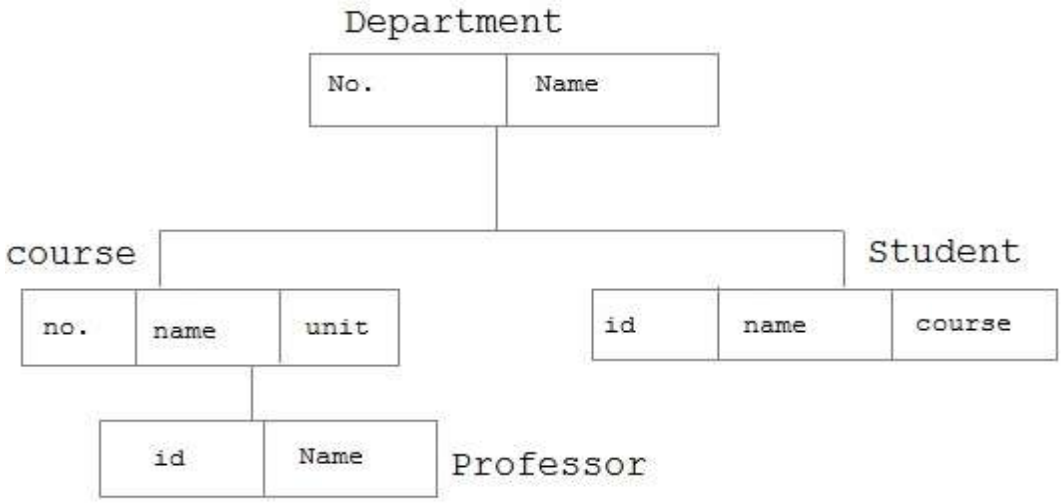
Network Model

- Data are represented by collections of records.
- Relationships among data are represented by links.
- Organization is that of an arbitrary graph.



Hierarchical Model

- In hierarchical model the data and relationships among the data are represented by records and links.
- It is same as network model but differs in terms of organization of records as collections of trees rather than graphs.



DBMS Languages

- A Database system provides two different types of languages one to specify the database schema and other to express database queries and updates.

Data-Definition Languages

- Specification notation for defining the database schema
- DDL compiler generates a set of tables stored in a *data dictionary*
- Data dictionary contains metadata (i.e., data about data)
- *Data storage and definition* language – special type of DDL in which the storage structure and access methods used by the database system are specified.

Data Manipulation Language

- Data Manipulation is:
  - Retrieval of information from the database
  - Insertion of new information into the database
  - Deletion of information in the database
  - Modification of information in the database
- A DML is a language which enables users to access and manipulate data.
- The goal is to provide efficient human interaction with the system.

There are two types of DML:

- procedural: the user specifies what data is needed and how to get it
- nonprocedural: the user only specifies what data is needed
  - Easier for user.
  - May not generate code as efficient as that produced by procedural languages.
- A query language is a portion of a DML involving information retrieval only. The terms DML and query language are often used synonymously.

COMPONENTS OF DBMS

- Basic Components: A database system has four components.
- These four components are important for understanding and designing the database system.

These are:

1. Data
2. Hardware
3. Software
4. Users

1. Data

- Data is raw hand information collected by us.
- It may consist of bits or bytes.
- A Data item is often referred to as field or data element.
- A Data aggregate is the collection of data items within the record, which is given a name and referred as a whole.
- Data can be collected orally or written.
- A database can be integrated and shared.

2. Hardware

- Hardware is also a major and primary part of the database.
- Without hardware nothing can be done

3. Software

- Software is another major part of the database system.
- Software is a system. Software is further subdivided into two categories.
- First type is system software (like all the operating systems, all the languages and system packages etc.)
- Second is application software (payroll, electricity billing, hospital management and hostel administration etc.).

- By using software, data can be manipulated, organized and stored.

4. Users

- User can collect the data, operate and handle the hardware.
- Also operator feeds the data and arranges the data in order by executing the software.

TRANSACTION MANAGEMENT

- A *transaction* is a collection of operations that performs a single logical function in a database application.
- Transaction-management component ensures that the database remains in a consistent (correct) state despite system failures (e.g. power failures and operating system crashes) and transaction failures.
- Concurrency-control manager controls the interaction among the concurrent transactions, to ensure the consistency of the database.

STORAGE MANAGEMENT

- A storage manager is a program module that provides the interface between the low-level data stored in the database and the application programs and queries submitted to the system.
- The storage manager is responsible for the following tasks:
  - interaction with the file manager
  - efficient storing, retrieving, and updating of data

DATABASE ADMINISTRATOR

- The database administrator is a person having central control over data and programs accessing that data.
- Functions of the database administrator include:

- **Scheme definition**: the creation of the original database scheme. This involves writing a set of definitions in a DDL (data storage and definition language), compiled by the DDL compiler into a set of tables stored in the data dictionary.
- **Storage structure and access method definition**: writing a set of definitions translated by the data storage and definition language compiler.
- **Scheme and physical organization modification:** writing a set of definitions used by the DDL compiler to generate modifications to appropriate internal system tables (e.g. data dictionary). This is done rarely, but sometimes the database scheme or physical organization must be modified.
- **Granting of authorization for data access:** granting different types of authorization for data access to various users
- **Integrity constraint specification:** generating integrity constraints. These are consulted by the database manager module whenever updates occur.

DATABASE USERS

The database users fall into several categories:

- **Application programmers** are computer professionals interacting with the system through DML calls embedded in a program written in a host language (e.g. C, PL/1, Pascal).
  - These programs are called application programs.
  - The DML precompiler converts DML calls (prefaced by a special character like $, #, etc.) to normal procedure calls in a host language.
  - The host language compiler then generates the object code.
  - Some special types of programming languages combine Pascal-like

control structures with control structures for the manipulation of a database.

- ❖ These are sometimes called fourth-generation languages.
- ❖ They often include features to help generate forms and display data.

- **Sophisticated users** interact with the system without writing programs.
  - ❖ They form requests by writing queries in a database query language.
  - ❖ These are submitted to a query processor that breaks a DML statement down into instructions for the database manager module.
- **Specialized users** are sophisticated users writing special database application programs. These may be CADD systems, knowledge-based and expert systems, complex data systems (audio/video), etc.
- **Naive users** are unsophisticated users who interact with the system by using permanent application programs (e.g. automated teller machine).

Overall System Structure

Components of DBMS are broadly classified as follows:

1. Query Processor Components:

- DML Pre-compiler: It translates DML statements in a query language into low level instructions that query evaluation engine understand. It also attempts to transform user's request into an equivalent but more efficient form.
- Embedded DML Pre-compiler: It converts DML statements embedded in an application program to normal procedure calls in the host language. The Pre-compiler must interact with the DML compiler to generate the appropriate code.
- DDL Interpreter: It interprets the DDL statements and records them in a set of tables containing metadata or data dictionary.
- Query Evaluation Engine: It executes low-level instructions generated by

the DML compiler.

2. Storage Manager Components:

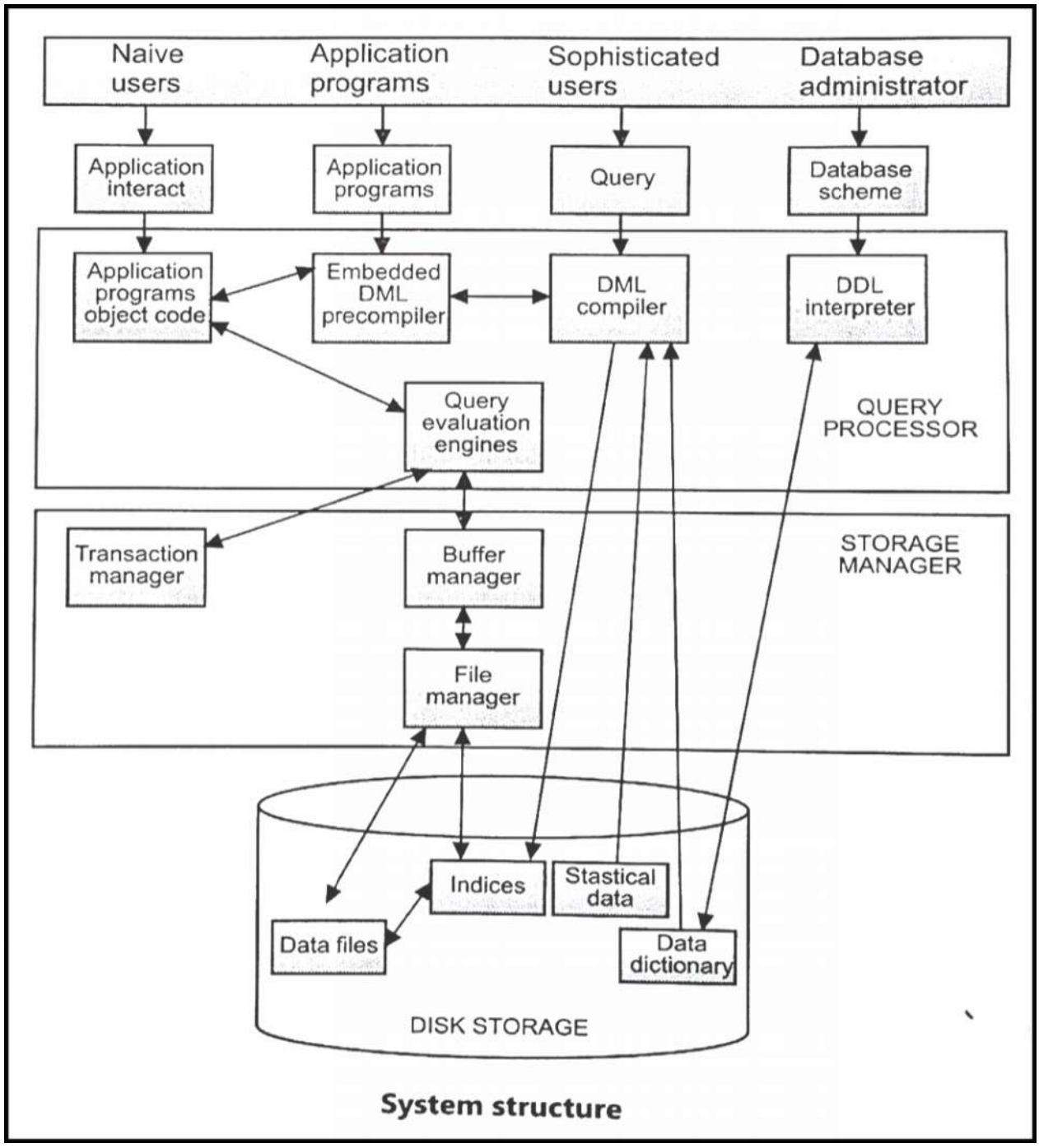
They provide the interface between the low-level data stored in the database and application programs and queries submitted to the system.

- Authorization and Integrity Manager: It tests for the satisfaction of integrity constraints checks the authority of users to access data.
- Transaction Manager: It ensures that the database remains in a consistent state despite the system failures and that concurrent transaction execution proceeds without conflicting.
- File Manager: It manages the allocation of space on disk storage and the data structures used to represent information stored on disk.
- Buffer Manager: It is responsible for fetching data from disk storage into main memory and deciding what data to cache in memory.

3. Data Structures:

Following data structures are required as a part of the physical system implementation.

- Data Files: It stores the database.
- Data Dictionary: It stores meta data (data about data) about the structure of the database.
- Indices: Provide fast access to data items that hold particular values.
- Statistical Data: It stores statistical information about the data in the database. This information is used by query processor to select efficient ways to execute query.



System structure

THE ENTITY-RELATIONSHIP MODEL

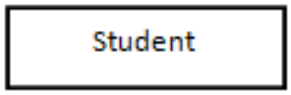
- The E-R (entity-relationship) data model views the real world as a set of basic objects (entities) and relationships among these objects.

Entities and Entity Sets

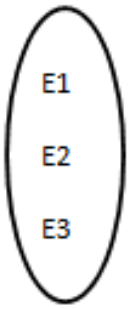
- An entity is an object that exists and is distinguishable from other objects.

  For example: specific person, company, event, plant
- An entity set is a set of entities of the same type.

  For example: set of all persons, companies, trees, holidays
- In ER diagram, Entity and Entity Set is represented as:



Entity Type



Entity Set

- An entity is represented by a set of attributes, that is, descriptive properties possessed by all members of an entity set.

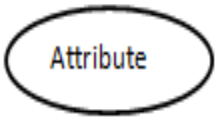
  For example:

  (Entity) customer = **attributes are** (customer-name, social-security,

customer-street, customer-city)

(Entity) account = **attributes are** (account-number, balance)

- In ER diagram, attribute is represented by an oval.



- Domain – the set of permitted values for each attribute (e.g. the telephone number must be seven positive integers).
- A domain is defined as the set of all unique values permitted for an attribute.
- Each table has certain set of columns and each column allows a same type of data, based on its data type. The column does not accept values of any other data type.
- For example, a domain of date is the set of all possible valid dates, a domain of integer is all possible whole numbers, a domain of day-of-week is Monday, Tuesday ... Sunday.

Types of Attributes

The different types of attributes are as follows

- Single valued attributes
- Multi valued attributes
- Compound /Composite attributes
- Simple / Atomic attributes
- Stored attributes
- Derived attributes
- Complex attributes
- Key attributes

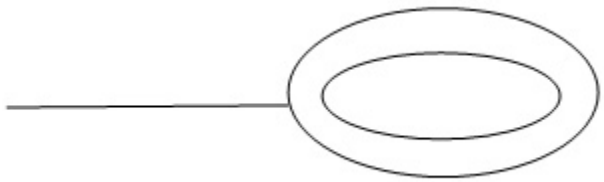
- Non key attributes
- Required attributes
- Optional/ null value attributes

Single Valued Attributes: It is an attribute with only one value.

- Example: Any manufactured product can have only one serial no. , but the single valued attribute cannot be simple valued attribute because it can be subdivided. Likewise in the above example the serial no. can be subdivided on the basis of region, part no. etc.

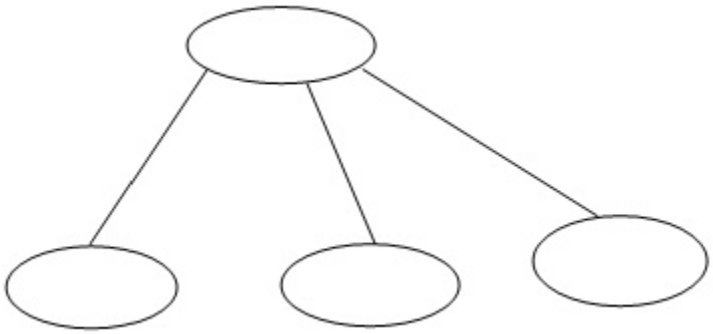
Multi Valued Attributes: These are the attributes which can have multiple values for a single or same entity.

- Example: Car's colors can be divided into many colors like for roof, trim.
- The notation for multi valued attribute is:

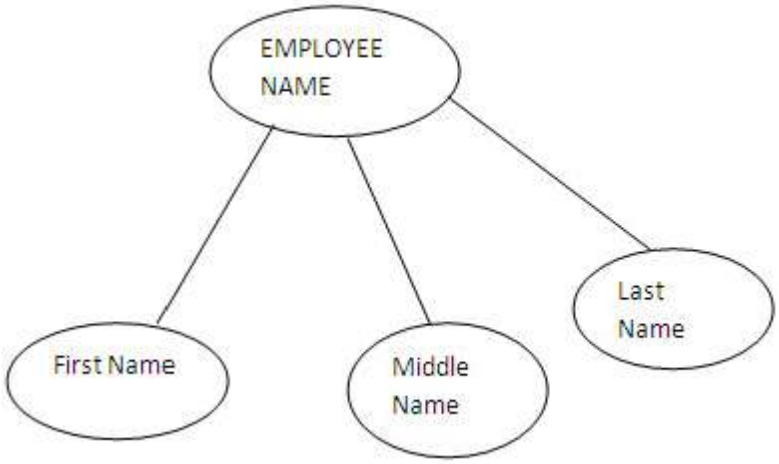


Compound / Composite attributes: This attribute can be further divided into more attributes.

- The notation for it is:



- Example: Entity Employee Name can be divided into sub divisions like FName, MName, LName.



Simple / Atomic Attributes: The attributes which cannot be further divided are called as simple / atomic attributes.

- Example: The entities like age, marital status cannot be subdivided and are simple attributes.

Stored Attributes: Attribute that cannot be derived from other attributes are called as stored attributes.

- Example: Birth date of an employee is a stored attribute.

Derived Attributes: These attributes are derived from other attributes. It can be derived from multiple attributes and also from a separate table.

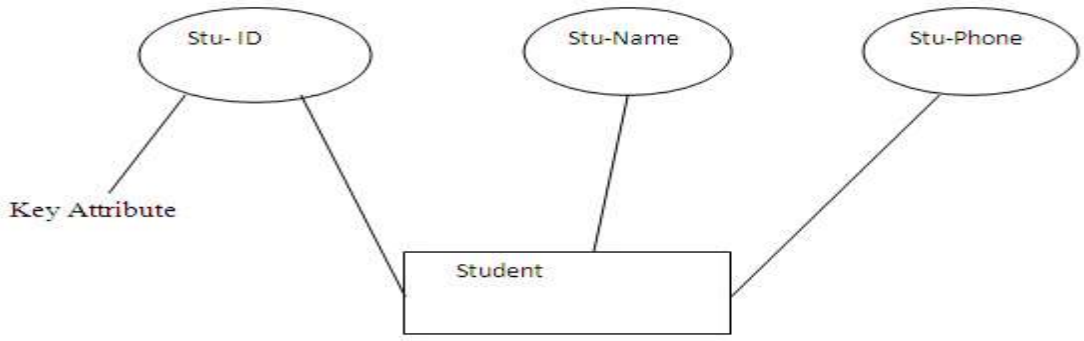
- Example: Today's date and age can be derived. Age can be derived by the difference between current date and date of birth.
- The notation for the derived attribute is:

Complex Attributes: For an entity, if an attribute is made using the multi valued attributes and composite attributes then it is known as complex attributes.

- Example: A person can have more than one residence; each residence can have more than one phone.

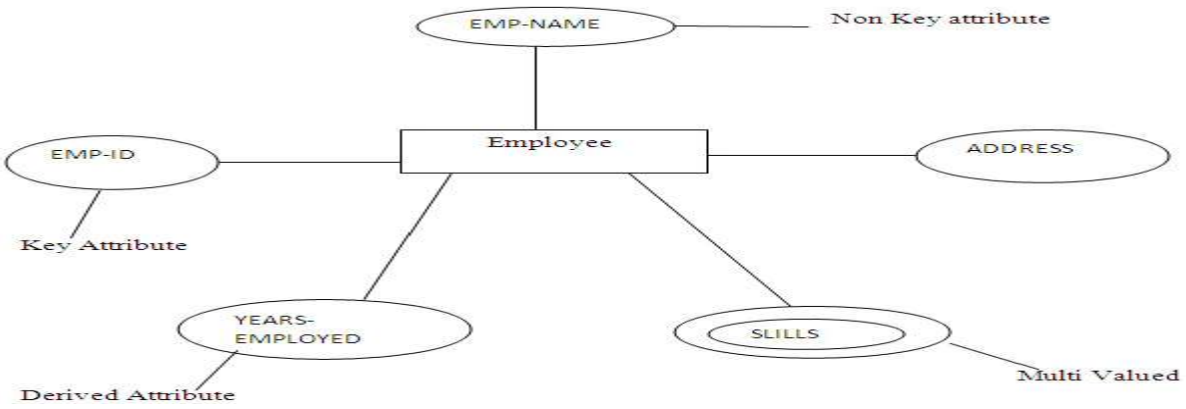
Key Attributes: This attribute represents the main characteristic of an entity i.e. primary key. Key attribute has clearly different value for each element in an entity set.

- Example: The entity student ID is a key attribute because no other student will have the same ID.



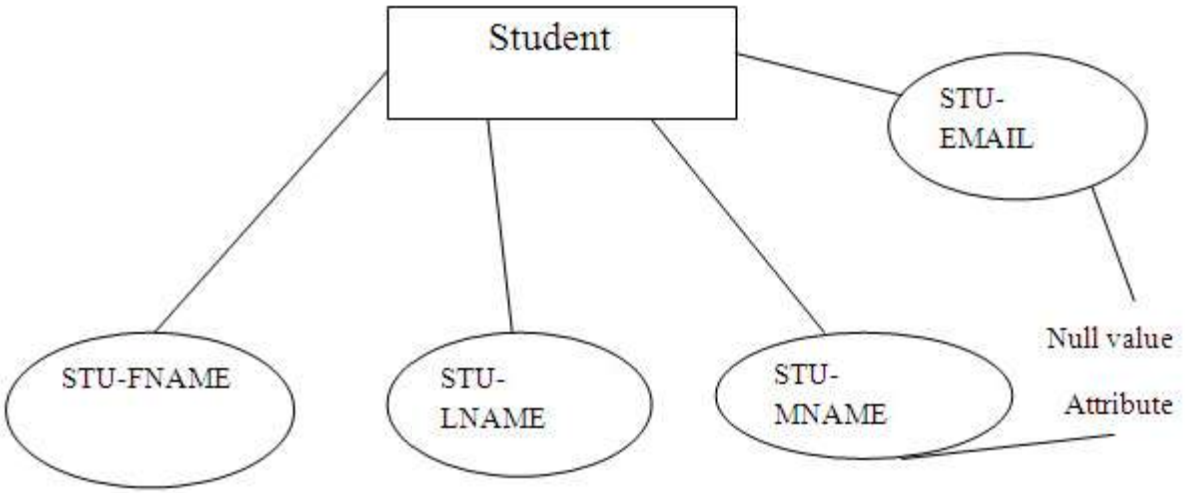
Non- Key Attributes: Excluding the candidate key attributes in an entity set are the non key attributes.

- Example: First name of a student or employee is a non-key attribute as it does not represent main characteristic of an entity.



Optional / Null value Attributes: It does not have a value and can be left blank, it's optional can be filled or cannot be.

- Example: Considering the entity student there the student's middle name and the email ID is optional.



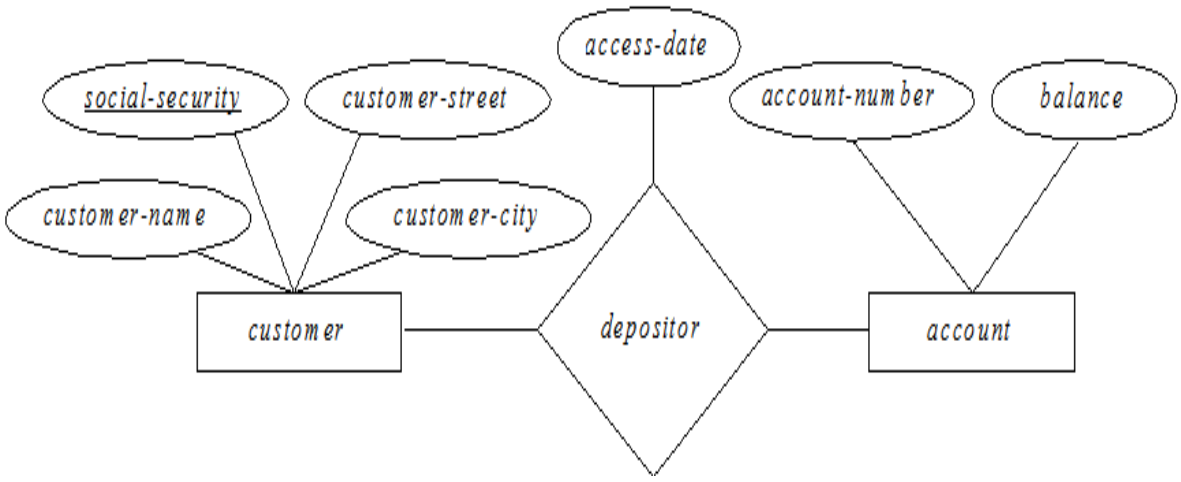
Relationship Sets

- A relationship is an association among several entities.
- A *relationship* set is a mathematical relation among $n \geq 2$ entities, each taken from entity sets

$$\{(e_1, e_2, \ldots e_n) \mid e_1 \in E_1, e_2 \in E_2, \ldots, e_n \in E_n\}$$

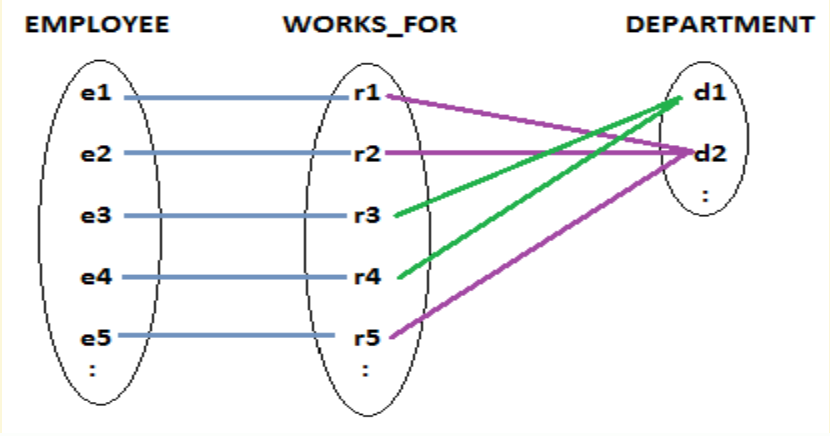
where $(e_1, e_2, \ldots, e_n)$ is a relationship.

- An *attribute* can also be a property of a relationship set.
  - For instance, the *depositor* relationship set between entity sets.
  - *customer* and *account* may have the attribute *access-date.*

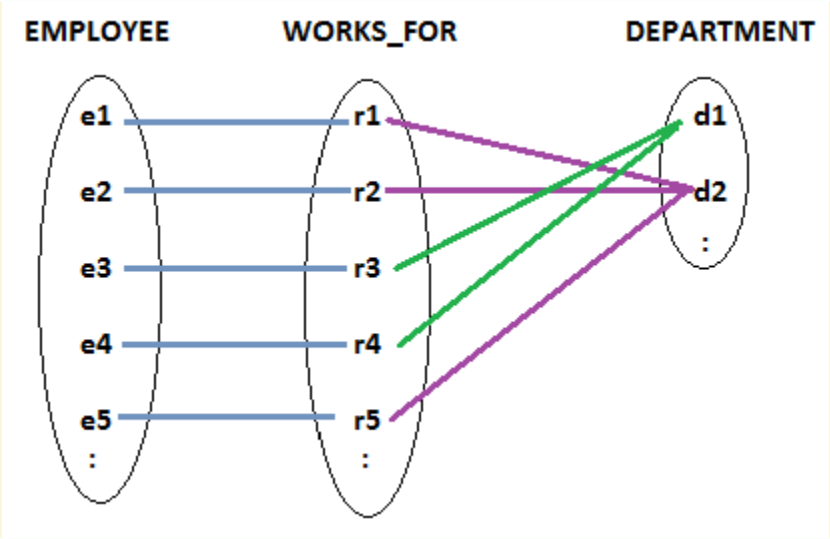


Degree of Relationship Sets

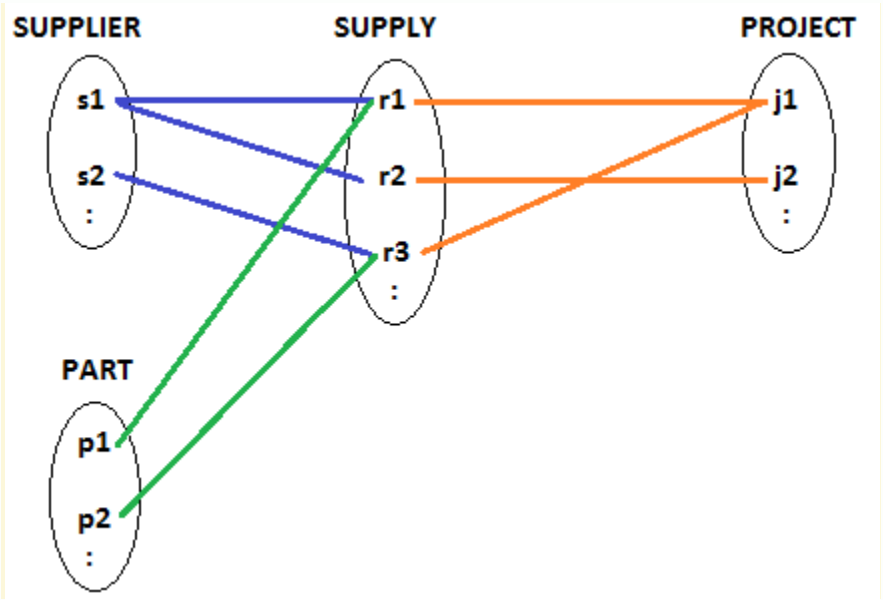
- Refers to number of entity sets that participate in a relationship set.
- Relationship sets that involve two entity sets are binary (or degree two). Generally, most relationship sets in a database system are binary.
- Relationship sets may involve more than two entity sets. The entity sets customer, loan, and branch may be linked by the ternary (degree three) relationship set CLB.



- In the above figure, each instance of relation type WORKS_FOR i.e.(r1, r2,…,r5) is connected to instances of employee and department entities. Employee e1, e2 and e5 work for department d2 and employee e3 and e4 work for department d1.
- **Binary Relationship** – A relationship type of degree two is called binary relationship. The WORKS_FOR in above figure is a binary relationship as there are two participating entities-employee and department

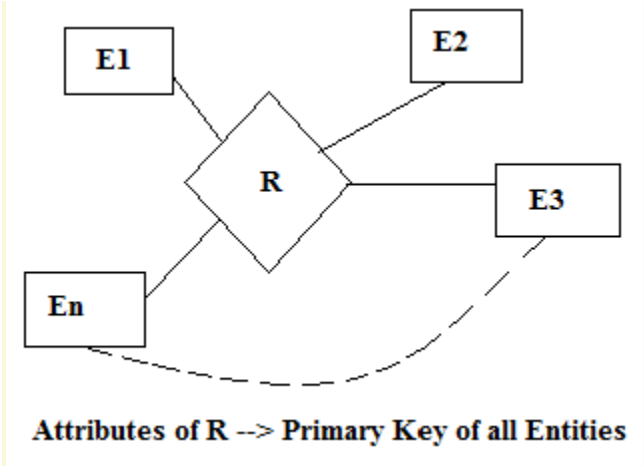


- **Ternary Relationship-** A relationship type of degree three is a ternary relationship for example, in the below figure **supply** relationship connects three entities SUPPLIER, PART AND PROJECT.



The above diagram can be read as – a supplier supplies the parts to projects

- **N-ary Relationship Set –** A relationship type of degree n is called n ary relationship . For example



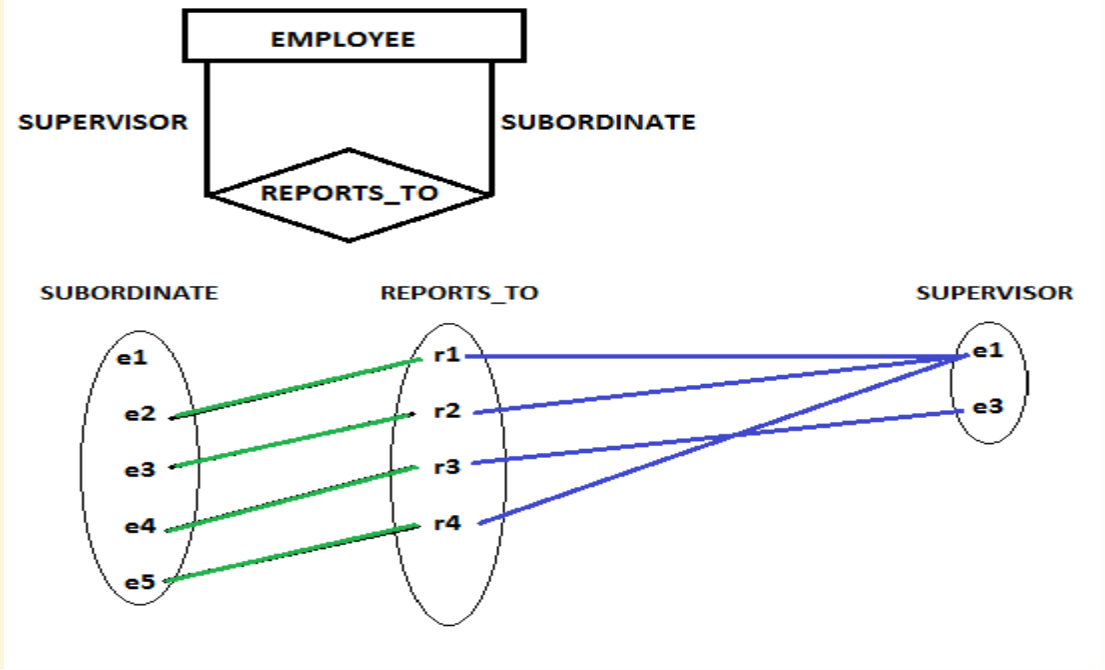
Role Names-

A relationship type has a name which signifies what role a participating entity plays in that relationship instance. The role names helps to explain what the relationship means.

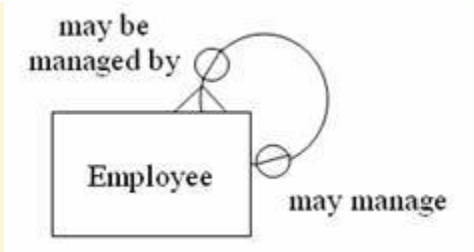
In the first example WORKS_FOR relationship type, employee plays the role of worker and department plays the role of employee(because a department consists of a number of employees.

Recursive Relationship

If the same entity type participate more than once in a relationship type in different roles then such relationship types are called recursive relationship. For example, in the below figure REPORTS_TO is a recursive relationship as the Employee entity type plays two roles – 1) Supervisor and 2) Subordinate.



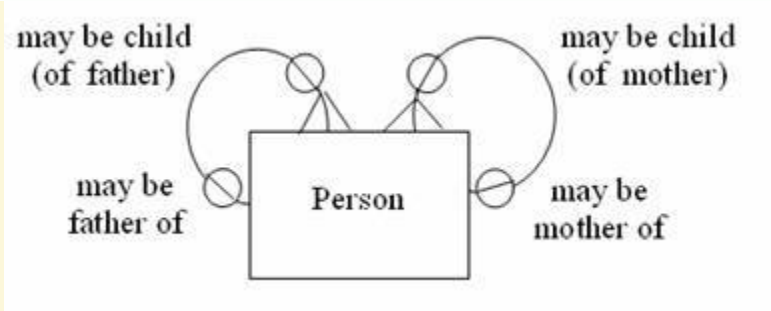
we can also define the above example of recursive relationship as the relationship between a manager and an employee. An employee is a manager as well as employee.



This is commonly known as a 'pig's ear'.

To implement recursive relationship, a foreign key of the employee's manager number would be held in each employee record.

Relationship between a person and their parents :



Mapping Cardinality-

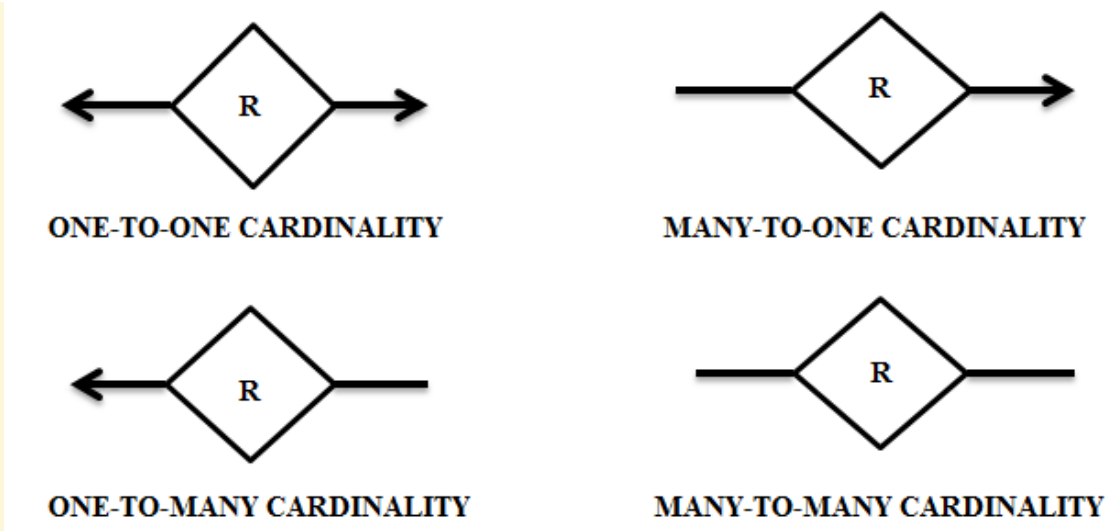
Cardinality expresses the number of entities to which another entity can be associated via a relationship set (or)It specifies the number of relationship instances that an entity can participate in a relation set.

There are 4 types of Cardinality Ratios :

- **One-to-One Cardinality (1:1)**
- **One-to-Many Cardinality (1:m)**

- **Many-to-One Cardinality (m:1)**
- **Many-to-Many Cardinality (m:n)**

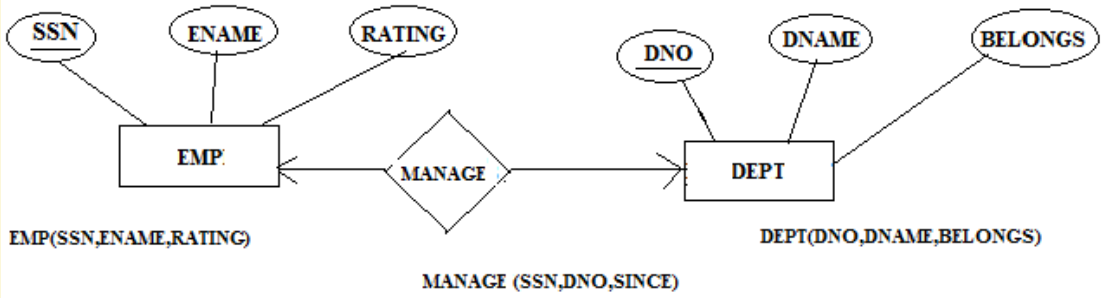
Notations of Different Types of Cardinality In ER Diagram –



One-to-One Cardinality (1:1) –

An entity in set A is associated with atmost one entity in B, and an entity in B is associated with atmost one entity in A. This type of cardinality is referred as one to one Cardinality.

For example, an Employee as a Manager manage only one Department and the vice versa is also true as a department have only one Manager.



Relational Tables -

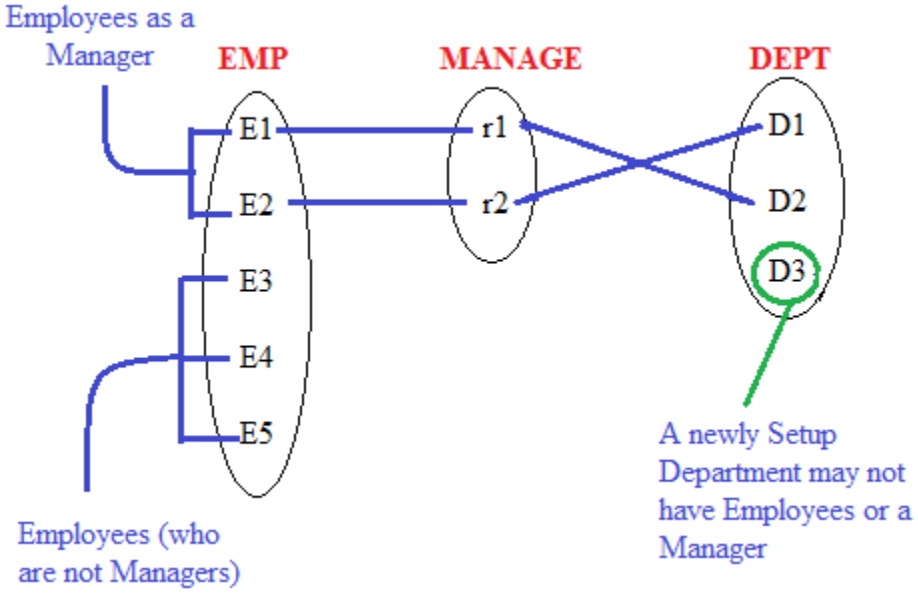
SSN	ENAME	RATING
E1		
E2		
E3		
E4		

SSN	DNO
E1	D2
E2	D1
E2	D2

(NOT POSSIBLE)

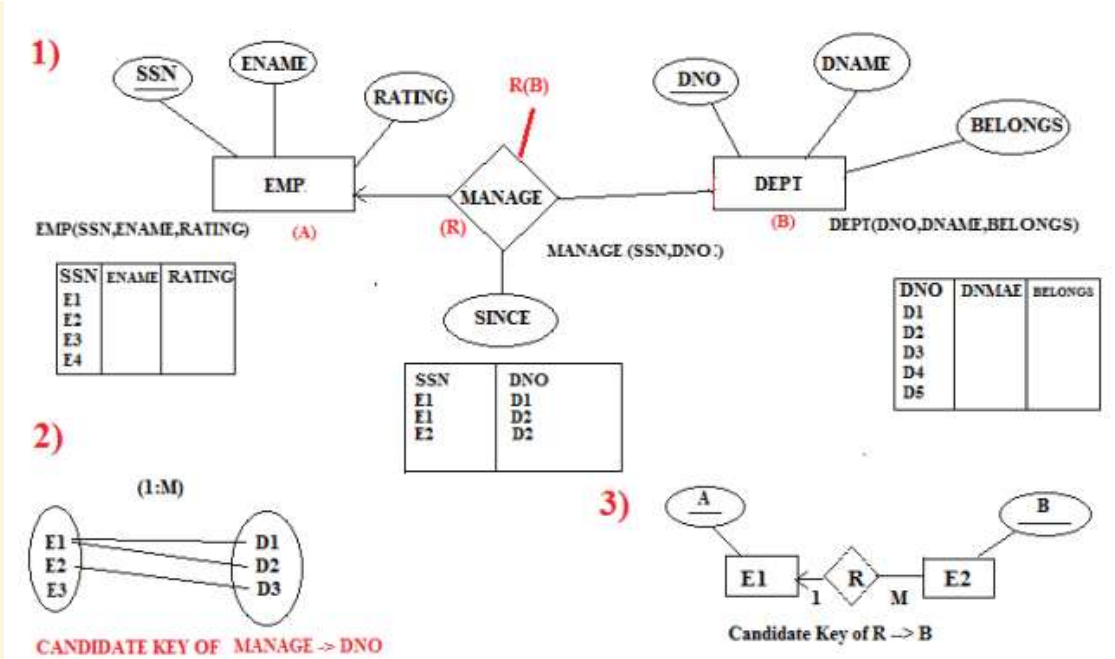
AS A MANAGER CAN MANAGE ONLY ONE DEPARTMENT

DNO	DNMAE	BELONGS
D1		
D2		
D3		
D4		
D5		



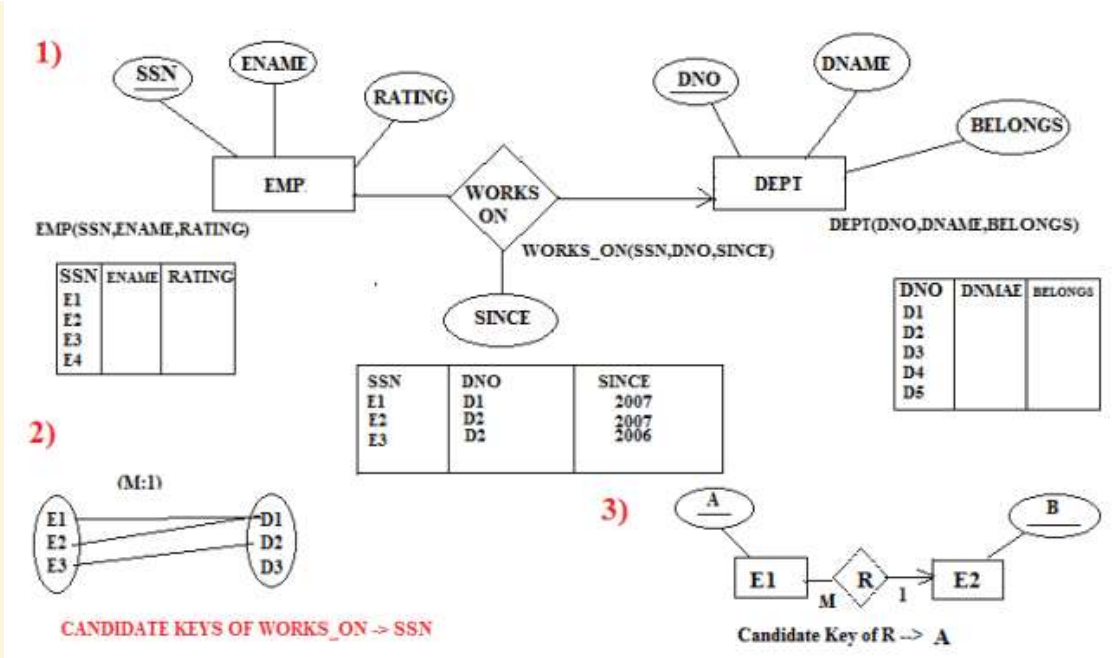
One to Many Cardinality (1:M) –

An entity in A is associated with any number (0 or more) with an entity B, but a entity in B, however can be associated with atmost one entity in A. For example, An employee as a Manager can manage more than one Department.



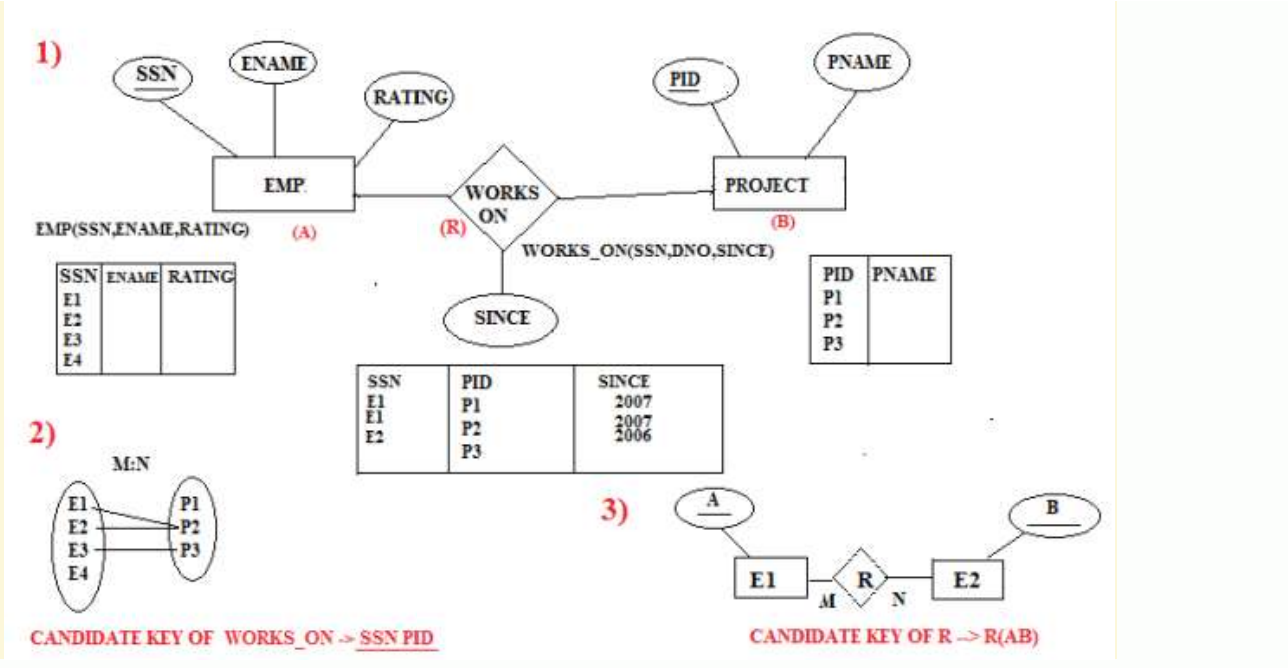
Many to One Cardinality (M:1) –

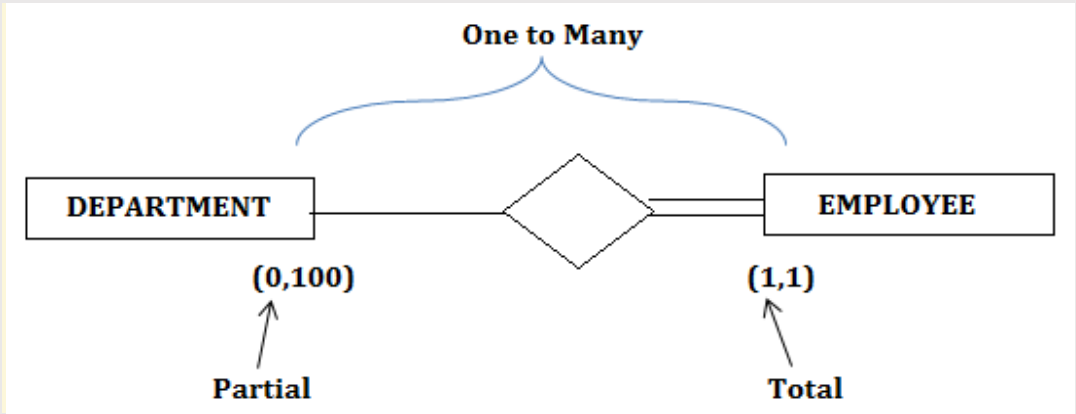
- An entity in A is associated with atmost one entity in B.
- An entity in B, however, can be associated with any number (0 or more) of entities in A.
- For example, An Employee can work only for one Department, But each Department can have 0 or more employees.



Many to Many Cardinality (M:N) –

- An entity in A is associated with any number (0 or more) of entities in B, and an entity in B is associated with any number(0 or more) of entities in A.
- For example, An Employee can works on several Projects and a Project may have several Employees.





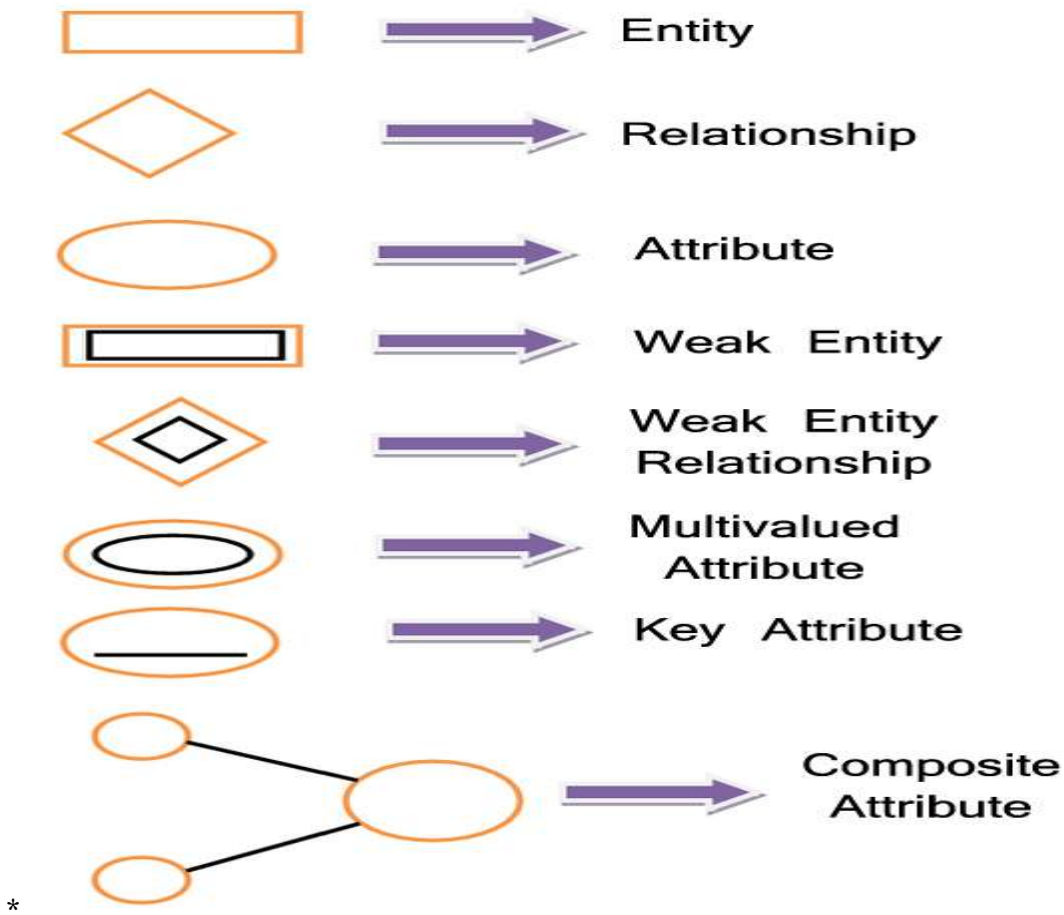
E-R Diagrams in DBMS: Components, Symbols, and Notations

E-R diagrams are used to model real-world objects like a person, a car, a company etc. and the relation between these real-world objects.

An e-r diagram has following features:

- E-R diagrams are used to represent E-R model in a database, which makes them easy to be converted into relations (tables).
- E-R diagrams provide the purpose of real-world modeling of objects which makes them intently useful.
- E-R diagrams require no technical knowledge & no hardware support.
- These diagrams are very easy to understand and easy to create even by a naive user.
- It gives a standard solution of visualizing the data logically.

ER Diagrams Symbols, And Notations



*

KEYS

- Key is a set of one or more columns whose combined values are *unique* among all occurrences in a given table.
- A key is the relational means of specifying uniqueness.

For example,

- In patient database, a patient number could be used as a key field to uniquely identify each patient's record in the doctors' patient file.
- The patient's name could not be a key field as there may be more than one patient with the same name. There must be at least one key field in each table.

TYPES OF KEYS

Primary Key

- A primary is a column or set of columns in a table that uniquely identifies tuples (rows) in that table.
- The candidate key which is very suitable to be the main key of table is a primary key.
- The primary keys are compulsory in every table.
- The properties of a primary key are:

  - Model stability
  - Occurrence of minimum fields
  - Defining value for every record i.e. being definitive
  - Feature of accessibility

Example

Student Id	First name of student	Last name of student	Course Id
123456	Jasmine	Shaik	001
123457	Rose	Mary	002
123458	Lily	Holmes	003

Primary key

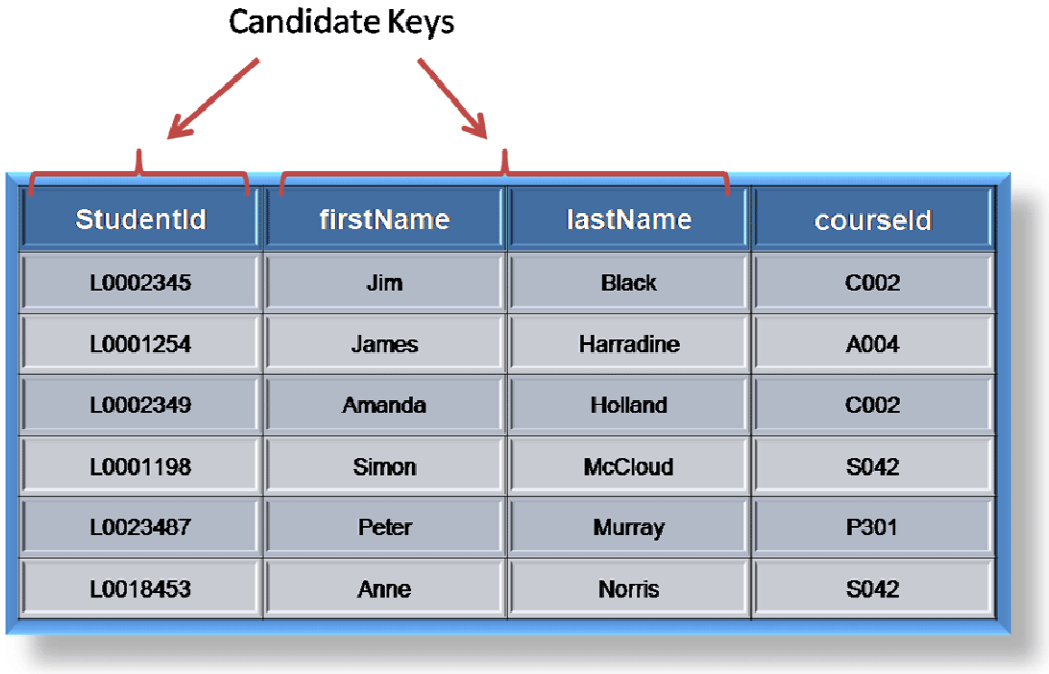
Super Key

- A super key is a set of one of more columns (attributes) to uniquely identify rows in a table.
- Super Key is a set of properties within a table; it specially identifies each record in a table. Candidate key is a unique case of super key.
- For example: Roll No. of a student is unique in relation. The set of properties like roll no., name, class, age, sex, is a super key for the relation student.

Candidate Key

- A candidate is a subset of a super key.
- A candidate key is a single field or the least combination of fields that uniquely identifies each record in the table.
- The least combination of fields distinguishes a candidate key from a super key.

- Every table must have at least one candidate key but at the same time can have several.

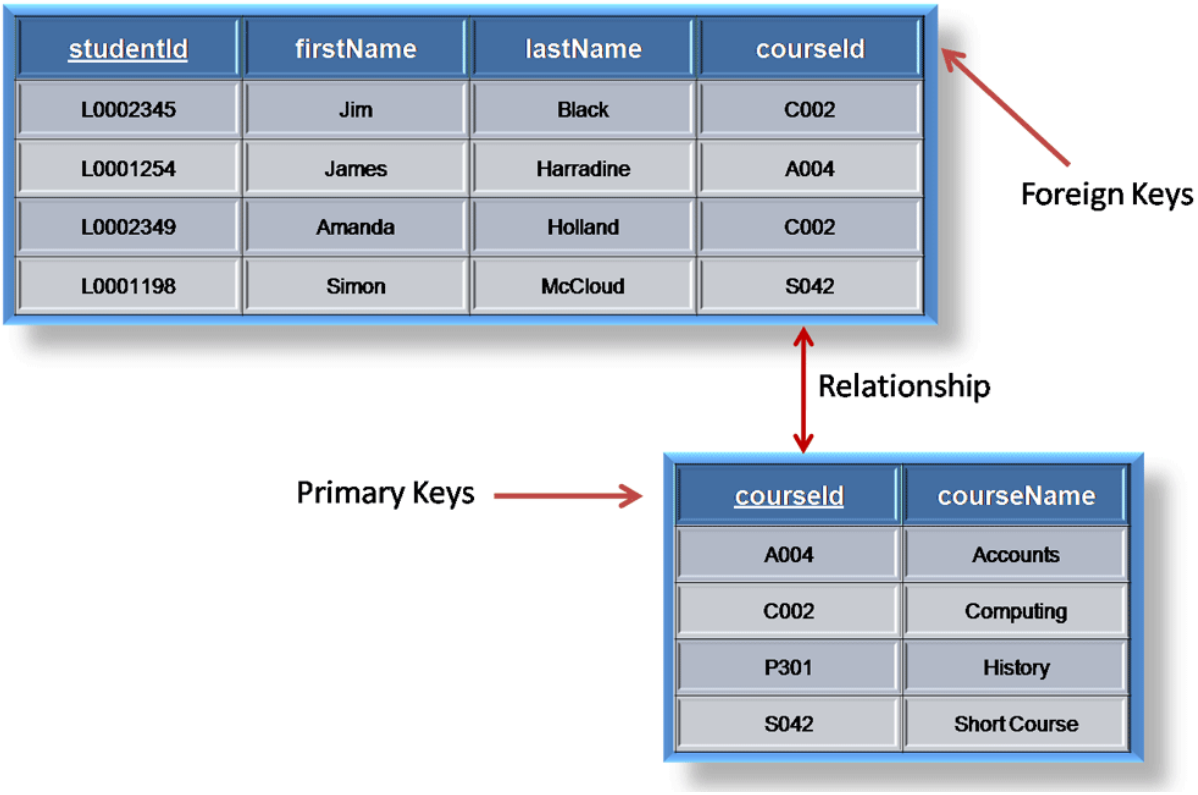


StudentId	firstName	lastName	courseId
L0002345	Jim	Black	C002
L0001254	James	Harradine	A004
L0002349	Amanda	Holland	C002
L0001198	Simon	McCloud	S042
L0023487	Peter	Murray	P301
L0018453	Anne	Norris	S042

Foreign Key

- A foreign key is generally a primary key from one table that appears as a field in another where the first table has a relationship to the second.
- In other words, if we had a table A with a primary key X that linked to a table B where X was a field in B, then X would be a foreign key in B.

For example, student table that contains the course_id the student is attending. Another table lists the courses on offer with course_id being the primary key. The 2 tables are linked through course_id and as such course_id would be a foreign key in the student table.



Secondary or Alternative key

- The rejected candidate keys as primary keys are called as secondary or alternative keys.

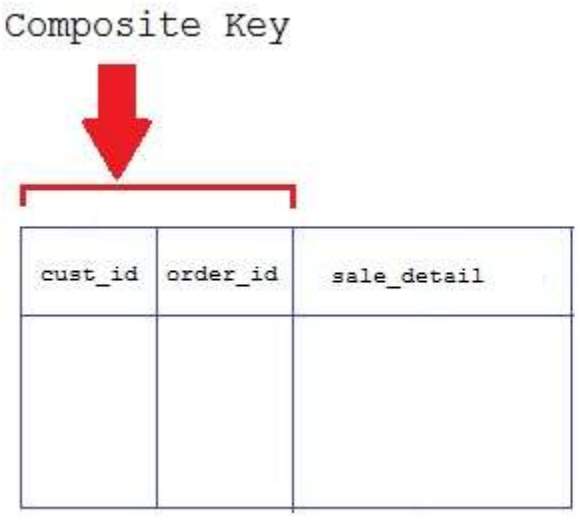
For Example:

Student Id	First name of student	Last name of student	Course Id
123456	Jasmine	Shaik	001
123457	Rose	Mary	002
123458	Lily	Holmes	003

Secondary or Alternative keys

Composite Key

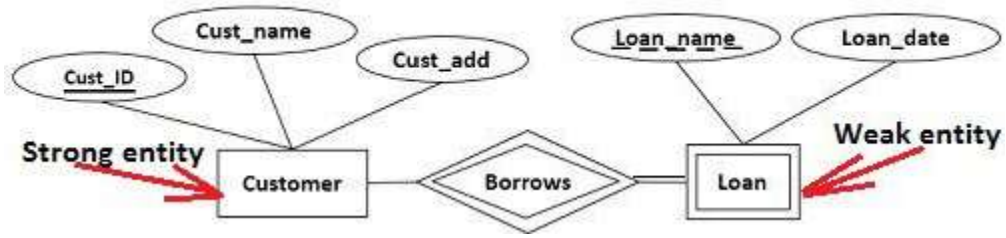
- Key that consists of two or more attributes that uniquely identify an entity occurrence is called **Composite key**.
- But any attribute that makes up the **Composite key** is not a simple key in its own.



Strong Entity Sets

- The **Strong Entity** is the one whose existence does not depend on the existence of any other entity in a schema.
- It is denoted by a **single rectangle**.
- A strong entity always has the **primary key** in the set of attributes that describes the strong entity.
- It indicates that each entity in a strong entity set can be uniquely identified.
- Set of similar types of strong entities together forms the **Strong Entity Set**.
- A strong entity holds the relationship with the weak entity via an **Identifying Relationship**, which is denoted by double diamond in the ER diagram.
- On the other hands, the relationship between two strong entities is denoted by a single diamond and it is simply called as a **relationship**.

For example; a customer borrows a loan. Here we have two entities first a customer entity, and second a loan entity.



Weak Entity Sets

- A **Weak entity** is the one that depends on its owner entity i.e. a strong entity for its existence.
- A weak entity is denoted by the **double rectangle**.

- Weak entity do **not** have the **primary key** instead it has a **partial key** that uniquely discriminates the weak entities.
- The **primary key of a weak entity** is a composite key formed from the **primary key of the strong entity** and **partial key of the weak entity**.
- The collection of similar weak entities is called **Weak Entity Set**.
- The relationship between a weak entity and a strong entity is always denoted with an **Identifying Relationship** i.e. **double diamond**.

BASIS FOR COMPARISON	STRONG ENTITY	WEAK ENTITY
Basic	The Strong entity has a primary key.	The weak entity has a partial discriminator key.
Depends	The Strong entity is independent of any other entity in a schema.	Weak entity depends on the strong entity for its existence.
Denoted	Strong entity is denoted by a single rectangle.	Weak entity is denoted with the double rectangle.
Relation	The relation between two strong entities is denoted by a single diamond simply called relationship.	The relationship between a weak and a strong entity is denoted by Identifying Relationship denoted with double diamond.

BASIS FOR COMPARISON	STRONG ENTITY	WEAK ENTITY
Participation	Strong entity may or may not have total participation in the relationship.	Weak entity always has total participation in the identifying relationship shown by double line.

Generalization Specialization and Aggregation

- Generalization Specialization and Aggregation in DBMS are abstraction mechanisms used to model information.
- The abstraction is the mechanism used to hide the superfluous details of a set of objects.
- For example, vehicle is a abstraction, that includes the types car, jeep and bus.

So, the two abstraction mechanisms used to model information:

- Generalization (Specialization is the reverse process of Generalization)
- Aggregation

Generalization in DBMS –

- Generalization is an abstracting process of viewing sets of objects as a single general class by concentrating on the general characteristics of the constituent sets while suppressing or ignoring their differences.

- In simple terms, Generalization is a process of extracting common characteristics from two or more classes and combining them into a generalized super class.
- So, it is a bottom up approach as two or lower lever entities are combined to form a higher level entity.
- The common characteristics means here attributes or methods.

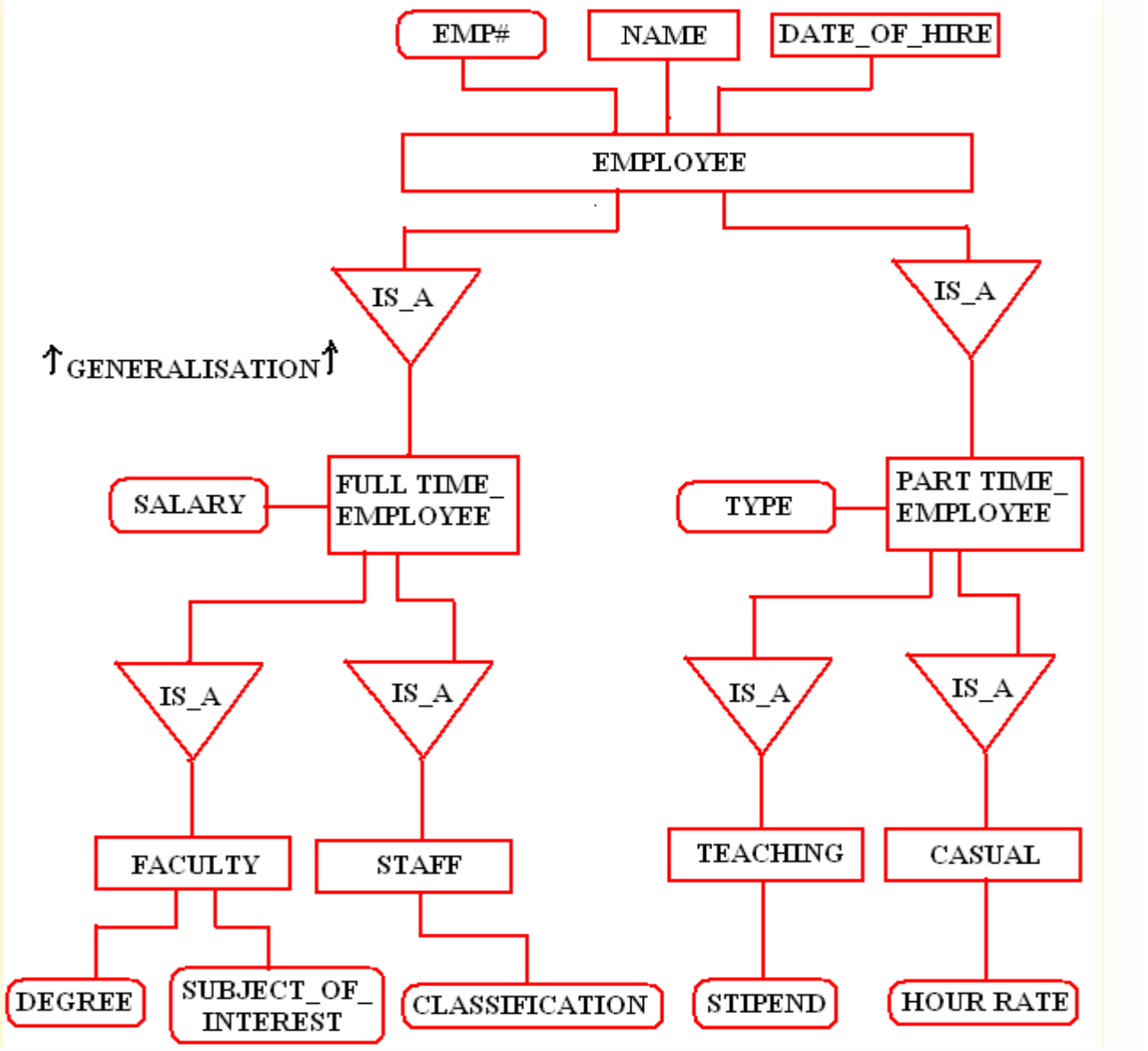
Notation of Generalization –

Generalization is represented by a triangle with a line.

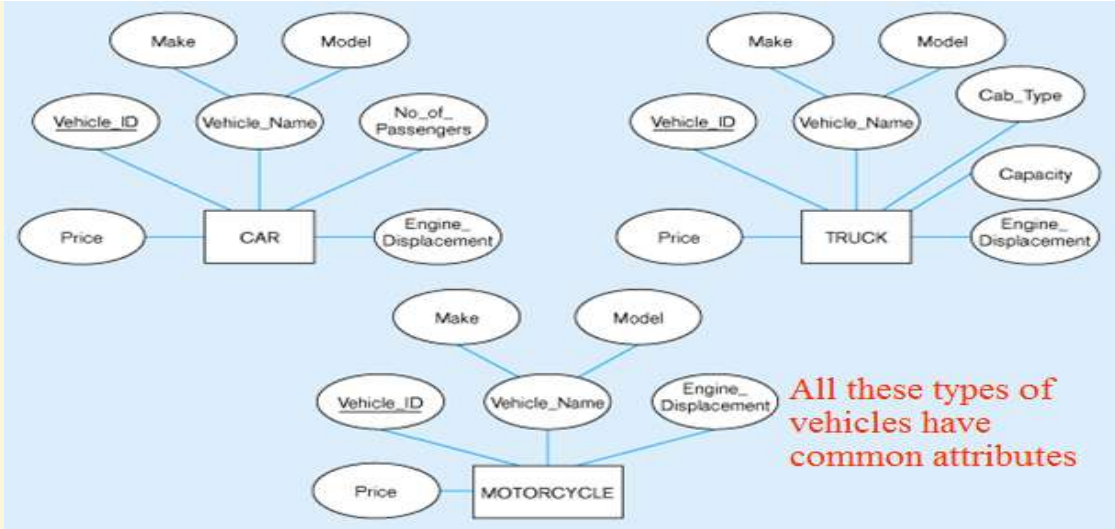
Generalization is an IS_A relationship

Example of Generalization:

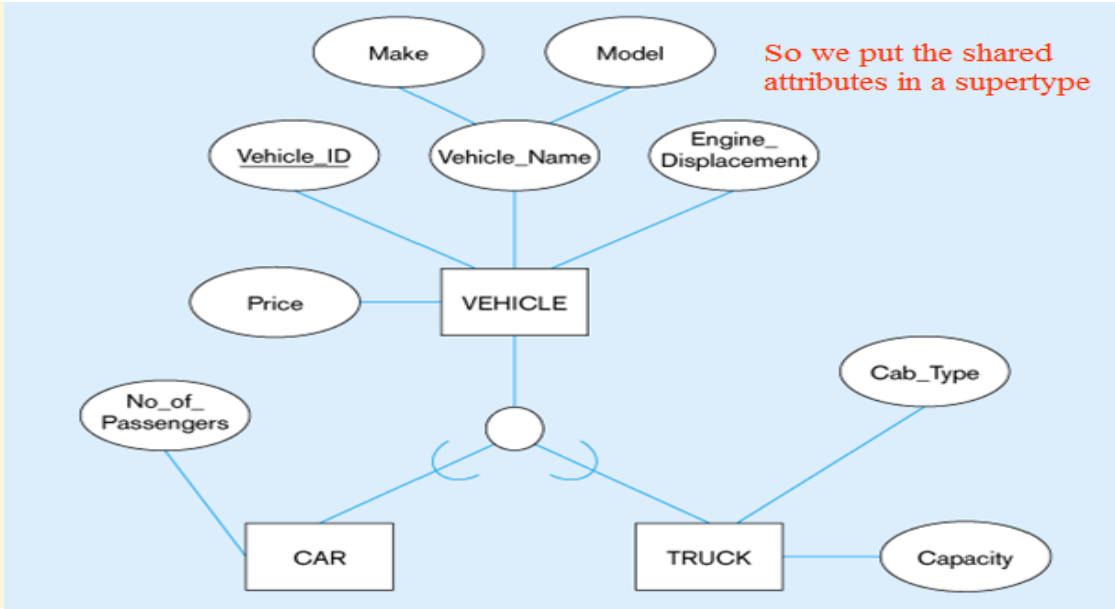
For example, a Part_Time Employee and Full_Time Employee entity sets can be generalized as EMPLOYEE entity sets;
The Full_Time_Employee is a generalization of the entity set Faculty and Staff;
The Part_Time_Employee is a generalization of the entity set Teaching and Casual.



Another Example : Following Figures shows 3 entities: CAR, TRUCK and MOTORCYCLE



In second Fig. The more general entity type VEHICLE is shown.

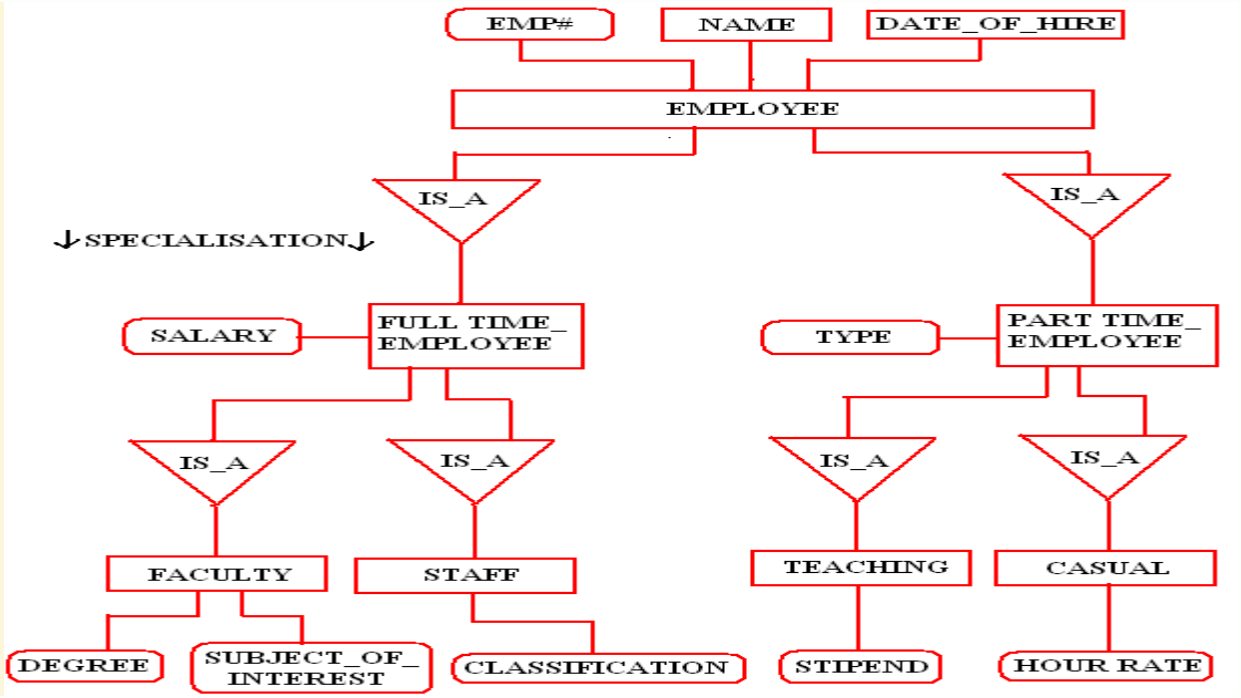


MOTORCYCLE entity is not shown as it does not satisfy conditions for a subtype because it has all the attributes common to all vehicles. So, there are no attributes specific to motorcycles. Further, MOTORCYCLE does not have a relationship to another entity type

Specialization in DBMS

- Specialization may be seen as the reverse process of Generalization.
- Specialization is the abstracting process of introducing new characteristics to an existing class of objects to create one or more new classes of objects.
- In simple terms, a group of entities in specialization can be categorized into sub-groups based on their characteristics.
- So it is a top-down approach in which one higher level entity can be broken down into two lower level entity.
- It defines one or more subtypes of the supertypes and forming supertype/subtype relationships.

Example of Specialization:



In the above example, Faculty and Staff inherits the attribute salary of the entity set Full_Time_Employee and latter, in turn inherits the attributes of Employee.

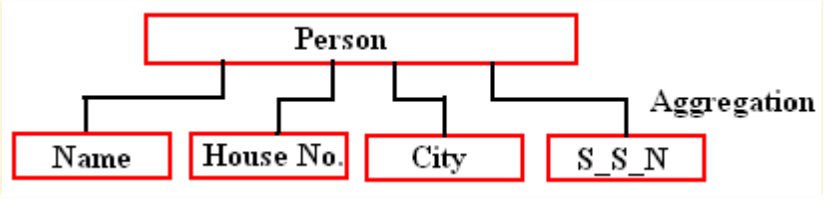
So, Faculty and Staff is a specialization of Full_Time_Employee and Full_Time_Employee is a specialization of Employee.

Similarly, Teaching and Casual inherits the attribute Wage of the entity set Part_Time_Employee and latter, in turn inherits the attributes of Employee.

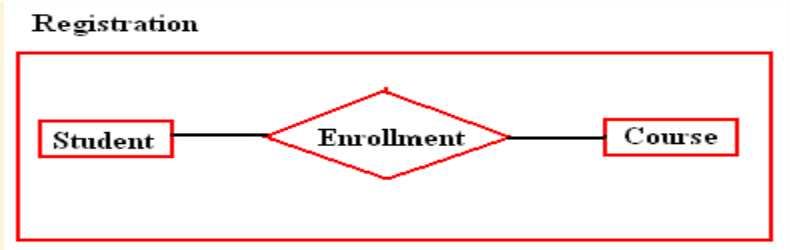
So, Teaching and Casual is a specialization of Part_Time_Employee and Part_Time_Employee is a specialization of Employee.

Aggregation in DBMS –

Aggregation is the process of compiling information on an object, thereby abstracting a higher level object. So,an entity Person is derived by aggregating the characteristics name, house_no., city and social security number(SSN).

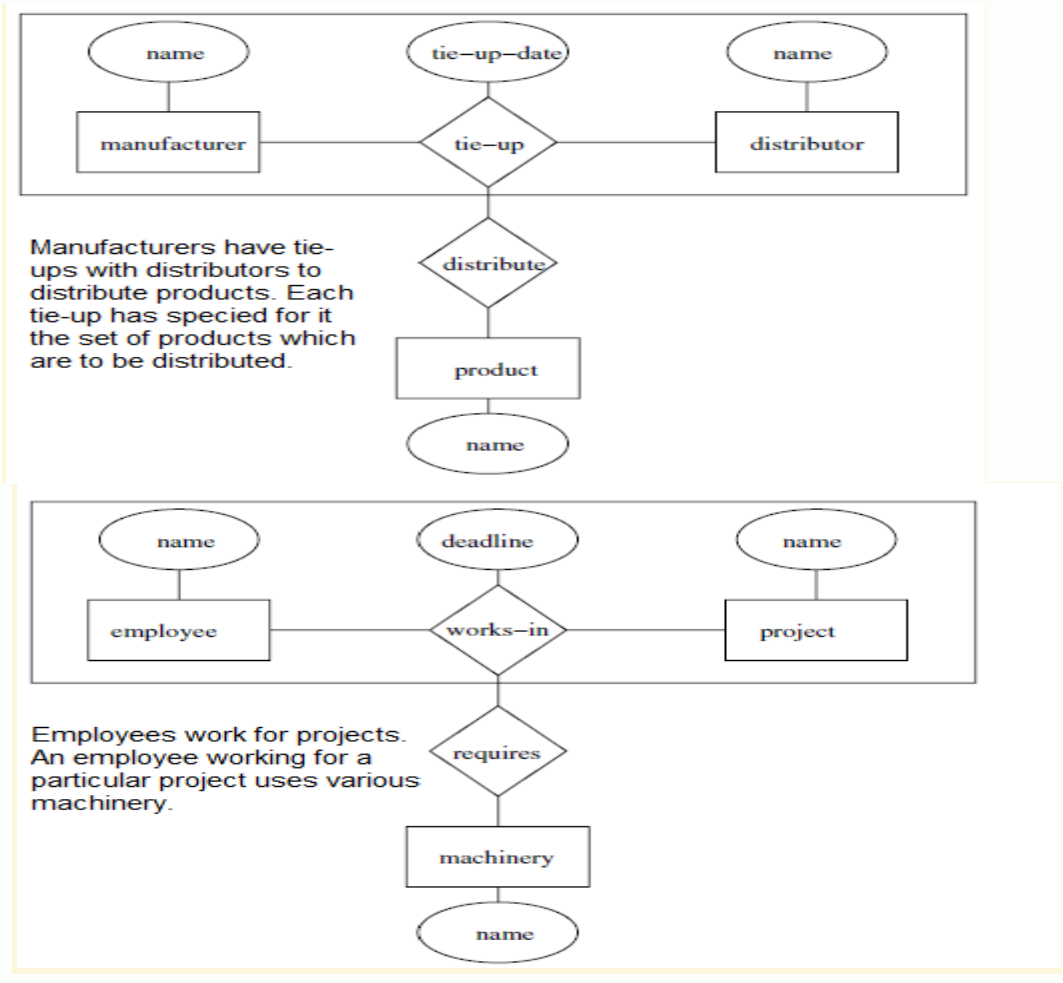


Another form of aggregation says that it is abstracting a relationship between objects and viewing the relationship as an object. So, in Figure , the Enrollment relationship between entities student and Course entity can be viewed as entity REGISTRATION.



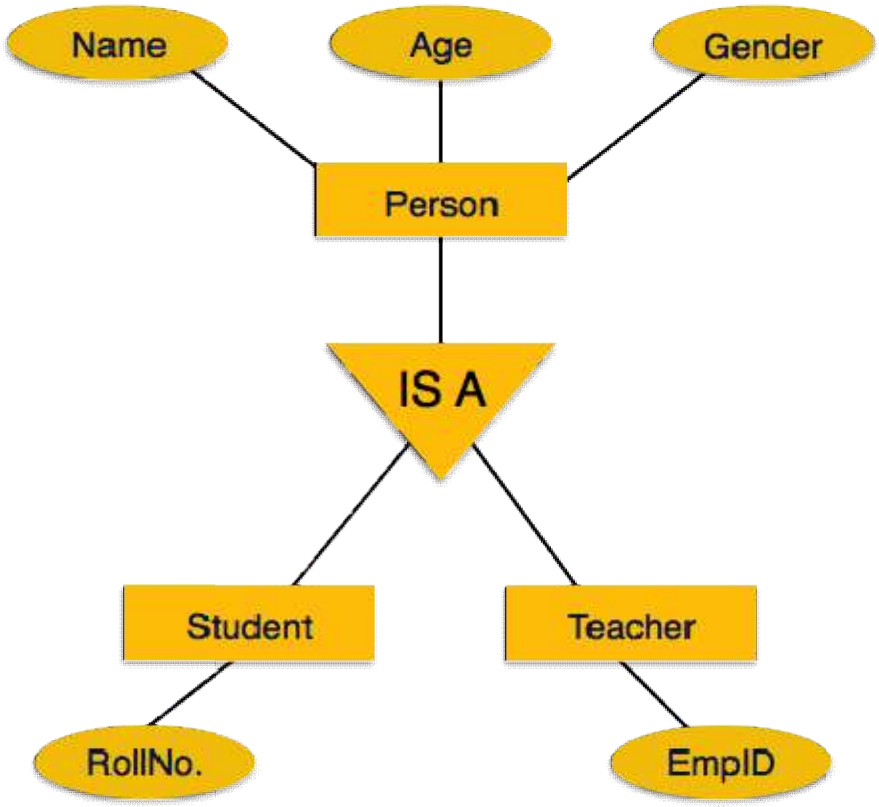
In simple terms, Aggregation is a process when relation between two entity is treated as a single entity.

Another Example of Aggregation :



Inheritance

Inheritance is an important feature of Generalization and Specialization. It allows lower-level entities to inherit the attributes of higher-level entities.



For example, the attributes of a Person class such as name, age, and gender can be inherited by lower-level entities such as Student or Teacher.

PART- A (1 Mark)

(Online Examinations)

PART- B (2 Mark)

1. What is a Database system?
2. What is the role of Database Administrator?
3. Disadvantage in File Processing System?
4. What is Data Independence?
5. What do you mean by instance &schema? Explain the difference between these.
6. What is the difference between Procedural DML and Non-Procedural DML?
7. What is a view? How it is related to data independence?
8. What is E-R model?
9. What do you mean by Hierarchical model?
10. What is an Entity?
11. What is an attribute?
12. What is degree of a Relation?
13. What are the unary operations in Relational Algebra?
14. What is a primary key?
15. Define foreign key.

PART- C (6 Mark)

1. Describe the three levels of data abstraction?
2. With a neat diagram, explain the structure of a DBMS?
3. Discuss E-R Model concept and extended E-R model.
4. Explain in detail about different type of attributes in ER model with an example.
5. Describe briefly on E-R Model with suitable example.
6. Mention the various data model and explain it.
7. Explain the various operators used in relational algebra.
8. Discuss about mapping cardinalities in E-R Model.
9. List out the type of keys and explain with examples.
10. Explain about purpose of database system.

PART A
ONLINE QUESTION

S. N0	QUESTIONS	OPTION 1	OPTION 2	OPTION 3	OPTION 4	OPTION 5	OPTION 6	ANSWER
	UNIT I							
1	The data stored in the system is partitioned into one or more _____	Database	data record	data field	stored field			Database
2	Database system involves _____ major components	2	4	5	3			4
3	Data is stored in _____ and_____	concept & physical	shared & concept	integrated & shared	stored			integrated & shared
4	_____ data refers to information entering the system from the outside world.	output	input	process	information			input
5	_____ data refers to messages and reports.	Output	input	process	both input and output			Output
6	_____ consists of secondary storage volumes.	Software	hardware	firmware	system			hardware
7	The users of the system are a layer of _____ usually called the DBMS.	Software	Hardware	Firmware	Users			Software
8	_____ is the application programmer.	Data	system	user	information			user
9	A _____ is a collection of stored operational data.	Field	database	memory	record			database
10	_____ linking the basic entities	Relations	sequence	selection	projection			Relationship

PART A
ONLINE QUESTION

	together.	hip		n				
11	_____ is impossible to change the storage structure	data independent	data dependent	data logic	dependent			data dependent
12	Different application will need different view of the same data called _____	data independent	data dependent	data logic	independent			data dependent
13	The _____ must have the freedom to change the storage structure.	DBA	DML	DDA	TCL			DBA
14	A stored _____ is the smallest collection of associated stored fields.	Record	data	file	field			Record
15	A stored _____ is the smallest named unit of data stored in the database.	record	data	file	field			field
16	A stored _____ is the collection of occurrences of one type of stored record.	Record	data	file	field			file
17	A _____ field may be stored in internal arithmetic form or a character string.	Char	interger	numeric	float			numeric
18	A _____ string field may be stored in any of several character codes.	Char	interger	numeric	float			Char

PART A
ONLINE QUESTION

19	The _____ in a numeric field may change from inches to centimeters.	Char	interger	numeric	units			units
20	_____ may be desirable to represent data in storage by coded values.	data coding	char	integer	data byte.			data coding
21	_____ constructing an occurrence of the logical field from the corresponding stored field occurrence and presenting it to the application.	data materialization	data independence	data dependence	record			data materialization
22	A given _____ file may be physically implemented in storage in a wide variety of ways.	Accessed	related	stored	record			stored
23	The architecture is divided into _____levels.	4	2	5	3			3
24	The _____level is the one closest to physical storage.	Internal	external	logical	conceptual			Internal
25	The _____ level is the one closest to the user.	Internal	external	logical	conceptual			external
26	The _____level is a level of indirection.	Internal	external	logical	conceptual			conceptual
27	_____ is a subset of the total language	DSL	DML	DDL	DCL			DSL

PART A
ONLINE QUESTION

	that is concerned with database objects and operations.							
28	The data sublanguage as being embedded in a _____ language.	source	host	designation	destination			host
29	_____ provides for the definition or description of database objects	DSL	DML	DDL	TCL			DDL
30	_____ supports the manipulation or processing of such objects	DSL	DML	DDL	TCL			DML
31	An _____ record is not necessarily the same as a stored reord.	internal	external	logical	conceptual			external
32	A _____ record is not necessarily the same as either an external record,on the one hand,or a stored record on the other.	internal	external	logical	conceptual			conceptual
33	_____database that is not stored in its entirely at a single physical location.	shared	source	distributed	designation			distributed
34	The component responsible for this internal / physical conversion is called an _____	access method	record	field method	interface			access method

PART A
ONLINE QUESTION

35	_____ key values uniquely identify the records in the file.	foreign	candidate	primary	superkey			primary
36	_____is a database that is not stored in its entirety at a single location, but rather is spread across a network of computers.	Network Database	Distributed Database	Database	central database			Distributed Database
37	The physical record interface is the interface between the _____method and the _____database.	access & internal	access & physical	access & external	access & conceptual.			access & physical
38	Indexed file can be accessed through direct and _____ access	Indirect	sequential access	both a& b	direct			Indirect
39	The _____ set provides fast direct access to the data	Sequence	group	index	record			index
40	The conceptual schema can sometimes called as _____	logical schema	physical schema	External schema	internal schema			logical schema
41	Each stored file is sequenced by the access method on its_____	Primay Key	Foreign Key	Candidate Key	Super key			Primay Key
42	The purpose of index is to provide an _____path	access	root	unaccessed	direct			access

PART A
ONLINE QUESTION

	to the file.							
43	The symbol _____ is used to mean "pointer to".	uparrow	downarrow	middle arrow	line			uparrow
44	rows of such tables are generally referred to as _____	tuples	attributes	domain	index			tuples
45	columns of such tables are generally referred to as _____	tuples	attributes	domain	index			attributes
46	A _____ is a pool of values from which the actual values apperring in a given column are drawn.	tuples	attributes	domain	index			domain
47	The _____ view the data is represented by a simple tree structure.	Relational	Hierarchical	Network	non relational			Hierarchical
48	The record type at the top of the tree is usually known as _____	Root	child	index	record			Root
49	_____ connecting occurrences of records.	Root node	Link	File	child node			Link
50	_____ is a major drawback of the hierarchical approach	symmentry	Asymmetric	reference	relational data			Asymmetric
51	_____to change the description of a	Insert	Delete	Update	View			Update

PART A
ONLINE QUESTION

	supplier.							
52	In the _____ approach the data is represented by records and links.	Relational	Hierarchical	Network	stored interface			Network
53	The _____ approach thus allow us to model a many to many correspondence more directly.	Relational	Hierarchical	Network	field			Network
54	_____ associations between tuples are represented solely by data values in columns drawn from a common domain.	Relational data structure	Domain	Keys	record			Relational data structure
55	_____ is a term that has a much more precise definition than the more traditional data processing.	Relational	Hierarchical	Network	rows			Relational
56	The relational model is divided into parts	3	2	5	1			3
57	what we have mostly calling as a table	tuple	degree	primary key	relation			relation
58	_____corres pondends to a row of a table	attribute	cardinality	primary key	tuple			attribute
59	_____is a unique definer of a table	domain	cardinalty	primary key	tuple			domain

PART A
ONLINE QUESTION

60	_____ is a value from which specific attributes drawn their actual values	domain	reletion	degree	tuple			degree

UNIT II

SYLLABUS

Relational Model - Structure - Formal Query Language - Relational Algebra - Tuple and Domain Relational Calculus.

Relational Model-Introduction

Relational model stores data in the form of tables. This concept purposed by Dr. E.F. Codd, a researcher of IBM in the year 1960s. The relational model consists of three major components:

1. The set of relations and set of domains that defines the way data can be represented (data structure).

2. Integrity rules that define the procedure to protect the data (data integrity).

3. The operations that can be performed on data (data manipulation).

A relational model database is defined as a database that allows you to group its data items into one or more independent tables that can be related to one another by using fields common to each related table.

Characteristics of Relational Database

Relational database systems have the following characteristics:

- The whole data is conceptually represented as an orderly arrangement of data into rows and columns, called a relation or table.
- All values are scalar. That is, at any given row/column position in the relation there is one and only one value.

All operations are performed on an entire relation and result is an entire relation, a concept known as closure.

Dr. Codd, when formulating the relational model, chose the term "relation" because it was comparatively free of connotations, unlike, for example, the word "table". It is a common misconception that the relational model is so called because relationships are established between tables. In fact, the name is derived from the relations on whom it is based. Notice that the model requires only that data be conceptually represented as a relation, it does not specify how the data should be physically implemented. A relation is a relation provided that it is arranged in row and column format and its values are scalar. Its existence is completely independent of any physical representation.

Structure of Relational Database

1. A relational database consists of a collection of **tables**, each having a unique **name**.

   A **row** in a table represents a **relationship** among a set of values.

   Thus a table represents a **collection of relationships**.

2. There is a direct correspondence between the concept of a table and the mathematical concept of a relation. A substantial theory has been developed for relational databases.

Basic Structure

1. Figure shows the *deposit* and *customer* tables for our banking example.

bname	account#	cname	balance
Downtown	101	Johnson	500
Lougheed Mall	215	Smith	700
SFU	102	Hayes	400
SFU	301	Adams	1300

cname	street	city
Johnson	Pender	Vancouver
Smith	North	Burnaby
Hayes	Curtis	Burnaby
Adams	No3 Road	Richmond
Jones	Oak	Vancouver

The *deposit* and *customer* relations.

- It has four attributes.
- For each attribute there is a permitted set of values, called the **domain** of that attribute.
- E.g. the domain of *bname* is the set of all branch names.

Let D_1 denote the domain of *bname*, and D_2, D_3 and D_4 the remaining attributes' domains respectively.

Then, any row of *deposit* consists of a four-tuple (v_1, v_2, v_3, v_4) where

$$v_1 \in D_1, v_2 \in D_2, v_3 \in D_3, v_4 \in D_4$$

In general, *deposit* contains a **subset** of the set of all possible rows.

That is, *deposit* is a subset of

$$D_1 \times D_2 \times D_3 \times D_4, \quad \text{or, abbreviated to,} \quad \times_{i=1}^{4} D_i$$

In general, a table of n columns must be a subset of

$$\times_{i=1}^{n} D_i \quad \text{(all possible rows)}$$

2. Mathematicians define a relation to be a subset of a Cartesian product of a list of domains.
3. The terms **relation** and **tuples** in place of **table** and **row**.
4. Some more formalities:
   - let the tuple variable t refer to a tuple of the relation r.
   - We say $t \in r$ to denote that the tuple t is in relation r.
   - Then t[*bname*] = t[1] = the value of t on the *bname* attribute.
   - So t[*bname*] = t[1] = ``Downtown'',

- and t[*cname*] = t[3] = ``Johnson''.

5. We'll also require that the domains of all attributes be **indivisible units.**
   - A domain is **atomic** if its elements are indivisible units.
   - For example, the set of integers is an atomic domain.
   - The set of all sets of integers is not.
   - Integers do not have subparts, but sets do - the integers comprising them.
   - We could consider integers non-atomic if we thought of them as ordered lists of digits.

Keys

1. The notions of **superkey**, **candidate key** and **primary key** all apply to the relational model.
2. For example, in *Branch-scheme*,
   - {*bname*} is a superkey.
   - {*bname, bcity*} is a superkey.
   - {*bname, bcity*} is not a candidate key, as the superkey {*bname*} is contained in it.
   - {*bname*} is a candidate key.
   - {*bcity*} is not a superkey, as branches may be in the same city.
   - We will use {*bname*} as our primary key.
3. The primary key for *Customer-scheme* is {*cname*}.
4. More formally, if we say that a subset K of R is a *superkey* for R, we are restricting consideration to relations $r(R)$ in which no two distinct tuples have the same values on all attributes in K. In other words,
   - If t_1 and t_2 are in r, and
   - $t_1 \neq t_2$,

- then $t_1[K] \neq t_2[K]$.

Query Languages

1. A **query language** is a language in which a user requests information from a database. These are typically higher-level than programming languages.

   They may be one of:

   - **Procedural**, where the user instructs the system to perform a sequence of operations on the database. This will compute the desired information.
   - **Nonprocedural**, where the user specifies the information desired without giving a procedure for obtaining the information.
2. A complete query language also contains facilities to insert and delete tuples as well as to modify parts of existing tuples.

The Relational Algebra

1. The **relational algebra** is a procedural query language.
   - Six fundamental operations:
     - select (unary)
     - project (unary)
     - rename (unary)
     - cartesian product (binary)
     - union (binary)
     - set-difference (binary)
   - Several other operations, defined in terms of the fundamental operations:
     - set-intersection
     - natural join

- division
- assignment

- Operations produce a new relation as a result.

Student(sid, name, addr, age, GPA)

Sid	Name	Addr	Age	GPA
301	John	183 Westwood	19	2.1
303	Elaine	301 Wilshire	17	3.9
401	James	183 Westwood	17	3.5
208	Esther	421 Wilshire	20	3.1

Class(dept, cnum, sec, unit, title, instructor)

Dept	Cnum	Sec	Unit	Title	Instructor
CS 112	01	03	Modeling	Dick	Muntz
CS 143	01	04	DB Systems	Carlo	Zaniolo
EE 143	01	03	Signal	Dick	Muntz
ME 183	02	05	Mechanics	Susan	Tracey

Enroll(sid, dept, cnum, sec)

Sid	Dept	Cnum	Sec
301	CS	112	01
301	CS	143	01
303	EE	143	01
303	CS	112	01
401	CS	112	01

Select operation(σ): To identify a set of tuples which is a part of a relation and to extract only these tuples out. The select operation selects tuples that satisfy a given predicate or condition.

- It is a unary operation defined on a single relation.
- It is denoted as **σ**.

This operation pulls the horizontal subset (subset of rows) of the relation that satisfies the conditions. This can use operators like <, >, <=, >=, = and != to filter the data from the relation. It can also use logical AND, OR and NOT operators to combine the various filtering conditions. This operation can be represented as below:

σ P (r)

Where σ is the symbol for select operation, r represents the relation/table, and p is the logical formula or the filtering conditions to get the subset.

Select all tuples satisfying a condition

• Query: Students with age < 18

σ age < 18 (Student)

Sid	Name	Addr	Age	GPA
303	Elaine	301 Wilshire	17	3.9
401	James	183 Westwood	17	3.5

• Query: Students with GPA > 3.7 and age < 18

σ age < 18 ^ GPA > 3.7 (Student)

Sid	Name	Addr	Age	GPA
303	Elaine	301 Wilshire	17	3.9

Project operation(π)

$\Pi A_1, A2,\ldots,A_K(r)$

where A1, A2 are attribute names and r is a relation name.

The result is defined as the relation of k columns obtained by erasing the columns that are not listed.

Duplicate rows removed from result, since relations are sets

This is a unary operator and is similar to select operation above. It creates the subset of relation based on the conditions specified. Here, it selects only selected columns/attributes from the relation- vertical subset of relation. The select operation above creates subset of relation but for all the attributes in the relation.

It is a unary operation defined on a single relation

Query: sid and GPA of all students

Π sid, GPA(Students)

Sid	Name
301	John
303	Elaine
401	James
208	Esther

Query: All departments offering classes

Π dept (Class)

Dept
CS 112

CS 143
EE 143
ME 183

Composition of Relational Operations

A relational – algebra operation is of the same type (relation) as its inputs, relational-algebra operations can be composed together into a relational-algebra expression.

Query: Find that student who has enrolled in dept "cs".

Π sid (σ dept= "cs" (Enroll)

Sid
301
303
401

Union Operation (U)

Defined as:

r ∪ s = {t | t ∈ r or t ∈ s}

It is a binary operator, which combines the tuples of two relations. It is denoted by

R U S

Where R and S are the relations and U is the operator.

It is different from cartesian product in:

Cartesian product combines the attributes of two relations into one relation whereas Union combines the tuples of two relations into one relation.

In Union, both relations should have same number of columns. Suppose we have to list the employees who are working for design and testing department. Then we will do the union on employee table. Since it is union on same table it has same number of attributes. Cartesian product does not concentrate on number of attribute or rows. It blindly combines the attributes.

In Union, both relations should have same types of attributes in same order. In the above example, since union is on employee relation, it has same type of attribute in the same order.

It need not have same number of tuples in both the relation. If there is a duplicate tuples as a result of union, then it keeps only one tuple. If a tuple is present in any one relation, then it keeps that tuple in the new relation. In the above example, number of employees in design department need not be same as employees in testing department. Below diagram shows the same. We can observe that it combines the table data in the order they appear in the table.

Design_Employee

Emp-id	EName
100	James
104	Kathy

U

Testing_Employee

Emp-id	EName
103	Rose
102	Marry
105	Laury

Emp-id	EName
100	James
104	Kathy

103	Rose
102	Marry
105	Laury

Cartesian product (X): - This is a binary operator. It combines the tuples of two relations into one relation.

Example: R × S

A
a1
a2

X

B
b1
b2
b3

=

A	B
a1	b1
a1	b2
a1	b3
a2	b1
a2	b2
a2	b3

R X S

Where R and S are two relations and X is the operator. If relation R has m tuples and relation S has n tuples, then the resultant relation will have mn tuples. For example, if we perform cartesian product on EMPLOYEE (5 tuples) and DEPT relations (3 tuples), then we will have new tuple with 15 tuples.

For Example

EMPLOYEE X DEPT

This operator will simply create a pair between the tuples of each table. i.e.; each employee in the EMPLOYEE table will be mapped with each department in DEPT table. Below diagram depicts the result of cartesian product.

Employee

Emp-id	EName
100	James

Dept

Dept-id	Dept-Name
10	Account

101	Kathy
102	Joseph
103	Rose
104	Marry

X

20	Design
30	Testing

Emp-id	EName	Dept-id	Dept-Name
100	James	10	Account
100	James	20	Design
100	James	30	Testing
101	Kathy	10	Account
101	Kathy	20	Design
101	Kathy	30	Testing
102	Joseph	10	Account
102	Joseph	20	Design
102	Joseph	30	Testing
103	Rose	10	Account
103	Rose	20	Design
103	Rose	30	Testing
104	Marry	10	Account
104	Marry	20	Design
104	Marry	30	Testing

Rename (ρ) - This is a unary operator used to rename the tables and columns of a relation. When we perform self join operation, we have to differentiate two same tables. In such case rename operator on tables comes into picture. When we join two or more tables and if those tables have same column names, then it is always better to rename the columns to differentiate them. This occurs when we perform Cartesian product operation.

ρ x(E)

Where ρ is the rename operator, E is the existing relation name, and x is the new relation name.

ρ_{EMP} (EMPLOYEE) – Renames EMPLOYEE table to EMP

If a relational-algebra expression E has arity n, then returns the result of expression E under the name X, and with the attributes renamed to A_1, A_2, …., A_n.

$\rho_{x(A_1, A_2, ..., A_n)}$

Example

Find the largest salary in the university

– Step 1: find instructor salaries that are less than some other

instructor salary (i.e. not maximum)

–using a copy of instructor under a new name d

$\Pi_{instructor.salary}$ ($\sigma_{instructor.salary < d.salary}$(instructor x ρ_d(instructor)))

– Step 2: Find the largest salary

$\prod_{salary}$ (instructor)-$\prod_{instructor.salary}$ ($\sigma_{instructor.salary < d.salary}$ (instructor x ρ_d(instructor)))

Set Difference(-)

Defined as:

$r - s = \{t \mid t \in r \text{ and } t \notin s\}$

For R − S The Set difference operation defines a relation consisting of the tuples that are in relation R, but not in S. R and S must be union-compatible.

$\Pi_{cutomer\text{-}name(}$depositor$_{)}$- $\Pi_{cutomer\text{-}name(}$borrower$_{)}$

Set differences must be taken between compatible relations.

- r and s must have the same arity
- attribute domains of r and s must be compatible

Formal Definition

A basic expression in the relational algebra consists of either one of the following:

- A relation in the database
- A constant relation
- Let E1 and E2 be relational-algebra expressions; the following are all relational-algebra expressions:

  – E1 ∪ E2

  – E1 – E2

  – E1 x E2

  – σ_p (E1), P is a predicate on attributes in E1

  – $\prod_s$(E1), S is a list consisting of some of the attributes in E1

  – ρ_x(E1), x is the new name for the result of E1

Additional Operations

Additional operations are defined in terms of the fundamental operations. They do not add power to the algebra, but are useful to simplify common queries.

1. **The Set Intersection Operation**

Set intersection is denoted by ∩, and returns a relation that contains tuples that are in **both** of its argument relations.

It does not add any power as

$$r \cap s = r - (r - s)$$

To find all customers having both a loan and an account at the SFU branch, we write

$$\Pi_{cname}(\sigma_{bname="SFU"}(borrow)) \cap \Pi_{cname}(\sigma_{bname="SFU"}(deposit))$$

2. **The Natural Join Operation**

Often we want to simplify queries on a cartesian product.

For example, to find all customers having a loan at the bank and the cities in which they live, we need *borrow* and *customer* relations:

$$\Pi_{borrow.cname,city}(\sigma_{borrow.cname=customer.cname}(borrow \times customer))$$

Our selection predicate obtains only those tuples pertaining to only one *cname*.

This type of operation is very common, so we have the **natural join**, denoted by a ⋈ sign. Natural join combines a cartesian product and a selection into one operation. It performs a selection forcing equality on those attributes that appear in both relation schemes. Duplicates are removed as in all relation operations.

To illustrate, we can rewrite the previous query as

$$\Pi_{cname,ccity}(borrow \bowtie customer)$$

cname	ccity
Smith	Burnaby
Hayes	Burnaby
Jones	Vancouver

Joining *borrow* and *customer* relations.

We can now make a more formal definition of natural join.

- Consider R and S to be **sets** of attributes.
- We denote attributes appearing in **both** relations by $R \cap S$.
- We denote attributes in **either or both** relations by $R \cup S$.
- Consider two relations $r(R)$ and $s(S)$.
- The natural join of r and s, denoted by $r \bowtie s$ is a relation on scheme $R \cup S$.
- It is a projection onto $R \cup S$ of a selection on $r \times s$ where the predicate requires $r.A = s.A$ for each attribute A in $R \cap S$.

Formally,

$$r \bowtie s = \Pi_{R \cup S}(\sigma_{r.A_1 = s.A_1 \wedge r.A_2 = s.A_2 \wedge \ldots \wedge r.A_n = s.A_n}(r \times s))$$

where $R \cap S = \{A_1, A_2, \ldots, A_n\}$.

To find the assets and names of all branches which have depositors living in Stamford, we need *customer*, *deposit* and *branch* relations:

$$\Pi_{bname,assets}\left(\sigma_{bcity="Stamford"}\left(customer \bowtie deposit \bowtie branch\right)\right)$$

Note that $\bowtie$ is associative.

To find all customers who have both an account and a loan at the SFU branch:

$$\Pi_{cname}\left(\sigma_{bname="SFU"}\left(borrow \bowtie deposit\right)\right)$$

This is equivalent to the set intersection version we wrote earlier. We see now that there can be several ways to write a query in the relational algebra.

If two relations $r(R)$ and $s(S)$ have no attributes in common, then $R \cap S = \emptyset$, and $r \bowtie s = r \times s$.

3. **The Division Operation**

Division, denoted ÷, is suited to queries that include the phrase ``for all''.

Suppose we want to find all the customers who have an account at **all** branches located in Brooklyn.

Strategy: think of it as three steps.

We can obtain the names of all branches located in Brooklyn by

$$r_1 = \Pi_{bname}\left(\sigma_{bcity="Brooklyn"}\left(branch\right)\right)$$

We can also find all *cname, bname* pairs for which the customer has an account by

$$r_2 = \Pi_{cname,bname}(deposit)$$

Now we need to find all customers who appear in r_2 with **every** branch name in r_1.

The divide operation provides exactly those customers:

$$\Pi_{cname,bname}(deposit) \div \Pi_{bname}(\sigma_{bcity="Brooklyn"}(branch))$$

which is simply $r_2 \div r_1$.

Formally,

- Let $r(R)$ and $s(S)$ be relations.
- Let $S \subseteq R$.
- The relation $r \div s$ is a relation on scheme $R - S$.
- A tuple t is in $r \div s$ if for every tuple t_s in s there is a tuple t_r in r satisfying both of the following:

$$t_r[S] = t_s[S] \quad (3.2.1)$$
$$t_r[R - S] = t[R - S] \quad (3.2.2)$$

- These conditions say that the $R - S$ portion of a tuple t is in $r \div s$ if and only if there are tuples with the $r - s$ portion **and** the S portion in r for **every** value of the S portion in relation S.

We will look at this explanation in class more closely.

The division operation can be defined in terms of the fundamental operations.

$$r \div s = \Pi_{R-S}(r) - \Pi_{R-S}((\Pi_{R-S}(r) \times s) - r)$$

Read the text for a more detailed explanation.

4. **The Assignment Operation**

Sometimes it is useful to be able to write a relational algebra expression in parts using a temporary relation variable (as we did with r_1 and r_2 in the division example).

The assignment operation, denoted $\leftarrow$, works like assignment in a programming language.

We could rewrite our division definition as

$$temp \leftarrow \Pi_{R-S}(r)$$
$$temp - \Pi_{R-S}((temp \times s) - r)$$

No extra relation is added to the database, but the relation variable created can be used in subsequent expressions. Assignment to a permanent relation would constitute a modification to the database.

Relational calculus

Relational calculus is an alternative to relational algebra. In contrast to the algebra, which is procedural, the relational calculus is non-procedural or declarative.
It uses mathematical predicate calculus. The relational calculus is not the same as that of differential and integral calculus in mathematics but takes its name from a branch of

symbolic logic termed as predicate calculus. When applied to databases, it is found in two forms.

These are

- Tuple relational calculus which was originally proposed by Codd in the year 1972 and
- Domain relational calculus which was proposed by Lacroix and Pirotte in the year 1977

- It is a formal language based upon a branch of mathematical logic called "predicate calculus".
- Variables in Tuple relational calculus takes tuples (rows) as values and it had strong influence on SQL.
- Variables in Domain relational calculus takes fields (attributes) as values and it had strong influence on QBE.

Tuple Relational Calculus

1. The tuple relational calculus is a nonprocedural language. (The relational algebra was procedural).

   We must provide a formal description of the information desired.

2. A query in the tuple relational calculus is expressed as

   {t | P(t)}

   i.e. the set of tuples **t** for which predicate **P** is true.

3. We also use the notation
   - t[a] to indicate the value of tuple t on attribute a.
   - $t \in r$ to show that tuple t is in relation r.

Example Queries

1. For example, to find the branch-name, loan number, customer name and amount for loans over $1200:

   $$\{t \mid t \in r \text{ borrower} \wedge t[\text{amount}]>1200\}$$

   This gives us all attributes, but suppose we only want the customer names. (We would use **project** in the algebra.)

   We need to write an expression for a relation on scheme *(cname)*.

   $$\{t \mid t \in r \text{ borrower} \wedge t[\text{amount}]>1200\}$$

   $$\{t \mid \exists_s \in \text{borrower}(t[\text{cname}]=s[\text{cname}]\wedge s[\text{amount}]>1200)\}$$

   To read this equation as ``the set of all tuples t such that there exists a tuple s in the relation *borrower* for which the values of t and s for the *cname* attribute are equal, and the value of s for the Λ*amount* attribute is greater than 1200.''

   The notation $\exists t \in rQ(t)$ means ``there exists a tuple t in relation r such that predicate Q(t) is true''.

   How did we get the above expression? We needed tuples on scheme *cname* such that there were tuples in *borrower* pertaining to that customer name with *amount* attribute >1200.

The tuples t get the scheme *cname* implicitly as that is the only attribute t is mentioned with.

Let's look at a more complex example.

Find all customers having a loan from the Coimbatore branch, and the cities in which they live:

$\{t \mid \exists_s \in$ borrower(t[cname]=s[cname]^s[bname]=”Coimbatore”

$\Lambda\ t \mid \exists_u \in$ Customer(u [cname]=s[cname]^t[ccity]=u[ccity])) }

In English, we might read this as ``the set of all *(cname,ccity)* tuples for which *cname* is a borrower at the SFU branch, and *ccity* is the city of *cname*''.

Tuple variable s ensures that the customer is a borrower at the SFU branch.

Tuple variable u is restricted to pertain to the same customer as s, and also ensures that *ccity* is the city of the customer.

The logical connectives Λ (AND) and V (OR) are allowed, as well as ¬ (negation).

We also use the existential quantifier ∃ and the universal quantifier ∀.

Some more examples:

1. Find all customers having a loan, an account, or both at the Coimbatore branch:
   $\{t \mid \exists_s \in$ borrower(t[cname]=s[cname] ∧ s[bname]=”Coimbatore”

$\Lambda \exists_u \in$ depositer(t[cname]=u[cname] $\wedge$ u[bname]= "Coimbatore") }

Note the use of the V connective. As usual, set operations remove all duplicates.

2. Find all customers who have **both** a loan and an account at the Coimbatore branch.

Solution: simply change the V connective in 1 to a $\wedge$.

2. Find customers who have an account, but **not** a loan at the SFU branch.

{t | $\exists_u \in$ borrower(t[cname]=u[cname] $\wedge$ u[bname]="Coimbatore"

$\Lambda \neg \exists_s \in$ depositer(t[cname]=s[cname] $\wedge$ s[bname]= "Coimbatore") }

4. Find all customers who have an account at **all** branches located in Brooklyn. (We used **division** in relational algebra.)

For this example we will use implication, denoted by a pointing finger in the text, but by here.

The formula P ➡Q means P implies Q, or, if P is true, then Q must be true.

{t | $\forall_u \in$ branch(u[bcity]= "Town hall" $\Longrightarrow$

$\exists_s \in$ depositer(t[cname]=s[cname] Λ u[bname]=s[bname])) }

In English: the set of all *cname* tuples t such that for all tuples u in the *branch* relation, if the value of u on attribute *bcity* is townhall, then the customer has an account at the branch whose name appears in the*bname* attribute of u.

Formal Definitions

1. A tuple relational calculus expression is of the form

$$\{t \mid P(t)\}$$

where P is a **formula**.

Several tuple variables may appear in a formula.

2. A tuple variable is said to be a **free variable** unless it is quantified by a ∃ or a ∀. Then it is said to be a **bound variable**.
3. A formula is built of **atoms**. An atom is one of the following forms:
   - s∈r, where s is a tuple variable, and r is a relation (∉ is not allowed).
   - s[x] θ u[y], where s and u are tuple variables, and x and y are attributes, and θ is a comparison operator (<, ≤, =, ≠, >, ≥).
   - S[x]θ c, where c is a constant in the domain of attribute x.
4. **Formulae** are built up from atoms using the following rules:
   - An atom is a formula.
   - If P is a formula, then so are ¬P and (P)
   - If P_1 and P_2 are formulae, then so are $P_1 \wedge P_2$, $P_1 \vee P_2$ and $P_1 \neq P_2$.
   - If P(s) is a formula containing a free tuple variable s, then

$$\exists s \in r(P(s)) \text{ and } \forall s \in r(P(s))$$

are formulae also.

5. Note some equivalences:
   - $P_1 \wedge P_2 = \neg(\neg P_1 \vee \neg P_2)$
   - $\forall t \in r(P(t)) = \neg\exists t \in r(\neg P(t))$
   - $P_1 \Rightarrow P_2 = \neg P_1 \vee P_2$

Safety of Expressions

1. A tuple relational calculus expression may generate an infinite expression, e.g.

$$\{t \mid \neg(t \in borrow\}$$

2. There are an infinite number of tuples that are not in *borrow*! Most of these tuples contain values that do not appear in the database.
3. **Safe Tuple Expressions**

   We need to restrict the relational calculus a bit.

   - The domain of a formula P, denoted dom(P), is the set of all values referenced in P.
   - These include values mentioned in P as well as values that appear in a tuple of a relation mentioned in P.
   - So, the domain of P is the set of all values explicitly appearing in P or that appear in relations mentioned in P.
   - $dom(t \in borrow \wedge t[amount] < 1200)$ is the set of all values appearing in *borrow*.
   - $dom(t \mid \neg(t \in borrow))$ is the set of all values appearing in *borrow*.

We may say an expression $\{t \mid P(t)\}$ is **safe** if all values that appear in the **result** are values from dom(P).

4. A **safe** expression yields a finite number of tuples as its result. Otherwise, it is called **unsafe**.

Expressive Power of Languages

1. The tuple relational calculus restricted to safe expressions is equivalent in expressive power to the relational algebra.

The Domain Relational Calculus

1. Domain variables take on values from an attribute's domain, rather than values for an entire tuple.

Formal Definitions

1. An expression is of the form

$$\{<x_1, x_2, \ldots, x_n> \mid P(x_1, x_2, \ldots, x_n)\}$$

where the $x_i, 1 \leq i \leq n$, represent domain variables, and P is a **formula**.

2. An atom in the domain relational calculus is of the following forms
   - $< x_1, \ldots, x_n > \in r$ where r is a relation on n attributes, and $x_i, 1 \leq i \leq n$, are domain variables or constants.

- $x \theta y$, where x and y are domain variables, and θ is a comparison operator.
- $x \theta c$, where c is a constant.

3. **Formulae** are built up from atoms using the following rules:
   - An atom is a formula.
   - If P is a formula, then so are $\neg P$ and (P).
   - If F_1 and F_2 are formulae, then so are $F_1 \vee F_2$, $F_1 \wedge F_2$ and $F_1 \Rightarrow F_2$.
   - If $P(x)$ is a formula where x is a domain variable, then so are $\exists x(P(x))$ and $\forall x(P(x))$.

Example Queries

1. Find branch name, loan number, customer name and amount for loans of over $1200.

$$\{< b, l, c, a > | < b, l, c, a > \in borrow \wedge a > 1200\}$$

2. Find all customers who have a loan for an amount > than $1200.

$$\{< c > | \exists b, l, a(< b, l, c, a > \in borrow \wedge a > 1200)\}$$

3. Find all customers having a loan from the SFU branch, and the city in which they live.

$$\{< c, x > | \exists b, l, a(< b, l, c, a > \in borrow \wedge b = \text{“SFU”} \wedge \exists y(< c, y, x > \in customer))\}$$

4. Find all customers having a loan, an account or both at the SFU branch.

$$\{< c > | \exists b, l, a(< b, l, c, a > \in borrow \wedge b = \text{“SFU”}) \vee \exists b, a, n(< b, a, c, n > \in deposit \wedge b = \text{“SFU”})\}$$

5. Find all customers who have an account at **all** branches located in Brooklyn.

$$\{< c > \mid \forall x, y, z(\neg(< x, y, z > \in branch) \\ \vee z \neq \text{“Brooklyn”} \vee (\exists a, n(< x, a, c, n > \in deposit)))\}$$

If you find this example difficult to understand, try rewriting this expression using implication, as in the tuple relational calculus example. Here's my attempt:

$$[< cn > \mid \forall bn, as, bc \\ ((< bn, as, bc > \in branch \wedge bc = \text{“Brooklyn”}) \Rightarrow \exists an, ba(< cn, an, ba, bn > \in deposit))]$$

I've used two letter variable names to get away from the problem of having to remember what x stands for.

Safety of Expressions

1. As in the tuple relational calculus, it is possible to generate infinite expressions. The solution is similar for domain relational calculus-restrict the form to safe expressions involving values in the **domain** of the formula.

Expressive Power of Languages

1. All three of the following are equivalent:
   - The relational algebra.
   - The tuple relational calculus restricted to safe expressions.
   - The domain relational calculus restricted to safe expressions.

Possible Questions

PART A (1 MARK)

(Online Examinations)

PART B (2 MARKS)

1. Define- relational algebra.
2. Write short notes on tuple relational calculus.
3. Write short notes on domain relational calculus
4. What is a SELECT operation?
5. What is a PROJECT operation?
6. What are the fundamental operations in relational algebra?
7. Mention the unary and binary operators in relational algebra.
8. List out the type of join operations
9. What is the use of rename operation?
10. What is foreign key?
11. Differentiate between Union and intersection operation.
12. Write short notes on formal definitions of relational algebra.
13. Compare the relational calculus and relational algebra.
14. Define query.
15. Write query for "Find the branch name, loan number and amount for loans of over $1200" using domain relational calculus.

PART C (6 Marks)

1. Define Keys. Classify various types of keys with examples.
2. Enlighten on various operators used in relational algebra.
3. Discuss the various type of join operations ? Why are these join required.
4. Describe in detail about tuple and domain relational calculus.
5. Differentiate between Cartesian product and natural join operations used in relational algebra.
6. Consider the following tables:

   Employee (Emp_no, Name, Emp_city)

   Company (Emp_no, Company_name, Salary)

   i. Write a SQL query to display Employee name and company name.

   ii. Write a SQL query to display employee name, employee city ,company name and salary of all the employees whose salary >10000.

   iii. Write a query to display all the employees working in 'XYZ' company.
7. Explain in detail about tuple relation calculus.
8. Describe in briefly on domain relation calculus.
9. What is Database Schema and explain with examples.
10. Portray on basic structure of relational database.

PART A
ONLINE QUESTION

SNO	QUESTIONS	OPTION 1	OPTION 2	OPTION 3	OPTION 4	OPTION 5	OPTION 6	ANSWER
			UNIT II					
1	_____is the responsible picture of relation	table	tuple	primary key	attributes			primary key
2	_____is a perceived database used as a collection of normalized relation	table	relational database	predicates	relation			relational database
3	A name relation is _____	Database	variable	table	database			table
4	The _____requirement needs a little elaboration	candidate key	irreducibilty	fereign key	nulls			candidate key
5	The database does not include any lnvalid foreign key	frencing	target relation	referential integait y	refrenced relation			referential integaity
6	Relation that contains the corresponding candidate key known as_____	reference	target relation	target tuple	referential diagram			target relation
7	the chain of arrow represents _____	referential tuple	referential path	referencing	target relation			referential path
8	principal component of the pice of the model is what is called _____	relational algebra	project	closeure	tradional set operations			relational algebra
9	The foreign key value for	Unmatch	Support for foreign	Support	None			Unmatch

PART A
ONLINE QUESTION

	which there does not exists a matching value of the candidate keys_____ _____.	ed foreign key values	keys	for referential integrity				ed foreign key values
10	_____ __ are of two types compatible relations.	Union	Interaction	Product	Closure			Union
11	_____ _____is a relation A on X,Y……Z.	Projection	Product	Closure	Restriction			Projection
12	_____ __ is defined as a data to be fetched as a result of retrival operation.	Retrieval	Security rules	Integrity rules	Snapshots			Retrieval
13	Defining the data to be inserted is called an _____ _____.	Virtual relations	Update	Snapshots	Integrity rules			Integrity rules
14	Defining the data to be made through a view is called as _____ _____.	Security rules	Retrival	Stability requirements	Virtual relations			Security rules
15	Defining the data that is to be the scope of same concurrency,	Stability requirements	update	integrity roles	snapshot			update
16	The attribute value in each	Atomic	component	quantity	null values			Atomic

PART A
ONLINE QUESTION

	tuple is known as_____,							
17	component of a primary key may be _____,	Quantity	atomic	null	not null			null
18	The naming structure consists of the relation name plus the name of _____,	Constraints	extension	attributes	tuples			extension
19	key constraints are constraints implied by the existence of _____ keys,	Quantity	attributes	candidate	null			candidate
20	attributes are ordered in a _____direction,	Left to right	right to left	left to left	right to right			Left to right
21	Each row of a table represents a _____ of a relation	n-tuple	m-tuple	D1D2	nm-tuple			n-tuple
22	The number of tuple in a relation is called _____	part	cardinality	domain	relation			cardinality
23	An attribute represents one use of domain within a relation _____	part	cardinality	domain	domain			domain
24	References are concerned with the _____	RELATIONAL CALCULAS	VERTICAL CALCULAS	HALF RELATIONAL	Cardinality			RELATIONAL CALCULAS
25	A relation satisfying the	NORMA	BALANC	HEADI	PARA GRAP			NORMA

PART A
ONLINE QUESTION

	foregoing condition is said to be _____	LIZED	ED	NG	H			LIZED
26	The combination consists of a _____ attribute	SINGLE	DOUBLE	Triple	Fourth			SINGLE
27	The integrity constraints can be subdivided into _____	CONST RAINTS	data	doain	functio n			CONST RAINTS
28	Each file contain _____ record type	two	three	one	four			one
29	Each record occurence has a _____	UNIQUE DEFINE R	address	data	data			UNIQUE DEFINE R
30	Relationl algebra is a collection of _____ on relations	operation s	address	data	relation			operation s
31	The union of two relations A and B is _____	A INTER B A	UNION B	A PART B	domain			UNION B
32	The intersection of two relations A and B is _____	A INTERS ECTION B	A UNION B	A PART B	A INTER SECT B			A INTERS ECTION B
33	The difference between two relation is A MINUS B	A INTER B A	UNION B	A MINUS B	A INTER SECT B			A MINUS B
34	The extended cartesion product of 2 relation is_____	A TIMES B	B TIMES A	A MINUS B	B MINUS			A TIMES B
35	The projection				none			VERTIC

PART A
ONLINE QUESTION

	operator yields a _____ subset of a given relation	HORIZONTAL	VERTICAL	STRAIGHT				AL
36	The division operator divides a _____ __ relation	SUBTRACTION	MULTIPLICATION	ADDITION	DIVIDEND			DIVIDEND
37	The system that supports relational data base but has a language that is power full than algebra called as _____	SEMI RELATIONAL	HALF RELATIONAL	FULL RELATIONAL	none			SEMI RELATIONAL
38	The host programming language is _____	PL/I	Cobol	C++	Java			PL/I
39	First embedded SQL document are prefixed by _____ _ sign	*	$	#	@			$
40	The term _____ to mean a select statement for which the retrieval table contains at most one row.	Delete	Create table	Singleton select	Update			Singleton select
41	_____ _____increase the status of all London supplier by the amount given by the program variable	Update	Insert	Syr_code	Delete			Update

PART A
ONLINE QUESTION

	RAISE.							
42	_____ _____Provide a mechanism for accessing the records in the set one by one.	Cursors	Cpu	Monitors	Keyboard			Cursors
43	The executable statements provided to operate on cursors are	FETCH	SELECT	INSERT	EXIT			FETCH
44	The of embedded SQL are provided to assist in the process	hardwire	Software	Dynamic	statement			Software
45	The is a principal dynamic statement	EXECUTE	SELECT	OPEN	FETCH.			EXECUTE
46	A machine language version of the statement is	Prepare	SQLsource	SQLOBL	SQLOBJ			SQLOBJ
47	Projection is denoted by the uppercase Greek letter pi_____	II	I	III	IIII			II
48	_____identifies primarykey of another table	Primay Key	Candidate key	Super Key	Foreign Key			Foreign Key
49	_____set the quantity and status to zero for all suppliers	Multiple-record update	Multiple-table update	Single-record insertion	single table			Multiple-table update
50	_____get names of all tables know to	Retrieval of table –	Retrieval of column-name	Multiple-record	Multiple-			Retrieval of table –

PART A
ONLINE QUESTION

	the system	names		up date	record in section			names
51	the newly stored table is said to be a _____	Discussion	Single record insertion	Snapshot	Fetch			Snapshot
52	_____ is a set of one or more attritbutes that, taken collectively,allow us to identify uniquely a tuple in the relation.	Primay Key	Candidate key	Super Key	Foreign Key			Super Key
53	unctional dependencies is an essential part of understanding the meaning of the ____	Information	Source	Data	Paragraph			Source
54	normalization leads to a simple means of declaring_____	Functional dependencies	Multiple-record update	Multiple-record insertion	single record			Functional dependencies
55	The entities identified by the primary key values are the fundamental entities about with data is recorded in the _____	Fetch	File	Database	Record			Database
56	normallization of given relation is a matter of _____	Semantics	Update	Delete	Inversion			Semantics

PART A
ONLINE QUESTION

57	_____uniquely identifies a record in a table.	Primay Key	Candidate key	Super Key	Foreign Key			Primay Key
58	The select, project and rename operations are called_____Operations.	binary	unary	ternary	single			unary
59	An executable sql statement can appear wherever an _____appear	Pl / I statement	rds precompiler	cobol	SQL			Pl / I statement
60	If data is lost on assignment_____is returned to the program	Delete indication	save indication	open indication	error indication			error indication

UNIT- III

SYLLABUS

Structured Query Language - Basic Structure - Set Operations - Aggregate Functions - Date, Numeric, and Character Functions - Nested Sub queries -Modification Of Databases - Joined Relations-DDL - Embedded SQL.

Structured Query Language

SQL has become *the* standard relational database language. It has several parts:

- Data definition language (DDL) - provides commands to
  - Define relation schemes.
  - Delete relations.
  - Create indices.
  - Modify schemes.
- Interactive data manipulation language (DML) - a query language based on both relational algebra and tuple relational calculus, plus commands to insert, delete and modify tuples.
- Embedded data manipulation language - for use within programming languages like C, PL/1, Cobol, Pascal, etc.
- View Definition - commands for defining views
- Authorization - specifying access rights to relations and views.
- Integrity - a limited form of integrity checking.
- Transaction control - specifying beginning and end of transactions.

Basic Structure

1. Basic structure of an SQL expression consists of **select, from** and **where** clauses.

   - **select** clause lists attributes to be copied - corresponds to relational algebra **project**.
   - **from** clause corresponds to Cartesian product - lists relations to be used.
   - **where** clause corresponds to selection predicate in relational algebra.

2. Typical query has the form

   select $A_1, A_2, \ldots, A_n$ **from** $r_1, r_2, \ldots, r_n$ **where** P

where each A_i represents an attribute, each a r_i relation, and P is a predicate.

3. This is equivalent to the relational algebra expression

$$\pi_{A_1, A_2, \ldots, A_n} (\sigma P(r_1 \times r_2 \times, \ldots, \times r_m))$$

   - If the where clause is omitted, the predicate P is true.
   - The list of attributes can be replaced with a * to select all.
   - SQL forms the Cartesian product of the relations named, performs a selection using the predicate, then projects the result onto the attributes named.
   - The result of an SQL query is a relation.
   - SQL may internally convert into more efficient expressions.

The select Clause

- An example: Find the names of all branches in the account relation.

  select bname from account
- **distinct vs. all**: elimination or not elimination of duplicates.
- Find the names of all branches in the account relation.

  select distinct bname from account
- By default, duplicates are not removed. We can state it explicitly using all.

  select all bname from account

  select * means select all the attributes.

  Arithmetic operations can also be in the selection list.

The where Clause

The predicates can be more complicated, and can involve

- Logical connectives and, or and not.
- Arithmetic expressions on constant or tuple values.
- The between operator for ranges of values.

Example: Find account number of accounts with balances between $90,000 and $100,000.

select account# from account where balance between 90000 and 100000

The from Clause

- The from class by itself defines a Cartesian product of the relations in the clause.
- SQL does not have a natural join equivalent. However, natural join can be expressed in terms of a Cartesian product, selection, and projection.

  For the relational algebra expression

$\Pi_{customer\text{-}name,loan\text{-}number}$(borrower ⋈ loan)

write as

select distinct cname, borrower.loan-number from borrower, loan where borrower.loan-number = loan.loan-number

- More selections with join: Find the names and loan numbers of all customers who have a loan at the SFU branch,

  write as

  select distinct cname, borrower.loan-number from borrower, loan where borrower.loan-number = loan.loan-number and bname= “Coimbatore”

The Rename Operation

Rename: a mechanism to rename both relations and attributes.

- as-clause can appear in both the select and from clauses:
- old-name as new-name.

Example

select distinct cname, borrower.loan-number as loan_id from borrower, loan where borrower.loan-number = loan.loan-number and bname= “Coimbatore”

Tuple Variables

- Tuple variables can be used in SQL, and are defined in the from clause:

  select distinct cname, T.loan-number from borrower as S, loan as T where S.loan-number = T.loan-number
- The keyword **as** is optional here.

- These variables can then be used throughout the expression. Think of it as being something like the rename operator.
- Finds the names of all branches that have assets greater than at least one branch located in Madurai.

  select distinct T.bname from branch S, branch T where S.bcity= “Madurai” and T.assets > S.assets

String Operations

- The most commonly used operation on strings is pattern matching using the operator like.
- String matching operators % (any substring) and _ (underscore, matching any character).

  E.g., ``___%'' matches any string with at least 3 characters.
- Patterns are case sensitive, e.g., ``Jim" does not match ``jim".
- Use the keyword escape to define the escape character.

  E.g., like “`ab%tely \%\” escape “\” matches all the strings beginning with “ab” followed by a sequence of characters and then “tely” and then “%\”.
- Backslash overrides the special meaning of these symbols.
- We can use not like for string mismatching.
- Example. Find all customers whose street includes the substring ``Main''.

  select cname from customer where street like “%Main%”
- SQL also permits a variety of functions on character strings, such as concatenating (using “||”), extracting substrings, finding the length of strings, converting between upper case and lower case, and so on.

Ordering the Display of tuples

- SQL allows the user to control the order in which tuples are displayed.
- order by makes tuples appear in sorted order (ascending order by default).
- desc specifies descending order.
- asc specifies ascending order.

Example

Customer ID	Customer name	Contact	Address	City	Postal code	Country
1	Alfreds Futterkiste	Maria Anders	Obere Str. 57	Berlin	12209	Germany
2	Ana Trujillo Emparedados y	Ana Trujillo	Avda. de la Constitución	México D.F.	05021	Mexico
3	Antonio Moreno Taquería	Antonio Moreno	Mataderos 2312	México D.F.	05023	Mexico
4	Around the Horn	Thomas Hardy	120 Hanover Sq.	London	WA1 1DP	UK
5	Berglunds snabbköp	Christina Berglund	Berguvsvägen 8	Luleå	S-958 22	Sweden

SELECT * FROM Customers ORDER BY Country DESC;

Customer ID	Customer name	Contact	Address	City	Postal code	Country
1	Berglunds snabbköp	Christina Berglund	Berguvsvägen 8	Luleå	S-958 22	Sweden
2	Around the Horn	Thomas Hardy	120 Hanover Sq.	London	WA1 1DP	UK
3	Antonio Moreno Taquería	Antonio Moreno	Mataderos 2312	México D.F.	05023	Mexico
4	Ana Trujillo Emparedados y	Ana Trujillo	Avda. de la Constitución	México D.F.	05021	Mexico
5	Alfreds Futterkiste	Maria Anders	Obere Str. 57	Berlin	12209	Germany

Duplicate Tuples

- Formal query languages are based on mathematical relations. Thus no duplicates appear in relations.
- As duplicate removal is expensive, SQL allows duplicates.
- To remove duplicates, we use the **distinct** keyword.
- To ensure that duplicates are not removed, we use the **all** keyword.

- *Multiset* (bag) versions of relational algebra operators.
  - if there are c_1 copies of tuples t_1 in r_1, and t_1 satisfies selection σ, then there are c_1 copies of t_1 in $\sigma(r_1)$.
  - for each copy of tuple t_1 in r_1, there is a copy of tuple $\pi_{A(t1)}$ in $\pi_{A(r1)}$.
  - if there are c_1 copies of tuple t_1 in r_1, and c_2 copies of tuple t_2 in r_2, there is $c_1 \times c_2$ copies of tuple t_1, t_2 in $r_1 \times r_2$.
- An SQL query of the form

select from $r_1, r_2, \ldots, r_n$ **where** *P* is equivalent to the algebra expression

$$\pi\, A_1, A_2, \ldots, A_n \; (\sigma_P (r_1 \times r_2 \times \ldots \times r_m)$$ **where** *P*

using the multiset versions of the relational operators σ,π and .

Set Operations

1. SQL has the set operations **union, intersect** and **except**.
2. Find all customers having an account.

select distinct *cname* **from** *depositor*

union: Find all customers having a loan, an account, or both. branch.

(**select** *cname* **from** *depositor*) **union** (**select** *cname* **from** *borrower*)

intersect: Find customers having a loan **and** an account.

(**select distinct** *cname* **from** *depositor*) **intersect**(**select distinct** *cname* **from** *borrower*)

except: Find customers having an account, but **not** a loan.

(**select distinct** *cname* **from** *depositor*) **except** (**select** *cname* **from** *borrower*)

3. Some additional details:
   - **union** eliminates duplicates, being a set operation. If we want to retain duplicates, we may use **union all**, similarly for **intersect** and **except**.
   - Not all implementations of SQL have these set operations.
   - **except** in SQL-92 is called **minus** in SQL-86.
   - It is possible to express these queries using other operations.

SQL Datatypes

Each column in a database table is required to have a name and a data type.

An SQL must decide what type of data that will be stored inside each column when creating a table.

The data type is a guideline for SQL to understand what type of data is expected inside of each column, and it also identifies how SQL will interact with the stored data.

Three main data types: text, number, and date.

Text data types:

Data type	Description
CHAR(size)	Holds a fixed length string (can contain letters, numbers, and special characters). The fixed size is specified in parenthesis. Can store up to 255 characters
VARCHAR(size)	Holds a variable length string (can contain letters, numbers, and special characters). The maximum size is specified in parenthesis. Can store up to 255 characters. **Note:** If you put a greater value than 255 it
TINYTEXT	Holds a string with a maximum length of 255 characters
TEXT	Holds a string with a maximum length of 65,535 characters
BLOB	For BLOBs (Binary Large OBjects). Holds up to 65,535 bytes of data

MEDIUMTEXT	Holds a string with a maximum length of 16,777,215 characters
MEDIUMBLOB	For BLOBs (Binary Large OBjects). Holds up to 16,777,215 bytes of data
LONGTEXT	Holds a string with a maximum length of 4,294,967,295 characters
LONGBLOB	For BLOBs (Binary Large OBjects). Holds up to 4,294,967,295 bytes of data
ENUM(x,y,z,etc.)	Let you enter a list of possible values. You can list up to 65535 values in an ENUM list. If a value is inserted that is not in the list, a blank value will be inserted
SET	Similar to ENUM except that SET may contain up to 64 list items and can store more than one choice

Number data types:

Data type	Description
TINYINT(size)	-128 to 127 normal. 0 to 255 UNSIGNED*. The maximum number of digits may be specified in parenthesis
SMALLINT(size)	-32768 to 32767 normal. 0 to 65535 UNSIGNED*. The maximum number of digits may be specified in parenthesis
MEDIUMINT(size)	-8388608 to 8388607 normal. 0 to 16777215 UNSIGNED*. The maximum number of digits may be specified in parenthesis
INT(size)	-2147483648 to 2147483647 normal. 0 to 4294967295 UNSIGNED*. The maximum number of digits may be specified in parenthesis

BIGINT(size)	-9223372036854775808 to 9223372036854775807 normal. 0 to 18446744073709551615 UNSIGNED*. The maximum number of digits may be specified in parenthesis
FLOAT(size,d)	A small number with a floating decimal point. The maximum number of digits may be specified in the size parameter. The maximum number of digits to the right of the decimal point is specified in the d parameter
DOUBLE(size,d)	A large number with a floating decimal point. The maximum number of digits may be specified in the size parameter. The maximum number of digits to the right of the decimal point is specified in the d parameter
DECIMAL(size,d)	A DOUBLE stored as a string , allowing for a fixed decimal point. The maximum number of digits may be specified in the size parameter. The maximum number of digits to the right of the decimal point is specified in the d parameter

Date data types:

Data type	Description
DATE()	A date. Format: YYYY-MM-DD **Note:** The supported range is from '1000-01-01' to '9999-12-31'
DATETIME()	*A date and time combination. Format: YYYY-MM-DD HH:MI:SS **Note:** The supported range is from '1000-01-01 00:00:00' to '9999-12-31 23:59:59'
TIMESTAMP()	*A timestamp. TIMESTAMP values are stored as the number of seconds since the Unix epoch ('1970-01-01 00:00:00' UTC). Format: YYYY-MM-DD HH:MI:SS **Note:** The supported range is from '1970-01-01 00:00:01' UTC to '2038-01-09 03:14:07' UTC
TIME()	A time. Format: HH:MI:SS **Note:** The supported range is from '-838:59:59' to '838:59:59'
YEAR()	A year in two-digit or four-digit format. **Note:** Values allowed in four-digit format: 1901 to 2155. Values allowed in two-digit format: 70 to 69, representing years from 1970 to 2069

Aggregate Functions

An aggregate function allows you to perform a calculation on a set of values to return a single scalar value. To use aggregate functions with the GROUP BY and HAVING clauses of the SELECT statement.

The following are the most commonly used SQL aggregate functions:

1. AVG – calculates the average of a set of values.
2. COUNT – counts rows in a specified table or view.
3. MIN – gets the minimum value in a set of values.
4. MAX – gets the maximum value in a set of values.
5. SUM – calculates the sum of values.

These are called **aggregate functions**. They return a single value.

Syntax

aggregate_function (DISTINCT | ALL expression)

ProductID	ProductName	SupplierID	CategoryID	Unit	Price
1	Chais	1	1	10 boxes x 20 bags	18
2	Chang	1	1	24 - 12 oz bottles	19
3	Aniseed Syrup	1	2	12 - 550 ml bottles	10
4	Chef Anton's Cajun Seasoning	2	2	48 - 6 oz jars	22
5	Chef Anton's Gumbo Mix	2	2	36 boxes	21.35

COUNT function

To get the number of the products in the products table, to use the COUNT function as follows

SELECT COUNT (ProductID) FROM Products;

COUNT(ProductID)
77

AVG function

To calculate the average units in stock of the products, to use the AVG function as follows:

SELECT AVG (Price) FROM Products;

AVG(Price)
28.866363636363637

SUM function

To calculate the sum of units in stock by product category, to use the SUM function with the GROUP BY clause as the following query:

SELECT SUM (Quantity) FROM OrderDetails;

SUM(Quantity)
12743

MIN function

To get the minimum units in stock of products in the products table, to use the MIN function as follows:

SELECT MIN (Price) AS SmallestPrice FROM Products;

SmallestPrice
2.5

MAX function

To get the maximum units in stock of products in the products table, to use the MAX function as shown in the following query:

SELECT MAX (Price) AS LargestPrice FROM Products;

LargestPrice
263.5

Date and Time Functions

GETDATE ()

Probably the most essential of the date4 functions,

SELECT GETDATE()

returns a datetime data type containing the current system data and time: 2009-07-07 11:52:26.687.

DATEADD (datepart, number, date)

DATEADD lets you add values to a given date and returns the result as a datetime data type.

SELECT DATEADD(DAY, 30, GETDATE())

adds 30 days to the date from the example above: 2009-08-06 12:01:38.950.

DATEDIFF (datepart, startdate, enddate)

This function returns a single integer data type that represents the difference between two dates. It can return values for years, months, days, hours, minutes, seconds, milliseconds, and more:

SELECT DATEDIFF(DAY, '01/01/2009', GETDATE())

returns 187 as the difference in days between the example date and the beginning of the year.

DATEPART (datepart, date)

To return an integer that represents a portion of a valid date, DATEPART extracts all parts of the datetime data type including years, months, days, hours, minutes, seconds and milliseconds:

SELECT DATEPART(MONTH, GETDATE())

returns 7 as the example date's month.

DATENAME (datepart, date)

Like its name suggests, DATENAME returns the name of a given part of the

DATE:

SELECT DATENAME(MONTH, GETDATE())

It can return almost all parts of the date including the name of the quarter, the weekday, or as here, the month: July.

ISDATE (expression)

This function tests if the value supplied is a valid date:

SELECT ISDATE ('07/44/09')

In this case, it returns a value of 0 (false) indicating the date is invalid; if it returns a value of 1 (true), the date is valid.

DAY(date), MONTH(date), YEAR(date)

These date functions are like DATEPART but a bit easier to work with:

SELECT MONTH(0), DAY(0), YEAR(0)

They each return an integer representing the supplied date value—in this case, 1,1,1900.

NUMERIC Functions

SQL numeric functions are used primarily for numeric manipulation and/or mathematical calculations.

ABS() function

A mathematical function that returns the absolute (positive) value of the specified numeric expression.

Function syntax:

ABS(numeric_expression)

ABS Example:

SQL server, MySQL, Oracle, PostgreSQL:

select isbn_no, price-35 No_ABS, ABS(price-35) With_ABS from bookstore where price-35 <0;

The result should be:

isbn_no	no_abs	with_abs
0471777781	-3	3
0596009747	-3	3
1861006314	-6	6

CEIL()/CEILING() FUNCTION

Returns the smallest integer greater than, or equal to, the specified numeric expression.

Function syntax:

CEIL(numeric_expression)

Function syntax:

CEILING(numeric_expression)

CEIL Example1:

select ISBN_NO, price, price+0.4 NewPrice ,CEIL(price+0.4) NewPrice_CEIL

from bookstore where price >30;

CEILING Example2:

select ISBN_NO, price, price+0.4 NewPrice ,CEILING(price+0.4) NewPrice_CEIL

from bookstore where price >30;

The result should be for both examples:

isbn_no	price	newprice	newprice_ceil
0201703092	39	39.4	40
0471777781	32	32.4	33
0596009747	32	32.4	33
0672325764	49	49.4	50
0764557599	42	42.4	43
0764579088	35	35.4	36
1861002025	38	38.4	39

EXP() FUNCTION

Returns the value of e (the base of natural logarithms) raised to the power of X.

Function syntax:

EXP(float_expression)

EXP Example:

select isbn_no, price , LOG(price) , EXP(LOG(price)) from bookstore

where price >34;

EXP Example:

select isbn_no, price , LN(price) , EXP(LN(price)) from bookstore

where price >34;

The result should be for both examples:

isbn_no	price	log(price)	exp(log(price))
0201703092	39	3.66356164612965	39
0672325764	49	3.89182029811063	49
0764557599	42	3.73766961828337	42
0764579088	35	3.55534806148941	35
1861002025	38	3.63758615972639	38

FLOOR() function

Returns the largest integer less than or equal to the specified numeric expression.

Function syntax:

FLOOR(float_expression)

FLOOR Example:

select isbn_no, price+0.6 No_FLOOR, FLOOR(price+0.6) With_FLOOR from bookstore

where price >34;

The result should be:

isbn_no	no_floor	with_floor
0201703092	39.6	39
0672325764	49.6	49
0764557599	42.6	42
0764579088	35.6	35
1861002025	38.6	38

LN()/LOG() FUNCTION

Returns the natural logarithm of the specified float expression. The inverse of this function is EXP().

LNfunction syntax:

LN(float_expression)

LOG() function syntax:

LOG(float_expression [, base])

LOG() function syntax:

LOG([base,] float_expression)

LN Example1:

select isbn_no, price , LN(price) , EXP(LN(price)) from bookstore

where price >34;

The result should be:

isbn_no	price	ln(price)	exp(ln(price))
0201703092	39	3.66356164612965	39
0672325764	49	3.89182029811063	49
0764557599	42	3.73766961828337	42
0764579088	35	3.55534806148941	35
1861002025	38	3.63758615972639	38

LN Example2:

select isbn_no, price , LOG(price) , EXP(LOG(price)) from bookstore

where price >34;

The result should be:

isbn_no	price	log(price)	exp(log(price))
0201703092	39	3.66356164612965	39
0672325764	49	3.89182029811063	49
0764557599	42	3.73766961828337	42
0764579088	35	3.55534806148941	35
1861002025	38	3.63758615972639	38

POWER() function

Returns the value of the specified expression to the specified power.

Function syntax:

POWER(float_expression ,power)

POWER Example:

```
SELECT isbn_no, item_qty, price,
POWER(price,2) NewPrice,
item_qty*POWER(price,2) NewCost
 FROM order_books;
```

The result should be:

isbn_no	item_qty	price	newprice	newcost
0201703092	2	39	1521	3042
0764557599	1	42	1764	1764
1861002025	5	38	1444	7220
1861006314	2	29	841	1682
0672325764	1	49	2401	2401
0764557599	2	42	1764	3528
0764579088	4	35	1225	4900
0201703092	10	39	1521	15210
0471777781	2	32	1024	2048
1861002025	5	38	1444	7220

1861006314	1	29	841	841

ROUND() function

Returns a numeric value, rounded to the specified length or precision.

Function syntax:

ROUND(numeric_expression , length)

Length is the precision to which numeric_expression is to be rounded. Length can be negative to cause Length digits left of the decimal point of the numeric_expression to become zero.

ROUND Example:

```
SELECT isbn_no, price,  price*1.077,ROUND( price*1.077,1) NewPrice
 FROM bookstore where price >0;
```

The result should be for both examples:

isbn_no	price	price*1.077	newprice
0201703092	39	42.003	42.0
0471777781	32	34.464	34.5
0596009747	32	34.464	34.5
0672325764	49	52.773	52.8
0764557599	42	45.234	45.2
0764579088	35	37.695	37.7

1861002025	38	40.926	40.9
1861006314	29	31.233	31.2

SIGN() function

Returns the positive (+1), zero (0), or negative (-1) sign of a numeric expression.

Function syntax:

SIGN(numeric_expression)

SIGN Example:

select isbn_no, price, price-35, SIGN(price-35) from bookstore

where price >0;

The result should be:

isbn_no	price	price-35	sign(price-35)
0201703092	39	4	1
0471777781	32	-3	-1
0596009747	32	-3	-1
0672325764	49	14	1

0764557599	42	7	1
0764579088	35	0	0
1861002025	38	3	1
1861006314	29	-6	-1

SQRT() function

Returns the square root of a nonnegative numeric expression.

Function syntax:

SQRT(numeric_expression)

SQRT Example:

SELECT isbn_no, item_qty, price,

ROUND(SQRT(price*price+20*20),1) NewPrice

FROM order_books;

The result should be for both examples:

isbn_no	item_qty	price	newprice
0201703092	2	39	43.8
0764557599	1	42	46.5
1861002025	5	38	42.9
1861006314	2	29	35.2

0672325764	1	49	52.9
0764557599	2	42	46.5
0764579088	4	35	40.3
0201703092	10	39	43.8
0471777781	2	32	37.7
1861002025	5	38	42.9
1861006314	1	29	35.2

Character Functions

SQL provides a rich set of character functions that allow you to get information about strings and modify the contents of those strings in multiple ways. Character functions are of the following two types:

1. Case-Manipulative Functions (LOWER, UPPER and INITCAP)
2. Character-Manipulative Functions (CONCAT, LENGTH, SUBSTR, INSTR, LPAD, RPAD, TRIM and REPLACE)

Case-Manipulative Functions

1. **LOWER :** This function converts alpha character values to lowercase. LOWER will actually return a fixed-length string if the incoming string is fixed-length. LOWER will not change any characters in the string that are not letters, since case is irrelevant for numbers and special characters, such as the dollar sign ($) or modulus (%).

2. **Syntax:**

LOWER(SQL course)

Input1: SELECT LOWER('GEEKSFORGEEKS') FROM DUAL;

Output1: geeksforgeeks

Input2: SELECT LOWER('DATABASE@456') FROM DUAL;

Output2: database@456

3. **UPPER :** This function converts alpha character values to uppercase. Also UPPER function too, will actually return a fixed-length string if the incoming string is fixed-length. UPPER will not change any characters in the string that are not letters, since case is irrelevant for numbers and special characters, such as the dollar sign ($) or modulus (%).
Syntax:

UPPER(SQL course)

Input1: SELECT UPPER('geeksforgeeks') FROM DUAL;

Output1: GEEKSFORGEEKS

Input2: SELECT UPPER('dbms$508%7') FROM DUAL;

Output2: DBMS$508%7

4. **INITCAP :** This function converts alpha character values to uppercase for the first letter of each word and all others in lowercase. The words in the string is must be separated by either # or _ or space.
Syntax:

INITCAP(SQL course)

Input1: SELECT INITCAP('geeksforgeeks is a computer science portal for geeks') FROM DUAL;

Output1: Geeksforgeeks Is A Computer Science Portal For Geeks

Input2: SELECT INITCAP('PRACTICE_CODING_FOR_EFFICIENCY') FROM DUAL;

Output2: Practice_Coding_For_Efficiency

Character-Manipulative Functions

1. **CONCAT :** This function always appends (concatenates) string2 to the end of string1. If either of the string is NULL, CONCAT function returns the non-NULL argument. If both strings are NULL, CONCAT returns NULL.
Syntax:

CONCAT('String1', 'String2')

Input1: SELECT CONCAT('computer' ,'science') FROM DUAL;

Output1: computerscience

Input2: SELECT CONCAT(NULL ,'Android') FROM DUAL;

Output2: Android

Input3: SELECT CONCAT(NULL ,NULL) FROM DUAL;

Output3: -

2. **LENGTH :** This function returns the length of the input string. If the input string is NULL, then LENGTH function returns NULL and not Zero. Also, if the input string contains extra spaces at the start, or in between or at the end of the string, then the LENGTH function includes the extra spaces too and returns the complete length of the string.
   Syntax:

LENGTH(Column|Expression)

Input1: SELECT LENGTH('Learning Is Fun') FROM DUAL;

Output1: 15

Input2: SELECT LENGTH(' Write an Interview Experience ') FROM DUAL;

Output2: 34

Input3: SELECT LENGTH('') FROM DUAL; or SELECT LENGTH(NULL) FROM DUAL;

Output3: -

3. **SUBSTR :** This function returns a portion of a string from a given start point to an end point. If a substring length is not given, then SUBSTR returns all the characters till the end of string (from the starting position specified). **Syntax:**

SUBSTR('String',start-index,length_of_extracted_string)

Input1: SELECT SUBSTR('Database Management System', 9) FROM DUAL;

Output1: Management System

Input2: SELECT SUBSTR('Database Management System', 9, 7) FROM DUAL;

Output2: Manage

4. **INSTR :** This function returns numeric position of a character or a string in a given string. Optionally, you can provide a position *m* to start searching, and the occurrence *n* of string. Also, if the starting position is not given, then it starts search from index 1, by default. If after searching in the string, no match is found then, INSTR function returns 0.

Syntax: INSTR(Column|Expression, 'String', [,m], [n])

Input: SELECT INSTR('Google apps are great applications','app',1,2) FROM DUAL;

Output: 23

5. **LPAD and RPAD :** These functions return the strings padded to the left or right (as per the use) ; hence the “L” in “LPAD” and the “R” in “RPAD” ; to a specified length, and with a specified pad string. If the pad string is not specified, then the given string is padded on the left or right (as per the use) with spaces.

   Syntax:

   LPAD**(Column|Expression, n, 'String')**

Syntax: RPAD(Column|Expression, n, 'String')

LPAD Input1: SELECT LPAD('100',5,'*') FROM DUAL;

LPAD Output1: **100

LPAD Input2: SELECT LPAD('hello', 21, 'geek') FROM DUAL;

LPAD Output2: geekgeekgeekgeekhello

RPAD Input1: SELECT RPAD('5000',7,'*') FROM DUAL;

RPAD Output1: 5000***

RPAD Input1: SELECT RPAD('earn', 19, 'money') FROM DUAL;

RPAD Output1: earnmoneymoneymoney

6. **TRIM :** This function trims the string input from the start or end (or both). If no string or char is specified to be trimmed from the string and there exists some extra space at start or end of the string, then those extra spaces are trimmed off.

Syntax:

TRIM(Leading|Trailing|Both, trim_character FROM trim_source)

Input1: SELECT TRIM('G' FROM 'GEEKS') FROM DUAL;

Output1: EEKS

Input2: SELECT TRIM(' geeksforgeeks ') FROM DUAL;

Output2:geeksforgeeks

7. **REPLACE :** This function searches for a character string and, if found, replaces it with a given replacement string at all the occurrences of the string. REPLACE is useful for searching patterns of characters and then changing all instances of that pattern in a single function call.
If a replacement string is not given, then REPLACE function removes all the occurrences of that character string in the input string. If neither a match string nor a replacement string is specified, then REPLACE returns NULL.

Syntax:

REPLACE(Text, search_string, replacement_string)

Input1: SELECT REPLACE('DATA MANAGEMENT', 'DATA','DATABASE') FROM DUAL;

Output1: DATABASE MANAGEMENT

Input2: SELECT REPLACE('abcdeabcccabdddeeabcc', 'abc') FROM DUAL;

Output2: deccabdddeec

Nested subqueries

A Subquery or Inner query or a Nested query is a query within another SQL query and embedded within the WHERE clause.

A subquery is used to return data that will be used in the main query as a condition to further restrict the data to be retrieved.

Subqueries can be used with the SELECT, INSERT, UPDATE, and DELETE statements along with the operators like =, <, >, >=, <=, IN, BETWEEN, etc.

There are a few rules that subqueries must follow −

- Subqueries must be enclosed within parentheses.
- A subquery can have only one column in the SELECT clause, unless multiple columns are in the main query for the subquery to compare its selected columns.
- An ORDER BY command cannot be used in a subquery, although the main query can use an ORDER BY. The GROUP BY command can be used to perform the same function as the ORDER BY in a subquery.
- Subqueries that return more than one row can only be used with multiple value operators such as the IN operator.

- The SELECT list cannot include any references to values that evaluate to a BLOB, ARRAY, CLOB, or NCLOB.
- A subquery cannot be immediately enclosed in a set function.
- The BETWEEN operator cannot be used with a subquery. However, the BETWEEN operator can be used within the subquery.

Subqueries with the SELECT Statement

Subqueries are most frequently used with the SELECT statement. The basic syntax is as follows −

SELECT column_name [, column_name] FROM table1 [, table2]
WHERE column_name OPERATOR (SELECT column_name [, column_name]
FROM table1 [, table2] [WHERE])

Example

Consider the CUSTOMERS table having the following records −

ID	NAME	AGE	ADDRESS	SALARY
1	Ramesh	35	Ahmedabad	2000.00
2	Khilan	25	Delhi	1500.00
3	kaushik	23	Kota	2000.00
4	Chaitali	25	Mumbai	6500.00
5	Hardik	27	Bhopal	8500.00
6	Komal	22	MP	4500.00
7	Muffy	24	Indore	10000.00

Now, let us check the following subquery with a SELECT statement.

SQL> SELECT * FROM CUSTOMERS WHERE ID IN (SELECT ID FROM CUSTOMERS WHERE SALARY > 4500) ;

This would produce the following result.

ID	NAME	AGE	DDRESS	SALARY	

4	Chaitali	25	Mumbai	6500.00	
5	Hardik	27	Bhopal	8500.00	
7	Muffy	24	Indore	10000.00	

Subqueries with the INSERT Statement

Subqueries also can be used with INSERT statements. The INSERT statement uses the data returned from the subquery to insert into another table. The selected data in the subquery can be modified with any of the character, date or number functions.

The basic syntax is as follows.

INSERT INTO table_name [(column1 [, column2])] SELECT [*|column1 [, column2] FROM table1 [, table2]

[WHERE VALUE OPERATOR]

Example

Consider a table CUSTOMERS_BKP with similar structure as CUSTOMERS table. Now to copy the complete CUSTOMERS table into the CUSTOMERS_BKP table, you can use the following syntax.

SQL> INSERT INTO CUSTOMERS_BKP SELECT * FROM CUSTOMERS WHERE ID IN (SELECT ID FROM CUSTOMERS) ;

Subqueries with the UPDATE Statement

The subquery can be used in conjunction with the UPDATE statement. Either single or multiple columns in a table can be updated when using a subquery with the UPDATE statement.

The basic syntax is as follows.

UPDATE table

SET column_name = new_value

[WHERE OPERATOR [VALUE]

(SELECT COLUMN_NAME

FROM TABLE_NAME)

[WHERE)]

Example

Assuming, we have CUSTOMERS_BKP table available which is backup of CUSTOMERS table. The following example updates SALARY by 0.25 times in the CUSTOMERS table for all the customers whose AGE is greater than or equal to 27.

```
SQL> UPDATE CUSTOMERS
   SET SALARY = SALARY * 0.25
   WHERE AGE IN (SELECT AGE FROM CUSTOMERS_BKP
      WHERE AGE >= 27 );
```

This would impact two rows and finally CUSTOMERS table would have the following records.

ID	NAME	AGE	ADDRESS	SALARY
1	Ramesh	35	hmedabad	125.00
2	Khilan	25	Delhi	1500.00
3	kaushik	23	Kota	2000.00
4	Chaitali	25	Mumbai	6500.00
5	Hardik	27	Bhopal	2125.00
6	Komal	22	MP	4500.00
7	Muffy	24	Indore	0000.00

Subqueries with the DELETE Statement

The subquery can be used in conjunction with the DELETE statement like with any other statements mentioned above.

The basic syntax is as follows.

```
DELETE FROM TABLE_NAME
[ WHERE OPERATOR [ VALUE ]
   (SELECT COLUMN_NAME
   FROM TABLE_NAME)
   [ WHERE) ]
```

Example

Assuming, we have a CUSTOMERS_BKP table available which is a backup of the CUSTOMERS table. The following example deletes the records from the CUSTOMERS table for all the customers whose AGE is greater than or equal to 27.

```
SQL> DELETE FROM CUSTOMERS
   WHERE AGE IN (SELECT AGE FROM CUSTOMERS_BKP
      WHERE AGE >= 27 );
```

This would impact two rows and finally the CUSTOMERS table would have the following records.

ID	NAME	AGE	ADDRESS	SALARY
2	Khilan	25	Delhi	1500.00
3	kaushik	23	Kota	2000.00
4	Chaitali	25	Mumbai	6500.00
6	Komal	22	MP	4500.00
7	Muffy	24	Indore	10000.00

Modification of Database

The SQL Modification Statements make changes to database data in tables and columns. There are 3 modification statements:

- INSERT Statement -- add rows to tables
- UPDATE Statement -- modify columns in table rows
- DELETE Statement -- remove rows from tables

INSERT Statement

The INSERT Statement adds one or more rows to a table. It has two formats:

INSERT INTO table-1 [(column-list)] VALUES (value-list)

and,

INSERT INTO table-1 [(column-list)] (query-specification)

The first form inserts a single row into table-1 and explicitly specifies the column values for the row. The second form uses the result of query-specification to insert one or more rows into table-1. The result rows from the query are the rows added to the insert table. Note: the query cannot reference table-1.

Both forms have an optional column-list specification. Only the columns listed will be assigned values. Unlisted columns are set to null, so unlisted columns must allow nulls. The values from the VALUES Clause (first form) or the columns from the query-specification rows (second form) are assigned to the corresponding column in column-list in order.

If the optional column-list is missing, the default column list is substituted. The default column list contains all columns in table-1 in the order they were declared in CREATE TABLE, or CREATE VIEW.

VALUES Clause

The VALUES Clause in the INSERT Statement provides a set of values to place in the columns of a new row. It has the following general format:

VALUES (value-1 [, value-2] ...)

value-1 and value-2 are Literal Values or Scalar Expressions involving literals. They can also specify NULL.

The values list in the VALUES clause must match the explicit or implicit column list for INSERT in degree (number of items). They must also match the data type of corresponding column or be convertible to that data type.

INSERT Examples

INSERT INTO p (pno, color) VALUES ('P4', 'Brown')

Before

pno	descr	color
P1	Widget	Blue
P2	Widget	Red

=>

After

pno	descr	color
P1	Widget	Blue
P2	Widget	Red

P3	Dongle	Green

P3	Dongle	Green
P4	NULL	Brown

INSERT INTO sp SELECT s.sno, p.pno, 500 FROM s, p WHERE p.color='Green' AND s.city='London'

Before

sno	pno	qty
S1	P1	NULL
S2	P1	200
S3	P1	1000
S3	P2	200

=>

After

sno	pno	qty
S1	P1	NULL
S2	P1	200
S3	P1	1000
S3	P2	200
S2	P3	500

UPDATE Statement

The UPDATE statement modifies columns in selected table rows. It has the following general format:

UPDATE table-1 SET set-list [WHERE predicate]

The optional WHERE Clause has the same format as in the SELECT Statement. See WHERE Clause. The WHERE clause chooses which table rows to update. If it is missing, all rows are in table-1 are updated.

The set-list contains assignments of new values for selected columns. See SET Clause.

The SET Clause expressions and WHERE Clause predicate can contain subqueries, but the subqueries cannot reference table-1. This prevents situations where results are dependent on the order of processing.

SET Clause

The SET Clause in the UPDATE Statement updates (assigns new value to) columns in the selected table rows. It has the following general format:

SET column-1 = value-1 [, column-2 = value-2] ...

column-1 and column-2 are columns in the Update table. value-1 and value-2 are expressions that can reference columns from the update table. They also can be the keyword -- NULL, to set the column to null.

Since the assignment expressions can reference columns from the current row, the expressions are evaluated first. After the values of all Set expressions have been computed, they are then assigned to the referenced columns. This avoids results dependent on the order of processing.

UPDATE Examples

UPDATE sp SET qty = qty + 20

Before After

sno	pno	qty
S1	P1	NULL
S2	P1	200
S3	P1	1000
S3	P2	200

=>

sno	pno	qty
S1	P1	NULL
S2	P1	220
S3	P1	1020
S3	P2	220

UPDATEs

SET name = 'Tony', city = 'Milan' WHERE sno = 'S3'

Before

sno	name	city
S1	Pierre	Paris
S2	John	London
S3	Mario	Rome

=>

After

sno	name	city
S1	Pierre	Paris
S2	John	London
S3	Tony	Milan

DELETE Statement

The DELETE Statement removes selected rows from a table. It has the following general format:

DELETE FROM table-1 [WHERE predicate]

The optional WHERE Clause has the same format as in the SELECT Statement. See WHERE Clause. The WHERE clause chooses which table rows to delete. If it is missing, all rows are in table-1 are removed.

The WHERE Clause predicate can contain subqueries, but the subqueries cannot reference table-1. This prevents situations where results are dependent on the order of processing.

DELETE Examples

DELETE FROM sp WHERE pno = 'P1'

Before

sno	pno	qty
S1	P1	NULL
S2	P1	200
S3	P1	1000
S3	P2	200

=>

After

sno	pno	qty
S3	P2	200

DELETE FROM p WHERE pno NOT IN (SELECT pno FROM sp)

Before

pno	descr	color
P1	Widget	Blue
P2	Widget	Red
P3	Dongle	Green

=>

After

pno	descr	color
P1	Widget	Blue
P2	Widget	Red

Joined Relations

The basic Cartesian-product mechanism for joining tuples of relations provided by earlier versions of SQL, SQL-92 also provides various mechanisms for joining relations, including condition joins and natural joins as well as various forms of outer joins.

These additional operations are typically used a subquery expressions in the from clause.

Examples

1. Two given relations: *loan* and *borrower*.

bname	loan#	amount
Downtown	L-170	3000
Redwood	L-230	4000
Perryridge	L-260	1700

cname	loan#
Jones	L-170
Smith	L-230
Hayes	L-155

The *loan* and *borrower* relations.

inner join:

loan **inner join** *borrower* **on** *loan.loan-number = borrower.loan-number*

Notice that the loan-number will appear twice in the inner joined relation.

bname	loan#	amount	cname	loan#
Downtown	L-170	3000	Jones	L-170
Redwood	L-230	4000	Smith	L-230

Result of *loan* inner join *borrower*.

left outer join:

loan **left outer join** *borrower* **on** *loan.loan# = borrower.loan#*

bname	loan#	amount	cname	loan#
Downtown	L-170	3000	Jones	L-170
Redwood	L-230	4000	Smith	L-230
Perryridge	L-260	1700	*null*	*null*

Result of *loan* left outer join *borrower*.

natural inner join:

loan **natural inner join** *borrower*

bname	loan#	amount	cname
Downtown	L-170	3000	Jones
Redwood	L-230	4000	Smith

Result of *loan* natural inner join *borrower*.

Join types and conditions

1. Each variant of the join operations in SQL-92 consists of a *join type* and a *join condition*.
2. Join types: **inner join, left outer join, right outer join, full outer join**.

The keyword **inner** and **outer** are optional since the rest of the join type enables us to deduce whether the join is an inner join or an outer join.

SQL-92 also provides two other join types:

1. **cross join**: an inner join without a join condition.
2. **union join**: a full outer join on the ``false'' condition, i.e., where the inner join is empty.
3. Join conditions: **natural**, **on** predicate, **using** A_1,A_2,A_3....A_n.

The use of join condition is mandatory for outer joins, but is optional for inner joins (if it is omitted, a Cartesian product results).

Ex. A natural full outer join:

loan **natural full outer join** *borrower* **using** (loan-number)

bname	loan#	amount	cname
Downtown	L-170	3000	Jones
Redwood	L-230	4000	Smith
Perryridge	L-260	1700	*null*
null	L-155	*null*	Hayes

Result of *loan* natural full outer join *borrower* **using** (loan#).

Example. Find all customers who have either an account or a loan (but not both) at the bank.

select cname from (**natural full outer join** *borrower*) **where** *account#* **is** *null* **or** *loan#* **is** *null*

Data-Definition Language

The SQL DDL (Data Definition Language) allows specification of not only a set of relations, but also the following information for each relation:

- The schema for each relation.
- The domain of values associated with each attribute.
- Integrity constraints.

- The set of indices for each relation.
- Security and authorization information.
- Physical storage structure on disk.

Domain Types in SQL

1. The SQL-92 standard supports a variety of built-in domain types:
   - **char**(n) (or **character**(n)): fixed-length character string, with user-specified length.
   - **varchar**(n) (or **character varying**): variable-length character string, with user-specified maximum length.
   - **int** or **integer**: an integer (length is machine-dependent).
   - **smallint**: a small integer (length is machine-dependent).
   - **numeric**(*p, d*): a fixed-point number with user-specified precision, consists of *p* digits (plus a sign) and *d* of *p* digits are to the right of the decimal point. E.g., **numeric**(*3, 1*) allows 44.5 to be stored exactly but not 444.5.
   - **real** or **double precision**: floating-point or double-precision floating-point numbers, with machine-dependent precision.
   - **float**(n): floating-point, with user-specified precision of at least *n* digits.
   - **date**: a calendar date, containing four digit year, month, and day of the month.
   - **time**: the time of the day in hours, minutes, and seconds.
2. SQL-92 allows arithmetic and comparison operations on various numeric domains, including, **interval** and *cast* (*type coercion*) such as transforming between *smallint* and *int*. It considers strings with different length are compatible types as well.
3. SQL-92 allows **create domain** statement, e.g.,

create domain *person-name* **char**(20)

Schema definition in SQL

1. An SQL relation is defined by:

create table *r* (A_1D_1,A_2D_2,A_3D_3....A_nD_n, (*integrity- constraint*$_1$) ,..., *integrity-constraint*$_K$)

where *r* is the relation name, A_i is the name of an attribute, and D_i is the domain of that attribute. The allowed integrity-constraints include

primary key (A_{ji},A_{j2},.....,A_{jm})and **check(*P*)**

Example.

create table *branch* (bname **char**(15) **not null** bcity **char**(30) assets **integer**
primary key (*bname*) **check** (*assets* >= *0*))

2. The values of primary key must be *not null* and *unique*. SQL-92 consider **not null** in primary key specification is redundant but SQL-89 requires to define it explicitly.
3. Check creates type checking functionality which could be quite useful. E.g.,

create table *student* (*name* **char**(15) **not null** *student-id* **char**(10) **not null** *degree-level* **char**(15) **not null check** (*degree-level* **in** ("Bachelors", "Masters", "Doctorate")))

4.

Some checking (such as *foreign-key* constraints) could be costly, e.g.,

check (*bname* **in** (**select** *bname* **from** *branch*))

5. A newly loaded table is empty. The **insert** command can be used to load it, or use special bulk loader untilities.
6. To remove a relation from the database, we can use the **drop table** command:

drop table *r*

This is not the same as **delete** *r* which retains the relation, but deletes all tuples in it.

7. The **alter table** command can be used to add or drop attributes to an existing relation *r*:

   alter table *r* **add** *A D* where *A* is the attribute and *D* is the domain to be added.

   alter table *r* **drop** *A* where *A* is the attribute to be dropped.

Embedded SQL

1. SQL provides a powerful declarative query language. However, access to a database from a general-purpose programming language is required because,
   - SQL is not as powerful as a general-purpose programming language. There are queries that cannot be expressed in SQL, but can be programmed in C, Fortran, Pascal, Cobol, etc.
   - Nondeclarative actions -- such as printing a report, interacting with a user, or sending the result to a GUI -- cannot be done from within SQL.
2. The SQL standard defines embedding of SQL as *embedded SQL* and the language in which SQL queries are embedded is referred as *host language*.
3. The result of the query is made available to the program one tuple (record) at a time.
4. To identify embedded SQL requests to the preprocessor, we use EXEC SQL statement:
5. EXEC SQL embedded SQL statement END-EXEC

Note: A semi-colon is used instead of END-EXEC when SQL is embedded in C or Pascal.

6. Embedded SQL statements: **declare cursor**, **open**, and **fetch** statements.

EXEC SQL

declare *c* **cursor for**

select *cname, ccity*

from *deposit, customer*

where *deposit.cname* = *customer.cname* **and** *deposit.balance* > *:amount*

END-EXEC

where *amount* is a host-language variable.

EXEC SQL **open** *c* END-EXEC

This statement causes the DB system to execute the query and to save the results within a temporary relation.

A series of **fetch** statement are executed to make tuples of the results available to the program.

EXEC SQL **fetch** *c* **into** *:cn, :cc* END-EXEC

The program can then manipulate the variable *cn* and *cc* using the features of the host programming language.

A single **fetch** request returns only one tuple. We need to use a **while** loop (or equivalent) to process each tuple of the result until no further tuples (when a variable in the SQLCA is set).

We need to use **close** statement to tell the DB system to delete the temporary relation that held the result of the query.

EXEC SQL **close** *c* END-EXEC

7. Embedded SQL can execute any valid **update**, **insert**, or **delete** statements.
8. *Dynamic* SQL component allows programs to construct and submit SQL queries ar run time.
9. SQL-92 also contains a *module* language, which allows procedures to be defined in SQL.

CLASS: II B.COM CA | COURSE NAME: DATABASE MANAGEMENT SYSTEM
COURSE CODE: 16CCU402 | UNIT: III (SQL) | BATCH: 2016-2019

POSSIBLE QUESTIONS

PART A (1 Mark)

(Online Examinations)

PART B (2 Marks)

1. List the set operations of SQL.
2. List the string operations supported by SQL.
3. What are aggregate functions? And list the aggregate functions supported by SQL?
4. List the table modification commands in SQ.L
5. .List the SQL domain Types.
6. What is view in SQL? How is it defined?
7. What is the use of group by clause?
8. Give the general form of SQL query.
9. What are the categories of SQL command?
10. What are the parts of SQL language?
11. What are various Data types in SQL ?
12. What is the use of sub queries?
13. Write the syntax of date and time functions.
14. What is meant by joined relations.
15. How are the nulls represented in database system?

PART C (6 Marks)

1. Explain the aggregate functions used in relational algebra.
2. Discuss briefly about Embedded SQL.
3. Portray on set operation with examples.
4. Describe on Nested Sub queries in DBMS.
5. Write in detail about Data- Definition Language.
6. Illustrate on joined relations with examples.
7. List out the operations in modification of database and explain with examples.
8. Discuss about the basic structure of SQL.
9. Depict on several parts of SQL Language.
10. What are the Character functions in SQL? Explain it.

PART A
ONLINE QUESTION

S.NO	QUESTIONS	OPTION 1	OPTION 2	OPTION 3	OPTION 4	OPTION 5	OPTION 6	ANSWER
				UNIT III				
1	A value of zero indicates that the sql statement executed_____	Failure	successfully	balance	null			successfully
2	A value of _____ indicates that no data was found in the data base that satisfied the request	100	200	11	90			100
3	_____ ___might be used to save an intermediate result	create table	rds precompiler	save indication	precompiler			create table
4	embedded sql provides a bridge by means of a new type of object called a_____ ___	keyboard	cpu	monitor	cursor			cursor
5	An operation does not involves cursor is _____ _-	Exit	single to select	open	select			single to select
6	_____ __retrive	single to n select	update	insert	delete			single to n select

PART A
ONLINE QUESTION

	status and city for the supplier							
7	_____ will be set for the negative value.	SYS_CODE	SQL	SELECT	UPDATE			SYS_CODE
8	A cursor is defined by means of _____ ____ statement, which takes in general form.	LET	COBOL	C++	JAVA			LET
9	The LET statement is _____ ____	Executable	Balanced	Negative	Declarative			Declarative
10	Sets of records that are associated with a cursor are always considered to have a _____ ____ Clause.	Position	Line	Paragraph	Ordering			Ordering
11	The _____ ___ Statement is normally executed with in a program loop	FETCH	OPEN	INSERT	DELETE			FETCH
12	The first	$BEGIN	$END		$FETC			$BEGIN

PART A
ONLINE QUESTION

	SQL statement executed in a program	TRANSACTION	TRANSACTION	$CONTINUE TRANSACTION	H			TRANSACTION
13	The last SQL statement executed in a program	$BEGIN TRANSACTION	$END TRANSACTION	$CONTINUE TRANSACTION	$FETCH			$END TRANSACTION
14	_____ _____ is used to receive feed back informatio n	PL/I Structure called SYR	SQL Statement	OPEN	EXIT			PL/I Structure called SYR
15	_____ _ Provides certain features to facilitate the writing of on-line application program.	SQL	BASIC	COBOL	JAVA			SQL
16	_____ _ of embedded SQL are provided to assists the process	LET statement	Dynamic statement	SQL statement	FETCH statem ent			Dynamic statement
17	SQL actually uses the keyword as in the place of _____	FORM	SELECT	OPEN	EXIT			FORM
18	It is probably much more convenient to construct	dynamic statement	S Q L statement	discussion	transac tion			S Q L statement

PART A
ONLINE QUESTION

	_____dynamical							
19	The generate statements can be replaced by another by issuing ----------	select	open	delete	prepare			prepare
20	The term_____ __mean to exclude the cursor statements	open	close	regular	delete			regular
21	Dynamically generated statement does not contain_____	reference	parameters	open	fetch			reference
22	_____ requires special treatment	save	delete	close	select			select
23	"DO" stand for_____ ___	order	paragraph	descending order	ascending order			descending order
24	"AO" students for_____ _____	order	paragraph	descending order	ascending order			ascending order
25	_____ _ is insert operator	I	J	O	K			I
26	_____ _ is the delete operator	A	B	C	D			D
27	Operations not involving	Select, Insert, Update,De	Open,fetch ,close	both a& b	delete			Select, Insert, Update,De

PART A
ONLINE QUESTION

	cursors include_____	lete						lete
28	Database design by definition is concerned with _____ __	Intentions	Extensions	Relations	Legal extensions			Intentions
29	_____ _____ to mean intentional part of the relational rather than the extensional part .	Combination	Result	Relation	Extension			Relation
30	_____ is a mechanism for accessing the records in the set one by one	Cursors	Management	Normal Form	relation			Cursors
31	_____ is defined by means of a _____Statement	OPEN	LET	CLOSE	FETCH			LET
32	_____is a Executable Statement	INSERT	Satisfactor	Balanced	Not balanced			INSERT
33	_____ is used to get part numbers form all parts	Simple Retrieval	Qulified Retrieval	Retrieval with ordering	Retrieval using a link			Retrieval using a link

PART A
ONLINE QUESTION

	supplied.							
34	_____ provides commands for defining relation schemas, deleting relations and modifying relation schemas.	DDL	DML	TCL	DCL			DDL
35	_____ includes commands to insert tuples into delete tuples from and modify tuples in the database	DDL	DML	TCL	DCL			DML
36	DDL includes commands for specifying _____	SQL	DML	DDL	Integrity Constraints			Integrity Constraints
37	_____control is used for specifying the beginning and ending of transaction	Embedded	DML	DDL	Transaction			Transaction
38	The _____ view consists then of a	conceptual	record	tree	field			conceptual

PART A
ONLINE QUESTION

	collection of physical database.							
39	The term _____ is somewhat misleading in this context, since the user does not see such a database exactly as it is stored.	physical	secondary	Hiercharcial	relational			physical
40	Each physical databse is defined by a _____	database record	database description	database view	database field			database description
41	_____is a fixed length character string with user-specified length n.	character	char(n)	int	float			char(n)
42	_____is a fixed poing number with user-specified precision.	number	number(p)	numeric(p, d)	number(d)			numeric(p, d)
43	_____is a floating poing number with precision of atleast n digits.	int	float	float(n)	char			float(n)

PART A
ONLINE QUESTION

44	_____ is a variable length character string with user-specified maximum length n.	char(n)	variable(n)	varchar(n)	int(n)			varchar(n)
45	To remove a relation from an SQL Database _____command is used.	delete table	alter table	drop table	create table			drop table
46	The _____clause is particularly useful in defining the notion of tuple variables.	from	as	like	orderby			as
47	_____clause causes the tuples in the result of a query to appear in sorted order	as	orderby	like	from			orderby
48	The _____operation cannot eliminate duplicates automatically	union	Intersect	orderby	except			orderby
49	_____is a command	alter	update	delete	drop			delete

PART A
ONLINE QUESTION

	to delete tuples from a relation							
50	The _____clause corresponds to the projection operation of the relational algebra.	select	from	where	drop			select
51	The _____clause corresponds to the cartesian product operation of the relational algebra.	select	from	where	drop			from
52	The ____clause corresponds to the selection predicate of the relational algebra.	select	from	where	drop			where
53	_____includes commands for specifying access rights to relations and views	View Definition	Authorization	dynamic sql	embedded sql			Authorization
54	_____command is used to add	create table	alter table	drop table	update table			alter table

PART A
ONLINE QUESTION

	attributes to an existing relation.							
55	SQL expresses patterns by using the _____comparison operator	escape	like	upper	not like			like
56	_____functions are functions that take a collection of values as input and return a single value	input	output	Aggregate	sum			Aggregate
57	The attribute or attributes given in the_____clause are used to form groups.	where	groupby	select	update			groupby
58	_____function is used to find the number of values	COUNT	SUM	AVG	MAX			COUNT
59	_____function is used to find the sum of the values	COUNT	SUM	AVG	MAX			SUM
60	The lowercase Greek	sigma	pi	union	Intersect			sigma

PART A
ONLINE QUESTION

	letter _____to denote Selection							

UNIT- IV

SYLLABUS

Relational Database Design - Pitfalls - Normalisation Using Functional Dependencies - First Normal Form-Second Normal Form-Third Normal Form-Fourth Normal Form And BCNF.

Pitfalls in Relational Database Design

Relational database design requires that we find a "good" collection of relation schemas. A bad design may lead to

- Repetition of Information.
- Inability to represent certain information.

Design Goals:

- Avoid redundant data
- Ensure that relationships among attributes are represented
- Facilitate the checking of updates for violation of database integrity constraints.

Example

Consider the relation schema:

Lending-schema = (branch-name, branch-city, assets, customer-name, loan-number, amount)

branch-	branch-	assets	customer-	loannumber	amount

name	city		name		
Downtown	Brooklyn	9000000	Jones	L-17	1000
Redwood	Palo Alto	2100000	Smith	L-23	2000
Perryridge	Horseneck	1700000	Hayes	L-15	1500
Downtown	Brooklyn	9000000	Jackson	L-14	1500

Problems:

Redundancy:

- Data for branch-name, branch-city, assets are repeated for each loan that a branch makes

Wastes space:

- Complicates updating, introducing possibility of inconsistency of assets value

Null values

- Cannot store information about a branch if no loans exist
- Can use null values, but they are difficult to handle.

What is functional dependency?

- Functional Dependency is a relationship that exists between multiple attributes of a relation.
- This concept is given by E. F. Codd.
- Functional dependency represents a formalism on the infrastructure of relation.
- It is a type of constraint existing between various attributes of a relation.
- It is used to define various normal forms.

- These dependencies are restrictions imposed on the data in database.
- If P is a relation with A and B attributes, a functional dependency between these two attributes is represented as {A → B}. It specifies that,

A	It is a determinant set.
B	It is a dependent attribute.
{A → B}	A functionally determines B. B is a functionally dependent on A.

- Each value of A is associated precisely with one B value. A functional dependency is trivial if B is a subset of A.
- 'A' Functionality determines 'B' {A → B} (Left hand side attributes determine the values of Right hand side attributes).

For example: <Employee> Table

EmpId	EmpName

- In the above <Employee> table, EmpName (employee name) is functionally dependent on EmpId (employee id) because the EmpId is unique for individual names.
- The EmpId identifies the employee specifically, but EmpName cannot distinguish the EmpId because more than one employee could have the same name.
- The functional dependency between attributes eliminates the repetition of information.

- It is related to a candidate key, which uniquely identifies a tuple and determines the value of all other attributes in the relation.

Advantages of Functional Dependency

- Functional Dependency avoids data redundancy where same data should not be repeated at multiple locations in same database.
- It maintains the quality of data in database.
- It allows clearly defined meanings and constraints of databases.
- It helps in identifying bad designs.
- It expresses the facts about the database design.

Introduction to Axioms Rules

- Armstrong's Axioms is a set of rules.
- It provides a simple technique for reasoning about functional dependencies.
- It was developed by William W. Armstrong in 1974.
- It is used to infer all the functional dependencies on a relational database.

Various Axioms Rules

A. Primary Rules

Rule 1	Reflexivity	If A is a set of attributes and B is a subset of A, then A holds B. { A → B }
Rule 2	Augmentation	If A hold B and C is a set of attributes, then AC holds BC. {AC → BC} It means that attribute in dependencies does not change the basic dependencies.

Rule 3	Transitivity	If A holds B and B holds C, then A holds C. If {A → B} and {B → C}, then {A → C} A holds B {A → B} means that A functionally determines B.

B. Secondary Rules

Rule 1	Union	If A holds B and A holds C, then A holds BC. If{A → B} and {A → C}, then {A → BC}
Rule 2	Decomposition	If A holds BC and A holds B, then A holds C. If{A → BC} and {A → B}, then {A → C}
Rule 3	Pseudo Transitivity	If A holds B and BC holds D, then AC holds D. If{A → B} and {BC → D}, then {AC → D}

Sometimes Functional Dependency Sets are not able to reduce if the set has following properties,

1. The Right-hand side set of functional dependency holds only one attribute.
2. The Left-hand side set of functional dependency cannot be reduced, it changes the entire content of the set.
3. Reducing any functional dependency may change the content of the set.

A set of functional dependencies with the above three properties are also called as Canonical or Minimal.

Trivial Functional Dependency

Trivial	If A holds B {A → B}, where A is a subset of B, then it is called a Trivial Functional Dependency. Trivial always holds Functional Dependency.
Non-Trivial	If A holds B {A → B}, where B is not a subset A, then it is called as a Non-Trivial Functional Dependency.
Completely Non-Trivial	If A holds B {A → B}, where A intersect Y = Φ, it is called as a Completely Non-Trivial Functional Dependency.

Example:

Consider relation E = (P, Q, R, S, T, U) having set of Functional Dependencies (FD).

P → Q P → R

QR → S Q → T

QR → U PR → U

Calculate some members of Axioms are as follows,

1. P → T

2. PR → S

3. QR → SU

4. PR → SU

Solution:

1. P → T

In the above FD set, P → Q and Q → T

So, Using Transitive Rule: If {A → B} and {B → C}, then {A → C}

∴ If P → Q and Q → T, then P → T.

P → T

2. PR → S

In the above FD set, P → Q

As, QR → S

So, Using Pseudo Transitivity Rule: If{A → B} and {BC → D}, then {AC → D}

∴ If P → Q and QR → S, then PR → S.

PR → S

3. QR → SU

In above FD set, QR → S and QR → U

So, Using Union Rule: If{A → B} and {A → C}, then {A → BC}

∴ If QR → S and QR → U, then QR → SU.

QR → SU

4. PR → SU

So, Using Pseudo Transitivity Rule: If{A → B} and {BC → D}, then {AC → D}

∴ If PR → S and PR → U, then PR → SU.

PR → SU

Decomposition

- Decomposition is the process of breaking down in parts or elements.
- It replaces a relation with a collection of smaller relations.
- It breaks the table into multiple tables in a database.
- It should always be lossless, because it confirms that the information in the original relation can be accurately reconstructed based on the decomposed relations.
- If there is no proper decomposition of the relation, then it may lead to problems like loss of information.

Properties of Decomposition

1. Lossless Decomposition

2. Dependency Preservation

3. Lack of Data Redundancy

1. Lossless Decomposition

Decomposition must be lossless. It means that the information should not get lost from the relation that is decomposed.

It gives a guarantee that the join will result in the same relation as it was decomposed.

Example:

Let's take 'E' is the Relational Schema, With instance 'e'; is decomposed into: E1, E2, E3, ... En; With instance: e1, e2, e3, ... en, If e1 ⋈ e2 ⋈ e3 . . . . ⋈ en, then it is called as 'Lossless Join Decomposition'.

In the above example, it means that, if natural joins of all the decomposition give the original relation, then it is said to be lossless join decomposition.

Example: <Employee_Department> Table

Eid	Ename	Age	City	Salary	Deptid	DeptName
E001	ABC	29	Pune	20000	D001	Finance
E002	PQR	30	Pune	30000	D002	Production
E003	LMN	25	Mumbai	5000	D003	Sales
E004	XYZ	24	Mumbai	4000	D004	Marketing
E005	STU	32	Bangalore	25000	D005	Human Resource

Decompose the above relation into two relations to check whether a decomposition is lossless or lossy.

Now, we have decomposed the relation that is Employee and Department.

Relation 1 : <Employee> Table

Eid	**Ename**	**Age**	**City**	**Salary**
E001	ABC	29	Pune	20000
E002	PQR	30	Pune	30000

E003	LMN	25	Mumbai	5000
E004	XYZ	24	Mumbai	4000
E005	STU	32	Bangalore	25000

Employee Schema contains (Eid, Ename, Age, City, Salary).

Relation 2 : <Department> Table

Deptid	**Eid**	**DeptName**
D001	E001	Finance
D002	E002	Production
D003	E003	Sales
D004	E004	Marketing
D005	E005	Human Resource

Department Schema contains (Deptid, Eid, DeptName).

So, the above decomposition is a Lossless Join Decomposition, because the two relations contains one common field that is 'Eid' and therefore join is possible.

Now apply natural join on the decomposed relations.

Employee ⋈ Department

Eid	**Ename**	**Age**	**City**	**Salary**	**Deptid**	**DeptName**
E001	ABC	29	Pune	20000	D001	Finance
E002	PQR	30	Pune	30000	D002	Production
E003	LMN	25	Mumbai	5000	D003	Sales
E004	XYZ	24	Mumbai	4000	D004	Marketing

E005	STU	32	Bangalore	25000	D005	Human Resource

Hence, the decomposition is Lossless Join Decomposition.

If the <Employee> table contains (Eid, Ename, Age, City, Salary) and <Department> table contains (Deptid and DeptName), then it is not possible to join the two tables or relations, because there is no common column between them. And it becomes Lossy Join Decomposition.

2. Dependency Preservation

- Dependency is an important constraint on the database.
- Every dependency must be satisfied by at least one decomposed table.
- If {A → B} holds, then two sets are functional dependent. And, it becomes more useful for checking the dependency easily if both sets in a same relation.
- This decomposition property can only be done by maintaining the functional dependency.
- In this property, it allows to check the updates without computing the natural join of the database structure.

3. Lack of Data Redundancy

- Lack of Data Redundancy is also known as a Repetition of Information.
- The proper decomposition should not suffer from any data redundancy.
- The careless decomposition may cause a problem with the data.
- The lack of data redundancy property may be achieved by Normalization process.

Introduction to Normalization

- Normalization is a process of organizing the data in the database.
- It is a systematic approach of decomposing tables to eliminate data redundancy.
- It was developed by E. F. Codd.
- Normalization is a multi-step process that puts the data into a tabular form by removing the duplicate data from the relation tables.
- It is a step by step decomposition of complex records into simple records.
- It is also called as Canonical Synthesis.
- It is the technique of building database structures to store data.

Definition of Normalization

"Normalization is a process of designing a consistent database by minimizing redundancy and ensuring data integrity through decomposition which is lossless."

Features of Normalization

- Normalization avoids the data redundancy.
- It is a formal process of developing data structures.
- It promotes the data integrity.
- It ensures data dependencies make sense that means data is logically stored.
- It eliminates the undesirable characteristics like Insertion, Updation and Deletion Anomalies.

Types of Normalization

1. First Normal Form
2. Second Normal Form
3. Third Normal Form

4. Fourth Normal Form
5. BCNF (Boyce – Codd Normal Form)

1. First Normal Form (1NF)

- First Normal Form (1NF) is a simple form of Normalization.
- It simplifies each attribute in a relation.
- In 1NF, there should not be any repeating group of data.
- Each set of column must have a unique value.
- It contains atomic values because the table cannot hold multiple values.

Example: Employee Table

ECode	Employee_Name	Department_Name
1	ABC	Sales, Production
2	PQR	Human Resource
3	XYZ	Quality Assurance, Marketing

Employee Table using 1NF

ECode	Employee_Name	Department_Name
1	ABC	Sales
1	ABC	Production
2	PQR	Human Resource
3	XYZ	Quality Assurance
3	XYZ	Marketing

2. Second Normal Form (2NF)

- In 2NF, the table is required in 1NF.
- The main rule of 2NF is, *'No non-prime attribute is dependent on the proper subset of any candidate key of the table.'*
- An attribute which is not part of candidate key is known as non-prime attribute.

Example : Employee Table using 1NF

ECode	Employee_Name	Employee_Age
1	ABC	38

1	ABC	38
2	PQR	38
3	XYZ	40
3	XYZ	40

Candidate Key: ECode, Employee_Name

Non prime attribute: Employee_Age

- The above table is in 1NF. Each attribute has atomic values. However, it is not in 2NF because non prime attribute Employee_Age is dependent on ECode alone, which is a proper subset of candidate key. This violates the rule for 2NF as the rule says 'No non-prime attribute is dependent on the proper subset of any candidate key of the table'.

2NF (Second Normal Form) : Employee1 Table

ECode	**Employee_Age**
1	38
2	38
3	40

Employee2 Table

ECode	Employee_Name
1	ABC
1	ABC
2	PQR
3	XYZ
3	XYZ

- Now, the above tables comply with the Second Normal Form (2NF).

3. Third Normal Form (3NF)

- Third Normal Form (3NF) is used to minimize the transitive redundancy.
- In 3NF, the table is required in 2NF.
- While using the 2NF table, there should not be any transitive partial dependency.
- 3NF reduces the duplication of data and also achieves the data integrity.

Example : <Employee> Table

EId	Ename	DOB	City	State	Zip
001	ABC	10/05/1990	Pune	Maharashtra	411038
002	XYZ	11/05/1988	Mumbai	Maharashtra	400007

- In the above <Employee> table, EId is a primary key but City, State depends upon Zip code.
- The dependency between Zip and other fields is called Transitive Dependency.
- Therefore we apply 3NF. So, we need to move the city and state to the new <Employee_Table2> table, with Zip as a Primary key.

<Employee_Table1> Table

EId	Ename	DOB	Zip
001	ABC	10/05/1990	411038
002	XYZ	11/05/1988	400007

<Employee_Table2> Table

City	State	Zip

Pune	Maharashtra	411038
Mumbai	Maharashtra	400007

- The advantage of removing transitive dependency is, it reduces the amount of data dependencies and achieves the data integrity.
- In the above example, using with the 3NF, there is no redundancy of data while inserting the new records.
- The City, State and Zip code will be stored in the separate table. And therefore the updation becomes more easier because of no data redundancy.

4. BCNF (Boyce – Code Normal Form)

- BCNF which stands for Boyce – Code Normal From is developed by Raymond F. Boyce and E. F. Codd in 1974.
- BCNF is a higher version of 3NF.
- It deals with the certain type of anomaly which is not handled by 3NF.
- A table complies with BCNF if it is in 3NF and any attribute is fully functionally dependent that is A → B. (Attribute 'A' is determinant).
- If every determinant is a candidate key, then it is said to be BCNF.
- Candidate key has the ability to become a primary key. It is a column in a table.

Example : <EmployeeMain> Table

Empid	Ename	DeptName	DepType
E001	ABC	Production	D001
E002	XYZ	Sales	D002

The functional dependencies are:

Empid → EmpName

DeptName → DeptType

Candidate Key:

Empid

DeptName

- The above table is not in BCNF as neither Empid nor DeptName alone are keys.
- We can break the table in three tables to make it comply with BCNF.

<Employee> Table

Empid	EmpName
E001	ABC
E002	XYZ

<Department> Table

DeptName	**DeptType**
Production	D001
Sales	D002

<Emp_Dept> Table

Empid	**DeptName**
E001	Production
E002	Sales

Now, the functional dependencies are:

Empid → EmpName

DeptName → DeptType

Candidate Key:

<Employee> Table : Empid

<Department> Table : DeptType

<Emp_Dept> Table : Empid, DeptType

- So, now both the functional dependencies left side part is a key, so it is in the BCNF.

5. Fourth Normal Form (4NF)

- Fourth Normal Form (4NF) does not have non-trivial multivalued dependencies other than a candidate key.
- 4NF builds on the first three normal forms (1NF, 2NF and 3NF) and the BCNF.
- It does not contain more than one multivalued dependency.
- This normal form is rarely used outside of academic circles.

For example : A table contains a list of three things that is 'Student', 'Teacher', 'Book'. Teacher is in charge of Student and recommended book for each student. These three elements (Student, Teacher and Book) are independent of one another. Changing the student's recommended book, for instance, has no effect on the student itself. This is an example of multivalued dependency, where an item depends on more than one value. In this example, the student depends on both teacher and book.

- Therefore, 4NF states that a table should not have more than one dependencies.
- While performing 5NF, the table must be in 4NF.

POSSIBLE QUESTIONS

PART A (1 Mark)

(Online Examinations)

PART B (2 Marks)

1. What is Functional Dependency?
2. What do you mean by redundancy ?How this can be avoided ?
3. What do you understand by dependency preservation?
4. What is transitive dependency?
5. What is lossy decomposition?
6. What is the necessity of normalization?
7. What is normalization?
8. What is normal from?
9. What are the different normal forms?
10. What is the dependency preservation property for decomposition?
11. Write the importance's of decomposition?
12. Define Boyce codd normal form.
13. List the pitfalls in Relational Database Design.
14. Define lossy-less decomposition.

PART C (6 Marks)

1. Explain 2NF and 3NF in detail.
2. Portray on normalization using functional dependencies.
3. Explain 1NF, 2Nf and BCNF with suitable example.
4. What are the pitfalls in relational database design? With a suitable example, explain the role of functional dependency in the process of normalization.
5. What is third normalization? Explain third normal forms with example.
6. Give a relation R with four attributes R={A B C D} and the following FD, identify the candidate keys for R and the highest normal forms.
7. Why normalization needed ? What are its disadvantages ?
8. Discuss the various normal form in normalization with suitable examples.
9. Define term anomalies.Explain BCNF in detail.
10. Explain the concepts of join dependency and lossless decomposition

DATABASE MANAGEMENT SYSTEM

PART A
ONLINE QUESTION

S.NO	QUESTIONS	OPTION 1	OPTION 2	OPTION 3	OPTION 4	OPTION 5	OPTION 6	ANSWER
				UNIT IV				
1	A fiunctional dependence is special form of ----------	integrity constraints	functionally determines	functionally dependent	prepare			integrity constraints
2	BCNF is conceptually _____ than 3NF	Difficult	Simpler	Balanced	Not balanced			Simpler
3	normallization of given relation is a matter of _____	Semantics	Update	Delete	Inversion			Semantics
4	The first normal _____	avoids repetation	remove repetation	delete repetation	accept repetation			remove repetation
5	normalization leads to a simple means of declaring_____	Functional dependencies	Multiple-record update	Multiple-record insertion	none			Functional dependencies
6	FD stands for	Functional dependency	Facilitate dependency	funcional data	Facilitate dependency			Functional dependency
7	Which are the dependencies types	full functional dependency	partial dependency	Trival functional dependency	All of these			All of these
8	FDs are the types of constraints that are based on _____	Key	Key revisited	Superset key	Primary key			Key
9	BCNF stands for		Boce-Codd Normal Forms	Boyce- C Normal Forms	B- Codd Normal Forms			Boyce-Codd Normal Forms

PART A
ONLINE QUESTION

10	In the _____ normal form, a composite attribute is converted to individual attributes.	First	Second	Third	Fourth			First
11	A table on the many side of a one to many or many to many relationship must:	Be in Second Normal Form (2NF)	b) Be in Third Normal Form (3NF)	Be in Third Normal Form (3NF)	Have a composite key			d) Have a composite key
12	Tables in second normal form (2NF):	Eliminate all hidden dependencies	Eliminate the possibility of a insertion anomalies	Have a composite key	Have all non key fields depend on the whole primary key			Eliminate all hidden dependencies
13	Which-one ofthe following statements about normal forms is FALSE?	a) BCNF is stricter than 3 NF	Lossless, dependency - preserving decomposition into 3 NF is always possible	Loss less, dependency – preserving decomposition into BCNF is always possible	Any relation with two attributes is BCNF			Loss less, dependency – preserving decomposition into BCNF is always possible
14	Which is a bottom-up approach to database design that design by examining the relationship between attributes:	Functional dependency	Database modeling	Normalization	Decomposition			Normalization
15	Which forms simplifies and ensures that there is	1NF	2NF	3NF	4NF			3NF

PART A
ONLINE QUESTION

	minimal data aggregates and repetitive groups:							
16	Which forms are based on the concept of functional dependency:	1NF	2NF	3NF	4NF			3NF
17	If there is more than one key for relation schema in DBMS then each key in relation schema is classified as	prime key	super key	candidate key	primary key			candidate key
18	The form of dependency in which the set of attributes that are neither a subset of any of the keys nor the candidate key is classified as	transitive dependency	full functional dependency	partial dependency	prime functional dependency			transitive dependency
19	The process of analyzing relation schemas to achieve minimal redundancy and insertion or update anomalies is classified as	normalization of data	denomination of data	isolation of data	de-normalization of data			normalization of data
20	Considering the relational database, the functional	$A \rightarrow B$	$B \leftarrow A$	$AB \rightarrow R$	$R \leftarrow AB$			$A \rightarrow B$

PART A
ONLINE QUESTION

	dependency between two attributes A and B is denoted by							
21	The procedure of storing higher normal form relations which are in lower normal form as a base relation is classified as	isolation of data	de-normalization of data	normalization of data	denomination of data			de-normalization of data
22	In the reflexive rule (IR1), the true dependencies generated are classified as	trivial	nontrivial	inferential	functional			trivial
23	The extensions of relation that satisfy the constraint of functional dependency are considered as	legal extensions	semantic extensions	state extension	relation extensions			legal extensions
24	In normalization of relations, the property which is critical and must be achieved is classified as	nonadditive join property	additive join property	independency reservation property	dependency preservation property			nonadditive join property
25	In the functional dependency between two sets of attributes	top right side	down left side	left hand side	right hand side			left hand side

PART A
ONLINE QUESTION

	A and B then the set of attributes A of database is classified as							
26	Considering the functional dependency, the one in which removal of some attributes does not affect dependency is called	full functional dependency	partial dependency	prime functional dependency	transitive dependency			partial dependency
27	The constraint between two different attributes sets is classified as	modification anomaly	functional dependency	insertion anomaly	deletion anomaly			functional dependency
28	The normalization form which is based on the transitive dependency is classified as	first normal form	second normal form	fourth normal form	third normal form			third normal form
29	Considering the functional dependency, the one in which removal from some attributes must affect dependency is called	full functional dependency	partial dependency	prime functional dependency	transitive dependency			full functional dependency
30	The normal form which only includes indivisible values or single atomic values	third normal form	first normal form	second normal form	fourth normal form			first normal form

PART A
ONLINE QUESTION

	is classified as							
31	The concept in normalization of relations which is based on the full functional dependency is classified as	fourth normal form	third normal form	first normal form	second normal form			second normal form
32	An Unnormalized relations contains values	Atomic	Non- Atomic	Classified	Unique values			Classified
33	A relation scheme is said to be in _____ form if the values in the domain of each attribute of the relation are atomic.	Unnormalized	first normal form	Boyce - Codd Normal forms				first normal form
34	A second Normal form does not permit _____ dependency betrween a non prime attribute and the relation Key.	Partial	Multi	Functional	Valued			Partial
35	Fifth Normal form is concerned with _____	Functional dependency	Multivalued dependency.	Join dependency	Domain-key.			Join dependency
36	In 2NF _____	No functional dependencies (FDs) exist.	No multivalued dependencies (MVDs) exist	No partial FDs exist	No partial MVDs exist.			No partial FDs exist

PART A
ONLINE QUESTION

37	The normalization was first proposed by _____	Code	Codd	Boyce Codd	Boyce			Codd
38	The FD A → B , DB → C implies _____	DA → C	A → C	B → A	DB → A			DA → C
39	Which normal form is considered adequate for normal relational database design?	2NF	5NF	4NF	3NF			3NF
40	Which of the following is not a consequence of non-normalized database?	Update Anomaly	Insertion Anomaly	Redundancy	Lost update problem			Lost update problem
41	Dependency preservation is not guaranteed in _____	BCNF	3NF	PJNF	DKNF			BCNF
42	Normalization theory is bulit around the concept of _____	normal forms	FD	Boyce	INF			normal forms
43	The fundamental notion of functional dependencies is _____	FD	FC	FP	FS			FD
44	A functional dependencies is a	integrity constraint	constraint	referential integrity	normal forms			integrity constraint

PART A
ONLINE QUESTION

	special form of _____							
45	_____ is one of the normal forms based on FDs	1NF	NF	7NF	Functional dependency			1NF
46	MVDs stands for	MultiValued Dependency	Multi Dependency	Maximum Valued Dependency	Multiple Valued Dependency			MultiValued Dependency
47	PD stands for _____	Partial dependency	Prime depencency	Partial dependent	Proper dependency			partial dependency
48	TD stand for _____	trival dependency	Transitive dependency	travel dependency	transaction dependency			Transitive dependency
49	JD stands for _____	join dependencies	joint dependencies	join dependent	join decomposing			join dependencies
50	The techniques used for functional dependencies is _____	Axioms	Anomalies	rredundancy	normal forms			Axioms
51	In _____normal form, an attribute (column) of a table cannot hold multiple values.	First	Second	Third	BCNF			First
52	_____ is the process of removing redundant data from your tables in order to improve storage efficiency, data integrity and scalability	Partial Functional Dependency	dependency	Normalization	fully dependency			Normalization

PART A
ONLINE QUESTION

53	_____is Due to lack of data i.e., all the data available for insertion such that null values in keys should be avoided	Insert Anomaly	Update Anomaly	External Anomaly	Deletion Anomaly			Insert Anomaly
54	_____ is a primary key composed of multiple columns.	Foreign Key	Candidate Key	Composite key	Super key			Composite key
55	_____a non-key column is dependent on some, but not all the columns in a composite primary key.	Partial Functional Dependency	dependency	Fully Functional Dependency	both a& b			Partial Functional Dependency
56	A _____ is a type of functional dependency in which the value in a non-key column is determined by the value in another non-key column.	Fully Functional Dependency	Transitive Dependency	dependency	Partial Functional Dependency			Transitive Dependency
57	_____ value of one column is dependent on another column.	Fully Functional Dependency	Functional Dependency	Partial Functional Dependency	dependency			Functional Dependency
58	A table is in BCNFif it is in 3NF and if every determinanat is a _____key	Dependent	Normal	Candidate	both a&b			Candidate

PART A
ONLINE QUESTION

59	Which forms has a relation that possesses data about an individual entity:	2 NF	3NF	4NF	5 NF			4NF
60	The primary key is selected from the_____	Foreign Key	super key	Candidate Key	composite keys			Candidate Key

UNIT- V

SYLLABUS

Oracle - Introduction - SQL (DDL,DML, DCL Commands) - Integrity Constraints - PL/SQL - PL/SQL Block - procedure, function - Cursor management - Triggers - Exception Handling.

What is Oracle

- ORACLE is a fourth generation relational database management system.
- In general, a database management system (DBMS) must be able to reliably manage a large amount of data in a multi-user environment so that many users can concurrently access the same data.
- A DBMS must also be secure from unauthorized access and provide efficient solutions for failure recovery.
- The ORACLE Server provides efficient and effective solutions for the major database features.
- ORACLE consists of many tools that allow to create an application with ease and flexibility.

Different editions of Oracle database

Enterprise Edition: It is the most robust and secure edition. It offers all features, including superior performance and security.

Standard Edition: It provides the base functionality for users that do not require Enterprise Edition's robust package.

Express Edition (XE): It is the lightweight, free and limited Windows and Linux edition.

Oracle Lite: It is designed for mobile devices.

The Oracle Corporation

Oracle Corporation is the largest software company in the field of database business. Its relational database was the first to support SQL which has since become the industry standard.

Oracle database is one of the most trusted and widely used relational database engines. The biggest rival of Oracle database is Microsoft's SQL Server.

History of Oracle

Oracle was originally developed by Lawrence Ellison (Larry Ellision) and his two friends and former co-worker in 1977. Oracle DB runs on the most major platforms like Windows, UNIX, Linux and Mac OS.

Oracle Database deployment

Oracle Database may be licensed and deployed on-premises on a choice of platforms including Oracle Engineered Systems, and on-Cloud with a choice of services running on general purpose hardware or Exadata. The various editions and Cloud services provide different levels of database functionality for difference use cases (e.g. dev/test, departmental and non-critical apps, mission-critical workloads) with different levels of performance, availability, etc. service levels.

- Oracle Database Cloud Services: for on-Cloud and Cloud at Customer deployments
- Oracle Database editions: mainly for on-prem deployments
- Engineered systems such as Oracle Exadata specifically built for Oracle Database deployment (on-prem, on-Cloud, Cloud at Customer)

SQL

SQL language is divided into four types of primary language statements: DML, DDL, DCL and TCL. Using these statements, we can define the structure of a database by

creating and altering database objects, and we can manipulate data in a table through updates or deletions. We also can control which user can read/write data or manage transactions to create a single unit of work.

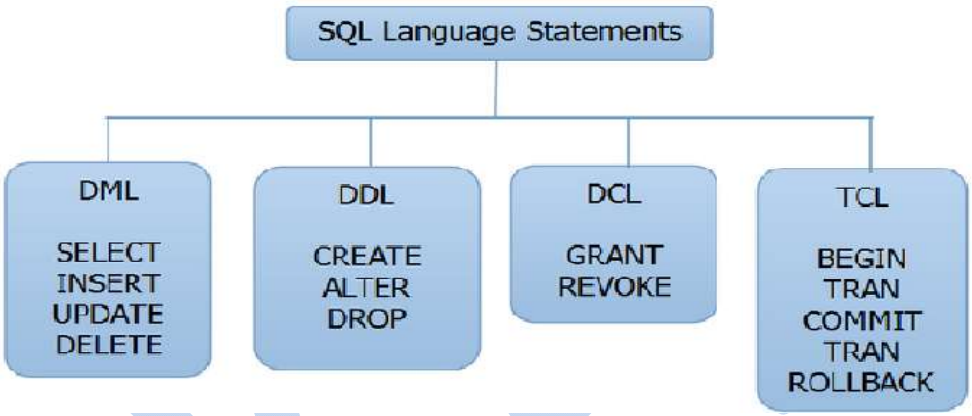
The four main categories of SQL statements are as follows:

1. DML (Data Manipulation Language)

2. DDL (Data Definition Language)

3. DCL (Data Control Language)

4. TCL (Transaction Control Language)



DML (Data Manipulation Language)

DML statements affect records in a table. These are basic operations we perform on data such as selecting a few records from a table, inserting new records, deleting unnecessary records, and updating/modifying existing records.

DML statements include the following:

SELECT – select records from a table

INSERT – insert new records

UPDATE – update/Modify existing records

DELETE – delete existing records

DDL (Data Definition Language)

DDL statements are used to alter/modify a database or table structure and schema. These statements handle the design and storage of database objects.

CREATE – create a new Table, database, schema

ALTER – alter existing table, column description

DROP – delete existing objects from database

DCL (Data Control Language)

DCL statements control the level of access that users have on database objects.

GRANT – allows users to read/write on certain database objects
REVOKE – keeps users from read/write permission on database objects

TCL (Transaction Control Language)

TCL statements allow to control and manage transactions to maintain the integrity of data within SQL statements.

BEGIN Transaction – opens a transaction

COMMIT Transaction – commits a transaction

ROLLBACK Transaction – ROLLBACK a transaction in case of any error

PL/SQL -Introduction

PL/SQL is a procedural language extension to SQL, making it extremely simple to write procedural code that includes SQL as if it were a single language. In

comparison, most other programming languages require mapping data types, preparing statements and processing result sets, all of which require knowledge of specific APIs.

The data types in PL/SQL are a super-set of those in the database, so we rarely need to perform data type conversions when using PL/SQL. Ask wer average Java or .NET programmer how they find handling date values coming from a database. They can only wish for the simplicity of PL/SQL.

INTEGRITY CONSTRAINTS OVER RELATION

- Database integrity refers to the validity and consistency of stored data. Integrity is usually expressed in terms of constraints, which are consistency rules that the database is not permitted to violate. Constraints may apply to each attribute or they may apply to relationships between tables.
- Integrity constraints ensure that changes (update deletion, insertion) made to the database by authorized users do not result in a loss of data consistency. Thus, integrity constraints guard against accidental damage to the database.

EXAMPLE- A brood group must be 'A' or 'B' or 'AB' or 'O' only (can not any other values else).

TYPES OF INTEGRITY CONSTRAINTS

Various types of integrity constraints are-

1. Domain Integrity
2. Entity Integrity Constraint
3. Referential Integrity Constraint
4. Key Constraints

1. Domain Integrity-

Domain integrity means the definition of a valid set of values for an attribute. To define data type, length or size, is null value allowed, is the value unique or not for an attribute, the default value, the range (values in between) and/or specific values for the attribute.

2. Entity Integrity Constraint-

This rule states that in any database relation value of attribute of a primary key can't be null.

EXAMPLE- Consider a relation "STUDENT" Where "Stu_id" is a primary key and it must not contain any null value whereas other attributes may contain null value e.g "Branch" in the following relation contains one null value.

Stu_id	Name	Branch
11255234	Aman	CSE
11255369	Kapil	EcE
11255324	Ajay	ME
11255237	Raman	CSE
11255678	Aastha	ECE

3.Referential Integrity Constraint-

It states that if a foreign key exists in a relation then either the foreign key value must match a primary key value of some tuple in its home relation or the foreign key value must be null.

The rules are:

1. Can't delete a record from a primary table if matching records exist in a related table.
2. Can't change a primary key value in the primary table if that record has related records.
3. Can't enter a value in the foreign key field of the related table that doesn't exist in the primary key of the primary table.
4. However, to enter a Null value in the foreign key, specifying that the records are unrelated.

EXAMPLE-

Consider 2 relations "stu" and "stu_1" Where "Stu_id " is the primary key in the "stu" relation and foreign key in the "stu_1" relation.

Relation "stu"

Stu_id	Name	Branch
11255234	Aman	CSE
11255369	Kapil	EcE
11255324	Ajay	ME
11255237	Raman	CSE
11255678	Aastha	ECE

Relation "stu_1"

Stu_id	Course	Duration

Stu_id	Course	Duration
11255234	B TECH	4 years
11255369	B TECH	4 years
11255324	B TECH	4 years
11255237	B TECH	4 years
11255678	B TECH	4 years

Examples

Rule 1. Can't delete any of the rows in the ”stu” relation that are visible since all the ”stu” are in use in the “stu_1” relation.

Rule 2. Can't change any of the ”Stu_id” in the “stu” relation since all the “Stu_id” are in use in the ”stu_1” relation. **Rule 3.** The values that can enter in the” Stu_id” field in the “stu_1” relation must be in the” Stu_id” field in the “stu” relation.

Rule 4 To enter a null value in the "stu_1" relation if the records are unrelated.

4.Key Constraints-

A Key Constraint is a statement that a certain minimal subset of the fields of a relation is a unique identifier for a tuple. The types of key constraints-

- Primary key constraints
- Unique key constraints
- Foreign Key constraints
- NOT NULL constraints
- Check constraints

1. Primary key constraints

Primary key is the term used to identify one or more columns in a table that make a row of data unique. Although the primary key typically consists of one column in a table, more than one column can comprise the primary key.

For example, either the employee's Social Security number or an assigned employee identification number is the logical primary key for an employee table. The objective is for every record to have a unique primary key or value for the employee's identification number. Because there is probably no need to have more than one record for each employee in an employee table, the employee identification number makes a logical primary key. The primary key is assigned at table creation.

The following example identifies the EMP_ID column as the PRIMARY KEY for the EMPLOYEES table:

```
CREATE TABLE EMPLOYEE_TBL
(EMP_ID          CHAR(9)          NOT NULL PRIMARY KEY,
EMP_NAME         VARCHAR (40)     NOT NULL,
EMP_ST_ADDR      VARCHAR (20)     NOT NULL,
EMP_CITY         VARCHAR (15)     NOT NULL,
EMP_ST           CHAR(2)          NOT NULL,
EMP_ZIP          INTEGER(5)       NOT NULL,
EMP_PHONE        INTEGER(10)      NULL,
EMP_PAGER        INTEGER(10)      NULL);
```

2. Unique Constraints

A unique column constraint in a table is similar to a primary key in that the value in that column for every row of data in the table must have a unique value. Although a

primary key constraint is placed on one column, to place a unique constraint on another column even though it is not actually for use as the primary key.

```
CREATE TABLE EMPLOYEE_TBL
(EMP_ID          CHAR(9)          NOT NULL    PRIMARY KEY,
EMP_NAME         VARCHAR (40)     NOT NULL,
EMP_ST_ADDR      VARCHAR (20)     NOT NULL,
EMP_CITY         VARCHAR (15)     NOT NULL,
EMP_ST           CHAR(2)          NOT NULL,
EMP_ZIP          INTEGER(5)       NOT NULL,
EMP_PHONE        INTEGER(10)      NULL        UNIQUE,
EMP_PAGER        INTEGER(10)      NULL)
```

3. Foreign Key Constraints

A foreign key is a column in a child table that references a primary key in the parent table. A foreign key constraint is the main mechanism used to enforce referential integrity between tables in a relational database. A column defined as a foreign key is used to reference a column defined as a primary key in another table.

```
CREATE TABLE EMPLOYEE_PAY_TBL
(EMP_ID          CHAR(9)          NOT NULL,
POSITION         VARCHAR2(15)     NOT NULL,
DATE_HIRE        DATE             NULL,
PAY_RATE         NUMBER(4,2)      NOT NULL,
DATE_LAST_RAISE  DATE             NULL,
```

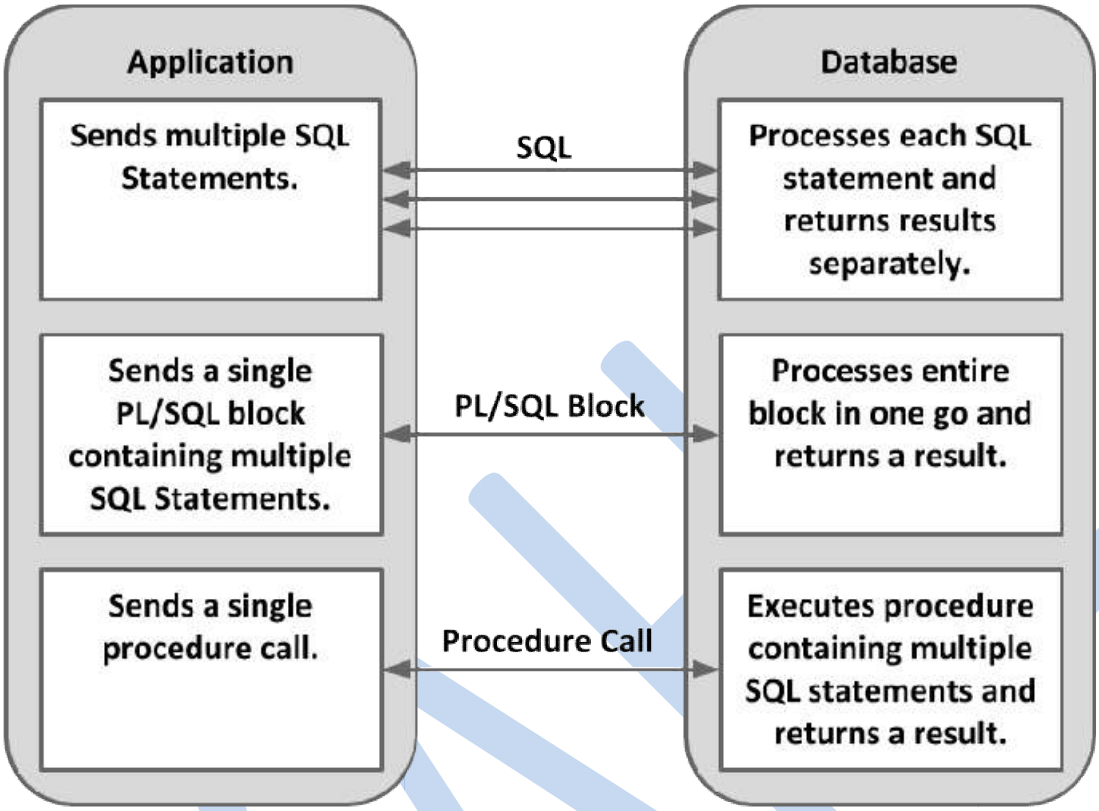
4. NOT NULL Constraints

Previous examples use the keywords NULL and NOT NULL listed on the same line as each column and after the data type. NOT NULL is a constraint that to place on a table's column. This constraint disallows the entrance of NULL values into a column; in other words, data is required in a NOT NULL column for each row of data in the table. NULL is generally the default for a column if NOT NULL is not specified, allowing NULL values in a column.

5. Check Constraints

Check (CHK) constraints can be utilized to check the validity of data entered into particular table columns. Check constraints are used to provide back-end database edits, although edits are commonly found in the front-end application as well. General edits restrict values that can be entered into columns or objects, whether within the database itself or on a front-end application. The check constraint is a way of providing another protective layer for the data.

```
CREATE TABLE EMPLOYEE_TBL
(EMP_ID          CHAR(9)          NOT NULL,
EMP_NAME         VARCHAR2(40)     NOT NULL,
EMP_ST_ADDR      VARCHAR2(20)     NOT NULL,
EMP_CITY         VARCHAR2(15)     NOT NULL,
EMP_ST           CHAR(2)          NOT NULL,
EMP_ZIP          NUMBER(5)        NOT NULL,
EMP_PHONE        NUMBER(10)       NULL,
EMP_PAGER        NUMBER(10)       NULL),
PRIMARY KEY (EMP_ID),
CONSTRAINT CHK_EMP_ZIP CHECK ( EMP_ZIP = '46234');
```



Oracle is a multi-platform database, making PL/SQL and incredibly portable language.

Programming languages go in and out of fashion continually. Over the last 35+ years Oracle databases have remained part of the enterprise landscape. Suggesting that any language is a safer bet than PL/SQL is rather naive.

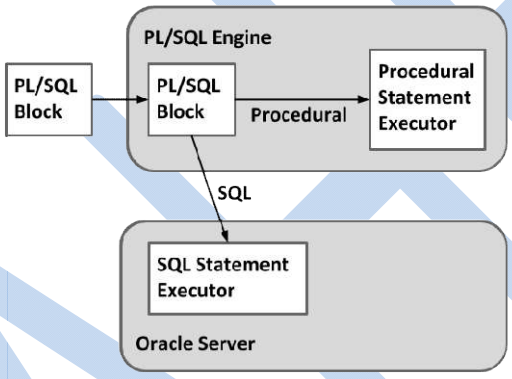
Centralizing application logic enables a higher degree of security and productivity. The use of Application Program Interfaces (APIs) can abstract complex data structures and security implementations from client application developers, leaving them free to do what they do best.

PL/SQL Architecture

The PL/SQL language is actually made up of two distinct languages. Procedural code is executed by the PL/SQL engine, while SQL is sent to the SQL statement executor.

The PL/SQL architecture mainly consists of following 3 components:

1. PL/SQL block
2. PL/SQL Engine
3. Database Server



PL/SQL block:

This is the component which has the actual PL/SQL code.

This consists of different sections to divide the code logically (declarative section for declaring purpose, execution section for processing statements, exception handling section for handling errors)

It also contains the SQL instruction that used to interact with the database server.

All the PL/SQL units are treated as PL/SQL blocks, and this is the starting stage of the architecture which serves as the primary input.

Following are the different type of PL/SQL units.

- Anonymous Block

- Function
- Library
- Procedure
- Package Body
- Package Specification
- Trigger
- Type
- Type Body

PL/SQL Engine

PL/SQL engine is the component where the actual processing of the codes takes place.

PL/SQL engine separates PL/SQL units and SQL part in the input (as shown in the image below).

The separated PL/SQL units will be handled with the PL/SQL engine itself.

The SQL part will be sent to database server where the actual interaction with database takes place.

It can be installed in both database server and in the application server.

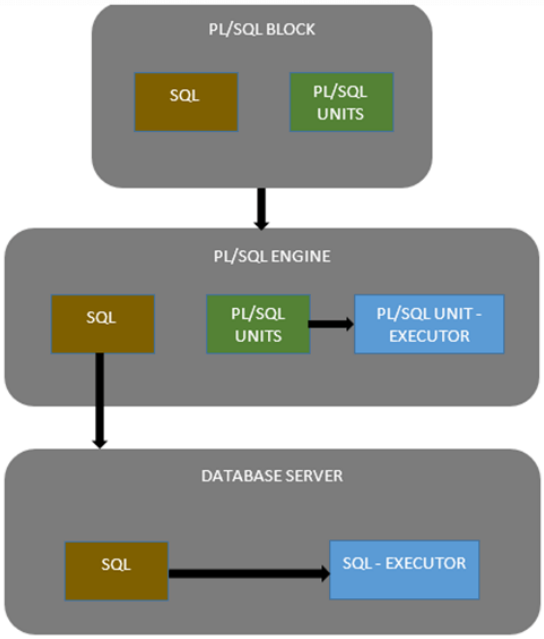
Database Server:

This is the most important component of Pl/SQL unit which stores the data.

The PL/SQL engine uses the SQL from PL/SQL units to interact with the database server.

It consists of SQL executor which actually parses the input SQL statements and execute the same.

Below is the pictorial representation of Architecture of PL/SQL.



Features of PL/SQL

- PL/SQL is tightly integrated with SQL.
- It offers extensive error checking.
- It offers numerous data types.
- It offers a variety of programming structures.
- It supports structured programming through functions and procedures.
- It supports object-oriented programming.
- It supports the development of web applications and server pages.

Advantage of Using PL/SQL

- Better performance, as sql is executed in bulk rather than a single statement
- High Productivity

- Tight integration with SQL
- Full Portability
- Tight Security
- Support Object Oriented Programming concepts.

Basic Difference between SQL and PL/SQL

In this section, we will discuss some differences between SQL and PL/SQL

SQL	PL/SQL
• SQL is a single query that is used to perform DML and DDL operations.	• PL/SQL is a block of codes that used to write the entire program blocks/ procedure/ function, etc.
• It is declarative, that defines what needs to be done, rather than how things need to be done.	• PL/SQL is procedural that defines how the things needs to be done.
• Execute as a single statement.	• Execute as a whole block.
• Mainly used to manipulate data.	• Mainly used to create an application.
• Interaction with Database	• No interaction with the

server.	database server.
• Cannot contain PL/SQL code in it.	• It is an extension of SQL, so it can contain SQL inside it.

Basic Syntax of PL/SQL

The Basic Syntax of PL/SQL which is a **block-structured** language; this means that the PL/SQL programs are divided and written in logical blocks of code. Each block consists of three sub-parts −

S.No	Sections & Description
1	**Declarations** This section starts with the keyword **DECLARE**. It is an optional section and defines all variables, cursors, subprograms, and other elements to be used in the program.
2	**Executable Commands** This section is enclosed between the keywords **BEGIN** and **END** and it is a mandatory section. It consists of the executable PL/SQL statements of the program. It should have at least one executable line of code, which may be just a **NULL command** to indicate that nothing should be executed.

3	**Exception Handling** This section starts with the keyword **EXCEPTION**. This optional section contains **exception(s)** that handle errors in the program.

Every PL/SQL statement ends with a semicolon (;). PL/SQL blocks can be nested within other PL/SQL blocks using **BEGIN** and **END**.

Following is the basic structure of a PL/SQL block –

```
DECLARE
   <declarations section>
BEGIN
   <executable command(s)>
EXCEPTION
   <exception handling>
END;
```

Example

```
DECLARE
   message  varchar2(20):= 'Hello, World!';
BEGIN
   dbms_output.put_line(message);
END;
/
```

The **end;** line signals the end of the PL/SQL block. To run the code from the SQL command line, we may need to type / at the beginning of the first blank line after the last line of the code. When the above code is executed at the SQL prompt, it produces the following result −

Hello World

PL/SQL procedure successfully completed.

The PL/SQL Identifiers

PL/SQL identifiers are constants, variables, exceptions, procedures, cursors, and reserved words. The identifiers consist of a letter optionally followed by more letters, numerals, dollar signs, underscores, and number signs and should not exceed 30 characters.

By default, **identifiers are not case-sensitive**. So we can use **integer** or **INTEGER** to represent a numeric value. We cannot use a reserved keyword as an identifier.

The PL/SQL Delimiters

A delimiter is a symbol with a special meaning. Following is the list of delimiters in PL/SQL −

Delimiter	**Description**
+, -, *, /	Addition, subtraction/negation, multiplication, division
%	Attribute indicator
'	Character string delimiter

.	Component selector
(,)	Expression or list delimiter
:	Host variable indicator
,	Item separator
"	Quoted identifier delimiter
=	Relational operator
@	Remote access indicator
;	Statement terminator
:=	Assignment operator
=>	Association operator
||	Concatenation operator
**	Exponentiation operator
<<, >>	Label delimiter (begin and end)
/*, */	Multi-line comment delimiter (begin and end)
--	Single-line comment indicator

..	Range operator
<, >, <=, >=	Relational operators
<>, '=, ~=, ^=	Different versions of NOT EQUAL

The PL/SQL Comments

Program comments are explanatory statements that can be included in the PL/SQL code that we write and helps anyone reading its source code. All programming languages allow some form of comments.

The PL/SQL supports single-line and multi-line comments. All characters available inside any comment are ignored by the PL/SQL compiler. The PL/SQL single-line comments start with the delimiter -- (double hyphen) and multi-line comments are enclosed by /* and */.

```
DECLARE
   -- variable declaration
   message  varchar2(20):= 'Hello, World!';
BEGIN
   /*
   *  PL/SQL executable statement(s)
   */
   dbms_output.put_line(message);
```

```
END;
/
```

When the above code is executed at the SQL prompt, it produces the following result –

```
Hello World

PL/SQL procedure successfully completed.
```

PL/SQL Program Units

A PL/SQL unit is any one of the following –

- PL/SQL block
- Function
- Package
- Package body
- Procedure
- Trigger
- Type
- Type body

Data Types

Data Types in PL/SQL.

The PL/SQL variables, constants and parameters must have a valid data type, which specifies a storage format, constraints, and a valid range of values. We will focus on the **SCALAR** and the **LOB** data types.

S.No	Category & Description
1	**Scalar** Single values with no internal components, such as a **NUMBER, DATE,** or **BOOLEAN**.
2	**Large Object (LOB)** Pointers to large objects that are stored separately from other data items, such as text, graphic images, video clips, and sound waveforms.
3	**Composite** Data items that have internal components that can be accessed individually. For example, collections and records.
4	**Reference** Pointers to other data items.

PL/SQL Scalar Data Types and Subtypes

PL/SQL Scalar Data Types and Subtypes come under the following categories −

S.No	Date Type & Description
1	**Numeric** Numeric values on which arithmetic operations are performed.
2	**Character** Alphanumeric values that represent single characters or strings of characters.
3	**Boolean** Logical values on which logical operations are performed.
4	**Datetime** Dates and times.

PL/SQL provides subtypes of data types. For example, the data type NUMBER has a subtype called INTEGER. We can use the subtypes in wer PL/SQL program to make the data types compatible with data types in other programs while embedding the PL/SQL code in another program, such as a Java program.

PL/SQL Numeric Data Types and Subtypes

Following table lists out the PL/SQL pre-defined numeric data types and their sub-types –

S.No	Data Type & Description
1	**PLS_INTEGER** Signed integer in range -2,147,483,648 through 2,147,483,647, represented in 32 bits
2	**BINARY_INTEGER** Signed integer in range -2,147,483,648 through 2,147,483,647, represented in 32 bits
3	**BINARY_FLOAT** Single-precision IEEE 754-format floating-point number
4	**BINARY_DOUBLE** Double-precision IEEE 754-format floating-point number
5	**NUMBER(prec, scale)** Fixed-point or floating-point number with absolute value in range 1E-130 to (but not including) 1.0E126. A NUMBER variable can also represent 0
6	**DEC(prec, scale)** ANSI specific fixed-point type with maximum precision of 38 decimal digits
7	**DECIMAL(prec, scale)**

	IBM specific fixed-point type with maximum precision of 38 decimal digits
8	**NUMERIC(pre, secale)** Floating type with maximum precision of 38 decimal digits
9	**DOUBLE PRECISION** ANSI specific floating-point type with maximum precision of 126 binary digits (approximately 38 decimal digits)
10	**FLOAT** ANSI and IBM specific floating-point type with maximum precision of 126 binary digits (approximately 38 decimal digits)
11	**INT** ANSI specific integer type with maximum precision of 38 decimal digits
12	**INTEGER** ANSI and IBM specific integer type with maximum precision of 38 decimal digits
13	**SMALLINT** ANSI and IBM specific integer type with maximum precision of 38 decimal digits

14	**REAL** Floating-point type with maximum precision of 63 binary digits (approximately 18 decimal digits)

Following is a valid declaration −

```
DECLARE
   num1 INTEGER;
   num2 REAL;
   num3 DOUBLE PRECISION;
BEGIN
   null;
END;
/
```

When the above code is compiled and executed, it produces the following result −

```
PL/SQL procedure successfully completed
```

PL/SQL Character Data Types and Subtypes

Following is the detail of PL/SQL pre-defined character data types and their sub-types

S.No	Data Type & Description
1	**CHAR** Fixed-length character string with maximum size of 32,767 bytes
2	**VARCHAR2** Variable-length character string with maximum size of 32,767 bytes
3	**RAW** Variable-length binary or byte string with maximum size of 32,767 bytes, not interpreted by PL/SQL
4	**NCHAR** Fixed-length national character string with maximum size of 32,767 bytes
5	**NVARCHAR2** Variable-length national character string with maximum size of 32,767 bytes
6	**LONG** Variable-length character string with maximum size of 32,760 bytes
7	**LONG RAW** Variable-length binary or byte string with maximum size of 32,760 bytes, not interpreted by PL/SQL

8	**ROWID** Physical row identifier, the address of a row in an ordinary table
9	**UROWID** Universal row identifier (physical, logical, or foreign row identifier)

PL/SQL Boolean Data Types

The **BOOLEAN** data type stores logical values that are used in logical operations. The logical values are the Boolean values **TRUE** and **FALSE** and the value **NULL**.

However, SQL has no data type equivalent to BOOLEAN. Therefore, Boolean values cannot be used in −

- SQL statements
- Built-in SQL functions (such as **TO_CHAR**)
- PL/SQL functions invoked from SQL statements

PL/SQL Date time and Interval Types

The **DATE** datatype is used to store fixed-length datetimes, which include the time of day in seconds since midnight. Valid dates range from January 1, 4712 BC to December 31, 9999 AD.

The default date format is set by the Oracle initialization parameter NLS_DATE_FORMAT. For example, the default might be 'DD-MON-YY', which includes a two-digit number for the day of the month, an abbreviation of the month name, and the last two digits of the year. For example, 01-OCT-12.

Each DATE includes the century, year, month, day, hour, minute, and second. The following table shows the valid values for each field –

Field Name	Valid Datetime Values	Valid Interval Values
YEAR	-4712 to 9999 (excluding year 0)	Any nonzero integer
MONTH	01 to 12	0 to 11
DAY	01 to 31 (limited by the values of MONTH and YEAR, according to the rules of the calendar for the locale)	Any nonzero integer
HOUR	00 to 23	0 to 23
MINUTE	00 to 59	0 to 59
SECOND	00 to 59.9(n), where 9(n) is the precision of time fractional seconds	0 to 59.9(n), where 9(n) is the precision of interval fractional seconds
TIMEZONE_HOUR	-12 to 14 (range accommodates daylight savings time changes)	Not applicable

TIMEZONE_MINUTE	00 to 59	Not applicable
TIMEZONE_REGION	Found in the dynamic performance view V$TIMEZONE_NAMES	Not applicable
TIMEZONE_ABBR	Found in the dynamic performance view V$TIMEZONE_NAMES	Not applicable

PL/SQL Large Object (LOB) Data Types

Large Object (LOB) data types refer to large data items such as text, graphic images, video clips, and sound waveforms. LOB data types allow efficient, random, piecewise access to this data. Following are the predefined PL/SQL LOB data types −

Data Type	Description	Size
BFILE	Used to store large binary objects in operating system files outside the database.	System-dependent. Cannot exceed 4 gigabytes (GB).
BLOB	Used to store large binary objects in the database.	8 to 128 terabytes (TB)
CLOB	Used to store large blocks of character data in the database.	8 to 128 TB

NCLOB	Used to store large blocks of NCHAR data in the database.	8 to 128 TB

PL/SQL User-Defined Subtypes

A subtype is a subset of another data type, which is called its base type. A subtype has the same valid operations as its base type, but only a subset of its valid values.

PL/SQL predefines several subtypes in package **STANDARD**. For example, PL/SQL predefines the subtypes **CHARACTER** and **INTEGER** as follows −

```
SUBTYPE CHARACTER IS CHAR;

SUBTYPE INTEGER IS NUMBER(38,0);
```

The following program illustrates defining and using a user-defined subtype

```
DECLARE
   SUBTYPE name IS char(20);
   SUBTYPE message IS varchar2(100);
   salutation name;
   greetings message;
BEGIN
   salutation := 'Reader ';
   greetings := 'Welcome to the World of PL/SQL';
```

```
dbms_output.put_line('Hello ' || salutation || greetings);
END;
```

When the above code is executed at the SQL prompt, it produces the following result –

```
Hello Reader Welcome to the World of PL/SQL

PL/SQL procedure successfully completed.
```

NULLs in PL/SQL

PL/SQL NULL values represent **missing** or **unknown data** and they are not an integer, a character, or any other specific data type. Note that **NULL** is not the same as an empty data string or the null character value '**\0**'. A null can be assigned but it cannot be equated with anything, including itself.

Variable Declaration in PL/SQL

PL/SQL variables must be declared in the declaration section or in a package as a global variable. When we declare a variable, PL/SQL allocates memory for the variable's value and the storage location is identified by the variable name.

The syntax for declaring a variable is –

```
variable_name [CONSTANT] datatype [NOT NULL] [:= | DEFAULT initial_value]
```

Where, *variable_name* is a valid identifier in PL/SQL, *datatype* must be a valid

```
sales number(10, 2);
pi CONSTANT double precision := 3.1415;
```

name varchar2(25);

address varchar2(100);

When we provide a size, scale or precision limit with the data type, it is called a **constrained declaration**. Constrained declarations require less memory than unconstrained declarations. For example −

sales number(10, 2);

name varchar2(25);

address varchar2(100);

Initializing Variables in PL/SQL

Whenever we declare a variable, PL/SQL assigns it a default value of NULL. If we want to initialize a variable with a value other than the NULL value, we can do so during the declaration, using either of the following −

- The **DEFAULT** keyword
- The **assignment** operator

For example −

counter binary_integer := 0;

greetings varchar2(20) DEFAULT 'Have a Good Day';

We can also specify that a variable should not have a **NULL** value using the **NOT NULL** constraint. If we use the NOT NULL constraint, we must explicitly assign an initial value for that variable.

It is a good programming practice to initialize variables properly otherwise, sometimes programs would produce unexpected results. Try the following example which makes use of various types of variables −

```
DECLARE
   a integer := 10;
   b integer := 20;
   c integer;
   f real;
BEGIN
   c := a + b;
   dbms_output.put_line('Value of c: ' || c);
   f := 70.0/3.0;
   dbms_output.put_line('Value of f: ' || f);
END;
/
```

When the above code is executed, it produces the following result −

```
Value of c: 30
Value of f: 23.333333333333333
PL/SQL procedure successfully completed.
```

Variable Scope in PL/SQL

PL/SQL allows the nesting of blocks, i.e., each program block may contain another inner block. If a variable is declared within an inner block, it is not accessible to the outer block. However, if a variable is declared and accessible to an outer block, it is also accessible to all nested inner blocks. There are two types of variable scope −

- **Local variables** − Variables declared in an inner block and not accessible to outer blocks.
- **Global variables** − Variables declared in the outermost block or a package.

Following example shows the usage of **Local** and **Global** variables in its simple form −

```
DECLARE
  -- Global variables
  num1 number := 95;
  num2 number := 85;
BEGIN
  dbms_output.put_line('Outer Variable num1: ' || num1);
  dbms_output.put_line('Outer Variable num2: ' || num2);
  DECLARE
    -- Local variables
    num1 number := 195;
    num2 number := 185;
  BEGIN
```

```
    dbms_output.put_line('Inner Variable num1: ' || num1);
    dbms_output.put_line('Inner Variable num2: ' || num2);
  END;
END;
/
```

When the above code is executed, it produces the following result −

```
Outer Variable num1: 95
Outer Variable num2: 85
Inner Variable num1: 195
Inner Variable num2: 185
PL/SQL procedure successfully completed.
```

Assigning SQL Query Results to PL/SQL Variables

We can use the **SELECT INTO** statement of SQL to assign values to PL/SQL variables. For each item in the **SELECT list**, there must be a corresponding, type-compatible variable in the **INTO list**. The following example illustrates the concept. Let us create a table named CUSTOMERS −

(**For SQL statements, please refer to the** SQL tutorial)

```
CREATE TABLE CUSTOMERS(
  ID   INT NOT NULL,
  NAME VARCHAR (20) NOT NULL,
  AGE INT NOT NULL,
```

```
   ADDRESS CHAR (25),
   SALARY   DECIMAL (18, 2),
   PRIMARY KEY (ID)
);
```

Table Created

Let us now insert some values in the table −

```
INSERT INTO CUSTOMERS (ID,NAME,AGE,ADDRESS,SALARY)
VALUES (1, 'Ramesh', 32, 'Ahmedabad', 2000.00 );
INSERT INTO CUSTOMERS (ID,NAME,AGE,ADDRESS,SALARY)
VALUES (2, 'Khilan', 25, 'Delhi', 1500.00 );
INSERT INTO CUSTOMERS (ID,NAME,AGE,ADDRESS,SALARY)
VALUES (3, 'kaushik', 23, 'Kota', 2000.00 ); INSERT INTO CUSTOMERS (ID,NAME,AGE,ADDRESS,SALARY)
VALUES (4, 'Chaitali', 25, 'Mumbai', 6500.00 );
INSERT INTO CUSTOMERS (ID,NAME,AGE,ADDRESS,SALARY)
VALUES (5, 'Hardik', 27, 'Bhopal', 8500.00 );
INSERT INTO CUSTOMERS (ID,NAME,AGE,ADDRESS,SALARY)
VALUES (6, 'Komal', 22, 'MP', 4500.00 );
```

The following program assigns values from the above table to PL/SQL variables using the **SELECT INTO clause** of SQL −

```
DECLARE
   c_id customers.id%type := 1;
   c_name  customers.name%type;
   c_addr customers.address%type;
   c_sal  customers.salary%type;
BEGIN
   SELECT name, address, salary INTO c_name, c_addr, c_sal
   FROM customers
   WHERE id = c_id;
   dbms_output.put_line
   ('Customer ' ||c_name || ' from ' || c_addr || ' earns ' || c_sal);
END;
/
```

When the above code is executed, it produces the following result −

```
Customer Ramesh from Ahmedabad earns 2000
PL/SQL procedure completed successfully
```

Declaring a Constant

A constant is declared using the **CONSTANT** keyword. It requires an initial value and does not allow that value to be changed. For example −

```
PI CONSTANT NUMBER := 3.141592654;
```

```
DECLARE
   -- constant declaration
   pi constant number := 3.141592654;
   -- other declarations
   radius number(5,2);
   dia number(5,2);
   circumference number(7, 2);
   area number (10, 2);
BEGIN
   -- processing
   radius := 9.5;
   dia := radius * 2;
   circumference := 2.0 * pi * radius;
   area := pi * radius * radius;
   -- output
   dbms_output.put_line('Radius: ' || radius);
   dbms_output.put_line('Diameter: ' || dia);
   dbms_output.put_line('Circumference: ' || circumference);
   dbms_output.put_line('Area: ' || area);
END;
```

/

When the above code is executed at the SQL prompt, it produces the following result –

Radius: 9.5

Diameter: 19

Circumference: 59.69

Area: 283.53

Pl/SQL procedure successfully completed.

The PL/SQL Literals

A literal is an explicit numeric, character, string, or Boolean value not represented by an identifier. For example, TRUE, 786, NULL, 'tutorialspoint' are all literals of type Boolean, number, or string. PL/SQL, literals are case-sensitive. PL/SQL supports the following kinds of literals −

- Numeric Literals
- Character Literals
- String Literals
- BOOLEAN Literals
- Date and Time Literals

The following table provides examples from all these categories of literal values.

S.No	Literal Type & Example
1	**Numeric Literals** 050 78 -14 0 +32767 6.6667 0.0 -12.0 3.14159 +7800.00 6E5 1.0E-8 3.14159e0 -1E38 -9.5e-3
2	**Character Literals** 'A' '%' '9' ' ' 'z' '('
3	**String Literals** 'Hello, world!' 'Tutorials Point' '19-NOV-12'
4	**BOOLEAN Literals** TRUE, FALSE, and NULL.
5	**Date and Time Literals** DATE '1978-12-25'; TIMESTAMP '2012-10-29 12:01:01';

To embed single quotes within a string literal, place two single quotes next to each other as shown in the following program −

```
DECLARE

   message  varchar2(30):= 'That''s tutorialspoint.com!';

BEGIN

   dbms_output.put_line(message);

END;

/
```

When the above code is executed at the SQL prompt, it produces the following result

PL/SQL procedure successfully completed.

Procedures in PL/SQL

A **subprogram** is a program unit/module that performs a particular task. These subprograms are combined to form larger programs. This is basically called the 'Modular design'. A subprogram can be invoked by another subprogram or program which is called the **calling program**.

A subprogram can be created −

- At the schema level
- Inside a package
- Inside a PL/SQL block

At the schema level, subprogram is a **standalone subprogram**. It is created with the CREATE PROCEDURE or the CREATE FUNCTION statement. It is stored in the database and can be deleted with the DROP PROCEDURE or DROP FUNCTION statement.

A subprogram created inside a package is a **packaged subprogram**. It is stored in the database and can be deleted only when the package is deleted with the DROP PACKAGE statement.

PL/SQL subprograms are named PL/SQL blocks that can be invoked with a set of parameters. PL/SQL provides two kinds of subprograms −

- **Functions** − These subprograms return a single value; mainly used to compute and return a value.

- **Procedures** – These subprograms do not return a value directly; mainly used to perform an action.

Parts of a PL/SQL Subprogram

Each PL/SQL subprogram has a name, and may also have a parameter list. Like anonymous PL/SQL blocks, the named blocks will also have the following three parts

S.No	Parts & Description
1	**Declarative Part** It is an optional part. However, the declarative part for a subprogram does not start with the DECLARE keyword. It contains declarations of types, cursors, constants, variables, exceptions, and nested subprograms. These items are local to the subprogram and cease to exist when the subprogram completes execution.
2	**Executable Part** This is a mandatory part and contains statements that perform the designated action.
3	**Exception-handling** This is again an optional part. It contains the code that handles run-time errors.

Creating a Procedure

A procedure is created with the **CREATE OR REPLACE PROCEDURE**statement. The simplified syntax for the CREATE OR REPLACE PROCEDURE statement is as follows –

CREATE [OR REPLACE] PROCEDURE procedure_name

[(parameter_name [IN | OUT | IN OUT] type [, ...])]

{IS | AS}

BEGIN

< procedure_body >

END procedure_name;

Where,

- *procedure-name* specifies the name of the procedure.
- [OR REPLACE] option allows the modification of an existing procedure.
- The optional parameter list contains name, mode and types of the parameters. **IN** represents the value that will be passed from outside and OUT represents the parameter that will be used to return a value outside of the procedure.
- *procedure-body* contains the executable part.
- The AS keyword is used instead of the IS keyword for creating a standalone procedure.

Example

The following example creates a simple procedure that displays the string 'Hello World!' on the screen when executed.

CREATE OR REPLACE PROCEDURE greetings

AS

```
BEGIN
   dbms_output.put_line('Hello World!');
END;
/
```

When the above code is executed using the SQL prompt, it will produce the following result −

Procedure created.

Executing a Standalone Procedure

A standalone procedure can be called in two ways −

- Using the **EXECUTE** keyword
- Calling the name of the procedure from a PL/SQL block

The above procedure named '**greetings**' can be called with the EXECUTE keyword as −

```
EXECUTE greetings;
```

The above call will display −

```
Hello World

PL/SQL procedure successfully completed.
```

The procedure can also be called from another PL/SQL block −

```
BEGIN
   greetings;
```

END;

/

The above call will display −

Hello World

PL/SQL procedure successfully completed.

Deleting a Standalone Procedure

A standalone procedure is deleted with the **DROP PROCEDURE** statement. Syntax for deleting a procedure is −

DROP PROCEDURE procedure-name;

DROP PROCEDURE greetings;

Parameter Modes in PL/SQL Subprograms

The following table lists out the parameter modes in PL/SQL subprograms −

S.No	Parameter Mode & Description
1	**IN** An IN parameter , to pass a value to the subprogram. **It is a read-only parameter**. Inside the subprogram, an IN parameter acts like a constant. It cannot be assigned a value. We can pass a constant, literal, initialized variable, or expression as an IN parameter. We can also initialize it to a default value; however, in that case, it is omitted from the subprogram call. **It is the default mode of parameter passing. Parameters are passed by reference**.

2	**OUT** An OUT parameter returns a value to the calling program. Inside the subprogram, an OUT parameter acts like a variable. We can change its value and reference the value after assigning it. **The actual parameter must be variable and it is passed by value**.
3	**IN OUT** An **IN OUT** parameter passes an initial value to a subprogram and returns an updated value to the caller. It can be assigned a value and the value can be read. The actual parameter corresponding to an IN OUT formal parameter must be a variable, not a constant or an expression. Formal parameter must be assigned a value. **Actual parameter is passed by value.**

IN & OUT Mode Example 1

This program finds the minimum of two values. Here, the procedure takes two numbers using the IN mode and returns their minimum using the OUT parameters.

```
DECLARE
   a number;
   b number;
   c number;
PROCEDURE findMin(x IN number, y IN number, z OUT number) IS
BEGIN
   IF x < y THEN
```

```
      z:= x;
   ELSE
      z:= y;
   END IF;
END;
BEGIN
   a:= 23;
   b:= 45;
   findMin(a, b, c);
   dbms_output.put_line(' Minimum of (23, 45) : ' || c);
END;
/
```

When the above code is executed at the SQL prompt, it produces the following result –

```
Minimum of (23, 45) : 23
PL/SQL procedure successfully completed.
```

IN & OUT Mode Example 2

This procedure computes the square of value of a passed value. This example shows how we can use the same parameter to accept a value and then return another result.

```
DECLARE
```

```
   a number;
PROCEDURE squareNum(x IN OUT number) IS
BEGIN
  x := x * x;
END;
BEGIN
   a:= 23;
   squareNum(a);
   dbms_output.put_line(' Square of (23): ' || a);
END;
/
```

When the above code is executed at the SQL prompt, it produces the following result –

```
Square of (23): 529
PL/SQL procedure successfully completed.
```

Methods for Passing Parameters

Actual parameters can be passed in three ways −

- Positional notation
- Named notation
- Mixed notation

Positional Notation

In positional notation, we can call the procedure as −

findMin(a, b, c, d);

In positional notation, the first actual parameter is substituted for the first formal parameter; the second actual parameter is substituted for the second formal parameter, and so on. So, **a** is substituted for **x,** **b** is substituted for **y,** **c** is substituted for **z** and **d** is substituted for **m**.

Named Notation

In named notation, the actual parameter is associated with the formal parameter using the **arrow symbol (=>)**. The procedure call will be like the following −

findMin(x => a, y => b, z => c, m => d);

Mixed Notation

In mixed notation, we can mix both notations in procedure call; however, the positional notation should precede the named notation.

The following call is legal −

findMin(a, b, c, m => d);

However, this is not legal:

findMin(x => a, b, c, d);

Functions in PL/SQL

A function is same as a procedure except that it returns a value.

Creating a Function

A standalone function is created using the CREATE FUNCTION statement. The simplified syntax for the CREATE OR REPLACE PROCEDURE statement is as follows

CREATE [OR REPLACE] FUNCTION function_name

[(parameter_name [IN | OUT | IN OUT] type [, ...])]

RETURN return_datatype

{IS | AS}

BEGIN

< function_body >

END [function_name];

Where,

- *function-name* specifies the name of the function.
- [OR REPLACE] option allows the modification of an existing function.
- The optional parameter list contains name, mode and types of the parameters. IN represents the value that will be passed from outside and OUT represents the parameter that will be used to return a value outside of the procedure.
- The function must contain a return statement.
- The *RETURN* clause specifies to return from the function.
- *function-body* contains the executable part.
- The AS keyword is used instead of the IS keyword for creating a standalone function.

Example

The following example illustrates how to create and call a standalone function. This function returns the total number of CUSTOMERS in the customers table.

To use the CUSTOMERS table, which we had created in the PL/SQL Variables we –

Select * from customers;

ID	NAME	AGE	ADDRESS	SALARY
1	Ramesh	32	hmedabad	000.00
2	Khilan	25	Delhi	500.00
3	kaushik	23	Kota	000.00
4	Chaitali	25	Mumbai	500.00
5	Hardik	27	Bhopal	500.00
6	Komal	22	MP	500.00

```
CREATE OR REPLACE FUNCTION totalCustomers
RETURN number IS
   total number(2) := 0;
BEGIN
   SELECT count(*) into total
   FROM customers;

   RETURN total;
END;
```

/

When the above code is executed using the SQL prompt, it will produce the following result −

Function created.

Calling a Function

While creating a function, to give a definition of what the function has to do. To use a function, to call that function to perform the defined task. When a program calls a function, the program control is transferred to the called function.

A called function performs the defined task and when its return statement is executed or when the last end statement is reached, it returns the program control back to the main program.

To call a function, simply need to pass the required parameters along with the function name and if the function returns a value, then we can store the returned value. Following program calls the function totalCustomers from an anonymous block −

```
DECLARE
   c number(2);
BEGIN
   c := totalCustomers();
   dbms_output.put_line('Total no. of Customers: ' || c);
END;
/
```

When the above code is executed at the SQL prompt, it produces the following result –

Total no. of Customers: 6

PL/SQL procedure successfully completed.

Example

The following example demonstrates Declaring, Defining, and Invoking a Simple PL/SQL Function that computes and returns the maximum of two values.

```
DECLARE
   a number;
   b number;
   c number;
FUNCTION findMax(x IN number, y IN number)
RETURN number
IS
    z number;
BEGIN
   IF x > y THEN
      z:= x;
   ELSE
      Z:= y;
```

```
   END IF;

   RETURN z;

END;

BEGIN

   a:= 23;

   b:= 45;

   c := findMax(a, b);

   dbms_output.put_line(' Maximum of (23,45): ' || c);

END;

/
```

When the above code is executed at the SQL prompt, it produces the following result –

```
Maximum of (23,45): 45

PL/SQL procedure successfully completed.
```

PL/SQL Recursive Functions

A program or subprogram may call another subprogram. When a subprogram calls itself, it is referred to as a recursive call and the process is known as recursion.

To illustrate the concept, let us calculate the factorial of a number. Factorial of a number n is defined as −

n! = n*(n-1)!

= n*(n-1)*(n-2)!

...

= n*(n-1)*(n-2)*(n-3)... 1

The following program calculates the factorial of a given number by calling itself recursively −

```
DECLARE
   num number;
   factorial number;


FUNCTION fact(x number)
RETURN number
IS
   f number;
BEGIN
   IF x=0 THEN
      f := 1;
   ELSE
      f := x * fact(x-1);
   END IF;
RETURN f;
```

```
END;


BEGIN
   num:= 6;
   factorial := fact(num);
   dbms_output.put_line(' Factorial '|| num || ' is ' || factorial);
END;
/
```

When the above code is executed at the SQL prompt, it produces the following result –

```
Factorial 6 is 720
  PL/SQL procedure successfully completed.
```

Cursor Management

A cursor is a pointer to this context area. PL/SQL controls the context area through a cursor. A cursor holds the rows (one or more) returned by a SQL statement. The set of rows the cursor holds is referred to as the active set.

To a cursor name so that it could be referred to in a program to fetch and process the rows returned by the SQL statement, one at a time. There are two types of cursors −

- Implicit cursors
- Explicit cursors

Implicit Cursors

Implicit cursors are automatically created by Oracle whenever an SQL statement is executed, when there is no explicit cursor for the statement. Programmers cannot control the implicit cursors and the information in it.

Whenever a DML statement (INSERT, UPDATE and DELETE) is issued, an implicit cursor is associated with this statement. For INSERT operations, the cursor holds the data that needs to be inserted. For UPDATE and DELETE operations, the cursor identifies the rows that would be affected.

In PL/SQL, to implicit cursor as the SQL cursor, which always has attributes such as %FOUND, %ISOPEN, %NOTFOUND, and %ROWCOUNT. The SQL cursor has additional attributes, %BULK_ROWCOUNT and %BULK_EXCEPTIONS, designed for use with the FORALL statement. The following table provides the description of the most used attributes –

S.No	Attribute & Description
1	%FOUND Returns TRUE if an INSERT, UPDATE, or DELETE statement affected one or more rows or a SELECT INTO statement returned one or more rows. Otherwise, it returns FALSE.
2	%NOTFOUND The logical opposite of %FOUND. It returns TRUE if an INSERT, UPDATE, or DELETE statement affected no rows, or a SELECT INTO statement returned no rows. Otherwise, it returns FALSE.

3	%ISOPEN Always returns FALSE for implicit cursors, because Oracle closes the SQL cursor automatically after executing its associated SQL statement.
4	%ROWCOUNT Returns the number of rows affected by an INSERT, UPDATE, or DELETE statement, or returned by a SELECT INTO statement.

Any SQL cursor attribute will be accessed as sql%attribute_name as shown below in the example.

Example

Select * from customers;

ID	NAME	AGE	ADDRESS	SALARY
1	Ramesh	32	Ahmedabad	2000.00
2	Khilan	25	Delhi	1500.00
3	kaushik	23	Kota	2000.00
4	Chaitali	25	Mumbai	6500.00
5	Hardik	27	Bhopal	8500.00
6	Komal	22	MP	4500.00

The following program will update the table and increase the salary of each customer by 500 and use the SQL%ROWCOUNT attribute to determine the number of rows affected

DECLARE

```
   total_rows number(2);
BEGIN
   UPDATE customers
   SET salary = salary + 500;
   IF sql%notfound THEN
      dbms_output.put_line('no customers selected');
   ELSIF sql%found THEN
      total_rows := sql%rowcount;
      dbms_output.put_line( total_rows || ' customers selected ');
   END IF;
END;
/
```

When the above code is executed at the SQL prompt, it produces the following result

6 customers selected

PL/SQL procedure successfully completed.

If we check the records in customers table, to find that the rows have been updated −

Select * from customers;

ID	NAME	AGE	ADDRESS	SALARY
1	Ramesh	32	Ahmedabad	2500.00
2	Khilan	25	Delhi	2000.00

3	kaushik	23	Kota	2500.00
4	Chaitali	25	Mumbai	7000.00
5	Hardik	27	Bhopal	9000.00
6	Komal	22	MP	5000.00

Explicit Cursors

Explicit cursors are programmer-defined cursors for gaining more control over the context area. An explicit cursor should be defined in the declaration section of the PL/SQL Block. It is created on a SELECT Statement which returns more than one row.

The syntax for creating an explicit cursor is −

CURSOR cursor_name IS select_statement;

Working with an explicit cursor includes the following steps −

- Declaring the cursor for initializing the memory
- Opening the cursor for allocating the memory
- Fetching the cursor for retrieving the data
- Closing the cursor to release the allocated memory

Declaring the Cursor

Declaring the cursor defines the cursor with a name and the associated SELECT statement. For example −

CURSOR c_customers IS

SELECT id, name, address FROM customers;

Opening the Cursor

Opening the cursor allocates the memory for the cursor and makes it ready for fetching the rows returned by the SQL statement into it. For example, we will open the above defined cursor as follows −

OPEN c_customers;

Fetching the Cursor

Fetching the cursor involves accessing one row at a time. For example, we will fetch rows from the above-opened cursor as follows −

FETCH c_customers INTO c_id, c_name, c_addr;

Closing the Cursor

Closing the cursor means releasing the allocated memory. For example, we will close the above-opened cursor as follows −

CLOSE c_customers;

Example

Following is a complete example to illustrate the concepts of explicit cursors &minua;

```
DECLARE
   c_id customers.id%type;
   c_name customerS.No.ame%type;
   c_addr customers.address%type;
   CURSOR c_customers is
      SELECT id, name, address FROM customers;
```

```
BEGIN
   OPEN c_customers;
   LOOP
   FETCH c_customers into c_id, c_name, c_addr;
      EXIT WHEN c_customers%notfound;
      dbms_output.put_line(c_id || ' ' || c_name || ' ' || c_addr);
   END LOOP;
   CLOSE c_customers;
END;
/
```

When the above code is executed at the SQL prompt, it produces the following result –

```
1 Ramesh Ahmedabad
2 Khilan Delhi
3 kaushik Kota
4 Chaitali Mumbai
5 Hardik Bhopal
6 Komal MP
  PL/SQL procedure successfully completed.
```

Exceptions in PL/SQL

An exception is an error condition during a program execution. PL/SQL supports programmers to catch such conditions using **EXCEPTION** block in the program and an appropriate action is taken against the error condition. There are two types of exceptions −

- System-defined exceptions
- User-defined exceptions

Syntax for Exception Handling

The general syntax for exception handling is as follows. The default exception will be handled using ***WHEN others THEN*** −

```
DECLARE
   <declarations section>
BEGIN
   <executable command(s)>
EXCEPTION
   <exception handling goes here >
   WHEN exception1 THEN
      exception1-handling-statements
   WHEN exception2  THEN
      exception2-handling-statements
```

```
    WHEN exception3 THEN
      exception3-handling-statements
    ........
    WHEN others THEN
      exception3-handling-statements
END;
```

Example

using the CUSTOMERS table

```
DECLARE
   c_id customers.id%type := 8;
   c_name  customerS.No.ame%type;
   c_addr customers.address%type;
BEGIN
   SELECT  name, address INTO  c_name, c_addr
   FROM customers
   WHERE id = c_id;
   DBMS_OUTPUT.PUT_LINE ('Name: '||  c_name);
   DBMS_OUTPUT.PUT_LINE ('Address: ' || c_addr);
EXCEPTION
   WHEN no_data_found THEN
```

```
    dbms_output.put_line('No such customer!');
  WHEN others THEN
    dbms_output.put_line('Error!');
END;
/
```

When the above code is executed at the SQL prompt, it produces the following result –

```
No such customer!
PL/SQL procedure successfully completed.
```

The above program displays the name and address of a customer whose ID is given. Since there is no customer with ID value 8 in our database, the program raises the run-time exception **NO_DATA_FOUND**, which is captured in the **EXCEPTION block**.

Raising Exceptions

Exceptions are raised by the database server automatically whenever there is any internal database error, but exceptions can be raised explicitly by the programmer by using the command **RAISE**. Following is the simple syntax for raising an exception −

```
DECLARE
  exception_name EXCEPTION;
BEGIN
  IF condition THEN
    RAISE exception_name;
```

```
   END IF;
EXCEPTION
   WHEN exception_name THEN
   statement;
END;
```

User-defined Exceptions

PL/SQL allows to define own exceptions according to the need of program. A user-defined exception must be declared and then raised explicitly, using either a RAISE statement or the procedure **DBMS_STANDARD.RAISE_APPLICATION_ERROR**.

The syntax for declaring an exception is −

```
DECLARE
   my-exception EXCEPTION;
```

Example

The following example illustrates the concept. This program asks for a customer ID, when the user enters an invalid ID, the exception **invalid_id** is raised.

```
DECLARE
   c_id customers.id%type := &cc_id;
   c_name  customerS.No.ame%type;
   c_addr customers.address%type;
   -- user defined exception
   ex_invalid_id  EXCEPTION;
```

```
BEGIN
  IF c_id <= 0 THEN
    RAISE ex_invalid_id;
  ELSE
    SELECT  name, address INTO  c_name, c_addr
    FROM customers
    WHERE id = c_id;
    DBMS_OUTPUT.PUT_LINE ('Name: '||  c_name);
    DBMS_OUTPUT.PUT_LINE ('Address: ' || c_addr);
  END IF;

EXCEPTION
  WHEN ex_invalid_id THEN
    dbms_output.put_line('ID must be greater than zero!');
  WHEN no_data_found THEN
    dbms_output.put_line('No such customer!');
  WHEN others THEN
    dbms_output.put_line('Error!');
END;
/
```

When the above code is executed at the SQL prompt, it produces the following result –

Enter value for cc_id: -6 (let's enter a value -6)

old 2: c_id customers.id%type := &cc_id;

new 2: c_id customers.id%type := -6;

ID must be greater than zero!

PL/SQL procedure successfully completed.

Pre-defined Exceptions

PL/SQL provides many pre-defined exceptions, which are executed when any database rule is violated by a program. For example, the predefined exception NO_DATA_FOUND is raised when a SELECT INTO statement returns no rows. The following table lists few of the important pre-defined exceptions –

Exception	**Oracle Error**	**SQLCODE**	**Description**
ACCESS_INTO_NULL	06530	-6530	It is raised when a null object is automatically assigned a value.
CASE_NOT_FOUND	06592	-6592	It is raised when none of the choices in the WHEN clause of a CASE

			statement is selected, and there is no ELSE clause.
COLLECTION_IS_NULL	06531	-6531	It is raised when a program attempts to apply collection methods other than EXISTS to an uninitialized nested table or varray, or the program attempts to assign values to the elements of an uninitialized nested table or varray.
DUP_VAL_ON_INDEX	00001	-1	It is raised when duplicate values are attempted to be stored in a column with unique index.
INVALID_CURSOR	01001	-1001	It is raised when attempts are made to make a cursor operation that is not allowed, such as closing an unopened cursor.

INVALID_NUMBER	01722	-1722	It is raised when the conversion of a character string into a number fails because the string does not represent a valid number.
LOGIN_DENIED	01017	-1017	It is raised when a program attempts to log on to the database with an invalid username or password.
NO_DATA_FOUND	01403	+100	It is raised when a SELECT INTO statement returns no rows.
NOT_LOGGED_ON	01012	-1012	It is raised when a database call is issued without being connected to the database.
PROGRAM_ERROR	06501	-6501	It is raised when PL/SQL has an internal problem.
ROWTYPE_MISMATCH	06504	-6504	It is raised when a cursor

			fetches value in a variable having incompatible data type.
SELF_IS_NULL	30625	-30625	It is raised when a member method is invoked, but the instance of the object type was not initialized.
STORAGE_ERROR	06500	-6500	It is raised when PL/SQL ran out of memory or memory was corrupted.
TOO_MANY_ROWS	01422	-1422	It is raised when a SELECT INTO statement returns more than one row.
VALUE_ERROR	06502	-6502	It is raised when an arithmetic, conversion, truncation, or sizeconstraint error occurs.
ZERO_DIVIDE	01476	1476	It is raised when an attempt is made to divide a

			number by zero.

Triggers in PL/SQL

Triggers are stored programs, which are automatically executed or fired when some events occur. Triggers are, in fact, written to be executed in response to any of the following events −

- A database manipulation (DML) statement (DELETE, INSERT, or UPDATE)
- A database definition (DDL) statement (CREATE, ALTER, or DROP).
- A database operation (SERVERERROR, LOGON, LOGOFF, STARTUP, or SHUTDOWN).

Triggers can be defined on the table, view, schema, or database with which the event is associated.

Benefits of Triggers

Triggers can be written for the following purposes −

- Generating some derived column values automatically
- Enforcing referential integrity
- Event logging and storing information on table access
- Auditing
- Synchronous replication of tables
- Imposing security authorizations

- Preventing invalid transactions

Creating Triggers

The syntax for creating a trigger is −

CREATE [OR REPLACE] TRIGGER trigger_name

{BEFORE | AFTER | INSTEAD OF }

{INSERT [OR] | UPDATE [OR] | DELETE}

[OF col_name]

ON table_name

[REFERENCING OLD AS o NEW AS n]

[FOR EACH ROW]

WHEN (condition)

DECLARE

Declaration-statements

BEGIN

Executable-statements

EXCEPTION

Exception-handling-statements

END;

Where,

- CREATE [OR REPLACE] TRIGGER trigger_name − Creates or replaces an existing trigger with the *trigger_name*.
- {BEFORE | AFTER | INSTEAD OF} − This specifies when the trigger will be executed. The INSTEAD OF clause is used for creating trigger on a view.
- {INSERT [OR] | UPDATE [OR] | DELETE} − This specifies the DML operation.
- [OF col_name] − This specifies the column name that will be updated.
- [ON table_name] − This specifies the name of the table associated with the trigger.
- [REFERENCING OLD AS o NEW AS n] − This allows to refer new and old values for various DML statements, such as INSERT, UPDATE, and DELETE.
- [FOR EACH ROW] − This specifies a row-level trigger, i.e., the trigger will be executed for each row being affected. Otherwise the trigger will execute just once when the SQL statement is executed, which is called a table level trigger.
- WHEN (condition) − This provides a condition for rows for which the trigger would fire. This clause is valid only for row-level triggers.

Example

Select * from customers;

ID	NAME	AGE	ADDRESS	SALARY
1	Ramesh	32	Ahmedabad	2000.00
2	Khilan	25	Delhi	1500.00
3	kaushik	23	Kota	2000.00
4	Chaitali	25	Mumbai	6500.00
5	Hardik	27	Bhopal	8500.00

6	Komal	22	MP	4500.00

The following program creates a row-level trigger for the customers table that would fire for INSERT or UPDATE or DELETE operations performed on the CUSTOMERS table. This trigger will display the salary difference between the old values and new values −

```
CREATE OR REPLACE TRIGGER display_salary_changes
BEFORE DELETE OR INSERT OR UPDATE ON customers
FOR EACH ROW
WHEN (NEW.ID > 0)
DECLARE
   sal_diff number;
BEGIN
   sal_diff := :NEW.salary  - :OLD.salary;
   dbms_output.put_line('Old salary: ' || :OLD.salary);
   dbms_output.put_line('New salary: ' || :NEW.salary);
   dbms_output.put_line('Salary difference: ' || sal_diff);
END;
/
```

When the above code is executed at the SQL prompt, it produces the following result Trigger created.

The following points need to be considered here −

- OLD and NEW references are not available for table-level triggers, rather to can use them for record-level triggers.
- If we want to query the table in the same trigger, then we should use the AFTER keyword, because triggers can query the table or change it again only after the initial changes are applied and the table is back in a consistent state.
- The above trigger has been written in such a way that it will fire before any DELETE or INSERT or UPDATE operation on the table, but we can write trigger on a single or multiple operations, for example BEFORE DELETE, which will fire whenever a record will be deleted using the DELETE operation on the table.

Triggering a Trigger

DML operations on the CUSTOMERS table. Here is one INSERT statement, which will create a new record in the table −

INSERT INTO CUSTOMERS (ID,NAME,AGE,ADDRESS,SALARY)

VALUES (7, 'Kriti', 22, 'HP', 7500.00);

When a record is created in the CUSTOMERS table, the above create trigger, display_salary_changes will be fired and it will display the following result −

Old salary:

New salary: 7500

Salary difference:

Because this is a new record, old salary is not available and the above result comes as null. Let us now perform one more DML operation on the CUSTOMERS table. The UPDATE statement will update an existing record in the table −

UPDATE customers

SET salary = salary + 500

WHERE id = 2;

When a record is updated in the CUSTOMERS table, the above create trigger, display_salary_changes will be fired and it will display the following result

Old salary: 1500

New salary: 2000

Salary difference: 500

POSSIBLE QUESTION

Part A (1Mark)

(Online Examinations)

Part B (2 Marks)

1. How are exceptions handled in PL/SQL?
2. What are the different types of cursors.
3. What is DDL, DCL, and DML (Data Manipulation Language)?
4. What are referential integrity constraints?
5. What is the need for triggers?
6. Give the forms of triggers
7. What is a cursor?
8. What types of cursors are supported in PL/SQL?
9. What is the purpose of cursor in PL/SQL?
10. What is trigger?
11. Write the syntax for defining a trigger.
12. What are the uses of using triggers?
13. Define: functions
14. What are the Exceptions in PL/SQL?
15. Mention the categories of SQL.

Part C (6 Marks)

1. Explain Triggers and its types with examples.
2. Illustrate a block of PL/SQL with neat diagram.
3. What is a cursor? What types of cursors are supported in PL/SQL? Explain Cursor attributes.
4. Write a PL/SQL code to display the Empno, Ename and Job of employees of DeptNo 10 with CURSOR FOR LOOP Statement.
5. What is the importance of cursor for loop? How it simplifies the operation? Explain with suitable example.
   Explain Triggers and its types with examples.
6. What is cursor? What are the cursors attributes? Explain.
7. Explain control structure statement on PL/SQL block.
8. Differentiate PL/SQL and SQL?
9. What are the data types available in PL/SQL? Explain it.
10. Explain types of cursor?

PART A
ONLINE QUESTION

S. N0	QUESTIONS	OPTION 1	OPTION 2	OPTION 3	OPTION 4	OPTION 5	OPTION 6	ANSWER
				UNIT - V				
1	Quer-By-Example have a _____ syntax	dimensional	two dimensional	no syntax	three dimensional			two dimensional
2	_____ will be set for the negative value.	SYS_CODE	SQL	SELECT	SIS_CODE			SYS_CODE
3	The first SQL statement executed in a program	$BEGIN TRANSACTION	$END TRANSACTION	$CONTINUE TRANSACTION	END			$BEGIN TRANSACTION
4	The last SQL statement executed in a program	$BEGIN TRANSACTION	$END TRANSACTION	$CONTINUE TRANSACTION	END			$END TRANSACTION
5	_____ _____ is used to receive feed back information	PL/I Structure called SYR	SQL Statement	OPEN	EXIT			PL/I Structure called SYR
6	_____ _ Provides certain features to facilitate the writing of on-line application program.	SQL	BASIC	COBOL	JAVA			SQL
7	_____ _ of embedded SQL are provided to	LET statement	Dynamic statement	SQL statement	End Statement			Dynamic statement

PART A
ONLINE QUESTION

	assists the process							
8	SQL actually uses the keyword as in the place of _____	FORM	SELECT	OPEN	EXIT			FORM
9	It is probably much more convenient to construct ------ dynamical	dynamic statement	S Q L statement	discussion	transaction			S Q L statement
10	The generate statements can be replaced by another by issuing ------	select	open	delete	prepare			prepare
11	----- requires special treatment	save	delete	close	select			select
12	“DO” stand for ------	order	paragraph	descending order	ascending order			descending order
13	. “AO” students for----------	order	paragraph	descending order	ascending order			ascending order
14	.---------- is insert operator	I	J	O	K			I
15	------ is the delete operator	A	B	C	D			D
16	In PL/I statements	integer	Balanced	FIXED BIN	Declarative			FIXED BIN

PART A
ONLINE QUESTION

	how the numeric data types are defined_____							
17	by pressing _____ key user can have a skeleton of the table	FUNTION	SHIFT+INSERT	CTRL+SHIFT	NONE			FUNTION
18	QBE stands for _____	Query by example	query by equation	Query by embedded	none			Query by example
19	PL/I stands for	programming language	physical database record	physical database language	none			programming language
20	Oracle was developed in the year	1977	1978	1979	1980			1977
21	in oracle _____ data type used for strings	CHAR R	VARCHAR	FIXED BIN	NONE			VARCHAR
22	Varchar data type can accept _____ bytes	2000	4 000	1000	NONE			4 000
23	Char data type can accept _____ bytes	2000	4 000	1000	NONE			2000
24	The initial release of an oracle is in the year_____	1977	1978	1979	1980			1979

PART A
ONLINE QUESTION

25	What is the latest version of the oracle?	8i	9i	10i	11i			11i
26	The latest version of the oracle was released in the year	2005	2006	2007	2008			2008
27	The latest version of the oracle was released in the month of	September	October	November	Decem ber			September
28	Oracle can be used as a _____ for projects	Back end	front end	Middle	None			Back end
29	_____ trims the unwanted space in the memory	CHAR R	VARCHA R	FIXED BIN	NONE			VARCHA R
30	Oracle is an a ____	Applicatio n	package	Both	None			Applicatio n
31	_____ is used to delete the whole table in the database	DROP	DELETE	Both	None			DROP
32	_____ _ is DDL command	DROP	DELETE	Both	None			None
33	_____ _ is DML command	UPDATE	DELETE	Both	none			Both
34	PL/SQL is a superset	SQL	PL/SQL	Linux	Unix			SQL

PART A
ONLINE QUESTION

	of							
35	SQL statements are passed to the oracle Engine	One at a time	Twice a time	three times	unlimited			One at a time
36	To erase the errors or mistake is occurred _____ key will not work	backspace	delete	insert	alt			delete
37	What can SQL do	Execute queries	insert records	retrieve data	all the above			all the above
38	specify the major commands in SQL	SELECT	INSERT	Both 1 and 2	Exit			Both 1 and 2
39	Most of the actions we need to perform on a database are done with _____	SQL statements	fucntions	COBOL	BASIC			SQL statements
40	SQL is _____ a case sensitive	not						
41	SQL Keywords are written in _____ __	Uppercase	lowercase	Both 1 and 2	Special characters			Uppercase
42	_____ command is used to modify a table	ALTER	UPDATE	DELETE	DROP			ALTER

PART A
ONLINE QUESTION

43	_____ command is used to create a new database	UPDATE	CREATE	INSERT	SELECT			CREATE
44	_____ command is used to create a new table	UPDATE	CREATE TABLE	INSERT	SELECT			CREATE TABLE
45	_____ command is used to extracts data from a database	SELECT	CREATE TABLE	Both 1 and 2	WHERE			SELECT
46	_____ command updates data in a database	UPDATE	ALTER	Both 1 and 2	WHERE			UPDATE
47	_____ command deletes data from a database	DELETE	UPDATE	Both 1 and 2	WHERE			DELETE
48	_____ command inserts new data into a database	INSERT INTO	UPDATE	INSERT	WHERE			INSERT INTO
49	_____ command deletes a table	DROP TABLE	SELECT	Both 1 and 2	WHERE			DROP TABLE
50	The _____	WHERE	SELECT	AND	UPDATE			WHERE

PART A
ONLINE QUESTION

	clause is used to extract only those records that fulfill a specified condition							
51	The _____ clause is used in a SELECT statement to sort results either in ascending or decending order	ORDER BY	SQL Functions	Roll Back	Commit			ORDER BY
52	The _____ Operator is used to select values within a range	BETWEEN	AND	OR	WHERE			BETWEEN
53	_____ command are used to temporarily rename a table or a column heading	Commit	ALIASES	Roll Back	SELECT			ALIASES
54	The _____ function returns the number of rows that matched a	COUNT()	MIN()	AVG()	SUM()			COUNT()

PART A
ONLINE QUESTION

	specified criteria							
55	The _____ function returns the smallest value of the selected column	MIN()	MAX()	Both 1 and 2	AVG()			MIN()
56	The _____ function returns the largest values of the selected column	MAX()	MIN()	Both 1 and 3	SUM()			MAX()
57	The ____ function returns the average value of a numeric column	AVG()	MAX()	Both 1 and 4	SUM()			AVG()
58	The _____ function returns the current system date and time.	LAST()	NOW()	FIRST ()	SUM()			NOW()
59	The _____ function returns the last value of the selected column.	LAST()	MAX()	AVG()	NOW( )			LAST()
60	The _____function	LAST()	MAX()	FIRST()	SUM()			FIRST()

PART A
ONLINE QUESTION

	returns the first value of the selected column.							