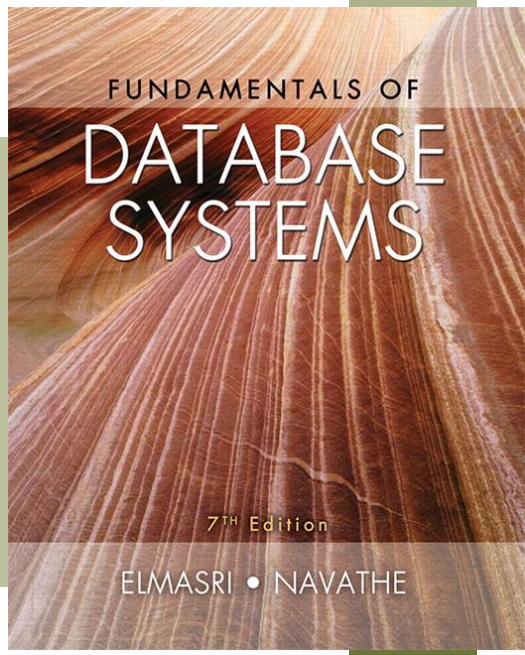
Data Base Management System



Module –III

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SQL-The Relational Database Standard

Introduction to SQL

- The name SQL is presently expanded as Structured Query Language.
- Originally, SQL was called SEQUEL (Structured English QUEry Language) and was designed and implemented at IBM Research as the interface for an experimental relational database system called SYSTEM R.
- SQL is now the standard language for commercial relational DBMSs.
- The standardization of SQL is a joint effort by the American National Standards Institute (ANSI) and the International Standards Organization (ISO), and the first SQL standard is called SQL-86 or SQL1.

Introduction to SQL

- SQL is a comprehensive database language: It has statements for data definitions, queries, and updates. Hence, it is both a Data Definition Language) DDL and a Data Manipulation Language (DML).
- In addition, it has facilities for defining views on the database, for specifying security and authorization, for defining integrity constraints, and for specifying transaction controls.
- It also has rules for embedding SQL statements into a general-purpose programming language such as Java or C/C++.

Why learn SQL?

- SQL is widely used in the industry for managing data in applications like websites, apps, and analytics.
- Knowing SQL enables us to retrieve specific information from large datasets and make data-driven decisions.
- Several commercial databases use SQL as their primary language for data management and manipulation.
- Oracle database, Microsoft SQL, IBM db2, snowflake, Amazon Aurora,
- Facebook has developed and uses a variety of database solutions to handle its massive data requirements.
- Many company has a hybrid approach, employing both open-source databases and custom-built data solutions tailored to its unique needs.

SQl and its dialects

- A **dialect** refers to a variation or a customized version of a standard language.
- Dialects maintain the core features of the base language but may add, modify, or omit certain functionalities to cater to specific needs or environments.
- SQL has several **dialects** tailored by different database management systems (DBMSs) such as MySQL, PostgreSQL, SQL Server, and Oracle SQL.
- T-SQl is used by SQLServer
- PL/SQL is used by ORACLE
- JET SQL is used by MS Access

SQL data definition and data types, schema and catalog concepts in SQL

- SQL uses the terms table, row, and column for the formal relational model terms relation, tuple, and attribute, respectively.
- Corresponding terms (table-ralation, row-tuple, column-attribute) are used interchangeably.
- The main SQL command for data definition is the CREATE statement, which can be used to create schemas, tables (relations), types, and domains, as well as other constructs such as **views, assertions, and triggers**.

Types of Schemas

- **Physical Schema**: This is how data is physically stored on the system.
- **Logical Schema**: This is the structure that defines what tables, fields, and relationships are in the database.
- **View Schema: These are customized views for users. For example, teachers might have a view showing student grades, while administrators have a different view with personal student information.**

DBMS language

- In several DBMS there is no clear separation between schema levels in 3 level schema architecture.
- In DBMS where there is no strict separation of schema levels, Data Definition Language (DDL) is used to define the internal and conceptual schemas.
- DDL is used by Database administrators and designers.
- A DDL compile is ued to compile the DDL statements
- **In several DBMS, if there is a clear separation, DDL is used to specify conceptual schema level only.**
- **Storage Definition Language (SDL) is ued to specify the storage schema.**
- **Data Manipulation Language(DML) is also used to manipulate data in the database.**
- **View Definition Language (DVL) is also used to create multiple views according to multiple users**

SQL Commands

- **Data Definition Language (DDL)**: Used to define and modify the structure of a database (e.g., CREATE, ALTER, DROP).
- **Data Manipulation Language (DML)**: Used to work with the data itself (e.g., SELECT, INSERT, UPDATE, DELETE).
- **Data Control Language (DCL)**: Used to manage permissions and access to the database (e.g., GRANT, REVOKE).

Schema and Catalog Concepts in SQL

- Schema and Catalog are organizational concepts that help manage and structure data within a database system, making it easier to locate and manage data objects like tables, views, and procedures.

Schema

- A schema is essentially a collection or container within a database that holds related objects (like tables, views, indexes, and procedures).
- Each schema organizes and categorizes these objects, making them easier to manage and find.
- In simpler terms, think of a schema as a "folder" that contains related files within a database.
- For example, a schema for a university's database might have objects like Students, Courses, and Enrollments.
- Each schema is owned by a user, which means only specific users or roles have access to that schema, providing a security layer.

Schema

- A schema is created via the CREATE SCHEMA statement, which can include all the schema elements' definitions.
- **CREATE SCHEMA University**;

- **CREATE SCHEMA COMPANY AUTHORIZATION** 'Jsmith';
- The above statement creates a schema called COMPANY owned by the user with authorization identifier 'Jsmith'.

Note that each statement in SQL ends with a semicolon.

Catalog

•A catalog is a higher-level structure that contains multiple schemas. It can be thought of as a container that holds all the schemas within a database.

•Think of a catalog as a "file cabinet" where each "drawer" is a schema, which in turn holds tables and other objects.

•Catalogs are generally managed by the database system, and each database typically has only one catalog by default, especially in simpler setups like MySQL.

•In complex systems, there can be multiple catalogs to further organize data.

•If a university database had two main schemas, one for "Admissions" and another for "Academics," both would be organized under a catalog, typically named after the entire database, like UniversityDB.

•Inside each schema, you would find specific tables, views, and other objects relevant to that part of the university's operations.

Catalog

- In SQL, a catalog is typically not created by users directly, as it refers to a system-level collection of schemas and objects that the database system manages.
- In MySQL or PostgreSQL, the catalog is automatically created when you initialize the database.
- In Oracle also the catalog is created automatically when we set up or initialize a new Oracle database.
- Oracle uses the data dictionary and catalog views to store and retrieve information about the database structure.

Role of Metadata in Catalog

- **Metadata** in the system catalog includes information about tables, columns, indexes, constraints, views, permissions, and relationships in the database.
- The **system catalog** (or data dictionary) is a centralized repository that stores this metadata, enabling the DBMS to understand the structure and rules of the data it manages.

The CREATE TABLE command in SQL

The CREATE TABLE command in SQL is used to create a new table in a database.

```
CREATE TABLE table_name (
    column1 datatype constraints,
    column2 datatype constraints,
     ... );
```

Key Parts of the Command:

1. **CREATE TABLE**: This is the SQL command to create a new table.
2. **table_name**: The name you want to give to your table. This name must be unique in your database.
3. **column1, column2, ...**: These define the columns (or fields) in the table. Each column represents a specific attribute of the data (e.g., student name, ID number).
4. **datatype**: Specifies the type of data the column can store, such as INT for integers, VARCHAR for text, DATE for dates, etc.
5. **constraints**: Optional rules for the column, such as PRIMARY KEY (uniquely identifies each row), NOT NULL (the column cannot be empty), or UNIQUE (ensures all values in the column are different).

Data types in SQL

- **Numeric**: INT, DECIMAL, FLOAT, REAL, DOUBLE, etc.
- **String**: CHAR, VARCHAR(n), TEXT, NCHAR(n), NVARCHAR(n), CLOB
- **Date and Time**: DATE, TIME, TIMESTAMP, etc.
- **Binary**: BINARY, VARBINARY, BLOB, etc.
- **Boolean**: BOOLEAN
- **Spatial**: GEOMETRY, POINT, POLYGON, etc.
- **JSON/XML**: JSON, XML
- **Special**: UUID, ENUM, SET, SERIAL

DATE, TIME, and TIMESTAMP Data Types in SQL

- **DATE:** Made up of year-month-day in the format yyyy-mm-dd
- **TIME:** Made up of hour:minute:second in the format hh:mm:ss
- **TIME(i):** Made up of hour:minute:second plus i additional digits specifying fractions of a second
  - format is hh:mm:ss:ii...i
- **TIMESTAMP:** Has both DATE and TIME components in the format YYYY-MM-DD HH:MM:SS
- **INTERVAL:**
  - Specifies a relative value rather than an absolute value
  - used to represent a period of time, such as days, hours, minutes, or seconds, and can be used in date/time arithmetic. It's particularly useful when you want to add or subtract a time span from a DATE, TIME, or TIMESTAMP.
  - Can be DAY/TIME intervals or YEAR/MONTH intervals
  - Can be positive or negative when added to or subtracted from an absolute value, the result is an absolute value.
  - Syntax: INTERVAL 'quantity unit'
  - Example: INTERVAL '1 DAY'

CREATE TABLE with NOT NULL constraint

```
SQL 1: CREATE TABLE   DEPARTMENT
       (DNAME         VARCHAR(10)  NOT NULL,
       DNUMBER        INTEGER          NOT NULL,
       MGRSSN         CHAR(9),
       MGRSTARTDATE   CHAR(9)  );
```

- The create table statement with a constraint NOT NULL specified on an attribute

CREATE TABLE with PRIMARY KEY and UNIQUE constraints

- In SQL2, the CREATE TABLE command specifying the primary key attributes.
- Key attributes can be specified via the PRIMARY KEY and UNIQUE phrases

```
SQL 2: CREATE TABLE   DEPARTMENT
      (    DNAME   VARCHAR(10)      NOT NULL,
           DNUMBER          INTEGER          NOT NULL,
           MGRSSN           CHAR(9),
           MGRSTARTDATE     CHAR(9),
           PRIMARY KEY (DNUMBER),
           UNIQUE (DNAME)
      );
```

CREATE TABLE with FOREIGN KEY constraints

- In SQL2, the CREATE TABLE command specifying the primary key attributes, secondary keys, and referential integrity constraints (foreign keys).
- Key attributes can be specified via the PRIMARY KEY and UNIQUE phrases

```
SQL 2: CREATE TABLE   DEPARTMENT
      (    DNAME   VARCHAR(10)      NOT NULL,
           DNUMBER          INTEGER          NOT NULL,
           MGRSSN           CHAR(9),
           MGRSTARTDATE     CHAR(9),
           PRIMARY KEY (DNUMBER),
           UNIQUE (DNAME),
           FOREIGN KEY (MGRSSN) REFERENCES EMP  );
```

DROP command for SCHEMA

- The CREATE DATABASE statement is used to create a new SQL database.

  Ex: CREATE DATABASE **databasename**;

- The DROP DATABASE statement is used to drop an existing SQL database.

  Ex: DROP DATABASE **databasename**;

- DROP DATABASE is a powerful command used to permanently delete a database and all its contents.
- It's ***irreversible***, so it should be used cautiously and typically after taking a backup of the database.
- Only users with ***appropriate permissions*** (like a Database Administrator) can execute the DROP DATABASE command.

How the DROP command works with schema?

1. **Identifies the Database**: The DROP DATABASE command locates the specified database on the server by name.
2. **Removes All Objects**: Once the database is identified, the command removes all tables, data, and other objects in that database.
3. **Deletes Database Metadata**: The system catalog or data dictionary entries associated with the database are deleted, meaning that the server will no longer recognize the database.
4. **Releases Storage Space**: The disk space previously occupied by the database is freed up, as the database is no longer present on the server.

DROP command with IF EXISTS Clause

- Most SQL implementations provide an IF EXISTS clause to prevent errors if the database does not exist.

  DROP DATABASE IF EXISTS **databasename**;

- Using IF EXISTS allows the command to execute without an error if **databasename** doesn't exist, which is useful in scripts where you want to drop the database only if it's already present.
- Without the IF EXISTS clause, this would throw an error if **databasename** does not exist. With IF EXISTS, it would silently do nothing if the database is not found.

DROP command with TABLE

- Used to remove a relation (base table) *and its definition*
- The relation can no longer be used in queries, updates, or any other commands since its description no longer exists.

Syntax: DROP TABLE **table_name**;

Example: **DROP TABLE DEPENDENT;**

How DROP command Works with table?

1. **Locates the Table**: The DROP TABLE command identifies the specified table in the database.
2. **Removes Data and Structure**: Once identified, it removes all data from the table along with its structure. The table will no longer exist in the database after this command.
3. **Frees Up Storage Space**: The disk space previously occupied by the table is released, making it available for other uses.

Irreversible: DROP TABLE is a **destructive command** and cannot be rolled back. Once executed, all data and the table structure are permanently deleted.

Permissions: Only users with appropriate permissions (such as Database Administrators or users with DROP privileges) can execute the command.

DROP command using IF EXISTS Clause

- To prevent an error if the table doesn't exist, you can use the IF EXISTS clause, which will execute the command only if the specified table is present.

  DROP TABLE **IF EXISTS** Employees;

- With IF EXISTS, the command will check if the table exists before attempting to drop it.
- If it doesn't exist, no error will be raised, which is useful in scripts where you want to ensure the table is dropped if it exists without throwing errors.

ALTER TABLE

ALTER command actions include

1. Adding or dropping a column (attribute)
2. Changing a column definition
3. Adding or dropping table constraints
4. Add an attribute to one of the base relations

The new attribute will have NULLs in all the tuples of the relation right after the command is executed; hence, the NOT NULL constraint is *not allowed* for such an attribute.

ALTER TABLE
1. Adding a column (attribute)

- Example:to add an attribute for keeping track of jobs of employees to the EMPLOYEE base relation in the COMPANY schema, we can use the command

ALTER TABLE COMPANY.EMPLOYEE ADD COLUMN Job VARCHAR(12);

OR

ALTER TABLE EMPLOYEE ADD JOB VARCHAR(12);

- The database users must still enter a value for the new attribute JOB for each EMPLOYEE tuple. This can be done using the UPDATE command.

ALTER TABLE
1. DROP a column (attribute)

- To drop a column, we must choose either CASCADE or RESTRICT for drop behavior.
- If CASCADE is chosen, all constraints and views that reference the column are dropped automatically from the schema, along with the column.

ALTER TABLE COMPANY.EMPLOYEE DROP COLUMN Address CASCADE;

- One can also change the constraints specified on a table by adding or dropping a named constraint.
- To be dropped, a constraint must have been given a name when it was specified.
- For example, to drop the constraint named EMPSUPERFK in the EMPLOYEE relation, we write:

ALTER TABLE COMPANY.EMPLOYEE

DROP CONSTRAINT EMPSUPERFK CASCADE;

ALTER TABLE
1. DROP a column (attribute)

- For example, to drop the constraint named EMPSUPERFK in the EMPLOYEE relation, we write:

ALTER TABLE COMPANY.EMPLOYEE

DROP CONSTRAINT EMPSUPERFK CASCADE;

- Once the above statement is executed, we can redefine a replacement constraint by adding a new constraint to the relation, if needed.
- This is specified by using the **ADD CONSTRAINT** keyword in the ALTER TABLE statement followed by the new constraint, which can be named or unnamed and can be of any of the table constraint types discussed.

ALTER TABLE
2. Changing a column definition

- **Rename can be done for column name**

ALTER TABLE table_name
RENAME COLUMN old-name TO new_name;

EX: ALTER TABLE Employee
RENAME COLUMN eid TO employeeid;

- **Modify datatype of column**

ALTER TABLE table_name
MODIFY COLUMN column_name new_data_type;
OR
ALTER TABLE table_name
ALTER COLUMN column_name TYPE new_data_type;
Ex: ALTER TABLE Employee
ALTER COLUMN dataofbirth date;

ALTER TABLE
3. Changing a column definition

- Add or drop constraints on a table enforce or remove rules for data validation.
- Common types of constraints include PRIMARY KEY, FOREIGN KEY, UNIQUE, CHECK, and NOT NULL
- **Adding constraints for column name**

```
ALTER TABLE table_name
ADD CONSTRAINT constraint_name constraint_type (column_name);
EX1:  ALTER TABLE Employees
        ADD CONSTRAINT pk_employee_id PRIMARY KEY (EmployeeID);

EX2: ALTER TABLE Orders
     ADD CONSTRAINT fk_customer_id FOREIGN KEY (CustomerID)
     REFERENCES Customers(CustomerID);

EX3: ALTER TABLE Employees ADD CONSTRAINT unique_email UNIQUE (Email);

EX4: ALTER TABLE Employees ADD CONSTRAINT check_salary CHECK (Salary > 0);
EX5: ALTER TABLE Employees DROP CONSTRAINT pk_employee_id;
EX6: ALTER TABLE Employees MODIFY COLUMN LastName VARCHAR(50) NULL;
```

Specifying Updates in SQL

- There are three SQL commands to modify the database; INSERT, DELETE, and UPDATE

INSERT command

- In its simplest form, it is used to **add one or more tuples** to a relation
- Attribute values should be listed in the same order as the attributes were specified in the CREATE TABLE command.

Syntax 1: INSERT INTO tablename
VALUES (value1, value2)

Syntax2: INSERT INTO table_name (column1, column2, column3, ...)VALUES (value1, value2, value3, ...);

INSERT (cont.)

- Example:

  EX1: INSERT INTO EMPLOYEE
  VALUES ('Richard','K','Marini', '653298653', '30-DEC-52',
  '98 Oak Forest,Katy,TX', 'M', 37000,'987654321', 4)

- An alternate form of INSERT specifies explicitly the attribute names that correspond to the values in the new tuple
- Attributes with NULL values can be left out
- Example: Insert a tuple for a new EMPLOYEE for whom we only know the FNAME, LNAME, and SSN attributes.

  Ex2: INSERT INTO EMPLOYEE (FNAME, LNAME, SSN)
  VALUES ('Richard', 'Marini', '653298653')

  Ex3: INSERT INTO Employees (FirstName, LastName, Age) VALUES ('David', 'White', 28), ('Emma', 'Green', 32);

Inserting NULL into a column

If you want to insert a NULL value into a specific column, you can do so by omitting that column from your INSERT statement or explicitly stating NULL for that column.

Ex1. omitting NULL attribute value

INSERT INTO Employees (FirstName, LastName) **VALUES** ('John', 'Doe');

In this case, if the Age column is omitted and allows NULL values, it will be set to NULL automatically.

EX2: Explicitly inserting NULL

INSERT INTO Employees (FirstName, LastName, Age) VALUES ('Jane', 'Doe', **NULL**);

FirstName	LastName	Age
John	Doe	NULL
Jane	Doe	NULL

This approach is common in databases where certain attributes may be optional or unknown, allowing them to remain NULL in the database.

DELETE

- Removes tuples from a relation
- Includes a WHERE-clause to select the tuples to be deleted
- Tuples are deleted from only *one table* at a time (unless CASCADE is specified on a referential integrity constraint)
- A missing WHERE-clause specifies that *all tuples* in the relation are to be deleted; the table then becomes an empty table
- The number of tuples deleted depends on the number of tuples in the relation that satisfy the WHERE-clause
- Referential integrity should be enforced

DELETE (cont.)

- Examples:

```
U4A:    DELETE FROM     EMPLOYEE
        WHERE           LNAME='Brown'

U4B:    DELETE FROM     EMPLOYEE
        WHERE           SSN='123456789'

U4C:    DELETE FROM     EMPLOYEE
        WHERE           DNO  IN
                (SELECT         DNUMBER
                FROM  DEPARTMENT
                WHERE           DNAME='Research')

U4D:    DELETE FROM     EMPLOYEE
```

UPDATE

- Used to modify attribute values of one or more selected tuples
- A WHERE-clause selects the tuples to be modified
- An additional SET-clause specifies the attributes to be modified and their new values
- Each command modifies tuples *in the same relation*
- Referential integrity should be enforced

UPDATE (cont.)

- Example: Change the location and controlling department number of project number 10 to 'Bellaire' and 5, respectively.

```
U5:  UPDATE      PROJECT
     SET         PLOCATION = 'Bellaire', DNUM = 5
     WHERE       PNUMBER=10
```

UPDATE (cont.)

- Example: Give all employees in the 'Research' department a 10% raise in salary.

```
U6:  UPDATE  EMPLOYEE
     SET     SALARY = SALARY *1.1
     WHERE   DNO  IN (SELECT  DNUMBER
                      FROM   DEPARTMENT
                      WHERE DNAME='Research')
```

- In this request, the modified SALARY value depends on the original SALARY value in each tuple
- The reference to the SALARY attribute on the right of = refers to the old SALARY value before modification
- The reference to the SALARY attribute on the left of = refers to the new SALARY value after modification

REFERENTIAL INTEGRITY OPTIONS

- In SQL, when defining **referential integrity constraints** (i.e., *foreign keys*), you can specify how the database should behave when a referenced row in the parent table is updated or deleted.
- This is where actions like **RESTRICT, CASCADE, SET NULL,** and **SET DEFAULT** come into play.
- These actions determine what happens to the rows in the child table when a related row in the parent table is deleted or updated.
- **CREATE TABLE DEPATMENT**

```
(   DNAME VARCHAR(10)    NOT NULL,
    DNUMBER          INTEGER NOT NULL,
    MGRSSN           CHAR(9),
    MGRSTARTDATE     CHAR(9),
    PRIMARY KEY (DNUMBER),
    UNIQUE (DNAME),
    FOREIGN KEY (MGRSSN) REFERENCES EMP
    ON DELETE SET DEFAULT ON UPDATE CASCADE  );
```

Option	Behavior on DELETE	Behavior on UPDATE	Use Case
RESTRICT	Prevents deletion if related records exist	Prevents update if related records exist	When you want to ensure no orphaned records are created by preventing deletion or update.
CASCADE	Deletes related records in child table	Updates related foreign key values in child table	When you want related records to be removed or updated automatically.

Example Use Case: If you have a Department table and an Employee table where each employee is assigned to a department, using ON DELETE CASCADE on the foreign key in the Employee table will ensure that if a department is deleted, all employees in that department are also deleted.

REFERENTIAL INTEGRITY CONSTRINTS: RESTRICT

- This prevents the deletion or update of a referenced row in the parent table if there are any matching rows in the child table.
- Example: If you try to delete a row from the parent table while there are still rows in the child table that reference it, the database will throw an error.
- It is useful when you want to ensure that no orphaned records (child records without a corresponding parent) exist.

REFERENTIAL INTEGRITY CONSTRINTS: CASCADE

- This option automatically updates or deletes the matching rows in the child table whenever the referenced row in the parent table is updated or deleted.
- **On DELETE CASCADE**: When a row in the parent table is deleted, all related rows in the child table are automatically deleted as well.
- **On UPDATE CASCADE**: If a row in the parent table is updated, the corresponding foreign key in the child table is updated to reflect this change.
- It is useful in scenarios where child records should be automatically cleaned up when their parent record is removed (for example, deleting an order when a customer is deleted).

REFERENTIAL INTEGRITY CONSTRINTS: SET DEFAULT

- This sets the foreign key column in the child table to a default value when the referenced row in the parent table is deleted or updated.
- **On DELETE/UPDATE SET DEFAULT**: When a referenced row is deleted or updated, the foreign key column in the child table is set to its default value (if a default value has been defined for that column).
- It is useful when you want to maintain a valid reference to a default parent row after the original parent row is removed or changed.

REFERENTIAL INTEGRITY CONSTRINTS: SET NULL

- When a referenced row in the parent table is deleted or updated, the foreign key values in the child table are set to NULL.
- **On DELETE SET NULL**: If a row in the parent table is deleted, the foreign key in the child table is set to NULL.
- **On UPDATE SET NULL**: If a referenced row is updated, the child rows are updated with NULL in their foreign key column.
- This is useful when you want to keep the child record but indicate that the relationship with the parent no longer exists.

REFERENTIAL INTEGRITY OPTIONS (continued)

```
CREATE TABLE   EMP
     (          ENAME  VARCHAR(30)      NOT NULL,
                ESSN      CHAR(9),
                BDATE    DATE,
                DNO       INTEGER  DEFAULT 1,
                SUPERSSN          CHAR(9),
                PRIMARY KEY (ESSN),
                FOREIGN KEY (DNO) REFERENCES DEPT
           ON DELETE SET DEFAULT ON UPDATE CASCADE,
                FOREIGN KEY (SUPERSSN) REFERENCES EMP
           ON DELETE SET NULL ON UPDATE CASCADE  );
```

Activity: Analyse the Query

```
CREATE TABLE Orders
( OrderID INT PRIMARY KEY,
 CustomerID INT,
 FOREIGN KEY (CustomerID) REFERENCES Customers(CustomerID) ON
DELETE  CASCADE ON UPDATE SET NULL );
```

In this example, when a Customer is deleted, all orders related to that customer are also deleted (CASCADE). If the CustomerID is updated, the corresponding CustomerID in the Orders table is set to NULL (SET NULL).

These options discussed allow for flexibility in maintaining referential integrity in relational databases, ensuring that related data in tables is handled appropriately during updates or deletions.

Retrieval Queries in SQL

- SQL has one basic statement for retrieving information from a database; the **SELECT** statement
- Basic form of the SQL SELECT statement is called a *mapping* or a *SELECT-FROM-WHERE block*

SELECT <attribute list>
FROM <table list>
WHERE <condition>

  - <attribute list> is a list of attribute names whose values are to be retrieved by the query
  - <table list> is a list of the relation names required to process the query
  - <condition> is a conditional (Boolean) expression that identifies the tuples to be retrieved by the query

Basic retrieval queries

Selecting All Columns

```
SELECT * FROM table_name;
```

Selecting Specific Columns

```
SELECT column1, column2 FROM table_name;
```

Filtering Rows with WHERE Clause

```
SELECT * FROM table_name WHERE condition;
```

Relational Database Schema--Figure 5.5

EMPLOYEE

FNAME	MINIT	LNAME	SSN	BDATE	ADDRESS	SEX	SALARY	SUPERSSN	DNO

DEPARTMENT

DNAME	DNUMBER	MGRSSN	MGRSTARTDATE

DEPT_LOCATIONS

DNUMBER	DLOCATION

PROJECT

PNAME	PNUMBER	PLOCATION	DNUM

WORKS_ON

ESSN	PNO	HOURS

DEPENDENT

ESSN	DEPENDENT_NAME	SEX	BDATE	RELATIONSHIP

Populated Database--Fig.5.6

EMPLOYEE	FNAME	MINIT	LNAME	SSN	BDATE	ADDRESS	SEX	SALARY	SUPERSSN	DNO
	John	B	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	M	30000	333445555	5
	Franklin	T	Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	40000	888665555	5
	Alicia	J	Zelaya	999887777	1968-07-19	3321 Castle, Spring, TX	F	25000	987654321	4
	Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Bellaire, TX	F	43000	888665555	4
	Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	M	38000	333445555	5
	Joyce	A	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5
	Ahmad	V	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	M	25000	987654321	4
	James	E	Borg	888665555	1937-11-10	450 Stone, Houston, TX	M	55000	null	1

DEPT_LOCATIONS	DNUMBER	DLOCATION
	1	Houston
	4	Stafford
	5	Bellaire
	5	Sugarland
	5	Houston

DEPARTMENT	DNAME	DNUMBER	MGRSSN	MGRSTARTDATE
	Research	5	333445555	1988-05-22
	Administration	4	987654321	1995-01-01
	Headquarters	1	888665555	1981-06-19

WORKS_ON	ESSN	PNO	HOURS
	123456789	1	32.5
	123456789	2	7.5
	666884444	3	40.0
	453453453	1	20.0
	453453453	2	20.0
	333445555	2	10.0
	333445555	3	10.0
	333445555	10	10.0
	333445555	20	10.0
	999887777	30	30.0
	999887777	10	10.0
	987987987	10	35.0
	987987987	30	5.0
	987654321	30	20.0
	987654321	20	15.0
	888665555	20	null

PROJECT	PNAME	PNUMBER	PLOCATION	DNUM
	ProductX	1	Bellaire	5
	ProductY	2	Sugarland	5
	ProductZ	3	Houston	5
	Computerization	10	Stafford	4
	Reorganization	20	Houston	1
	Newbenefits	30	Stafford	4

DEPENDENT	ESSN	DEPENDENT_NAME	SEX	BDATE	RELATIONSHIP
	333445555	Alice	F	1986-04-05	DAUGHTER
	333445555	Theodore	M	1983-10-25	SON
	333445555	Joy	F	1958-05-03	SPOUSE
	987654321	Abner	M	1942-02-28	SPOUSE
	123456789	Michael	M	1988-01-04	SON
	123456789	Alice	F	1988-12-30	DAUGHTER
	123456789	Elizabeth	F	1967-05-05	SPOUSE

Simple SQL Queries

Example of a simple query on *one* relation

Ex1: Retrieve the birthdate of the employee whose first name is 'John'.

```
SELECT   BDATE
FROM     EMPLOYEE
WHERE    FNAME='John' ;
```

Ex2: Retrieve the birthdate and address of the employee whose first name is 'John'.

```
SELECT   BDATE, ADDRESS
FROM     EMPLOYEE
WHERE    FNAME='John‘;
```

Simple queries with AND operator in WHERE clause

- In SQL, the **AND** operator is used in the WHERE clause to combine multiple conditions. It ensures that **both conditions** (or multiple conditions) must be true for a record to be included in the result set.

How AND Works?

- **Multiple Conditions**: When using AND, each condition specified must evaluate to TRUE for a row to be selected.
- **Logical Operation**: The AND operator acts as a logical operator that allows more precise filtering.

Ex3: Retrieve the birthdate and address of the employee whose name is 'John B. Smith'.

```
SELECT   BDATE, ADDRESS
FROM     EMPLOYEE
WHERE    FNAME='John' AND MINIT='B'  AND LNAME='Smith';
```

Simple SQL Queries (cont.)

- Ex4: Retrieve the name and address of all employees who work for the 'Research' department.

```
SELECT   FNAME, LNAME, ADDRESS
FROM     EMPLOYEE, DEPARTMENT
WHERE    DNAME='Research' AND DNUMBER=DNO;
```

- **SELECT FNAME, LNAME, ADDRESS**: The query retrieves the columns FNAME (first name), LNAME (last name), and ADDRESS from the result set.
- **FROM EMPLOYEE, DEPARTMENT**: It specifies that the data should come from both the EMPLOYEE and DEPARTMENT tables.
- **WHERE DNAME = 'Research' AND DNUMBER = DNO**:**DNAME = 'Research'**: This condition filters the rows in the DEPARTMENT table to only include those where the department name (DNAME) is 'Research'.
- **DNUMBER = DNO**: This condition establishes a relationship between the EMPLOYEE and DEPARTMENT tables. It ensures that the department number (DNUMBER) in the DEPARTMENT table matches the department number (DNO) in the EMPLOYEE table, effectively joining the two tables on this column.

UNSPECIFIED WHERE-clause

- A *missing WHERE-clause* indicates no condition; hence, *all tuples* of the relations in the FROM-clause are selected
- This is equivalent to the condition WHERE TRUE
- Ex6: Retrieve the SSN values for all employees.

  SELECT SSN
  FROM EMPLOYEE;

- If more than one relation is specified in the FROM-clause *and* there is no join condition, then the *CARTESIAN PRODUCT* of tuples is selected.
- Ex7: **SELECT SSN, DNAME**
  FROM EMPLOYEE, DEPARTMENT;

Simple SQL Queries (cont.)

- Ex8: For every project located in 'Stafford', list the project number, the controlling department number, and the department manager's last name, address, and birthdate.

```
Ex8: SELECT   PNUMBER, DNUM, LNAME, BDATE, ADDRESS
     FROM     PROJECT, DEPARTMENT, EMPLOYEE
     WHERE    DNUM=DNUMBER AND MGRSSN=SSN  AND
     PLOCATION='Stafford'
```

SELECT: Retrieves the columns PNUMBER, DNUM, LNAME, BDATE, and ADDRESS.

FROM: Specifies the tables to use, which are PROJECT, DEPARTMENT, and EMPLOYEE.

WHERE:

- DNUM = DNUMBER - Joins the PROJECT and DEPARTMENT tables based on matching department numbers.
- MGRSSN = SSN - Joins the DEPARTMENT and EMPLOYEE tables where the manager's SSN in the DEPARTMENT table matches the SSN in the EMPLOYEE table.
- PLOCATION = 'Stafford' - Filters the results to include only projects located in "Stafford".

EMPLOYEE	FNAME	MINIT	LNAME	SSN	BDATE	ADDRESS	SEX	SALARY	SUPERSSN	DNO
	John	B	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	M	30000	333445555	5
	Franklin	T	Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	40000	888665555	5
	Alicia	J	Zelaya	999887777	1968-07-19	3321 Castle, Spring, TX	F	25000	987654321	4
	Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Bellaire, TX	F	43000	888665555	4
	Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	M	38000	333445555	5
	Joyce	A	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5
	Ahmad	V	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	M	25000	987654321	4
	James	E	Borg	888665555	1937-11-10	450 Stone, Houston, TX	M	55000	null	1

DEPT_LOCATIONS	DNUMBER	DLOCATION
	1	Houston
	4	Stafford
	5	Bellaire
	5	Sugarland
	5	Houston

DEPARTMENT	DNAME	DNUMBER	MGRSSN	MGRSTARTDATE
	Research	5	333445555	1988-05-22
	Administration	4	987654321	1995-01-01
	Headquarters	1	888665555	1981-06-19

WORKS_ON	ESSN	PNO	HOURS
	123456789	1	32.5
	123456789	2	7.5
	666884444	3	40.0
	453453453	1	20.0
	453453453	2	20.0
	333445555	2	10.0
	333445555	3	10.0
	333445555	10	10.0
	333445555	20	10.0
	999887777	30	30.0
	999887777	10	10.0
	987987987	10	35.0
	987987987	30	5.0
	987654321	30	20.0
	987654321	20	15.0
	888665555	20	null

PROJECT	PNAME	PNUMBER	PLOCATION	DNUM
	ProductX	1	Bellaire	5
	ProductY	2	Sugarland	5
	ProductZ	3	Houston	5
	Computerization	10	Stafford	4
	Reorganization	20	Houston	1
	Newbenefits	30	Stafford	4

DEPENDENT	ESSN	DEPENDENT_NAME	SEX	BDATE	RELATIONSHIP
	333445555	Alice	F	1986-04-05	DAUGHTER
	333445555	Theodore	M	1983-10-25	SON
	333445555	Joy	F	1958-05-03	SPOUSE
	987654321	Abner	M	1942-02-28	SPOUSE
	123456789	Michael	M	1988-01-04	SON
	123456789	Alice	F	1988-12-30	DAUGHTER
	123456789	Elizabeth	F	1967-05-05	SPOUSE

USE OF DISTINCT

- SQL does not treat a relation as a set; *duplicate tuples can appear*
- To eliminate duplicate tuples in a query result, the keyword **DISTINCT** is used
- For example, the result of Ex9 may have duplicate SALARY values whereas Ex10 does not have any duplicate values

Ex9: **SELECT** **SALARY**
FROM **EMPLOYEE**

Ex10: **SELECT DISTINCT** **SALARY**
FROM **EMPLOYEE**

Use of AND, OR, BETWEEN, IN and NOT IN Operators

```
SELECT *
FROM table_name
WHERE condition1 AND condition2 AND...conditionN;
```

```
SELECT *
FROM table_name
WHERE condition1 OR condition2 OR... conditionN;
```

Ex11: `SELECT * FROM Employees WHERE Department = 'Sales' OR Department = 'Research'`

Ex12: `SELECT * FROM Employees WHERE Department = 'Sales' OR Department = 'Research' OR Location = 'New York';`

Use of AND, OR, BETWEEN, IN and NOT IN Operators (cont…)

SELECT column_name(s)
FROM table_name
WHERE column_name BETWEEN value1 AND value2;

Ex13: SELECT EmployeeID, FirstName, LastName, Salary
FROM Salaries
WHERE Salary BETWEEN 50000 AND 80000;

SELECT column_name(s)
FROM table_name
WHERE column_name IN (list_of_values);

Ex14: SELECT EmployeeID, FirstName, LastName, DepartmentID
FROM Employees
WHERE DepartmentID IN (1, 3, 5);

Use of AND, OR, BETWEEN, IN, NOT IN and LIKE Operators (conti..)

```
SELECT column_name(s)
FROM table_name
WHERE column_name NOT IN (list_of_values);
```

Ex15:
```
SELECT Name
FROM Employee
WHERE DeptID NOT IN (3, 5, 7);
```

```
SELECT column_name(s)
FROM table_name
WHERE Name LIKE '_pattern%';
```

Ex16:
```
SELECT Name
FROM Employee
WHERE Name LIKE '_ohn%‘;
```

Use of binary (=,<, > and <>) Operators

SELECT *

FROM table_name

WHERE condition = value;

Ex17: SELECT *

FROM Employee

WHERE DeptID = 10;

SELECT *

FROM table_name

WHERE condition > values;

Ex18: SELECT Name

FROM Employee

WHERE salary > 10;

Ex19: SELECT *

FROM Employee

WHERE DeptID <> 5;

ARITHMETIC OPERATIONS

- The standard arithmetic operators '+', '-'. '*', and '/' (for addition, subtraction, multiplication, and division, respectively) can be applied to numeric values in an SQL query result
- Ex20: Return the first name, last name, and an increased salary (10% higher than the original salary) for each employee in the EMPLOYEE table.

Ex20:SELECT FNAME, LNAME, 1.1*SALARY
FROM EMPLOYEE, WORKS_ON, PROJECT

FNAME	LNAME	SALARY
John	Doe	50000
Jane	Smith	60000

FNAME	LNAME	1.1 * SALARY
John	Doe	55000
Jane	Smith	66000

ARITHMETIC OPERATIONS(conti…)

- Using UPDATE and SET command to increases the salary of every employee in the Employee table by 10%. The UPDATE statement updates the salary column by multiplying its current value by 1.10, effectively giving each employee a 10% raise.

Ex21: UPDATE Employee SET salary = salary * 1.10;

Ex22: UPDATE Employee SET salary = salary * 1.10 WHERE department = 'Sales';

Ex23: Show the effect of giving all employees who work on the 'ProductX' project a 10% raise in salary.

```
Ex23:   SELECT  FNAME, LNAME, 1.1*SALARY
        FROM    EMPLOYEE, WORKS_ON, PROJECT
        WHERE   SSN=ESSN AND PNO=PNUMBER AND  PNAME='ProductX'
```

ARITHMETIC OPERATIONS(conti…)

- Arithmetic Operator

Ex24: SELECT salary + 1000 AS new_salary
FROM Employee;

- String concatenation using ‘+’

Ex25: SELECT first_name + ' ' + last_name AS full_name
FROM Employee;

SET OPERATIONS

- SQL has directly incorporated some set operations
- There is a union operation (**UNION)**, and in *some versions* of SQL there are set difference (**MINUS)** and intersection (**INTERSECT)** operations
- The resulting relations of these set operations are sets of tuples; *duplicate tuples are eliminated from the result*
- The set operations apply only to *union compatible relations* ; the two relations must have the same attributes and the attributes must appear in the same order

- There are certain rules which must be followed to perform operations using SET operators in SQL. Rules are as follows:
  - The number and order of columns must be the same.
  - Data types must be compatible.

SET OPERATIONS -UNION

- The UNION operator is used to combine the result-set of two or more SELECT statements.
- Every SELECT statement within UNION must have the same number of columns
- The columns must also have similar data types
- The columns in every SELECT statement must also be in the same order
- **UNION Syntax:**

```
SELECT column_name(s) FROM table1
UNION
SELECT column_name(s) FROM table2;
```

- **UNION ALL Syntax**
- The UNION operator selects only distinct values by default. To allow duplicate values, use UNION ALL:

```
SELECT column_name(s) FROM table1
UNION ALL
SELECT column_name(s) FROM table2;
```

SET OPERATIONS -UNION

EX 26: Create a list of **all unique projects**

```
SELECT PROJ_ID, PROJ_NAME, DEPT_ID FROM PROJECT
UNION
SELECT PROJ_ID, PROJ_NAME, DEPT_ID FROM TEMP_PROJECT;
```

EX27:Create a list of all projects - include duplicates, use UNION ALL

```
SELECT PROJ_ID, PROJ_NAME, DEPT_ID FROM PROJECT
UNION ALL
SELECT PROJ_ID, PROJ_NAME, DEPT_ID FROM TEMP_PROJECT;
```

Ex28: Make a list of cities (only distinct values) from both the "Customers" and the "Suppliers" table:

- SELECT City FROM Customers
  UNION
  SELECT City FROM Suppliers
  ORDER BY City;

City
Bangalore
Delhi
Finland
Trivandrum
Tumakuru

SET OPERATIONS -UNION

- Ex29: Make a list of all project numbers for projects that involve an employee whose last name is 'Smith' as a worker or as a manager of the department that controls the project.
-

```
Ex29:(SELECT  PNAME
      FROM    PROJECT, DEPARTMENT, EMPLOYEE
      WHERE   DNUM=DNUMBER AND MGRSSN=SSN  AND LNAME='Smith')
      UNION
      (SELECT  PNAME
      FROM    PROJECT, WORKS_ON, EMPLOYEE
      WHERE   PNUMBER=PNO AND ESSN=SSN AND LNAME='Smith');
```

SET OPERATIONS -INTERSECTION

- The INTERSECT clause in SQL is used to combine two SELECT statements but the dataset returned by the INTERSECT statement will be the intersection of the data sets of the two SELECT statements.
- In simple words, the INTERSECT statement will return only those rows which will be common to both of the SELECT statements.

SELECT column1 [, column2] FROM table1 [, table2] [WHERE condition]

INTERSECT

SELECT column1 [, column2] FROM table1 [, table2] [WHERE condition]

EX30: SELECT Name
FROM Customers
INTERSECT
SELECT name
FROM Salesman;

Name	Age
Sara	26
Dev	22
Jay	29
Aarohi	30

INTERSECT

Name	Salary
Dev	3000
Rahul	2000
Aarohi	5000
Rohan	4000

=

Name
Dev
Aarohi

SET OPERATIONS -INTERSECTION

EX31:

SELECT NAME, AGE, HOBBY FROM STUDENTS_HOBBY

WHERE AGE BETWEEN 25 AND 30

INTERSECT

SELECT NAME, AGE, HOBBY FROM STUDENTS

WHERE AGE BETWEEN 20 AND 30;

Analyze the above query

NAME	AGE	HOBBY
Varun	26	Football

SET OPERATIONS -MINUS

- MINUS compares the data between tables and returns the rows of data that exist only in the first table you specify.
- This operation is also known as the **EXCEPT** operation in some DBMSs like SQL Server.

Ex32: You want to find the employees who are not managers.

SELECT EMP_ID, EMP_NAME, DEPT_ID FROM EMPLOYEE

MINUS

SELECT EMP_ID, EMP_NAME, DEPT_ID FROM MANAGER;

EMP_ID	EMP_NAME	DEPT_ID
101	Alice	D1
102	Bob	D2
103	Charlie	D3
104	Diana	D1

EMP_ID	EMP_NAME	DEPT_ID
101	Alice	D1
103	Charlie	D3

EMP_ID	EMP_NAME	DEPT_ID
102	Bob	D2
104	Diana	D1

EXCEPT Operator

- The EXCEPT operator in SQL is used to retrieve all the unique records from the left operand (query), except the records that are present in the result set of the right operand (query).
- This operator compares the distinct values of the left query with the result set of the right query.
- If a value from the left query is found in the result set of the right query, it is excluded from the final result.

```
SELECT column1, column2,..., columnN
FROM table1, table2,..., tableN  [Conditions] //optional
EXCEPT
SELECT column1, column2,..., columnN
FROM table1, table2,..., tableN [Conditions] //optional
```

EX33:

```
SELECT NAME, HOBBY, AGE FROM STUDENTS
EXCEPT
SELECT NAME, HOBBY, AGE FROM STUDENTS_HOBBY;
```

Figure 6.4

The set operations UNION, INTERSECTION, and MINUS. (a) Two union-compatible relations. (b) STUDENT ∪ INSTRUCTOR. (c) STUDENT ∩ INSTRUCTOR. (d) STUDENT – INSTRUCTOR. (e) INSTRUCTOR – STUDENT.

(a) **STUDENT**

Fn	Ln
Susan	Yao
Ramesh	Shah
Johnny	Kohler
Barbara	Jones
Amy	Ford
Jimmy	Wang
Ernest	Gilbert

INSTRUCTOR

Fname	Lname
John	Smith
Ricardo	Browne
Susan	Yao
Francis	Johnson
Ramesh	Shah

(b)

Fn	Ln
Susan	Yao
Ramesh	Shah
Johnny	Kohler
Barbara	Jones
Amy	Ford
Jimmy	Wang
Ernest	Gilbert
John	Smith
Ricardo	Browne
Francis	Johnson

(c)

Fn	Ln
Susan	Yao
Ramesh	Shah

(d)

Fn	Ln
Johnny	Kohler
Barbara	Jones
Amy	Ford
Jimmy	Wang
Ernest	Gilbert

(e)

Fname	Lname
John	Smith
Ricardo	Browne
Francis	Johnson

NESTING OF QUERIES

- **NESTED query/ INNER query/SUB query** is a SQL query within another SQL query embedded within a WHERE clause.
- The result of inner query is used in execution of outer query.
- Query execution starts from innermost query to outermost queries. The execution of inner query is independent of outer query, but the result of inner query is used in execution of outer query. Various operators like IN, NOT IN, ANY, ALL etc are used in writing independent nested queries.
- Many of the previous queries can be specified in an alternative form using nesting.
- Query 11a: Write the employee name who is drawing the second highest salary.

```
SELECT EName
FROM Employee
WHERE IN  (SELECT MAX (Salary)
                FROM employee)
```

NESTING OF QUERIES

EX34: Retrieve the name and address of all employees who work for the 'Research' department.

```
EX34:   SELECT  FNAME, LNAME, ADDRESS
        FROM    EMPLOYEE
        WHERE   DNO IN  (SELECT  DNUMBER
                         FROM  DEPARTMENT
                         WHERE  DNAME='Research' )
```

----------OR (SQL without nesting)----------

```
EX34: SELECT E.FNAME,E.ADDRESS
      FROM EMPLOYEE E, DEPARTMENT D
      WHERE D.DNAME="RESEARCH" AND D.DNUMBER = E.DNO;
```

- The nested query selects the number of the 'Research' department
- The outer query select an EMPLOYEE tuple if its DNO value is in the result of either nested query
- The comparison operator **IN** compares a value v with a set (or multi-set) of values V, and evaluates to **TRUE** if v is one of the elements in V
- In general, we can have several levels of nested queries
- A reference to an *unqualified attribute* refers to the relation declared in the *innermost nested query*
- In this example, the nested query is *not correlated* with the outer query

CORRELATED NESTED QUERIES

- If a condition in the WHERE-clause of a *nested query* references an attribute of a relation declared in the *outer query* , the two queries are said to be ***correlated***
- The result of a correlated nested query is *different for each tuple (or combination of tuples) of the relation(s) the outer query*
- EX35: Retrieve the name of each employee who has a dependent with the same first name as the employee.

```
EX35: SELECT   E.FNAME, E.LNAME
      FROM     EMPLOYEE AS E
      WHERE    E.SSN IN (SELECT   ESSN
                         FROM     DEPENDENT
                         WHERE    ESSN=E.SSN AND E.FNAME=DEPENDENT_NAME)
```

CORRELATED NESTED QUERIES (cont.)

- In EX35, the nested query has a different result *for each tuple* in the outer query
- A query written with nested SELECT... FROM... WHERE... blocks and using the = or IN comparison operators can ***always*** be expressed as a single block query. For example, EX35 may be written as in EX35A

```
EX35A:SELECT   E.FNAME, E.LNAME
      FROM     EMPLOYEE E, DEPENDENT D
      WHERE    E.SSN=D.ESSN AND E.FNAME=D.DEPENDENT_NAME
```

- The original SQL as specified for SYSTEM R also had a **CONTAINS** comparison operator, which is used in conjunction with nested correlated queries
- This operator was dropped from the language, possibly because of the difficulty in implementing it efficiently

CORRELATED NESTED QUERIES (cont.)

- Most implementations of SQL *do not* have this operator
- The CONTAINS operator compares two *sets of values* , and returns TRUE if one set contains all values in the other set (reminiscent of the *division* operation of algebra).

EX36: Retrieve the name of each employee who works on *all* the projects controlled by department number 5.

```
EX36: SELECT   FNAME, LNAME
      FROM     EMPLOYEE
      WHERE    ( (SELECT PNO
                  FROM   WORKS_ON
                  WHERESSN=ESSN)
                 CONTAINS
                (SELECT  PNUMBER
                 FROM    PROJECT
                 WHERE DNUM=5) )
```

CORRELATED NESTED QUERIES (cont.)

- In EX36, the second nested query, which is not correlated with the outer query, retrieves the project numbers of all projects controlled by department 5
- The first nested query, which is correlated, retrieves the project numbers on which the employee works, which is different *for each employee tuple* because of the correlation

THE EXISTS FUNCTION

- The EXISTS operator/function is used to test for the existence of any record in a subquery.
- The EXISTS operator returns TRUE if the subquery returns one or more records.
- We can formulate EX35 in an alternative form that uses EXISTS as EX35B below
- EX35B: Retrieve the name of each employee who has a dependent with the same first name as the employee.

```
Q12B: SELECT  FNAME, LNAME
            FROM   EMPLOYEE
            WHERE EXISTS  (SELECT *
                                FROM  DEPENDENT
                                WHERE SSN=ESSN AND FNAME=DEPENDENT_NAME)
```

```
_EX35: SELECT  E.FNAME, E.LNAME
       FROM    EMPLOYEE AS E
       WHERE   E.SSN IN (SELECT  ESSN
                         FROM        DEPENDENT
                         WHERE       ESSN=E.SSN AND E.FNAME=DEPENDENT_NAME)
```

THE EXISTS FUNCTION (cont.)

- EX37: Retrieve the names of employees who have no dependents.

```
EX37:SELECT  FNAME, LNAME
       FROM  EMPLOYEE
       WHERE   NOT EXISTS   (SELECT *
                             FROM  DEPENDENT
                             WHERE SSN=ESSN)
```

- In EX37, the correlated nested query retrieves all DEPENDENT tuples related to an EMPLOYEE tuple. If *none exist* , the EMPLOYEE tuple is selected
- EXISTS is necessary for the expressive power of SQL

EXPLICIT SETS

- It is also possible to use an **explicit (enumerated) set of values** in the WHERE-clause rather than a nested query
- EX38: Retrieve the social security numbers of all employees who work on project number 1, 2, or 3.

```
EX38:    SELECT  DISTINCT ESSN
         FROM  WORKS_ON
         WHERE  PNO IN  (1, 2, 3)
```

NULLS IN SQL QUERIES

- SQL allows queries that check if a value is NULL (missing or undefined or not applicable)
- SQL uses **IS** or **IS NOT** to compare NULLs because it considers each NULL value distinct from other NULL values, so equality comparison is not appropriate .
- EX39: Retrieve the names of all employees who do not have supervisors.

  EX39: **SELECT FNAME, LNAME**
  FROM EMPLOYEE
  WHERE SUPERSSN IS NULL

  Note: If a join condition is specified, tuples with NULL values for the join attributes are not included in the result

ALIASES

- In SQL, we can use the same name for two (or more) attributes as long as the attributes are in *different relations*
- A query that refers to two or more attributes with the same name must *qualify* the attribute name with the relation name by *prefixing* the relation name to the attribute name

SYNATX: When alias is used on column:

```
SELECT column_name AS alias_name
FROM table_name;
```

SYNATX: When alias is used on table:

```
SELECT column_name(s)
FROM table_name AS alias_name;
```

EX40: **SELECT EMPLOYEEID AS ID**
FROM EMPLOYEE;

ALIASES

- Some queries need to refer to the same relation twice
- In this case, *aliases* are given to the relation name
- EX41: For each employee, retrieve the employee's name, and the name of his or her immediate supervisor.

EX41: **SELECT E.FNAME, E.LNAME, S.FNAME, S.LNAME**
FROM EMPLOYEE E S
WHERE E.SUPERSSN=S.SSN

  - In EX41, the alternate relation names E and S are called *aliases* or *tuple variables* for the EMPLOYEE relation
  - We can think of E and S as two *different copies* of EMPLOYEE; E represents employees in role of *supervisees* and S represents employees in role of *supervisors*

ALIASES (cont.)

– Aliasing can also be used in any SQL query for convenience
  Can also use the AS keyword to specify aliases

EX42:
```
SELECT  E.FNAME, E.LNAME, S.FNAME, S.LNAME
FROM    EMPLOYEE AS E, EMPLOYEE AS S
WHERE   E.SUPERSSN=S.SSN
```

Joined Relations Feature in SQL2

- Can specify a "joined relation" in the FROM-clause
- Looks like any other relation but is the result of a join
- While joining there should be some common attribute.
- Allows the user to specify different types of joins

1. regular "theta" JOIN
2. NATURAL JOIN
3. LEFT OUTER JOIN
4. RIGHT OUTER JOIN
5. FULL OUTER JOIN
6. CROSS JOIN

NATURAL JOIN

- In JOIN, only combinations of tuples satisfying the join condition appear in the result
- In the CARTESIAN PRODUCT all combinations of tuples are included in the result.
- The join condition is specified on attributes from the two relations R and S and is evaluated for each combination of tuples.
- Each tuple combination for which the join condition evaluates to TRUE is included in the resulting relation Q as a single combined tuple.

NATURAL JOIN

Features of natural join

1. It will perform the Cartesian product.
2. It finds consistent tuples and deletes inconsistent tuples.
3. Then it deletes the duplicate attributes.

- If we join R1 and R2 on equal condition then it is called natural join or equi join.
- Natural join of R1 and R2 is – R1 NATURAL JOIN R2

```
SELECT  *  FROM TABLE1
NATURAL JOIN TABLE2;
```

NATURAL JOIN

SELECT * FROM employee;

EMP_ID	EMP_NAME	DEPT_NAME
1	SUMIT	HR
2	JOEL	IT
3	BISWA	MARKETING
4	VAIBHAV	IT
5	SAGAR	SALES

SELECT * FROM department;

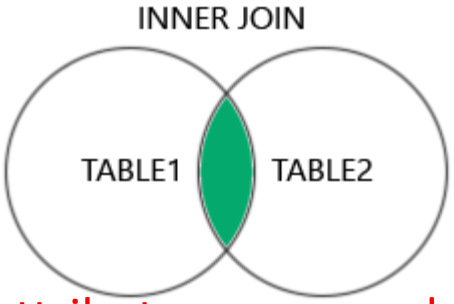
DEPT_NAME	MANAGER_NAME
IT	ROHAN
SALES	RAHUL
HR	TANMAY
FINANCE	ASHISH
MARKETING	SAMAY

```
SELECT *
FROM employee
NATURAL JOIN department;
```

EMP_ID	EMP_NAME	DEPT_NAME	MANAGER_NAME
1	SUMIT	HR	TANMAY
2	JOEL	IT	ROHAN
3	BISWA	MARKETING	SAMAY
4	VAIBHAV	IT	ROHAN
5	SAGAR	SALES	RAHUL

INNER JOIN (equi-join)

- Inner Join in SQL is the most common type of join.
- Returns records that have matching values in both tables, i.e., combines the table based on the **common columns and selects the records that have matching values in these columns.**
- It is similar to the intersection of the sets in Mathematics. i.e. when you take the intersection of two or more sets only the common element (in all the sets) are taken together.
- Inner Join joins two tables on the basis of the column which is explicitly specified in the ON clause. The resulting table will contain all the attributes from both tables including the common column also.



- SELECT *column_name(s)*
  FROM *table1*
  INNER JOIN *table2*
  ON *table1.column_name = table2.column_name*;
- Natural Join joins two tables based on the same attribute name and datatypes. The resulting table will contain all the attributes of both the table but keep only one copy of each common column.

```
SELECT Student.StudentID,
Student.Name,Department.Departmen
tName
FROM Student INNER JOIN Department
ON Student.DepartmentID =
Department.DepartmentID
```

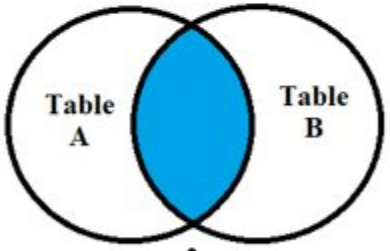
INNERJOIN- Returns records that have matching values in both tables, i.e., combines the table based on the common columns and selects the records that have matching values in these columns.

Student ID	Name
1001	A
1002	B
1003	C
1004	D

Table A

Student ID	Department
1004	Mathematics
1005	Mathematics
1006	History
1007	Physics
1008	Computer Science

Table B



Student ID	Name	Department
1004	D	Mathematics

```
SELECT Student.StudentID, Student.Name, Student.Email, Student.Percentage,
Department.DepartmentName
FROM Student INNER JOIN Department
ON Student.DepartmentID = Department.DepartmentID
```

Student Record Table

StudentID	Name	E-mail	Percentage(%)	DepartmentID
1001	Ajay	ajay@xyz.com	85	1
1002	Babloo	babloo@xyz.com	67	2
1003	Chhavi	chhavi@xyz.com	89	3
1004	Dheeraj	dheeraj@xyz.com	75	
1005	Evina	evina@xyz.com	91	1
1006	Krishna	krishna@xyz.com	99	5

Department Record Table

Department ID	Department Name
1	Mathematics
2	Physics
3	English

StudentID	Name	E-mail	Percentage(%)	DepartmentName
1001	Ajay	ajay@xyz.com	85	Mathematics
1002	Babloo	babloo@xyz.com	67	Physics
1003	Chhavi	chhavi@xyz.com	89	English
1005	Evina	evina@xyz.com	91	Mathematics

OUTER JOIN

- **Outer join**: It is an extension of natural join to deal with missing values of relation.
  - **Left Join:** Returns all records from the left table, and the matched records from the right table.
  - **Right Join:** Returns all records from the right table, and the matched records from the left table.
  - **Full Join:** Returns all records when there is a match in either left or right table

Left Join: Left Join in SQL is used to return all the rows from the left table but only the matching rows from the right table where the join condition is fulfilled.

- Here all the tuples of R1(left table) appear in output.
- The mismatching values of R2 are filled with NULL.
- Left outer join = natural join + mismatch / extra tuple of R1

```
SELECT column_name(s)
FROM table1
LEFT JOIN table2
ON table1.column_name = table2.column_name;
```

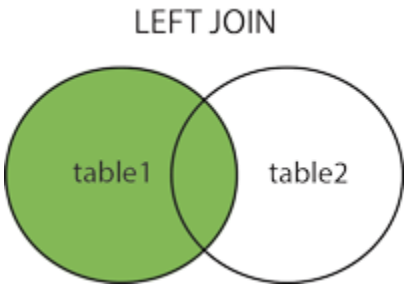


Table R1

RegNo	Branch	Section
1	CSE	A
2	ECE	B
3	CIVIL	A
4	IT	B
5	IT	A

Table R2

Name	Regno
Bhanu	2
Priya	4
Hari	7

Left outer join

```
SELECT RegNo, Branch, Section, Name
FROM table R1
LEFT JOIN tableR2
ON tableR1.RegNo = tableR2.RegNo;
```

RegNo	Branch	Section	Name	Regno
2	-	-	Bhanu	2
4	-	-	Priya	4
1	-	-	NULL	NULL
3	-	-	NULL	NULL
5	-	-	NULL	NULL

Q1: **SELECT E.FNAME, E.LNAME, S.FNAME, S.LNAME**
FROM EMPLOYEE E S
WHERE E.SUPERSSN=S.SSN

can be written as:

Q2: **SELECT E.FNAME, E.LNAME, S.FNAME, S.LNAME**
FROM (EMPLOYEE E LEFT OUTER JOIN EMPLOYEES
ON E.SUPERSSN=S.SSN)

Select all customers, and any orders they might have:

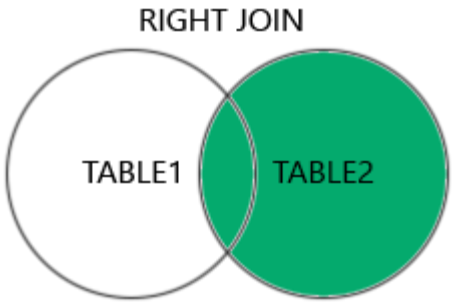
Example

```
SELECT Customers.CustomerName, Orders.OrderID
FROM Customers
LEFT JOIN Orders ON Customers.CustomerID=Orders.CustomerID
ORDER BY Customers.CustomerName;
```

The **LEFT JOIN** keyword returns all records from the left table (Customers), even if there are no matches in the right table (Orders).

- **Right Join:** Right Join in SQL is used to return all the rows from the right table but only the matching rows from the left table where the join condition is fulfilled.
- Here all the tuples of S(right table) appear in output. The mismatching values of S are filled with NULL.

- ```
  SELECT column_name(s)
  FROM table1
  RIGHT JOIN table2
  ON table1.column_name = table2.column_name;
  ```


  ```

```
SELECT RegNo, Branch, Section, Name
FROM table R1
RIGHT JOIN table R2
ON table R1.RegNo = table R2.RegNo;
```

Table R1

RegNo	Branch	Section
1	CSE	A
2	ECE	B
3	CIVIL	A
4	IT	B
5	IT	A

Table R2

Name	Regno
Bhanu	2
Priya	4
Hari	7

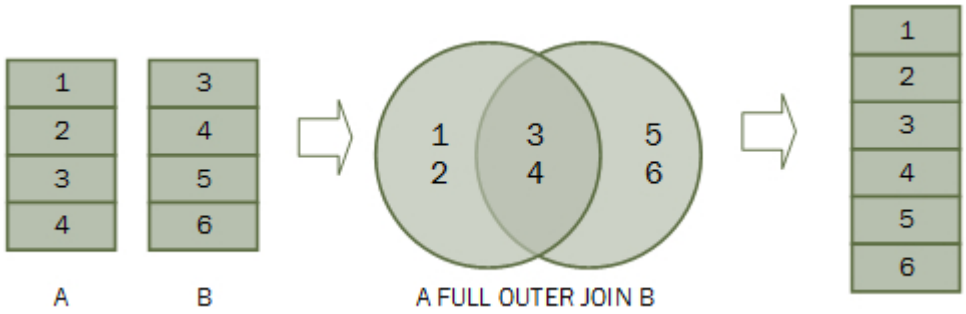
Right outer join

RegNo	Branch	Section	Name	Regno
2	-	-	Bhanu	2
4	-	-	Priya	4
NULL	NULL	NULL	Hari	7

Here all the tuples of R2(right table) appear in output. The mismatching values of R1 are filled with NULL.

Full Join: Full join returns all the records when there is a match in any of the tables. Therefore, it returns all the rows from the left-hand side table and all the rows from the right-hand side table.

Full outer join=left outer join U right outer join.




```
SELECT column_name(s)
FROM table1
FULL OUTER JOIN table2
ON table1.column_name = table2.column_name
WHERE condition;
```

Table R1

RegNo	Branch	Section
1	CSE	A
2	ECE	B
3	CIVIL	A
4	IT	B
5	IT	A

Table R2

Name	Regno
Bhanu	2
Priya	4
Hari	7

Full outer join

```
SELECT RegNo
FROM tableR1
FULL OUTER JOIN tableR2
ON tableR1.RegNo = tableR2.RegNo
WHERE condition;
```

RegNo	Branch	Section	Name	Regno
2	-	-	Bhanu	2
4	-	-	Priya	4
1	-	-	NULL	NULL
3	-	-	NULL	NULL
5	-	-	NULL	NULL
NULL	NULL	NULL	Hari	7

THETA JOIN(non equi-join)

- A theta join is a join that links tables based on a relationship other than equality between two columns.
- A theta join could use any operator other than the "equal" operator.
- A general join condition is of the form

<condition> **AND** <condition> **AND**...**AND** <condition>

where each <condition> is of the form $Ai\ \theta\ Bj$, *Ai* is an attribute of *R*, *Bj* is an attribute of *S*, *Ai* and *Bj* have the same domain, and θ (theta) is one of the comparison operators $\{=, <, \leq, >, \geq, \neq\}$.

- A JOIN operation with such a general join condition is called a **THETA JOIN**.

Table R1

RegNo	Branch	Section
1	CSE	A
2	ECE	B
3	CIVIL	A
4	IT	B
5	IT	A

Table R2

Name	RegNo
Bhanu	2
Priya	4

```
SELECT RegNo
FROM tableR1, tableR2
WHERE (tableR1.RegNo BETWEEN tab
leR2.RegNo AND table R1. branch,
table R1.section AND
tableR1.name;
```

- R1 thetajoin R2 with condition R1.regno > R2.regno
- In the join operation, we select those rows from the cartesian product where R1.regno>R2.regno.
- Join operation = select operation + cartesian product operation

RegNo	Branch	Section	Name	Regno
3	CIVIL	A	Bhanu	2
4	IT	B	Bhanu	2
5	IT	A	Bhanu	2
5	IT	B	Priya	4

In theta join we join relations R1 and R2 other than the equal to condition

DIVISION Operation

- The DIVISION operation, denoted by ÷, is useful for a special kind of query that sometimes occurs in database applications.
- DIVISION operation is applied to two relations $R(Z) \div S(X)$,
- Where the attributes of R are a subset of the attributes of S; that is, X ⊆ Z. Let Y be the set of attributes of R that are not attributes of S; that is, Y = Z – X (and hence Z = X ∪ Y).
- For a tuple t to appear in the result T of the DIVISION, the values in t must appear in R in combination with every tuple in S.

Joined Relations Feature in SQL2 (cont.)

- Examples:

Q8:

```
Q1:  SELECT  FNAME, LNAME, ADDRESS
     FROM    EMPLOYEE, DEPARTMENT
     WHERE   DNAME='Research' AND DNUMBER=DNO
```

Joined Relations Feature in SQL2 (cont.)

- could be written as:

```
Q1:  SELECT  FNAME, LNAME, ADDRESS
     FROM    (EMPLOYEE JOIN DEPARTMENT
              ON DNUMBER=DNO)
     WHERE   DNAME='Research'
```

or as:

```
Q1:  SELECT  FNAME, LNAME, ADDRESS
     FROM    (EMPLOYEE NATURAL JOIN DEPARTMENT
              AS DEPT(DNAME, DNO, MSSN, MSDATE)
     WHERE   DNAME='Research'
```

Joined Relations Feature in SQL2 (cont.)

- Another Example;

–Q2 could be written as follows; this illustrates multiple joins in the joined tables

```
Q2:SELECT  PNUMBER, DNUM, LNAME, BDATE, ADDRESS
     FROM (PROJECT JOIN  DEPARTMENT ON DNUM=DNUMBER)
               JOIN  (EMPLOYEE ON  MGRSSN=SSN) )
    WHERE  PLOCATION='Stafford'
```

AGGREGATE FUNCTIONS

- An aggregate function in SQL performs a **calculation on multiple values and returns a single value.**
- SQL provides many aggregate functions that include AVG, COUNT, SUM, MIN, MAX, etc.
- An aggregate function ignores NULL values when it performs the calculation, except for the count function.

- Query 15a: Find the salary, among all employees.
- **Q15: SELECT ***
  FROM EMPLOYEE

- Query 15b: Find the maximum salary, among all employees.
- **Q15: SELECT MAX(SALARY)**
  FROM EMPLOYEE

AGGREGATE FUNCTIONS

- Query 15c: Find the maximum salary, the minimum salary, and the average salary among all employees.
- **Q15: SELECT MAX(SALARY), MIN(SALARY), AVG(SALARY)**
  FROM EMPLOYEE

- Some SQL implementations *may not allow more than one function* in the SELECT-clause
- Query 16: Find the maximum salary, the minimum salary, and the average salary among employees who work for the 'Research' department.

- **Q16: SELECT MAX(SALARY), MIN(SALARY), AVG(SALARY)**
  FROM EMPLOYEE, DEPARTMENT
  WHERE DNO=DNUMBER AND DNAME='Research'

AGGREGATE FUNCTIONS (cont.)

- The COUNT() aggregate function returns the total number of rows that match the specified criteria.
- i.e., **get the number of rows** for a particular group in the table.
- Here is the basic syntax:

  SELECT COUNT(column_name)

  FROM table_name;

- COUNT(column_name) will not include NULL values as part of the count.

```
SELECT COUNT(ProductID)
FROM Products;
```

AGGREGATE FUNCTIONS (cont.)

- The COUNT(*) function will **return the total number of items** in that group including **NULL values**.
- Queries 17 and 18: Retrieve the total number of employees in the company (Q17), and the number of employees in the 'Research' department (Q18).

```
Q17:  SELECT  COUNT (*)
      FROM    EMPLOYEE

Q18:  SELECT  COUNT (*)
      FROM    EMPLOYEE, DEPARTMENT
      WHERE   DNO=DNUMBER AND DNAME='Research'
```

ORDER BY

- The ORDER BY clause is **used to sort the tuples** in a query result based on the values of some attribute(s)
- Query 28: Retrieve a list of employees and the projects each works in, ordered by the employee's department, and within each department ordered alphabetically by employee last name.

```
Q28: SELECT    DNAME, LNAME, FNAME, PNAME
     FROM      DEPARTMENT, EMPLOYEE, WORKS_ON, PROJECT
     WHERE     DNUMBER=DNO AND SSN=ESSN AND PNO=PNUMBER
     ORDER BY  DNAME, LNAME
```

- The default order is in ascending order of values
- We can specify the keyword DESC if we want a **descending order**; the keyword ASC can be used to explicitly specify **ascending order**, even though it is the default.

GROUPING

***GROUP BY** clause is used in conjunction with the **SELECT** statement and **aggregate function** to group rows together by common values*

- In many cases, we want to apply the **aggregate functions** *to* **subgroups of tuples in a relation**
- Each subgroup of tuples consists of the set of tuples that have *the same value* for the *grouping attribute(s)*
- The function is applied to each subgroup independently
- SQL has a **GROUP BY**-clause for specifying the grouping attributes, which *must also appear in the **SELECT-clause***

GROUPING (cont.)

- Query 20a: For each department, retrieve the department number.

```
Q20: SELECT   DNO
     FROM     EMPLOYEE
     GROUP BY DNO
```

- Query 20b: For each department, retrieve the department number, the number of employees in the department, and their average salary.

```
Q20: SELECT   DNO, COUNT (*), AVG (SALARY)
     FROM     EMPLOYEE
     GROUP BY DNO
```

In Q20 the EMPLOYEE tuples are divided into groups--each group having the same value for the grouping attribute DNO

  - The COUNT and AVG functions are applied to each such group of tuples separately
  - The SELECT-clause includes only the grouping attribute and the functions to be applied on each group of tuples
  - A join condition can be used in conjunction with grouping

GROUPING (cont.)

- Query 21a: For each project, retrieve the project number, project name, and the number of employees who work on that project.

```
Q21: SELECT    PNUMBER, PNAME, COUNT (*)
     FROM      PROJECT, WORKS_ON
     WHERE     PNUMBER=PNO
     GROUP BY PNUMBER, PNAME
```

In this case, the grouping and functions are applied *after* the joining of the two relations

- Query 21b: For each project, retrieve the project number, project name, and the number of employees who work on that project. Sort by high to low

```
Q21: SELECT    PNUMBER, PNAME, COUNT (*)
     FROM      PROJECT, WORKS_ON
     WHERE     PNUMBER=PNO
     GROUP BY PNUMBER, PNAME
     ORDER BY COUNT(PNUMBER) DESC;
```

THE HAVING-CLAUSE

- Sometimes we want to retrieve the values of these functions for only those *groups that satisfy certain conditions*
- The HAVING-clause is used for specifying a **selection condition on groups** (rather than on **individual tuples**)
- **The HAVING clause was added to SQL because the WHERE keyword cannot be used with aggregate functions.**

```
SELECT column_name(s)
FROM table_name
WHERE condition
GROUP BY column_name(s)
HAVING condition
ORDER BY column_name(s);
```

THE HAVING-CLAUSE

- Query 22: For each project on which more than two employees work , retrieve the project number, project name, and the number of employees who work on that project.

- **Q22:**
```
SELECT    PNUMBER, PNAME, COUNT (*)
FROM      PROJECT, WORKS_ON
WHERE     PNUMBER=PNO
GROUP BY  PNUMBER, PNAME
HAVING    COUNT (*) > 2
```

- The main difference between WHERE and HAVING clause is that the **WHERE clause allows you to filter data from specific rows** (individual rows) from a table **based on certain conditions**.
- In contrast, the **HAVING clause allows you to filter data from a group of rows** in a query **based on conditions involving aggregate values**.

THE HAVING-CLAUSE

Display the departments where the sum of salaries is 50,000 or more.

```
SELECT Department, SUM(Salary) as Salary
FROM employee
GROUP BY department
HAVING SUM(Salary) >= 50000;
```

Department	Salary
Finance	75000
IT	95000
Marketing	55000
Sales	65000

HAVING	WHERE
In the HAVING clause it will check the condition in group of a row.	In the WHERE condition it will check or execute at each row individual.
HAVING clause can only be used with aggregate function.	The WHERE Clause cannot be used with aggregate function like Having
Priority Wise HAVING Clause is executed after Group By.	Priority Wise WHERE is executed before Group By.

SUBSTRING COMPARISON

- The **LIKE** comparison operator is used to compare partial strings
- Two reserved characters are used: '%' (or '*' in some implementations) replaces an arbitrary number of characters, and '_' replaces a single arbitrary character.

- Query 25: Retrieve all employees whose address is in Houston, Texas. Here, the value of the ADDRESS attribute must contain the substring 'Houston,TX'.

```
Q25:SELECT   FNAME, LNAME
    FROM     EMPLOYEE
    WHERE    ADDRESS LIKE  '%Houston,TX%'
```

SUBSTRING COMPARISON (cont.)

- Query 26: Retrieve all employees who were born during the 1950s. Here, '5' must be the 8th character of the string (according to our format for date), so the BDATE value is '_____5_', with each underscore as a place holder for a single arbitrary character.
- **Q26: SELECT FNAME, LNAME**
  FROM EMPLOYEE
  WHERE BDATE LIKE '_____5_'
- The LIKE operator allows us to get around the fact that each value is considered atomic and indivisible; hence, in SQL, character string attribute values are not atomic

Summary of SQL Queries

- A query in SQL can consist of up to six clauses, but only the first two, SELECT and FROM, are mandatory. The clauses are specified in the following order:

SELECT <attribute list>
FROM <table list>
[WHERE <condition>]
[GROUP BY <grouping attribute(s)>]
[HAVING <group condition>]
[ORDER BY <attribute list>]

Summary of SQL Queries (cont.)

- The SELECT-clause lists the attributes or functions to be retrieved
- The FROM-clause specifies all relations (or aliases) needed in the query but not those needed in nested queries
- The WHERE-clause specifies the conditions for selection and join of tuples from the relations specified in the FROM-clause
- GROUP BY specifies grouping attributes
- HAVING specifies a condition for selection of groups
- ORDER BY specifies an order for displaying the result of a query
- A query is evaluated by first applying the WHERE-clause, then GROUP BY and HAVING, and finally the SELECT-clause