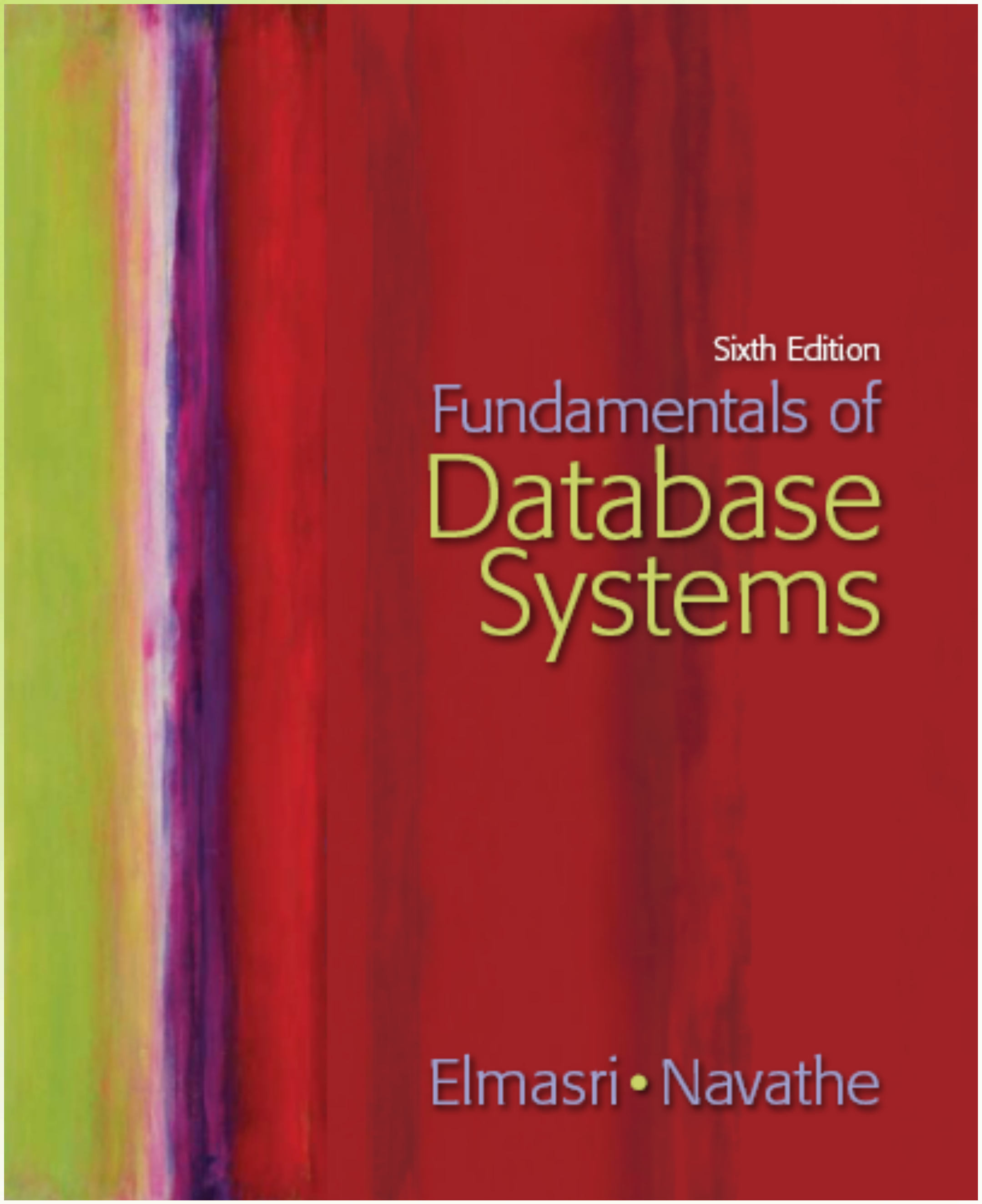
# Chapter 4

# Basic SQL



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# Chapter 4 Outline

- SQL Data Definition and Data Types
- Specifying Constraints in SQL
- Basic Retrieval Queries in SQL
- `INSERT`, `DELETE`, and `UPDATE` Statements in SQL
- Additional Features of SQL

## Basic SQL

- SQL language
  - Considered one of the major reasons for the commercial success of relational databases
- **SQL**
  - **Structured Query Language**
  - Statements for data definitions, queries, and updates (both DDL and DML)
  - **Core specification**
  - Plus specialized **extensions**

## SQL Data Definition and Data Types

- Terminology:
  - **Table**, **row**, and **column** used for relational model terms relation, tuple, and attribute
- `CREATE` statement
  - Main SQL command for data definition

# Schema and Catalog Concepts in SQL

- **SQL schema**
  - Identified by a **schema name**
  - Includes an **authorization identifier** and **descriptors** for each element
- Schema **elements** include
  - Tables, constraints, views, domains, and other constructs
- Each statement in SQL ends with a semicolon

## Schema and Catalog Concepts in SQL (cont'd.)

- `CREATE SCHEMA` statement
  - `CREATE SCHEMA COMPANY AUTHORIZATION 'Jsmith';`
- **Catalog**
  - Named collection of schemas in an SQL environment
- SQL **environment**
  - Installation of an SQL-compliant RDBMS on a computer system

## The CREATE TABLE Command in SQL

- Specify a new relation
  - Provide name
  - Specify attributes and initial constraints
- Can optionally specify schema:
  - `CREATE TABLE COMPANY.EMPLOYEE ...`

  or
  - `CREATE TABLE EMPLOYEE ...`

## The CREATE TABLE Command in SQL (cont'd.)

- **Base tables (base relations)**
  - Relation and its tuples are actually created and stored as a file by the DBMS
- **Virtual relations**
  - Created through the `CREATE VIEW` statement

```
CREATE TABLE EMPLOYEE
        ( Fname               VARCHAR(15)          NOT NULL,
          Minit               CHAR,
          Lname               VARCHAR(15)          NOT NULL,
          Ssn                 CHAR(9)              NOT NULL,
          Bdate               DATE,
          Address             VARCHAR(30),
          Sex                 CHAR,
          Salary              DECIMAL(10,2),
          Super_ssn           CHAR(9),
          Dno                 INT                  NOT NULL,
        PRIMARY KEY (Ssn),
        FOREIGN KEY (Super_ssn) REFERENCES EMPLOYEE(Ssn),
        FOREIGN KEY (Dno) REFERENCES DEPARTMENT(Dnumber) );
CREATE TABLE DEPARTMENT
        ( Dname               VARCHAR(15)          NOT NULL,
          Dnumber             INT                  NOT NULL,
          Mgr_ssn             CHAR(9)              NOT NULL,
          Mgr_start_date      DATE,
        PRIMARY KEY (Dnumber),
        UNIQUE (Dname),
        FOREIGN KEY (Mgr_ssn) REFERENCES EMPLOYEE(Ssn) );
```

**Figure 4.1**
SQL CREATE TABLE data definition statements for defining the COMPANY schema from Figure 3.7.

```
CREATE TABLE DEPT_LOCATIONS
        ( Dnumber              INT               NOT NULL,
          Dlocation            VARCHAR(15)       NOT NULL,
        PRIMARY KEY (Dnumber, Dlocation),
        FOREIGN KEY (Dnumber) REFERENCES DEPARTMENT(Dnumber) );
CREATE TABLE PROJECT
        ( Pname                VARCHAR(15)       NOT NULL,
          Pnumber              INT               NOT NULL,
          Plocation            VARCHAR(15),
          Dnum                 INT               NOT NULL,
        PRIMARY KEY (Pnumber),
        UNIQUE (Pname),
        FOREIGN KEY (Dnum) REFERENCES DEPARTMENT(Dnumber) );
CREATE TABLE WORKS_ON
        ( Essn                 CHAR(9)           NOT NULL,
          Pno                  INT               NOT NULL,
          Hours                DECIMAL(3,1)      NOT NULL,
        PRIMARY KEY (Essn, Pno),
        FOREIGN KEY (Essn) REFERENCES EMPLOYEE(Ssn),
        FOREIGN KEY (Pno) REFERENCES PROJECT(Pnumber) );
CREATE TABLE DEPENDENT
        ( Essn                 CHAR(9)           NOT NULL,
          Dependent_name       VARCHAR(15)       NOT NULL,
          Sex                  CHAR,
          Bdate                DATE,
          Relationship         VARCHAR(8),
        PRIMARY KEY (Essn, Dependent_name),
        FOREIGN KEY (Essn) REFERENCES EMPLOYEE(Ssn) );
```

**Figure 4.1**
SQL CREATE TABLE data definition statements for defining the COMPANY schema from Figure 3.7.

# The CREATE TABLE Command in SQL (cont'd.)

- Some foreign keys may cause errors
  - Specified either via:
    - Circular references
    - Or because they refer to a table that has not yet been created

## Attribute Data Types and Domains in SQL

- Basic **data types**
  - **Numeric** data types
    - Integer numbers: `INTEGER`, `INT`, and `SMALLINT`
    - Floating-point (real) numbers: `FLOAT` or `REAL`, and `DOUBLE PRECISION`
  - **Character-string** data types
    - Fixed length: `CHAR(`*n*`)`, `CHARACTER(`*n*`)`
    - Varying length: `VARCHAR(`*n*`)`, `CHAR VARYING(`*n*`)`, `CHARACTER VARYING(`*n*`)`

## Attribute Data Types and Domains in SQL (cont'd.)

- **Bit-string** data types
  - Fixed length: `BIT(n)`
  - Varying length: `BIT VARYING(n)`
- **Boolean** data type
  - Values of `TRUE` or `FALSE` or `NULL`
- **DATE** data type
  - Ten positions
  - Components are `YEAR`, `MONTH`, and `DAY` in the form YYYY-MM-DD

## Attribute Data Types and Domains in SQL (cont'd.)

- Additional data types
  - **Timestamp** data type (`TIMESTAMP`)
    - Includes the `DATE` and `TIME` fields
    - Plus a minimum of six positions for decimal fractions of seconds
    - Optional `WITH TIME ZONE` qualifier
  - **`INTERVAL`** data type
    - Specifies a relative value that can be used to increment or decrement an absolute value of a date, time, or timestamp

## Attribute Data Types and Domains in SQL (cont'd.)

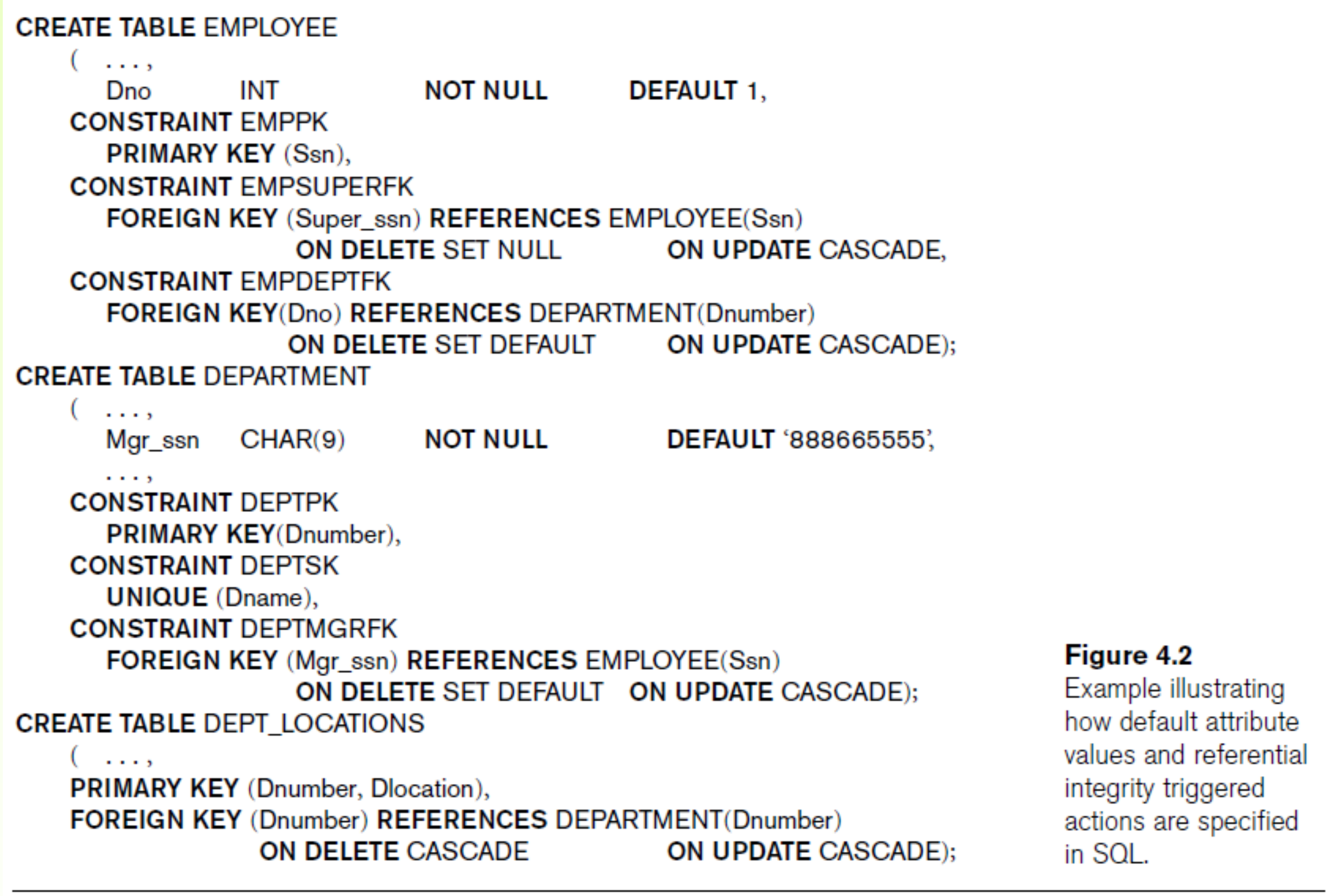
- Domain
  - Name used with the attribute specification
  - Makes it easier to change the data type for a domain that is used by numerous attributes
  - Improves schema readability
  - Example:
    - `CREATE DOMAIN SSN_TYPE AS CHAR(9);`

## Specifying Constraints in SQL

- Basic constraints:
  - Key and referential integrity constraints
  - Restrictions on attribute domains and NULLs
  - Constraints on individual tuples within a relation

# Specifying Attribute Constraints and Attribute Defaults

- `NOT NULL`
  - `NULL` is not permitted for a particular attribute
- Default value
  - **`DEFAULT`** `<value>`
- **`CHECK`** clause
  - `Dnumber INT NOT NULL CHECK (Dnumber > 0 AND Dnumber < 21);`



```
CREATE TABLE EMPLOYEE
    (   . . . ,
        Dno         INT             NOT NULL        DEFAULT 1,
    CONSTRAINT EMPPK
        PRIMARY KEY (Ssn),
    CONSTRAINT EMPSUPERFK
        FOREIGN KEY (Super_ssn) REFERENCES EMPLOYEE(Ssn)
                            ON DELETE SET NULL          ON UPDATE CASCADE,
    CONSTRAINT EMPDEPTFK
        FOREIGN KEY(Dno) REFERENCES DEPARTMENT(Dnumber)
                            ON DELETE SET DEFAULT       ON UPDATE CASCADE);
CREATE TABLE DEPARTMENT
    (   . . . ,
        Mgr_ssn     CHAR(9)         NOT NULL            DEFAULT '888665555',
        . . . ,
    CONSTRAINT DEPTPK
        PRIMARY KEY(Dnumber),
    CONSTRAINT DEPTSK
        UNIQUE (Dname),
    CONSTRAINT DEPTMGRFK
        FOREIGN KEY (Mgr_ssn) REFERENCES EMPLOYEE(Ssn)
                            ON DELETE SET DEFAULT   ON UPDATE CASCADE);
CREATE TABLE DEPT_LOCATIONS
    (   . . . ,
    PRIMARY KEY (Dnumber, Dlocation),
    FOREIGN KEY (Dnumber) REFERENCES DEPARTMENT(Dnumber)
                        ON DELETE CASCADE               ON UPDATE CASCADE);
```

**Figure 4.2**
Example illustrating how default attribute values and referential integrity triggered actions are specified in SQL.

## Specifying Key and Referential Integrity Constraints

- **`PRIMARY KEY`** clause
  - Specifies one or more attributes that make up the primary key of a relation
  - `Dnumber INT PRIMARY KEY;`
- **`UNIQUE`** clause
  - Specifies alternate (secondary) keys
  - `Dname VARCHAR(15) UNIQUE;`

## Specifying Key and Referential Integrity Constraints (cont'd.)

- **`FOREIGN KEY`** clause
  - Default operation: reject update on violation
  - Attach **referential triggered action** clause
    - Options include `SET NULL`, `CASCADE`, and `SET DEFAULT`
    - Action taken by the DBMS for `SET NULL` or `SET DEFAULT` is the same for both `ON DELETE` and `ON UPDATE`
    - `CASCADE` option suitable for "relationship" relations

## Giving Names to Constraints

- Keyword **`CONSTRAINT`**
  - Name a constraint
  - Useful for later altering

## Specifying Constraints on Tuples Using CHECK

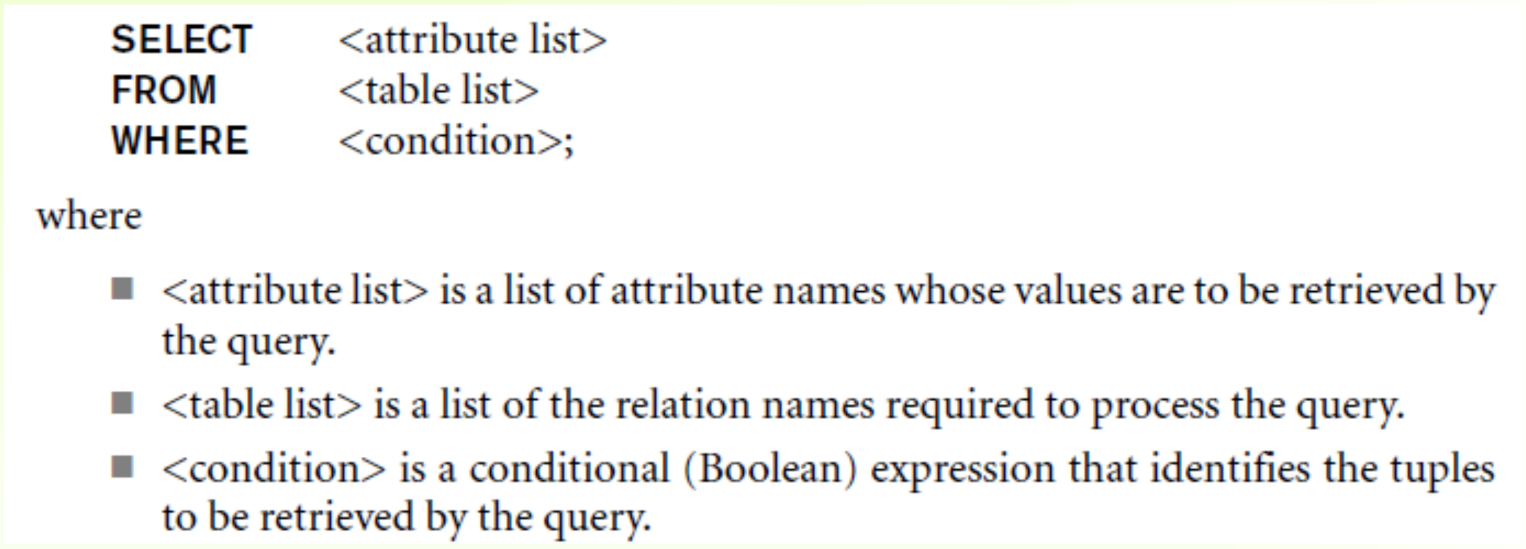
- `CHECK` clauses at the end of a `CREATE TABLE` statement
  - Apply to each tuple individually
  - `CHECK (Dept_create_date <= Mgr_start_date);`

## Basic Retrieval Queries in SQL

- `SELECT` statement
  - One basic statement for retrieving information from a database
- SQL allows a table to have two or more tuples that are identical in all their attribute values
  - Unlike relational model
  - Multiset or bag behavior

## The SELECT-FROM-WHERE Structure of Basic SQL Queries

- Basic form of the `SELECT` statement:



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

where

- <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.

## The SELECT-FROM-WHERE Structure of Basic SQL Queries (cont'd.)

- Logical comparison operators
  - =, <, <=, >, >=, and <>
- **Projection attributes**
  - Attributes whose values are to be retrieved
- **Selection condition**
  - Boolean condition that must be true for any retrieved tuple

**Figure 4.3**
Results of SQL queries when applied to the COMPANY database state shown in Figure 3.6. (a) Q0. (b) Q1. (c) Q2. (d) Q8. (e) Q9. (f) Q10. (g) Q1C.

(a)

| Bdate | Address |
|---|---|
| 1965-01-09 | 731Fondren, Houston, TX |

(b)

| Fname | Lname | Address |
|---|---|---|
| John | Smith | 731 Fondren, Houston, TX |
| Franklin | Wong | 638 Voss, Houston, TX |
| Ramesh | Narayan | 975 Fire Oak, Humble, TX |
| Joyce | English | 5631 Rice, Houston, TX |

**Query 0.** Retrieve the birth date and address of the employee(s) whose name is 'John B. Smith'.

```
Q0:     SELECT    Bdate, Address
        FROM      EMPLOYEE
        WHERE     Fname='John' AND Minit='B' AND Lname='Smith';
```

**Query 1.** Retrieve the name and address of all employees who work for the 'Research' department.

```
Q1:     SELECT    Fname, Lname, Address
        FROM      EMPLOYEE, DEPARTMENT
        WHERE     Dname='Research' AND Dnumber=Dno;
```

**Figure 4.3**
Results of SQL queries when applied to the COMPANY database state shown in Figure 3.6. (a) Q0. (b) Q1. (c) Q2. (d) Q8. (e) Q9. (f) Q10. (g) Q1C.

(c)

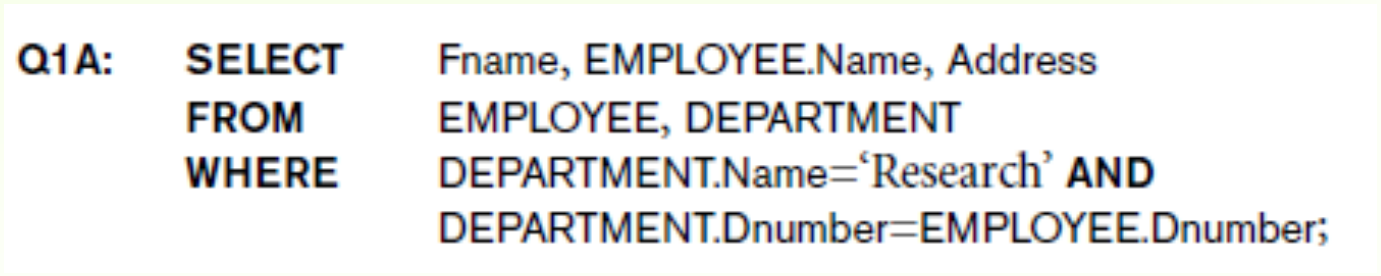
| Pnumber | Dnum | Lname | Address | Bdate |
|---|---|---|---|---|
| 10 | 4 | Wallace | 291Berry, Bellaire, TX | 1941-06-20 |
| 30 | 4 | Wallace | 291Berry, Bellaire, TX | 1941-06-20 |

**Query 2.** For every project located in 'Stafford', list the project number, the controlling department number, and the department manager's last name, address, and birth date.

```
Q2:    SELECT    Pnumber, Dnum, Lname, Address, Bdate
       FROM      PROJECT, DEPARTMENT, EMPLOYEE
       WHERE     Dnum=Dnumber AND Mgr_ssn=Ssn AND
                 Plocation='Stafford';
```

## Ambiguous Attribute Names

- Same name can be used for two (or more) attributes
  - As long as the attributes are in different relations
  - Must **qualify** the attribute name with the relation name to prevent ambiguity



```
Q1A:    SELECT    Fname, EMPLOYEE.Name, Address
        FROM      EMPLOYEE, DEPARTMENT
        WHERE     DEPARTMENT.Name='Research' AND
                  DEPARTMENT.Dnumber=EMPLOYEE.Dnumber;
```

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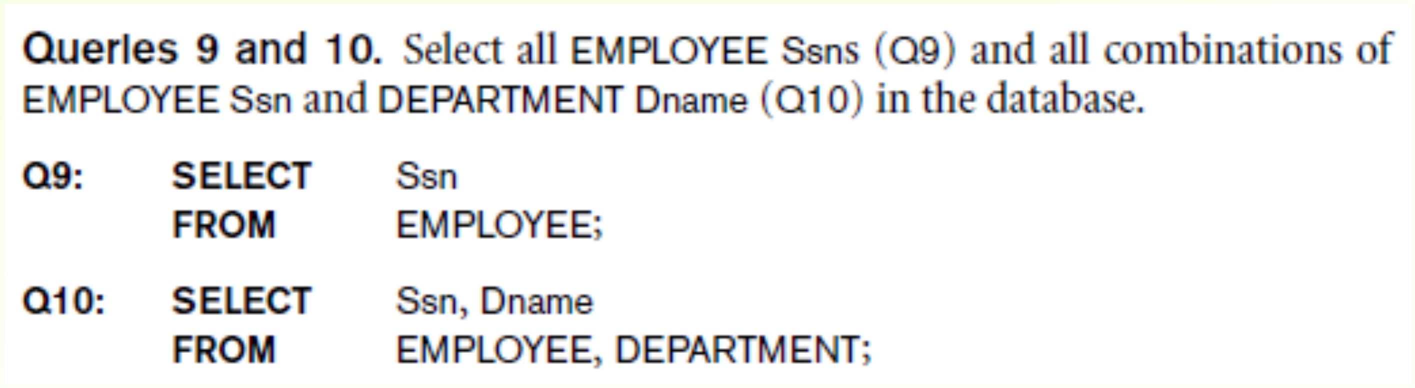
## Aliasing, Renaming, and Tuple Variables

- **Aliases** or **tuple variables**
  - Declare alternative relation names E and S
  - `EMPLOYEE AS E(Fn, Mi, Ln, Ssn, Bd, Addr, Sex, Sal, Sssn, Dno)`

# Unspecified WHERE Clause and Use of the Asterisk

- Missing `WHERE` clause
  - Indicates no condition on tuple selection
- `CROSS PRODUCT`
  - All possible tuple combinations

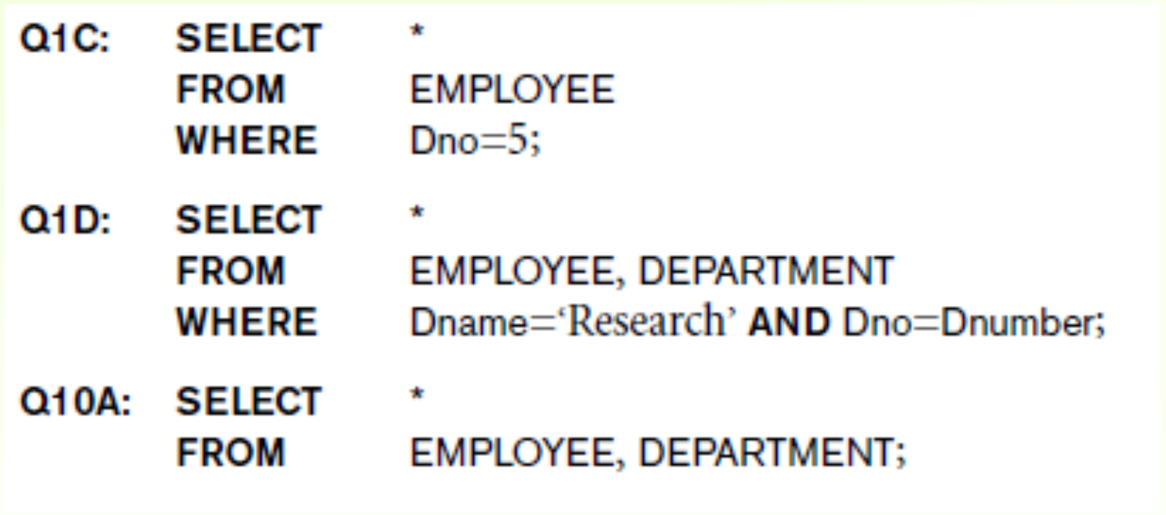


**Queries 9 and 10.** Select all EMPLOYEE Ssns (Q9) and all combinations of EMPLOYEE Ssn and DEPARTMENT Dname (Q10) in the database.

```
Q9:     SELECT    Ssn
        FROM      EMPLOYEE;

Q10:    SELECT    Ssn, Dname
        FROM      EMPLOYEE, DEPARTMENT;
```

## Unspecified WHERE Clause and Use of the Asterisk (cont'd.)

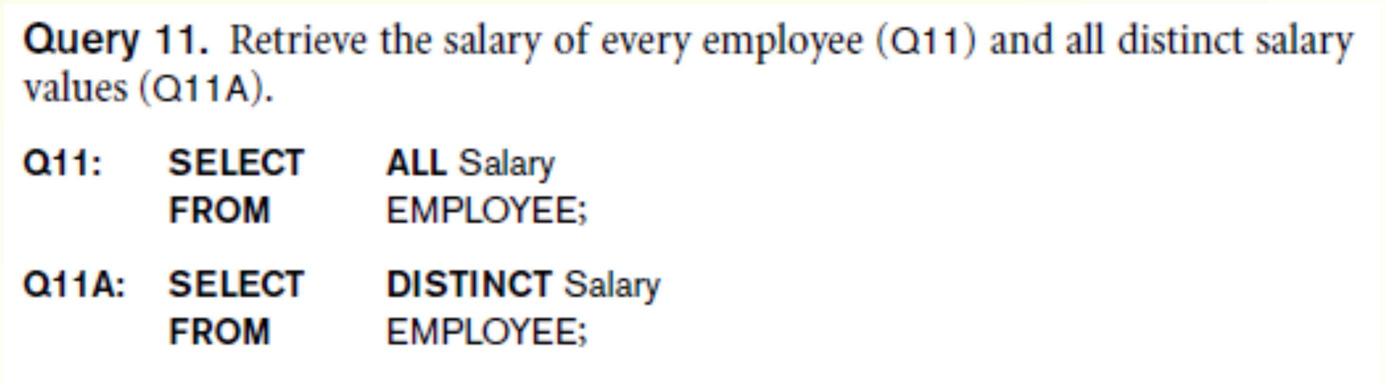
- Specify an asterisk (*)
  - Retrieve all the attribute values of the selected tuples



```
Q1C:   SELECT   *
       FROM     EMPLOYEE
       WHERE    Dno=5;

Q1D:   SELECT   *
       FROM     EMPLOYEE, DEPARTMENT
       WHERE    Dname='Research' AND Dno=Dnumber;

Q10A:  SELECT   *
       FROM     EMPLOYEE, DEPARTMENT;
```

# Tables as Sets in SQL

- SQL does not automatically eliminate duplicate tuples in query results
- Use the keyword **`DISTINCT`** in the `SELECT` clause
  - Only distinct tuples should remain in the result

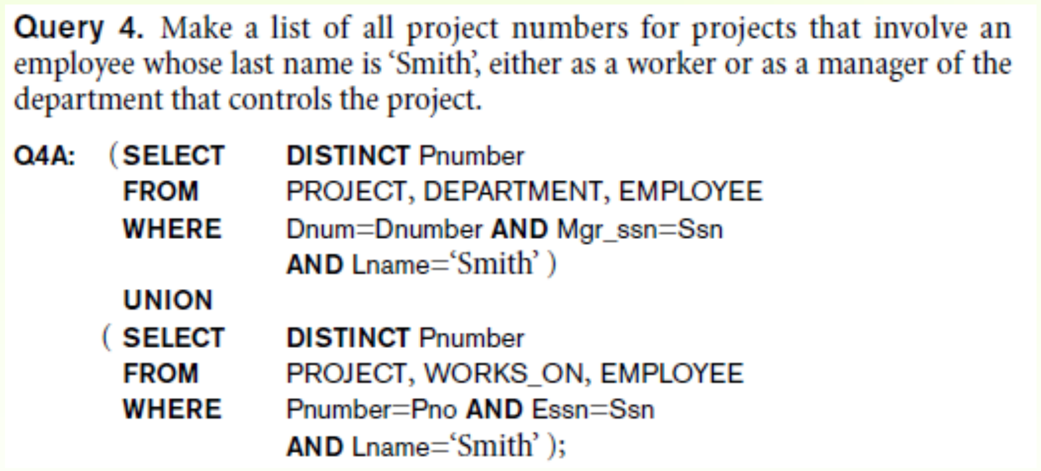


**Query 11.** Retrieve the salary of every employee (Q11) and all distinct salary values (Q11A).

```
Q11:    SELECT    ALL Salary
        FROM      EMPLOYEE;

Q11A:   SELECT    DISTINCT Salary
        FROM      EMPLOYEE;
```

## Tables as Sets in SQL (cont'd.)

- Set operations
  - `UNION`, **`EXCEPT`** (difference), **`INTERSECT`**
  - Corresponding multiset operations: `UNION ALL`, `EXCEPT ALL`, `INTERSECT ALL`)



**Query 4.** Make a list of all project numbers for projects that involve an employee whose last name is 'Smith', either as a worker or as a manager of the department that controls the project.

```
Q4A:  (SELECT    DISTINCT Pnumber
       FROM      PROJECT, DEPARTMENT, EMPLOYEE
       WHERE     Dnum=Dnumber AND Mgr_ssn=Ssn
                 AND Lname='Smith' )
       UNION
      ( SELECT   DISTINCT Pnumber
       FROM      PROJECT, WORKS_ON, EMPLOYEE
       WHERE     Pnumber=Pno AND Essn=Ssn
                 AND Lname='Smith' );
```

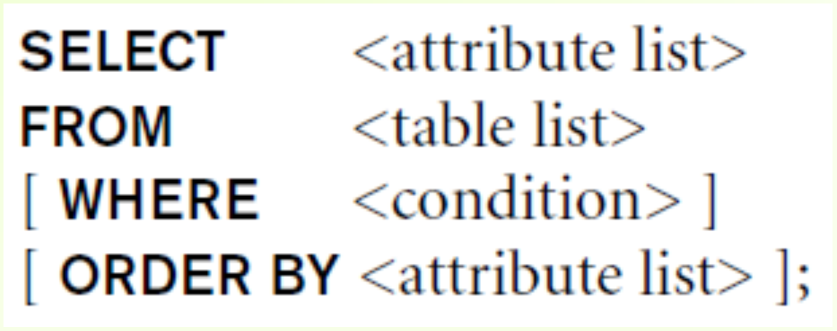
## Substring Pattern Matching and Arithmetic Operators

- **`LIKE`** comparison operator
  - Used for string **pattern matching**
  - % replaces an arbitrary number of zero or more characters
  - underscore (_) replaces a single character
- Standard arithmetic operators:
  - Addition (+), subtraction (–), multiplication (*), and division (/)
- **`BETWEEN`** comparison operator

## Ordering of Query Results

- Use **`ORDER BY`** clause
  - Keyword **`DESC`** to see result in a descending order of values
  - Keyword **`ASC`** to specify ascending order explicitly
  - `ORDER BY D.Dname DESC, E.Lname ASC, E.Fname ASC`

# Discussion and Summary of Basic SQL Retrieval Queries



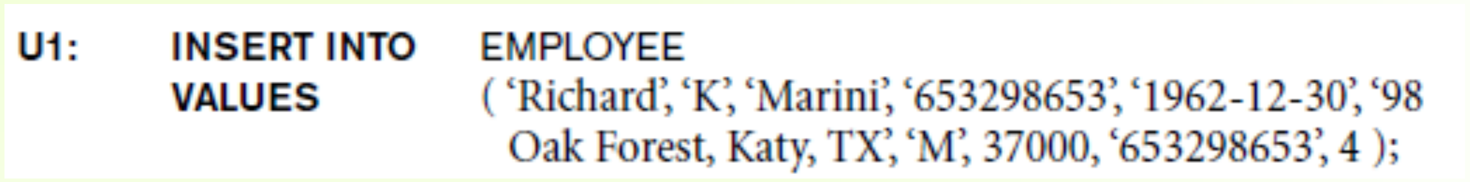
```
SELECT      <attribute list>
FROM        <table list>
[ WHERE     <condition> ]
[ ORDER BY <attribute list> ];
```

## INSERT, DELETE, and UPDATE Statements in SQL

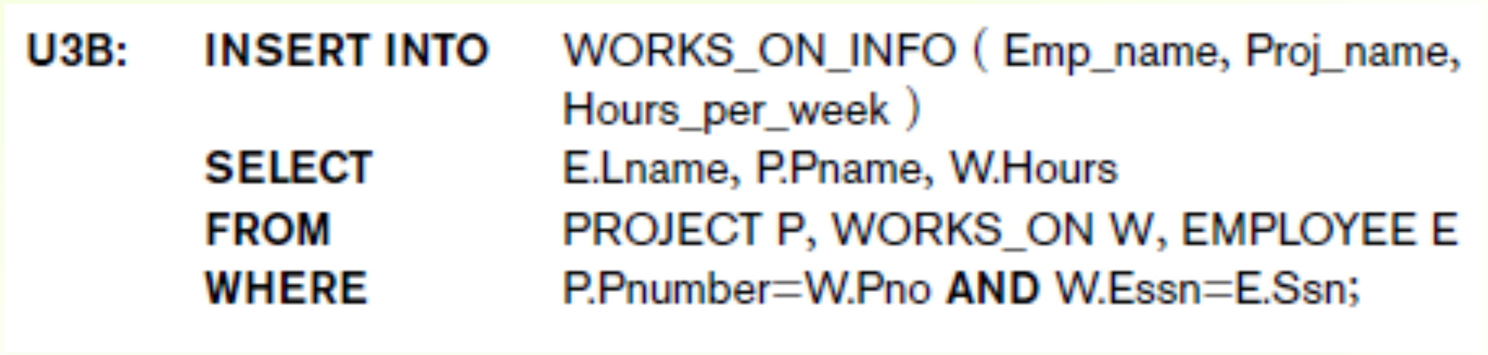
- Three commands used to modify the database:
  - `INSERT`, `DELETE`, and `UPDATE`

# The INSERT Command

- Specify the relation name and a list of values for the tuple



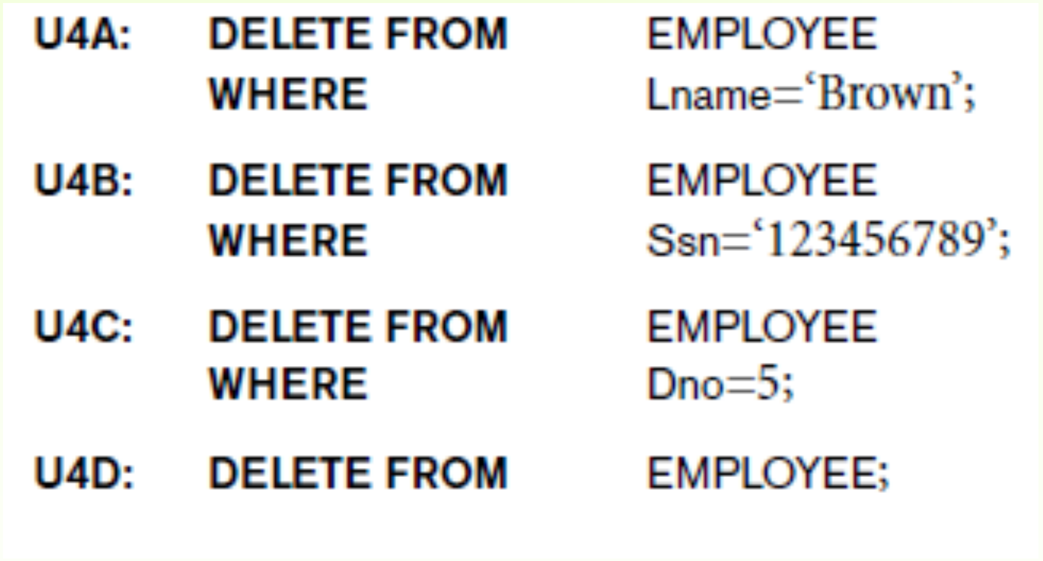
```
U1:     INSERT INTO   EMPLOYEE
        VALUES        ( 'Richard', 'K', 'Marini', '653298653', '1962-12-30', '98
                        Oak Forest, Katy, TX', 'M', 37000, '653298653', 4 );
```



```
U3B:    INSERT INTO   WORKS_ON_INFO ( Emp_name, Proj_name,
                      Hours_per_week )
        SELECT        E.Lname, P.Pname, W.Hours
        FROM          PROJECT P, WORKS_ON W, EMPLOYEE E
        WHERE         P.Pnumber=W.Pno AND W.Essn=E.Ssn;
```

## The DELETE Command

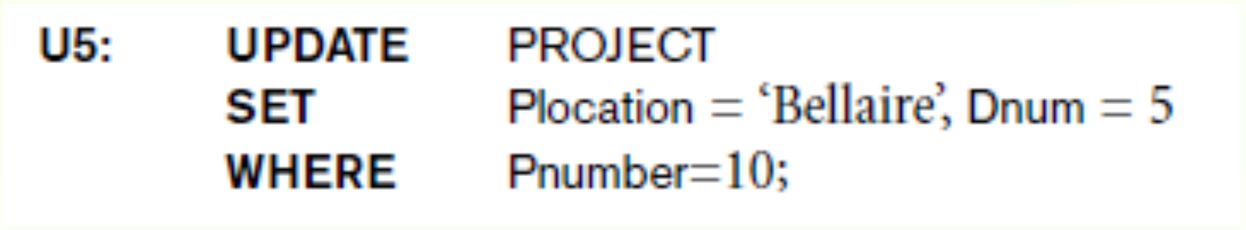
- Removes tuples from a relation
  - Includes a `WHERE` clause to select the tuples to be deleted



```
U4A:    DELETE FROM    EMPLOYEE
        WHERE          Lname='Brown';

U4B:    DELETE FROM    EMPLOYEE
        WHERE          Ssn='123456789';

U4C:    DELETE FROM    EMPLOYEE
        WHERE          Dno=5;

U4D:    DELETE FROM    EMPLOYEE;
```

# The UPDATE Command

- Modify attribute values of one or more selected tuples
- Additional **`SET`** clause in the `UPDATE` command
  - Specifies attributes to be modified and new values



```
U5:    UPDATE    PROJECT
       SET       Plocation = 'Bellaire', Dnum = 5
       WHERE     Pnumber=10;
```

## Additional Features of SQL

- Techniques for specifying complex retrieval queries
- Writing programs in various programming languages that include SQL statements
- Set of commands for specifying physical database design parameters, file structures for relations, and access paths
- Transaction control commands

# Additional Features of SQL (cont'd.)

- Specifying the granting and revoking of privileges to users
- Constructs for creating triggers
- Enhanced relational systems known as object-relational
- New technologies such as XML and OLAP

## Summary

- SQL
  - Comprehensive language
  - Data definition, queries, updates, constraint specification, and view definition
- Covered in Chapter 4:
  - Data definition commands for creating tables
  - Commands for constraint specification
  - Simple retrieval queries
  - Database update commands