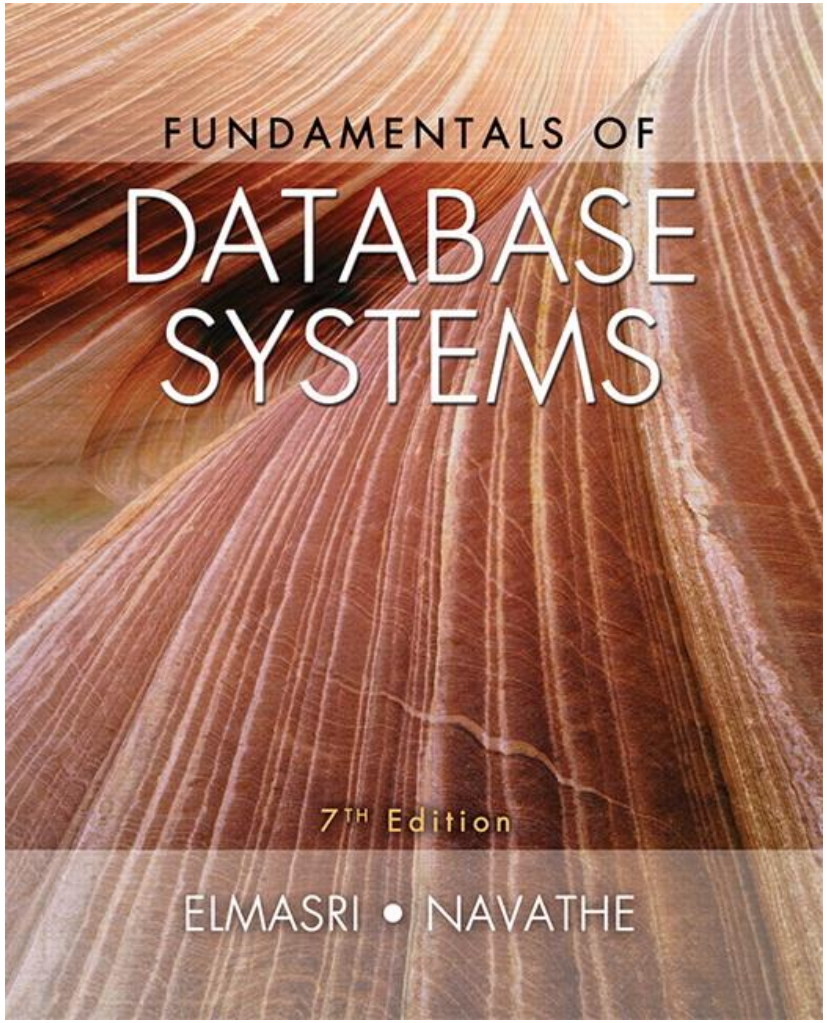


CHAPTER 7

More SQL: Complex Queries, Triggers, Views, and Schema Modification

Chapter 7 Outline

- More Complex SQL Retrieval Queries
- Specifying Semantic Constraints as Assertions and Actions as Triggers
- Views (Virtual Tables) in SQL
- Schema Modification in SQL

More Complex SQL Retrieval Queries

- Additional features allow users to specify more complex retrievals from database:
  - Nested queries, joined tables, and outer joins (in the FROM clause), aggregate functions, and grouping

Comparisons Involving NULL and Three-Valued Logic

- Meanings of NULL
  - **Unknown value**
  - **Unavailable or withheld value**
  - **Not applicable attribute**
- Each individual NULL value considered to be different from every other NULL value
- SQL uses a three-valued logic:
  - TRUE, FALSE, and UNKNOWN (like Maybe)
- **NULL = NULL comparison is avoided**

Comparisons Involving NULL and Three-Valued Logic (cont'd.)

Table 7.1 Logical Connectives in Three-Valued Logic

(a)

AND	TRUE	FALSE	UNKNOWN
TRUE	TRUE	FALSE	UNKNOWN
FALSE	FALSE	FALSE	FALSE
UNKNOWN	UNKNOWN	FALSE	UNKNOWN

(b)

OR	TRUE	FALSE	UNKNOWN
TRUE	TRUE	TRUE	TRUE
FALSE	TRUE	FALSE	UNKNOWN
UNKNOWN	TRUE	UNKNOWN	UNKNOWN

(c)

NOT	
TRUE	FALSE
FALSE	TRUE
UNKNOWN	UNKNOWN

Comparisons Involving NULL and Three-Valued Logic (cont'd.)

- SQL allows queries that check whether an attribute value is `NULL`
  - `IS` or `IS NOT NULL`

Query 18. Retrieve the names of all employees who do not have supervisors.

```
Q18:  SELECT  Fname, Lname
      FROM    EMPLOYEE
      WHERE   Super_ssn IS NULL;
```

Comparisons Involving NULL and Three-Valued Logic (cont'd.)

- SQL allows queries that check whether an attribute value is `NULL`
  - `IS` or `IS NOT NULL`

Query 18. Retrieve the names of all employees who do not have supervisors.

```
Q18:  SELECT  Fname, Lname
      FROM    EMPLOYEE
      WHERE   Super_ssn IS NULL;
```

Fname	Lname
Ahmad	Borg

Nested Queries, Tuples, and Set/Multiset Comparisons

- **Nested queries**
  - Complete select-from-where blocks within WHERE clause of another query
  - **Outer query and nested subqueries**
- Comparison operator `IN`
  - Compares value *v* with a set (or multiset) of values *V*
  - Evaluates to `TRUE` if *v* is one of the elements in *V*

Nested Queries (cont'd.)

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.

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

Nested Queries (cont'd.)

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

Pnumber
40
1
2

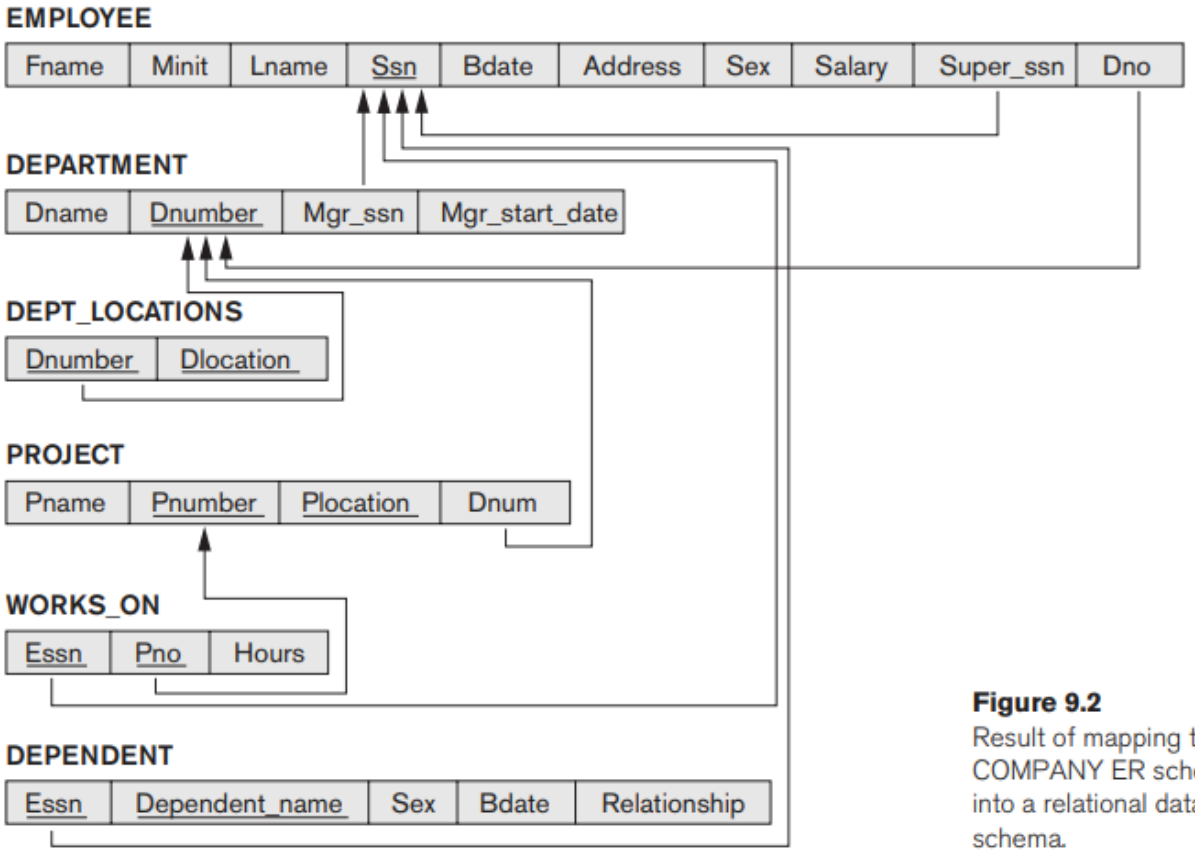


Figure 9.2
Result of mapping the COMPANY ER schema into a relational database schema.

Nested Queries (cont'd.)

- Use tuples of values in comparisons
  - Place them within parentheses

```
SELECT    DISTINCT Essn
FROM      WORKS_ON
WHERE     (Pno, Hours) IN ( SELECT    Pno, Hours
                            FROM      WORKS_ON
                            WHERE     Essn='123456789' );
```

Nested Queries (cont'd.)

- Use tuples of values in comparisons
  - Place them within parentheses

base: company » Table: works_on

SQL | Search | Ins

Essn	Pno	Hours
123456700	40	30.0
123456789	1	32.5
123456789	2	7.5
333445555	2	7.5
333445555	3	10.0
333445555	10	10.0
333445555	20	10.0

```
SELECT    DISTINCT Essn
FROM      WORKS_ON
WHERE     (Pno, Hours) IN ( SELECT    Pno, Hours
                            FROM      WORKS_ON
                            WHERE     Essn='123456789' );
```

Essn
123456789
333445555

```
SELECT Pno, Hours
FROM WORKS_ON
WHERE Essn = '123456789'
```

Pno	Hours
1	32.5
2	7.5

Nested Queries (cont'd.)

- Use other comparison operators to compare a single value *v*
  - = ANY (or = SOME) operator
    - Returns TRUE if the value *v* is equal to some value in the set *V* and is hence equivalent to IN
  - Other operators that can be combined with ANY (or SOME): >, >=, <, <=, and <>
  - ALL: value must exceed all values from nested query

```
SELECT  Lname, Fname
FROM    EMPLOYEE
WHERE   Salary > ALL ( SELECT  Salary
                       FROM    EMPLOYEE
                       WHERE   Dno=5 );
```

Nested Queries (cont'd.)

```
SELECT   Lname, Fname
FROM     EMPLOYEE
WHERE    Salary > ALL  ( SELECT   Salary
                         FROM     EMPLOYEE
                         WHERE    Dno=5 );
```

Lname	Fname
Borg	Ahmad
Wallace	Alicia

```
SELECT Salary
FROM EMPLOYEE
WHERE Dno = 5
```

Salary
30000.00
40000.00
25000.00
38000.00

Nested Queries (cont'd.)

- Avoid potential errors and ambiguities
  - Create tuple variables (aliases) for all tables referenced in SQL query

Query 16. Retrieve the name of each employee who has a dependent with the same first name and is the same sex as the employee.

```
Q16:  SELECT   E.Fname, E.Lname
      FROM     EMPLOYEE AS E
      WHERE    E.Ssn IN ( SELECT   Essn
                          FROM     DEPENDENT AS D
                          WHERE    E.Fname=D.Dependent_name
                          AND E.Sex=D.Sex );
```

Nested Queries (cont'd.)

Query 16. Retrieve the name of each employee who has a dependent with the same first name and is the same sex as the employee.

```
Q16:  SELECT   E.Fname, E.Lname
      FROM     EMPLOYEE AS E
      WHERE    E.Ssn IN ( SELECT   Essn
                          FROM     DEPENDENT AS D
                          WHERE    E.Fname=D.Dependent_name
                          AND E.Sex=D.Sex );
```

Fname	Lname
Alicia	Wallace

```
--Q16A   Queries that are nested using the = or IN comparison operator
--can be collapsed into one single block: E.g., Q16 can be written as:

SELECT E.Fname, E.Lname
FROM   EMPLOYEE AS E, DEPENDENT AS D
WHERE  E.Ssn = D.Essn AND E.Sex = D.Sex
       AND E.Fname = D.Dependent_name;


--Q16B
SELECT E.Fname, E.Lname
FROM EMPLOYEE AS E
WHERE EXISTS ( SELECT *
               FROM   DEPENDENT AS D
               WHERE  E.Ssn = D.Essn AND E.Sex = D.Sex
                      AND E.Fname = D.Dependent_name);
```

Correlated Nested Queries

- **Queries that are nested using the = or IN comparison operator** can be collapsed into one single block: E.g., Q16 can be written as:

- **Q16A:**

```
SELECT   E.Fname, E.Lname
FROM     EMPLOYEE AS E, DEPENDENT AS D
WHERE    E.Ssn=D.Essn AND E.Sex=D.Sex
                      AND
         E.Fname=D.Dependent_name;
```

- **Correlated** nested query
  - Evaluated once for each tuple in the outer query

The EXISTS and UNIQUE Functions in SQL for correlating queries

- `EXISTS` function
  - Check whether the result of a correlated nested query is empty or not. They are Boolean functions that return a TRUE or FALSE result.
- `EXISTS` and `NOT EXISTS`
  - Typically used in conjunction with a correlated nested query
- SQL function `UNIQUE(Q)`
  - Returns `TRUE` if there are no duplicate tuples in the result of query Q

USE of EXISTS

Q7:

```
SELECT Fname, Lname
FROM Employee
WHERE EXISTS (SELECT *
                  FROM DEPENDENT
                  WHERE Ssn= Essn)

          AND EXISTS (SELECT   *
                        FROM Department
                        WHERE Ssn= Mgr_Ssn)
```

Fname	Lname
Franklin	Wong
Alicia	Wallace

USE OF NOT EXISTS

To achieve the “for all” (universal quantifier- see Ch.8) effect, we use double negation this way in SQL:

Query: List first and last name of employees who work on ALL projects controlled by Dno=5.

```
SELECT Fname, Lname
FROM Employee
WHERE NOT EXISTS ( (SELECT  Pnumber
                    FROM PROJECT
                    WHERE Dno=5)

                   EXCEPT (SELECT   Pno
                           FROM WORKS_ON
                           WHERE Ssn= ESsn)
```

The above is equivalent to double negation: List names of those employees for whom there does NOT exist a project managed by department no. 5 that they do NOT work on.

Double Negation to accomplish "for all" in SQL

- **Q3B:**
```
SELECT      Lname, Fname
FROM        EMPLOYEE
WHERE   NOT EXISTS (    SELECT  *
                        FROM    WORKS_ON B
                        WHERE   ( B.Pno IN  (  SELECT Pnumber
                                               FROM PROJECT
                                               WHERE Dnum=5
                         AND
                                        NOT EXISTS (SELECT      *
                                         FROM  WORKS_ON C
                                         WHERE  C.Essn=Ssn
                                         AND    C.Pno=B.Pno )));
```

The above is a direct rendering of: List names of those employees for whom there does NOT exist a project managed by department no. 5 that they do NOT work on.

Explicit Sets and Renaming of Attributes in SQL

- Can use explicit set of values in WHERE clause

```
Q17:    SELECT    DISTINCT Essn
        FROM      WORKS_ON
        WHERE     Pno IN (1, 2, 3);
```

- Use qualifier AS followed by desired new name
  - Rename any attribute that appears in the result of a query

```
Q8A:    SELECT    E.Lname AS Employee_name, S.Lname AS Supervisor_name
        FROM      EMPLOYEE AS E, EMPLOYEE AS S
        WHERE     E.Super_ssn=S.Ssn;
```

Explicit Sets and Renaming of Attributes in SQL

Can use explicit set of values in WHERE clause

```
Q17:    SELECT    DISTINCT Essn
        FROM      WORKS_ON
        WHERE     Pno IN (1, 2, 3);
```

Essn
123456789
453453453
333445555
666884444

Use qualifier AS followed by desired new name

- Rename any attribute that appears in the result of a query

```
Q8A:    SELECT    E.Lname AS Employee_name, S.Lname AS Supervisor_name
        FROM      EMPLOYEE AS E, EMPLOYEE AS S
        WHERE     E.Super_ssn=S.Ssn;
```

Employee_name	Supervisor_name
Bana	Smith
Smith	Wong
Smith	Wong
Wong	Borg
English	Wong
Narayan	Wong
Wallace	Borg
Jabbar	Wallace
Zelaya	Borg

Specifying Joined Tables in the FROM Clause of SQL

- **Joined table**
  - Permits users to specify a table resulting from a join operation in the FROM clause of a query
- The FROM clause in Q1A
  - Contains a single joined table. JOIN may also be called INNER JOIN

```
Q1A:    SELECT    Fname, Lname, Address
        FROM      (EMPLOYEE JOIN DEPARTMENT ON Dno=Dnumber)
        WHERE     Dname='Research';
```

Different Types of JOINed Tables in SQL

- Specify different types of join
  - NATURAL JOIN
  - Various types of OUTER JOIN (LEFT, RIGHT, FULL)
- NATURAL JOIN on two relations R and S
  - No join condition specified
  - Is equivalent to an implicit EQUIJOIN condition for each pair of attributes with same name from R and S

NATURAL JOIN

- Rename attributes of one relation so it can be joined with another using NATURAL JOIN:

```
Q1B:    SELECT    Fname, Lname, Address
        FROM      (EMPLOYEE NATURAL JOIN
                  (DEPARTMENT AS DEPT (Dname, Dno, Mssn,
                   Msdate)))
        WHERE     Dname='Research';
```

The above works with EMPLOYEE.Dno = DEPT.Dno as an implicit join condition

INNER and OUTER Joins

- INNER JOIN **(versus** OUTER JOIN**)**
  - Default type of join in a joined table
  - Tuple is included in the result only if a matching tuple exists in the other relation
- LEFT OUTER JOIN
  - Every tuple in left table must appear in result
  - If no matching tuple
    - Padded with NULL values for attributes of right table
- RIGHT OUTER JOIN
  - Every tuple in right table must appear in result
  - If no matching tuple
    - Padded with NULL values for attributes of left table

Example: LEFT OUTER JOIN

SELECT E.Lname **AS** Employee_Name
S.Lname **AS** Supervisor_Name

FROM (Employee **AS** E **LEFT OUTER JOIN** EMPLOYEE **AS** S
ON E.Super_ssn = S.Ssn)

ALTERNATE SYNTAX:

SELECT E.Lname **,** S.Lname
FROM EMPLOYEE E, EMPLOYEE S
WHERE E.Super_ssn + = S.Ssn

Example: Natural JOIN

```
--Q1A
SELECT Fname, Lname, Address
FROM (EMPLOYEE JOIN DEPARTMENT ON Dno = Dnumber)
WHERE Dname = 'Research';
```

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

```
--Q1B
SELECT  Fname, Lname, Address
FROM    (EMPLOYEE NATURAL JOIN
        (DEPARTMENT AS DEPT (Dname, Dno, Mssn, Msdate)))
WHERE Dname = 'Research';
```

Example: LEFT OUTER JOIN

```
--Q8B
SELECT  E.Lname AS Employee_name,S.Lname AS Supervisor_name
FROM    (EMPLOYEE AS E LEFT OUTER JOIN EMPLOYEE AS S ON E.Super_ssn = S.Ssn);
```

Employee_Name	Supervisor_Name
Bana	Smith
Smith	Wong
Smith	Wong
Wong	Borg
English	Wong
Narayan	Wong
Borg	*NULL*
Wallace	Borg
Jabbar	Wallace
Zelaya	Borg

Example: Without/With OUTER JOIN

```
SELECT E.Fname, E.Lname,D.Dependent_name,D.Relationship
FROM   EMPLOYEE AS E, DEPENDENT AS D
WHERE  E.Ssn = D.Essn;
```

Fname	Lname	Dependent_name	Relationship
John	Smith	Alice	Daughter
John	Smith	Elizabeth	Spouse
John	Smith	Michael	Son
Franklin	Wong	Alice	Daughter
Franklin	Wong	Joy	Spouse
Franklin	Wong	Theodore	Son
Alicia	Wallace	Abner	Spouse
Alicia	Wallace	Alicia	Daughter

```
SELECT E.Fname, E.Lname,D.Dependent_name,D.Relationship
FROM   EMPLOYEE AS E LEFT OUTER JOIN DEPENDENT AS D ON E.Ssn = D.Essn
```

```
SELECT D.Dependent_name,D.Relationship, E.Fname, E.Lname
FROM   DEPENDENT AS D RIGHT OUTER JOIN EMPLOYEE AS E ON D.Essn = E.Ssn
```

Dependent_name	Relationship	Fname	Lname
NULL	*NULL*	Tana	Bana
NULL	*NULL*	Mary	Smith
Alice	Daughter	John	Smith
Elizabeth	Spouse	John	Smith
Michael	Son	John	Smith
Alice	Daughter	Franklin	Wong
Joy	Spouse	Franklin	Wong
Theodore	Son	Franklin	Wong
NULL	*NULL*	Ramesh	English
NULL	*NULL*	Jennifer	Narayan
NULL	*NULL*	Ahmad	Borg
Abner	Spouse	Alicia	Wallace
Alicia	Daughter	Alicia	Wallace
NULL	*NULL*	Joyce	Jabbar
NULL	*NULL*	Jennifer	Zelaya

Fname	Lname	Dependent_name	Relationship
Tana	Bana	*NULL*	*NULL*
Mary	Smith	*NULL*	*NULL*
John	Smith	Alice	Daughter
John	Smith	Elizabeth	Spouse
John	Smith	Michael	Son
Franklin	Wong	Alice	Daughter
Franklin	Wong	Joy	Spouse
Franklin	Wong	Theodore	Son
Ramesh	English	*NULL*	*NULL*
Jennifer	Narayan	*NULL*	*NULL*
Ahmad	Borg	*NULL*	*NULL*
Alicia	Wallace	Abner	Spouse
Alicia	Wallace	Alicia	Daughter
Joyce	Jabbar	*NULL*	*NULL*
Jennifer	Zelaya	*NULL*	*NULL*

Multiway JOIN in the FROM clause

- FULL OUTER JOIN – combines result if LEFT and RIGHT OUTER JOIN
- Can nest JOIN specifications for a multiway join:

```
Q2A:  SELECT Pnumber, Dnum, Lname, Address, Bdate
      FROM   ((PROJECT JOIN DEPARTMENT ON
               Dnum=Dnumber)  JOIN EMPLOYEE ON
               Mgr_ssn=Ssn)
      WHERE  Plocation='Stafford';
```

Multiway JOIN in the FROM clause

Q2A: **SELECT** Pnumber, Dnum, Lname, Address, Bdate
FROM ((PROJECT **JOIN** DEPARTMENT **ON** Dnum=Dnumber) **JOIN** EMPLOYEE **ON** Mgr_ssn=Ssn)
WHERE Plocation='Stafford';

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

Aggregate Functions in SQL

- Used to summarize information from multiple tuples into a single-tuple summary
- Built-in aggregate functions
  - **COUNT**, **SUM**, **MAX**, **MIN**, and **AVG**
- **Grouping**
  - Create subgroups of tuples before summarizing
- To select entire groups, `HAVING` clause is used
- Aggregate functions can be used in the `SELECT` clause or in a `HAVING` clause

Renaming Results of Aggregation

- Following query returns a single row of computed values from EMPLOYEE table:

```
Q19:    SELECT  SUM (Salary), MAX (Salary), MIN (Salary), AVG
                (Salary)
        FROM    EMPLOYEE;
```

- The result can be presented with new names:

```
Q19A:   SELECT  SUM (Salary) AS Total_Sal, MAX (Salary) AS
                Highest_Sal, MIN (Salary) AS Lowest_Sal, AVG
                (Salary) AS Average_Sal
        FROM    EMPLOYEE;
```

Renaming Results of Aggregation

- Following query returns a single row of computed values from EMPLOYEE table:

```
Q19 Find the sum of the salaries of all employees, the
    maximum salary,the minimum salary, and the average salary.
     SELECT SUM(Salary), MAX(Salary), MIN(Salary), AVG(Salary)
     FROM EMPLOYEE;
```

SUM(Salary)	MAX(Salary)	MIN(Salary)	AVG(Salary)
342000.00	56000.00	25000.00	34200.000000

- The result can be presented with new names:

```
Q19A  single-row summary of all the rows in the EMPLOYEE table
      SELECT SUM(Salary) AS Total_Sal, MAX(Salary) AS Highest_Sal,
      MIN(Salary) AS Lowest_Sal, AVG(Salary) AS Average_Sal
      FROM EMPLOYEE;
```

Total_Sal	Highest_Sal	Lowest_Sal	Average_Sal
342000.00	56000.00	25000.00	34200.000000

```
--Q20   NULL values are discarded when aggregate functions are applied to a column
       SELECT SUM(Salary), MAX(Salary), MIN(Salary), AVG(Salary)
       FROM (EMPLOYEE JOIN DEPARTMENT ON Dno = Dnumber)
       WHERE Dname = 'Research';
```

SUM(Salary)	MAX(Salary)	MIN(Salary)	AVG(Salary)
133000.00	40000.00	25000.00	33250.000000

Aggregate Functions in SQL (cont'd.)

- NULL values are discarded when aggregate functions are applied to a particular column

Query 20. Find the sum of the salaries of all employees of the 'Research' department, as well as the maximum salary, the minimum salary, and the average salary in this department.

```
Q20:  SELECT  SUM (Salary), MAX (Salary), MIN (Salary), AVG (Salary)
      FROM    (EMPLOYEE JOIN DEPARTMENT ON Dno=Dnumber)
      WHERE   Dname='Research';
```

Queries 21 and 22. Retrieve the total number of employees in the company (Q21) and the number of employees in the 'Research' department (Q22).

```
Q21:  SELECT  COUNT (*)
      FROM    EMPLOYEE;

Q22:  SELECT  COUNT (*)
      FROM    EMPLOYEE, DEPARTMENT
      WHERE   DNO=DNUMBER AND DNAME='Research';
```

Aggregate Functions in SQL (cont'd.)

- NULL values are discarded when aggregate functions are applied to a particular column

```
--Q21   Retrieve total number of employees in the company
        SELECT COUNT(*)
        FROM EMPLOYEE;
```

COUNT(*)
10

```
-Q22:  Retrieve total number of employees in the Research department.
       SELECT COUNT(*)
       FROM EMPLOYEE, DEPARTMENT
       WHERE DNO = DNUMBER AND DNAME = 'Research';
```

COUNT(*)
4

Aggregate Functions on Booleans

- SOME and ALL may be applied as functions on Boolean Values.
- SOME returns true if at least one element in the collection is TRUE (similar to OR)
- ALL returns true if all of the elements in the collection are TRUE (similar to AND)

Grouping: The GROUP BY Clause

- **Partition** relation into subsets of tuples
  - Based on **grouping attribute(s)**
  - Apply function to each such group independently
- **`GROUP BY`** clause
  - Specifies grouping attributes
- COUNT (*) counts the number of rows in the group

Examples of GROUP BY

- The grouping attribute must appear in the SELECT clause:

```
Q24:    SELECT      Dno, COUNT (*), AVG (Salary)
        FROM        EMPLOYEE
        GROUP BY    Dno;
```

- If the grouping attribute has NULL as a possible value, then a separate group is created for the null value (e.g., null Dno in the above query)
- GROUP BY may be applied to the result of a JOIN:

```
Q25:    SELECT      Pnumber, Pname, COUNT (*)
        FROM        PROJECT, WORKS_ON
        WHERE       Pnumber=Pno
        GROUP BY    Pnumber, Pname;
```

Examples of GROUP BY

The grouping attribute must appear in the SELECT clause:

Q24:
```
SELECT   Dno, COUNT (*), AVG (Salary)
FROM     EMPLOYEE
GROUP BY Dno;
```

Dno	COUNT(*)	AVG (Salary)
1	1	55000.000000
2	2	30000.000000
4	3	31000.000000
5	4	33250.000000

Q25:
```
SELECT   Pnumber, Pname, COUNT (*)
FROM     PROJECT, WORKS_ON
WHERE    Pnumber=Pno
GROUP BY Pnumber, Pname;
```

Pnumber	Pname	COUNT(*)
1	ProductX	2
2	ProductY	3
3	ProductZ	2
10	Computerization	3
20	Reorganization	3
30	Newbenefits	3
40	IT_PROJ	1

Grouping: The GROUP BY and HAVING Clauses (cont'd.)

- **HAVING** clause
  - Provides a condition to select or reject an entire group:
- **Query 26.** For each project *on which more than two employees work,* retrieve the project number, the project name, and the number of employees who work on the project.

```
Q26:    SELECT      Pnumber, Pname, COUNT (*)
        FROM        PROJECT, WORKS_ON
        WHERE       Pnumber=Pno
        GROUP BY    Pnumber, Pname
        HAVING      COUNT (*) > 2;
```

Grouping: The GROUP BY and HAVING Clauses (cont'd.)

- **HAVING** clause: Provides a condition to select or reject an entire group:
- **Query 26.** For each project *on which more than two employees work,* retrieve the project number, the project name, and the number of employees who work on the project.

```
Q26:    SELECT      Pnumber, Pname, COUNT (*)
        FROM        PROJECT, WORKS_ON
        WHERE       Pnumber=Pno
        GROUP BY    Pnumber, Pname
        HAVING      COUNT (*) > 2;
```

Pnumber	Pname	COUNT(*)
2	ProductY	3
10	Computerization	3
20	Reorganization	3
30	Newbenefits	3

Combining the WHERE and the HAVING Clause

- Consider the query: we want to count the *total* number of employees whose salaries exceed $40,000 in each department, but only for departments where more than five employees work.

- INCORRECT QUERY:

```
SELECT      Dno, COUNT (*)
FROM        EMPLOYEE
WHERE       Salary>40000
GROUP BY    Dno
HAVING      COUNT (*) > 5;
```

Combining the WHERE and the HAVING Clause (continued)

Correct Specification of the Query:

- Note: the WHERE clause applies tuple by tuple whereas HAVING applies to entire group of tuples

Query 28. For each department that has more than five employees, retrieve the department number and the number of its employees who are making more than $40,000.

```
Q28:  SELECT   Dnumber, COUNT (*)
      FROM     DEPARTMENT, EMPLOYEE
      WHERE    Dnumber=Dno AND Salary>40000 AND
               ( SELECT       Dno
                 FROM         EMPLOYEE
                 GROUP BY Dno
                 HAVING       COUNT (*) > 5)
```

Q28 For each department that has more than five employees, retrieve the department number and the number of its employees who are making more than $40,000

```
SELECT Dno, COUNT(*)
FROM EMPLOYEE
WHERE Salary>40000 AND Dno IN
      ( SELECT Dno
        FROM EMPLOYEE
        GROUP BY Dno
        HAVING COUNT(*) > 2)
GROUP BY Dno;
```

Dno	COUNT(*)
4	1

```
SELECT Dno, COUNT(*)
FROM EMPLOYEE
WHERE Salary>20000
GROUP BY Dno
```

Dno	COUNT(*)
1	1
2	2
4	3
5	4

```
SELECT      Dno, COUNT(*)
FROM        EMPLOYEE
WHERE       Salary>20000
GROUP BY    Dno
HAVING      COUNT(*)>=2
```

Dno	COUNT(*)
2	2
4	3
5	4

Use of WITH

- The WITH clause allows a user to define a table that will only be used in a particular query (not available in all SQL implementations)
- Used for convenience to create a temporary "View" and use that immediately in a query
- Allows a more straightforward way of looking a step-by-step query

Example of WITH

- See an alternate approach to doing Q28:

- **Q28':**

```
WITH    BIGDEPTS (Dno) AS
        ( SELECT  Dno
          FROM    EMPLOYEE
          GROUP BY Dno
          HAVING  COUNT (*) > 5)
SELECT          Dno, COUNT (*)
FROM            EMPLOYEE
WHERE           Salary>40000 AND Dno IN BIGDEPTS
GROUP BY Dno;
```

Use of CASE

- SQL also has a CASE construct
- Used when a value can be different based on certain conditions.
- Can be used in any part of an SQL query where a value is expected
- Applicable when querying, inserting or updating tuples

EXAMPLE of use of CASE

- The following example shows that employees are receiving different raises in different departments (A variation of the update U6)
- **U6':**

```
UPDATE   EMPLOYEE
SET      Salary =
CASE     WHEN  Dno = 9 THEN   Salary + 2000
         WHEN  Dno = 8 THEN   Salary + 1500
         WHEN  Dno = 1 THEN   Salary + 1000
         ELSE Salary + 0 ;
END
```

1 row affected. (Query took 0.0084 seconds.)

Recursive Queries in SQL

- An example of a **recursive relationship** between tuples of the same type is the relationship between an employee and a supervisor.
- This relationship is described by the foreign key Super_ssn of the EMPLOYEE relation
- An example of a **recursive operation** is to retrieve all supervisees of a supervisory employee *e* at all levels—that is, all employees *e′* directly supervised by *e*, all employees *e′’* directly supervised by each employee *e′*, all employees *e‴* directly supervised by each employee *e″*, and so on. Thus the CEO would have each employee in the company as a supervisee in the resulting table. Example shows such table SUP_EMP with 2 columns (Supervisor,Supervisee(any level)):

An EXAMPLE of RECURSIVE Query

- **Q29: WITH RECURSIVE** SUP_EMP (SupSsn, EmpSsn) **AS**

```
        SELECT   SupervisorSsn, Ssn
        FROM     EMPLOYEE
                 UNION
        SELECT   E.Ssn, S.SupSsn
        FROM     EMPLOYEE AS E, SUP_EMP AS S
        WHERE    E.SupervisorSsn = S.EmpSsn)
        SELECT       *
        FROM     SUP_EMP;
```

- The above query starts with an empty SUP_EMP and successively builds SUP_EMP table by computing immediate supervisees first, then second level supervisees, etc. until a **fixed point** is reached and no more supervisees can be added

An EXAMPLE of RECURSIVE Query

http://www.mysqltutorial.org/mysql-recursive-cte/

```
WITH RECURSIVE employee_paths AS
  ( SELECT employeeNumber,
           reportsTo managerNumber,
           officeCode,
           1 lvl
   FROM employees
   WHERE reportsTo IS NULL
     UNION ALL
     SELECT e.employeeNumber,
            e.reportsTo,
            e.officeCode,
            lvl+1
     FROM employees e
     INNER JOIN employee_paths ep ON ep.employeeNumber = e.reportsTo )
SELECT employeeNumber,
       managerNumber,
       lvl,
       city
FROM employee_paths ep
INNER JOIN offices o USING (officeCode)
ORDER BY lvl, city;
```

employeeNumber	managerNumber	lvl
1002	NULL	1
1076	1002	2
1056	1002	2
1102	1056	3
1143	1056	3
1088	1056	3
1621	1056	3
1188	1143	4
1216	1143	4
1504	1102	4
1501	1102	4
1286	1143	4
1323	1143	4
1401	1102	4
1702	1102	4
1337	1102	4
1370	1102	4
1166	1143	4

The above query starts with an empty employee_paths and successively builds employee_paths table by computing immediate supervisees first, then second level supervisees, etc. until a fixed point is reached and no more supervisees can be added

EXPANDED Block Structure of SQL Queries

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

Specifying Constraints as Assertions and Actions as Triggers

- Semantic Constraints: The following are beyond the scope of the EER and relational model
- **`CREATE ASSERTION`**
  - Specify additional types of constraints outside scope of built-in relational model constraints
- **`CREATE TRIGGER`**
  - Specify automatic actions that database system will perform when certain events and conditions occur

Specifying General Constraints as Assertions in SQL

- **CREATE ASSERTION**
  - Specify a query that selects any tuples that violate the desired condition
  - Use only in cases where it goes beyond a simple `CHECK` which applies to individual attributes and domains

```
CREATE ASSERTION SALARY_CONSTRAINT
CHECK ( NOT EXISTS  ( SELECT     *
                      FROM       EMPLOYEE E, EMPLOYEE M,
                                 DEPARTMENT D
                      WHERE      E.Salary>M.Salary
                                 AND E.Dno=D.Dnumber
                                 AND D.Mgr_ssn=M.Ssn ) );
```

Introduction to Triggers in SQL

- `CREATE TRIGGER` statement
  - Used to monitor the database
- Typical trigger has three components which make it a rule for an “active database “ (more on active databases in section 26.1) :
  - **Event(s)**
  - **Condition**
  - **Action**

USE OF TRIGGERS

- AN EXAMPLE with standard Syntax.(Note : other SQL implementations like PostgreSQL use a different syntax.)

R5:
CREATE TRIGGER SALARY_VIOLATION
BEFORE INSERT OR UPDATE OF Salary, Supervisor_ssn **ON** EMPLOYEE

FOR EACH ROW
WHEN (NEW.SALARY > **(** SELECT Salary FROM EMPLOYEE
WHERE Ssn = NEW. Supervisor_Ssn))
INFORM_SUPERVISOR (NEW.Supervisor.Ssn, New.Ssn)

Views (Virtual Tables) in SQL

- Concept of a view in SQL
  - Single table derived from other tables called the **defining tables**
  - Considered to be a virtual table that is not necessarily populated

Specification of Views in SQL

- **`CREATE VIEW`** command
  - Give table name, list of attribute names, and a query to specify the contents of the view
  - In V1, attributes retain the names from base tables. In V2, attributes are assigned names

```
V1:   CREATE VIEW   WORKS_ON1
      AS SELECT     Fname, Lname, Pname, Hours
          FROM      EMPLOYEE, PROJECT, WORKS_ON
          WHERE     Ssn=Essn AND Pno=Pnumber;

V2:   CREATE VIEW   DEPT_INFO(Dept_name, No_of_emps, Total_sal)
      AS SELECT     Dname, COUNT (*), SUM (Salary)
          FROM      DEPARTMENT, EMPLOYEE
          WHERE     Dnumber=Dno
          GROUP BY  Dname;
```

```
V1:   CREATE VIEW   WORKS_ON1
      AS SELECT     Fname, Lname, Pname, Hours
          FROM      EMPLOYEE, PROJECT, WORKS_ON
          WHERE     Ssn=Essn AND Pno=Pnumber;

V2:   CREATE VIEW   DEPT_INFO(Dept_name, No_of_emps, Total_sal)
      AS SELECT     Dname, COUNT (*), SUM (Salary)
          FROM      DEPARTMENT, EMPLOYEE
          WHERE     Dnumber=Dno
          GROUP BY  Dname;
```

ase: company » View: works_on1

SQL | Search | Insert

Fname	Lname	Pname	Hours
Franklin	Wong	Computerization	10.0
Joyce	Jabbar	Computerization	35.0
Jennifer	Zelaya	Computerization	10.0
Tana	Bana	IT_PROJ	30.0
Alicia	Wallace	Newbenefits	20.0
Joyce	Jabbar	Newbenefits	5.0
Jennifer	Zelaya	Newbenefits	30.0
John	Smith	ProductX	32.5
Ramesh	English	ProductX	20.0
John	Smith	ProductY	7.5

Salary	Super_ssn	Dno
30000.00	123456780	2
30000.00	333445555	2
30000.00	333445555	5
40000.00	888665555	5
25000.00	333445555	5
38000.00	333445555	5
55000.00	*NULL*	1
43000.00	888665555	4
25000.00	987654321	4
25000.00	888665555	4

Dept_name	No_of_emps	Total_sal
Administration	3	93000.00
Headquarters	1	56000.00
IT	2	60000.00
Research	4	133000.00

Specification of Views in SQL (cont'd.)

- Once a View is defined, SQL queries can use the View relation in the FROM clause
- View is always up-to-date
  - Responsibility of the DBMS and not the user
- **`DROP VIEW`** command
  - Dispose of a view

View Implementation, View Update, and Inline Views

- Complex problem of efficiently implementing a view for querying
- **Strategy1: Query modification** approach
  - Compute the view as and when needed. Do not store permanently
  - Modify view query into a query on underlying base tables
  - Disadvantage: inefficient for views defined via complex queries that are time-consuming to execute

View Materialization

- **Strategy 2: View materialization**
  - Physically create a temporary view table when the view is first queried
  - Keep that table on the assumption that other queries on the view will follow
  - Requires efficient strategy for automatically updating the view table when the base tables are updated
- **Incremental update strategy for materialized views**
  - DBMS determines what new tuples must be inserted, deleted, or modified in a materialized view table

View Materialization (contd.)

- Multiple ways to handle materialization:
  - **immediate update** strategy updates a view as soon as the base tables are changed
  - **lazy update** strategy updates the view when needed by a view query
  - **periodic update** strategy updates the view periodically (in the latter strategy, a view query may get a result that is not up-to-date). This is commonly used in Banks, Retail store operations, etc.

View Update

- Update on a view defined on a single table without any aggregate functions
  - Can be mapped to an update on underlying base table- possible if the primary key is preserved in the view
- Update not permitted on aggregate views. E.g.,

```
UV2:  UPDATE    DEPT_INFO
      SET       Total_sal=100000
      WHERE     Dname='Research';
```

cannot be processed because Total_sal is a computed value in the view definition

View Update and Inline Views

- View involving joins
  - Often not possible for DBMS to determine which of the updates is intended
- Clause **`WITH CHECK OPTION`**
  - Must be added at the end of the view definition if a view is to be updated to make sure that tuples being updated stay in the view
- **In-line view**
  - Defined in the `FROM` clause of an SQL query (e.g., we saw its used in the WITH example)

Views as authorization mechanism

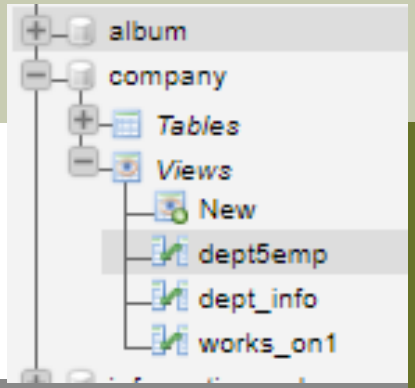
- SQL query authorization statements (GRANT and REVOKE) are described in detail in Chapter 30
- Views can be used to hide certain attributes or tuples from unauthorized users
- E.g., For a user who is only allowed to see employee information for those who work for department 5, he may only access the view DEPT5EMP:

```
CREATE VIEW   DEPT5EMP  AS
SELECT        *
FROM          EMPLOYEE
WHERE         Dno = 5;
```

Views as authorization mechanism

DEPT5EMP:

```
CREATE VIEW   DEPT5EMP  AS
SELECT        *
FROM          EMPLOYEE
WHERE         Dno = 5;
```



ase: company » View: dept5emp

SQL | Search | Insert | Export | Privileges | Operations | Tracking

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
John	B	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	M	30000.00	333445555	5
Franklin	T	Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	40000.00	888665555	5
Ramesh	A	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000.00	333445555	5
Jennifer	K	Narayan	666884444	1962-09-15	Fire Oak, Humble, TX	M	38000.00	333445555	5

base: company » Table: employee

SQL | Search | Insert | Export | Import | Privileges | Operations | Tracking

Fname	Minit	Lname ▾ 1	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
Jennifer	J	Zelaya	999887777	1968-01-19	3321 Castle, Spring, TX	F	25000.00	888665555	4
Franklin	T	Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	40000.00	888665555	5
Alicia	S	Wallace	987654321	1941-06-20	291 Berry, Bellaire, TX	F	43000.00	888665555	4
Mary	A	Smith	123456780	1967-01-08	700 Alma, Houston, TX	M	30000.00	333445555	2
John	B	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	M	30000.00	333445555	5
Jennifer	K	Narayan	666884444	1962-09-15	Fire Oak, Humble, TX	M	38000.00	333445555	5
Joyce	V	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	M	25000.00	987654321	4
Ramesh	A	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000.00	333445555	5
Ahmad	E	Borg	888665555	1937-11-10	450 Stone, Houston, TX	M	56000.00	*NULL*	1
Tana	A	Bana	123456700	1968-01-08	900 Whitney, Houston, TX	M	30000.00	123456780	2

Schema Change Statements in SQL

- **Schema evolution commands**
  - DBA may want to change the schema while the database is operational
  - Does not require recompilation of the database schema

The DROP Command

- `DROP` command
  - Used to drop named schema elements, such as tables, domains, or constraint
- Drop behavior options:
  - `CASCADE` and `RESTRICT`
- Example:
  - `DROP SCHEMA COMPANY CASCADE;`
  - This removes the schema and all its elements including tables,views, constraints, etc.

The ALTER table command

- **Alter table actions** include:
  - Adding or dropping a column (attribute)
  - Changing a column definition
  - Adding or dropping table constraints
- Example:
  - `ALTER TABLE COMPANY.EMPLOYEE ADD COLUMN Job VARCHAR(12);`

Adding and Dropping Constraints

- Change constraints specified on a table
  - Add or drop a named constraint

```
ALTER TABLE COMPANY.EMPLOYEE
DROP CONSTRAINT EMPSUPERFK CASCADE;
```

Dropping Columns, Default Values

- To drop a column
  - Choose either `CASCADE` or `RESTRICT`
  - `CASCADE` would drop the column from views etc. `RESTRICT` is possible if no views refer to it.

    ALTER TABLE COMPANY.EMPLOYEE **DROP COLUMN** Address **CASCADE**;
- Default values can be dropped and altered :

  ALTER TABLE COMPANY.DEPARTMENT **ALTER COLUMN** Mgr_ssn **DROP DEFAULT**;

  ALTER TABLE COMPANY.DEPARTMENT **ALTER COLUMN** Mgr_ssn **SET DEFAULT** '333445555';

Table 7.2 Summary of SQL Syntax

Table 7.2 Summary of SQL Syntax

```
CREATE TABLE <table name> ( <column name> <column type> [ <attribute constraint> ]
                            { , <column name> <column type> [ <attribute constraint> ] }
                            [ <table constraint> { , <table constraint> } ] )

DROP TABLE <table name>
ALTER TABLE <table name> ADD <column name> <column type>

SELECT [ DISTINCT ] <attribute list>
FROM ( <table name> { <alias> } | <joined table> ) { , ( <table name> { <alias> } | <joined table> ) }
[ WHERE <condition> ]
[ GROUP BY <grouping attributes> [ HAVING <group selection condition> ] ]
[ ORDER BY <column name> [ <order> ] { , <column name> [ <order> ] } ]

<attribute list> ::= ( * | ( <column name> | <function> ( ( [ DISTINCT ] <column name> | * ) ) )
                       { , ( <column name> | <function> ( ( [ DISTINCT] <column name> | * ) ) } ) )

<grouping attributes> ::= <column name> { , <column name> }

<order> ::= ( ASC | DESC )

INSERT INTO <table name> [ ( <column name> { , <column name> } ) ]
( VALUES ( <constant value> , { <constant value> } ) { , ( <constant value> { , <constant value> } ) }
| <select statement> )
```

continued on next slide

Table 7.2 (continued)
Summary of SQL Syntax

Table 7.2 Summary of SQL Syntax

DELETE FROM <table name> [WHERE <selection condition>]
UPDATE <table name> SET <column name> = <value expression> { , <column name> = <value expression> } [WHERE <selection condition>]
CREATE [UNIQUE] INDEX <index name> ON <table name> (<column name> [<order>] { , <column name> [<order>] }) [CLUSTER]
DROP INDEX <index name>
CREATE VIEW <view name> [(<column name> { , <column name> })] AS <select statement>
DROP VIEW <view name>

NOTE: The commands for creating and dropping indexes are not part of standard SQL.

Summary

- Complex SQL:
  - Nested queries, joined tables (in the FROM clause), outer joins, aggregate functions, grouping
- Handling semantic constraints with `CREATE ASSERTION` and `CREATE TRIGGER`
- `CREATE VIEW` statement and materialization strategies
- Schema Modification for the DBAs using `ALTER TABLE , ADD and DROP COLUMN, ALTER CONSTRAINT` etc.