

# SQL

- SQL = Structured Query Language has become a standard in relational systems.
- Virtually all relational DBMS's support SQL.
- They usually provide "a superset of a subset," but the differences for large systems are typically in details and newer ideas not yet included in the standard.
- In the course, we will try to stick to common feature which most vendors are likely to support.
- SQL provides several types of commands:
  - Data definition
    - Define and alter the relational schema
    - Define views of the schema
  - Data control
    - Control of access
  - Data manipulation
    - Query
    - Update

In this presentation, emphasis will be placed upon data definition and queries.

## Basic Syntax for queries in SQL:

```
Select <attribute-list>  
From   <relation-list>  
[Where <condition>]
```

The examples presented here will use the schema of the text (Figure 5.7; Figure 8.1, fifth and fourth editions); (Figure 7.7; Figure 8.1(a), third edition). First, the basic SPJ operations of the relational algebra are covered.

Example (Selection): List the tuples of the Employee relation which identify females.

```
Select  *  
From    Employee  
Where   Sex = 'F'
```

Example (Projection): List the first, last, and middle names of all Employees.

```
Select  FName, MInit, LName  
From    Employee
```

Note that the Where clause is optional, and not needed here.

Example (Combine selection and projection): List the first, last, and middle names of all female Employees.

```
Select  FName, MInit, LName
From    Employee
Where   Sex = 'F'
```

Example (Join): Join the Employee and Department tables on the DNumber and DNo keys.

```
Select  *
From    Employee, Department
Where   DNo = DNumber
```

Example (Natural join): Suppose that the attribute DNo in the Employee relation is changed to be DNumber, exactly the same as in Department. Then it is necessary to qualify the attributes of the join. Here is the solution to the same query as above.

```
Select  *
From    Employee, Department
Where   Employee.DNumber =
        Department.DNumber
```

Example (SPJ combination): List the names of all female Employees, together with the name of the department in which they work.

```
Select  LName, FName, MInit, DName
From    Employee, Department
Where   (DNo = DNumber) and (Sex = 'F')
```

Example (Logical connectives): List the SSN and names of all Employees who either are female or else work in the research department.

```
Select  SSN, LName, FName, MInit
From    Employee, Department
Where   (DNo = DNumber) and
        ((Sex = 'F') or (DName = 'Research'))
```

Example (Union): An alternative solution to the previous query.

```
Select  SSN, LName, FName, MInit
From    Employee
Where   Sex = 'F'
Union
Select  SSN, LName, FName, MInit
From    Employee, Department
Where   (DNo = DNumber) and
        (DName = 'Research')
```

Example (Logical connectives): List the SSN and names of all Employees who are both female and work in the research department.

```
Select  SSN, LName, FName, MInit
From    Employee, Department
Where   (DNo = DNumber) and
        (Sex = 'F')
        and (DName = 'Research')
```

Example (Intersection): An alternative solution to the previous query.

```
Select  SSN, LName, FName, MInit
From    Employee
Where   Sex = 'F'
Intersect
Select  SSN, LName, FName, MInit
From    Employee, Department
Where   (DNo = DNumber) and
        (DName = 'Research')
```

- Note that these two queries are not equivalent if SSN is omitted, since two distinct individuals may have the same name. (The union queries on the previous page are, however, equivalent even if SSN is omitted.)

Example (Logical connectives): List the SSN and names of all Employees who are female but do not work in the research department.

```
Select  SSN, LName, FName, MInit
From    Employee, Department
Where   (DNo = DNumber) and
        ((Sex = 'F') and
         (NOT (DName = 'Research')))
```

Example (Set difference): An alternative solution to the previous query.

```
Select  SSN, LName, FName, MInit
From    Employee
Where   Sex = 'F'
Except
Select  LName, FName, MInit
From    Employee, Department
Where   (DNo = DNumber) and
        (DName = 'Research')
```

- Again, these will not be equivalent if the key SSN is not included.

Example (Removing duplicate elements): By default, SQL will not remove duplicate elements in a query. For example, suppose we want to obtain a list of all project locations. The following query will do the trick, but will duplicate the locations which are the homes of more than one project.

```
Select Plocation  
From Project
```

To obtain a list with duplicates removed, the following query may be used.

```
Select Distinct Plocation  
From Project
```

Example (Order operations): The usual order operations are available in SQL. For example, here a query which finds the names of all Employees who have a salary greater than 40000.

```
Select LName, FName, MInit  
From Employee  
Where Salary > 40000
```

Example (Embedded queries): The “Where” part of a query may itself be a query. For example, here is another version of the query which finds the names of all Employees who work in the department which houses the “Computerization” project.

```
Select  LName, FName, MInit
From    Employee
Where   DNo In
        (Select DNum
         From   Project
         Where  PName='Computerization')
```

Example (Aliases): Sometimes, it is useful to introduce an alias name for a relation. Here is another solution to query which lists the names of all Employees who either are female or else work in the research department.

```
Select  LName, FName, MInit
From    Employee E, Department D
Where   (E.DNo = D.DNumber) and
        ((E.Sex = 'F')
         or (D.DName = 'Research'))
```

Here E is an alias for Employee, and D for Department.



Example (Aliases): Sometimes, it is essential to use aliases. This example retrieves the Last Name of each Employee, together with the Last Name of the supervisor of that Employee. Employees with no supervisor are not listed.

```
Select  E.LName, S.LName
From    Employee E, Employee S
Where   E.SuperSSN = S.SSN
```

Example (Quotient): Unfortunately, SQL does not have the quotient operation defined directly. However, it is easy to realize it. In this example, the names of those Employees who work on every project are found.

```
Select  LName, FName, MInit
From    Employee
Where   Not Exists
        (Select PNumber
         From Project
         Except
         (Select PNo
          From Works_On
          Where SSN=E_SSN
         )
        )
```

While Microsoft Access does not support the Except and Intersect operations, PostgreSQL does.



Here is an alternate way to realize the division operator:

```
Select  LName, FName, MInit
From    Employee
Where   Not Exists
        (Select PNumber
         From Project
         Where Not Exists
           (Select *
            From Works_On
            Where (PNumber=PNo)
                  and(SSN = ESSN)
           )
        )
)
```

Example (Pattern matching): The Like operator effects pattern matching. Here is a query which finds all Employees whose first names begin with the letter "J".

```
Select  LName, FName, MInit
From    Employee
Where   FName like 'J%'
```

Example (Pattern matching): Here is a similar example; this time the first name must contain exactly five characters as well.

```
Select LName, FName, MInit
From Employee
Where FName like 'J_____'
```

Example (Pattern matching): To search for values in the range 40% to 49%, use the following

```
Select Percentage, Item
From Sales
Where Percentage like '4_~%' Escape '~'
```

- Since PostgreSQL is case sensitive, it supports the "ilike" operator which provides case-insensitive matching.
- Pattern-matching features vary substantially from system to system. Check the manual for the flavor of SQL which you are using.

Example (Ordering the result): The following query orders the Employee names by salary, smallest to largest.

```
Select  LName, FName, MInit, Salary
From    Employee
Order by Salary
```

Example (Sense of ordering): Here is how to list the Employees with largest-to-smallest salary ordering.

```
Select  LName, FName, MInit, Salary
From    Employee
Order by Salary Desc
```

Example (Sort fields): It is not necessary to include the sort field in the select component.

```
Select  LName, FName, MInit
From    Employee
Order by Salary Desc
```

Example (Aggregation operations): Here is a query which provides the minimum, maximum, and average salary of the Employees.

```
Select  Min(Salary), Max(Salary),  
        Avg(Salary)  
From    Employee
```

Example (Naming columns): The above query will not name the columns with anything useful. Here is how to provide explicit names.

```
Select  Min(Salary) as MIN_Salary  
        Max(Salary) as MAX_Salary,  
        Avg(Salary) as AVG_Salary  
From    Employee
```

Example (Grouping aggregated results): This query groups minimum, maximum, and average salary by supervisor identity number.

```
Select  Min(Salary) as MIN_Salary  
        Max(Salary) as MAX_Salary,  
        Avg(Salary) as AVG_Salary,  
        SuperSSN  
From    Employee  
Group by SuperSSN
```

Example (The Having operation: Grouping aggregation with conditions): This is similar to the previous example, except that only aggregations for those supervisors who supervise an Employee who earns less than 30000 are listed.

```
Select  Min(Salary) as MIN_Salary
        Max(Salary) as MAX_Salary,
        Avg(Salary) as AVG_Salary,
        SuperSSN
From    Employee
Group by SuperSSN
Having Min(Salary) < 30000
```

Example (Counting): The following query counts the number of Employees for each supervisor:

```
Select  SuperSSN,
        Count(SSN) as No_Supervisees
From    Employee
Group by SuperSSN
```

Example (Eliminating null indicators): The following query does the same as the above, save that it does not show the tuple for which the supervisor's SSN is null.

```
Select  SuperSSN,  
        Count(SSN) as No_Supervisees  
From    Employee  
Where   SuperSSN Is Not Null  
Group by SuperSSN
```



## Further Comments on the *Group By* and *Having* Directives

When using these directives, every field in the *Select* clause must be either an attribute which is used in the *Group By* directive, or an aggregation. Thus, the following query is not legal, even though it makes perfect sense.

```
Select    E.SSN, E.Salary
From      Employee as E
Group by  E.SSN
Having    E.Salary > 30000;
```

The following query, which has exactly the same semantics, is legal.

```
Select    E.SSN, Avg(E.Salary)
From      Employee as E
Group by  E.SSN
Having    Avg(E.Salary) > 30000;
```

Of course, the following is a simpler way to achieve the same result.

```
Select    E.SSN
From      Employee as E
Where     E.Salary > 30000;
```

If the *Having* directive is used without a *Group By* directive, the effect is to collect all tuples into a single group. Thus, the following query is illegal, and does not make sense.

```
Select    E.SSN, E.Salary
From      Employee as E
Having    E.Salary > 30000;
```

To obtain a list of all Employees with a salary greater than 30000, use the following query.

```
Select    E.SSN, E.Salary
From      Employee as E
Where     E.Salary > 30000;
```

## Remarks on the *Contains* directive

- Query 3 on page 260 (page 233 in the fourth edition and page 263 in the third Edition) of the textbook illustrates the use of the *Contains* directive.
- Note that this directive is NOT part of SQL, as is noted on page 260 (233 in the fourth edition and 264 in the third edition).
- Do not use it in any submissions or on examinations answers; it will be marked as incorrect.

# Defining Relations in SQL

## General Format:

```
Create Table <Table Name>
    (<Attribute>      <Format>      <Condition>,
     .                .                .
     .                .                .
 [Constraint <constraint_name>]
     Primary Key (<Attribute>+),
 [Constraint <constraint_name>]
     Unique(<Attribute>),
 [Constraint <constraint_name>]
     Foreign Key (<Attribute>+)
         References <TableName>(<Attribute>+),
 [Constraint <constraint_name>]
     Foreign Key ...
    )
```

## Notes:

- [...] denotes zero or one occurrences of the enclosed item.
- ...+ denotes one or more occurrences of the preceding item.

- SQL syntax for actions on updates

Create Table <name>

.

.

Foreign Key <attribute> References <attribute>  
On Delete {Set Null, Set Default}  
On Update Cascade

Note: {...} means select one.

# Update Operations in Relational Systems:

- There are three main update operations:
  - Insert
  - Delete
  - Modify
- These are tuple-at-a-time operations semantics are self-evident.
- Note that a modify operation may not be equivalent to a delete operation followed by an insert operation, because integrity constraints may be violated after the deletion but before the insertion.