Chapter 6

SQL: Data Manipulation

Chapter 6 - Objectives

- Purpose and importance of SQL.
- How to retrieve data from database using SELECT and:
  - Use compound WHERE conditions.
  - Sort query results using ORDER BY.
  - Use aggregate functions.
  - Group data using GROUP BY and HAVING.
  - Use subqueries.

Chapter 6 - Objectives

  - Join tables together.
  - Perform set operations (UNION, INTERSECT, EXCEPT).

- How to update database using INSERT, UPDATE, and DELETE.

Objectives of SQL

- Ideally, database language should allow user to:
  - create the database and relation structures;
  - perform insertion, modification, deletion of data from relations;
  - perform simple and complex queries.
- Must perform these tasks with minimal user effort and command structure/syntax must be easy to learn.
- It must be portable.

Objectives of SQL

- SQL is a transform-oriented language with 2 major components:
  - A DDL for defining database structure.
  - A DML for retrieving and updating data.
- Until SQL:1999, SQL did not contain flow of control commands. These had to be implemented using a programming or job-control language, or interactively by the decisions of user.

Objectives of SQL

- SQL is relatively easy to learn:
  - it is non-procedural - you specify *what* information you require, rather than *how* to get it;
  - it is essentially free-format.

Objectives of SQL

- Consists of standard English words:

```
1) CREATE TABLE Staff(staffNo VARCHAR(5),
                      lName VARCHAR(15),
                      salary DECIMAL(7,2));
2) INSERT INTO Staff VALUES ('SG16', 'Brown',
   8300);
3) SELECT staffNo, lName, salary
   FROM Staff
   WHERE salary > 10000;
```

Objectives of SQL

- Can be used by range of users including DBAs, management, application developers, and other types of end users.

- An ISO standard now exists for SQL, making it both the formal and *de facto* standard language for relational databases.

SELECT Statement

```
SELECT [DISTINCT | ALL]
   {* | [columnExpression [AS newName]] [,...] }
FROM          TableName [alias] [, ...]
[WHERE        condition]
[GROUP BY     columnList]  [HAVING condition]
[ORDER BY     columnList]
```

SELECT Statement

FROM	Specifies table(s) to be used.
WHERE	Filters rows.
GROUP BY	Forms groups of rows with same column value.
HAVING	Filters groups subject to some condition.
SELECT	Specifies which columns are to appear in output.
ORDER BY	Specifies the order of the output.

SELECT Statement

- Order of the clauses cannot be changed.
- Only SELECT and FROM are mandatory.

Example 5.1 All Columns, All Rows

List full details of all staff.

```
SELECT staffNo, fName, lName, address,
        position, sex, DOB, salary, branchNo
FROM Staff;
```

- Can use * as an abbreviation for ‘all columns’:

```
SELECT *
FROM Staff;
```

Example 5.1 All Columns, All Rows

Table 5.1 Result table for Example 5.1.

staffNo	fName	lName	position	sex	DOB	salary	branchNo
SL21	John	White	Manager	M	1-Oct-45	30000.00	B005
SG37	Ann	Beech	Assistant	F	10-Nov-60	12000.00	B003
SG14	David	Ford	Supervisor	M	24-Mar-58	18000.00	B003
SA9	Mary	Howe	Assistant	F	19-Feb-70	9000.00	B007
SG5	Susan	Brand	Manager	F	3-Jun-40	24000.00	B003
SL41	Julie	Lee	Assistant	F	13-Jun-65	9000.00	B005

Example 5.2 Specific Columns, All Rows

Produce a list of salaries for all staff, showing only staff number, first and last names, and salary.

```
SELECT staffNo, fName, lName, salary
FROM Staff;
```

Example 5.2 Specific Columns, All Rows

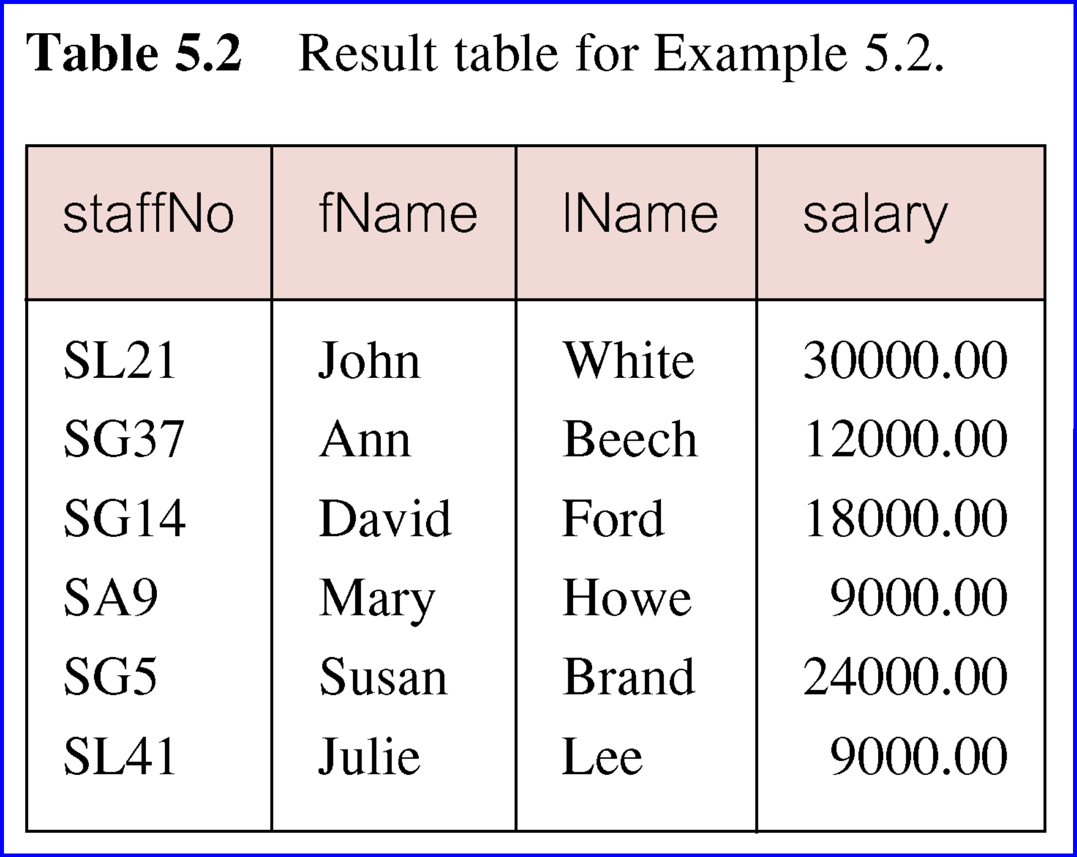


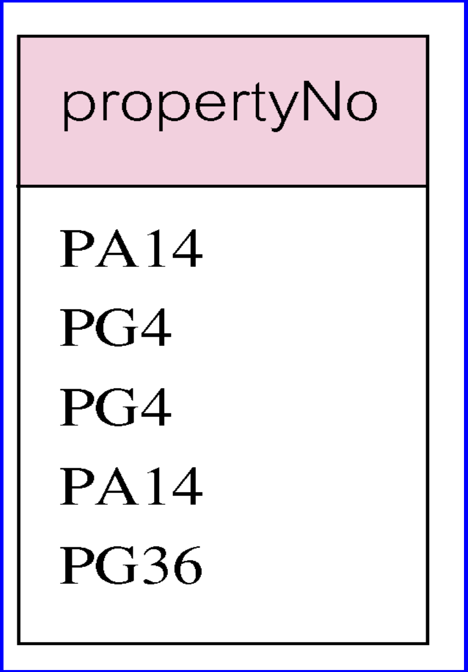
Table 5.2 Result table for Example 5.2.

staffNo	fName	lName	salary
SL21	John	White	30000.00
SG37	Ann	Beech	12000.00
SG14	David	Ford	18000.00
SA9	Mary	Howe	9000.00
SG5	Susan	Brand	24000.00
SL41	Julie	Lee	9000.00

Example 5.3 Use of DISTINCT

List the property numbers of all properties that have been viewed.

```
SELECT propertyNo
FROM Viewing;
```

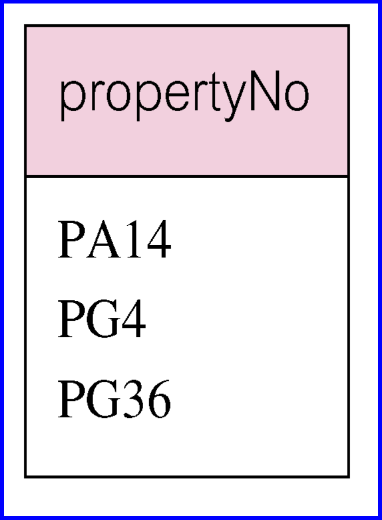


propertyNo
PA14
PG4
PG4
PA14
PG36

Example 5.3 Use of DISTINCT

- Use DISTINCT to eliminate duplicates:

```
SELECT DISTINCT propertyNo
FROM Viewing;
```



propertyNo
PA14
PG4
PG36

Example 5.4 Calculated Fields

Produce list of monthly salaries for all staff, showing staff number, first/last name, and salary.

```
SELECT staffNo, fName, lName, salary/12
FROM Staff;
```

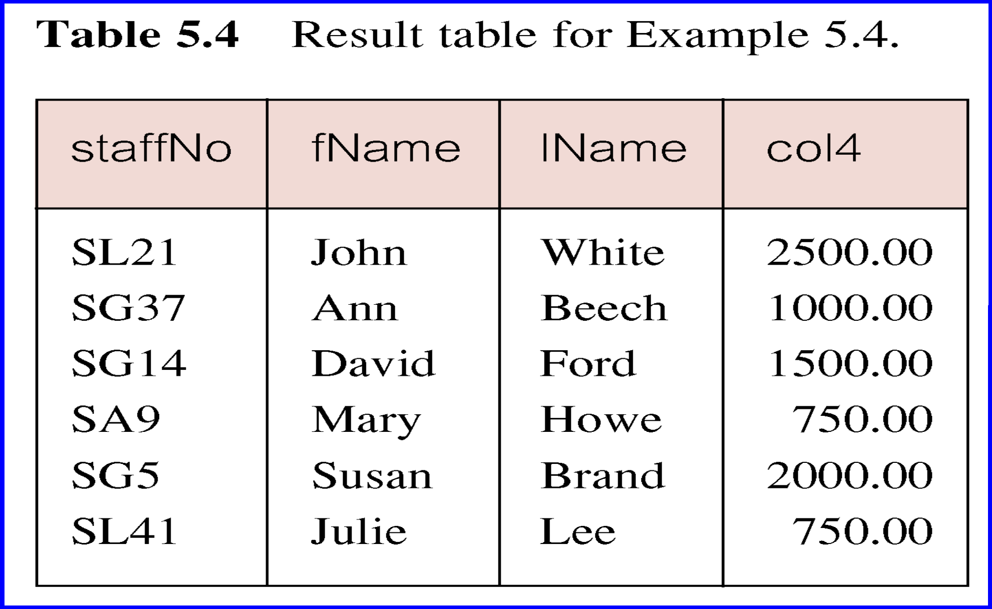


Table 5.4 Result table for Example 5.4.

staffNo	fName	lName	col4
SL21	John	White	2500.00
SG37	Ann	Beech	1000.00
SG14	David	Ford	1500.00
SA9	Mary	Howe	750.00
SG5	Susan	Brand	2000.00
SL41	Julie	Lee	750.00

Example 5.4 Calculated Fields

- To name column, use AS clause:

```
SELECT staffNo, fName, lName, salary/12
                AS monthlySalary
FROM Staff;
```

Example 5.5 Comparison Search Condition

List all staff with a salary greater than 10,000.

```
SELECT staffNo, fName, lName, position, salary
FROM Staff
WHERE salary > 10000;
```

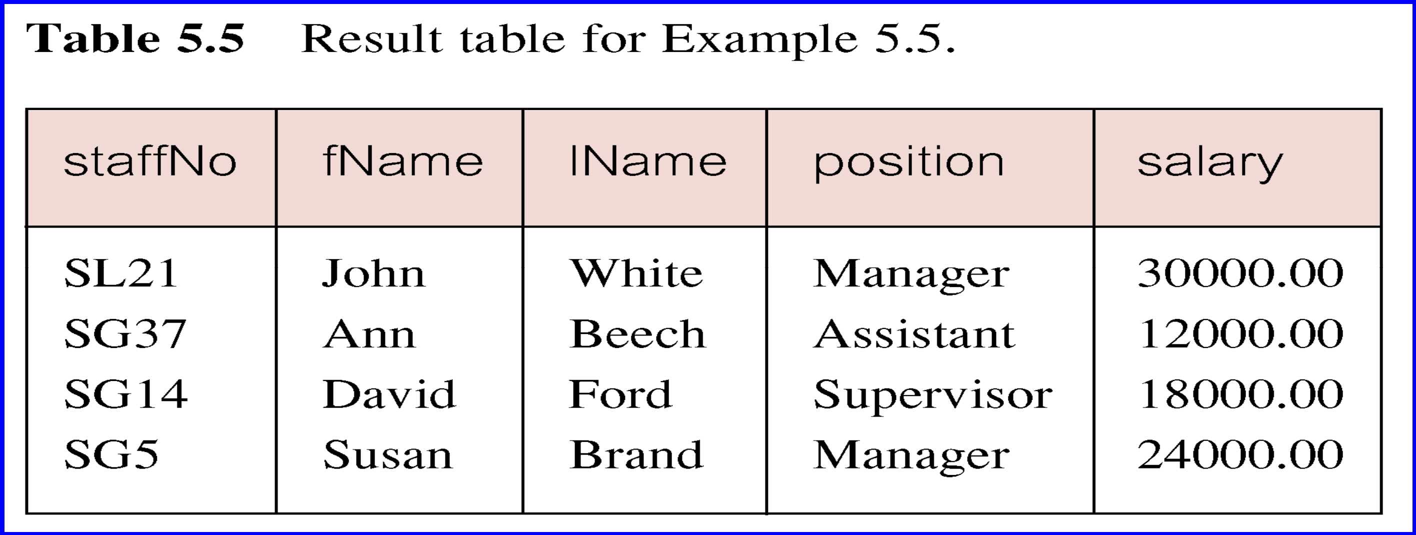


Table 5.5 Result table for Example 5.5.

staffNo	fName	lName	position	salary
SL21	John	White	Manager	30000.00
SG37	Ann	Beech	Assistant	12000.00
SG14	David	Ford	Supervisor	18000.00
SG5	Susan	Brand	Manager	24000.00

Example 5.6 Compound Comparison Search Condition

List addresses of all branch offices in London or Glasgow.

```
SELECT *
FROM Branch
WHERE city = ‘London’ OR city = ‘Glasgow’;
```

Table 5.6 Result table for Example 5.6.

branchNo	street	city	postcode
B005	22 Deer Rd	London	SW1 4EH
B003	163 Main St	Glasgow	G11 9QX
B002	56 Clover Dr	London	NW10 6EU

Example 5.8 Set Membership

List all managers and supervisors.

```
SELECT staffNo, fName, lName, position
FROM Staff
WHERE position IN (‘Manager’, ‘Supervisor’);
```

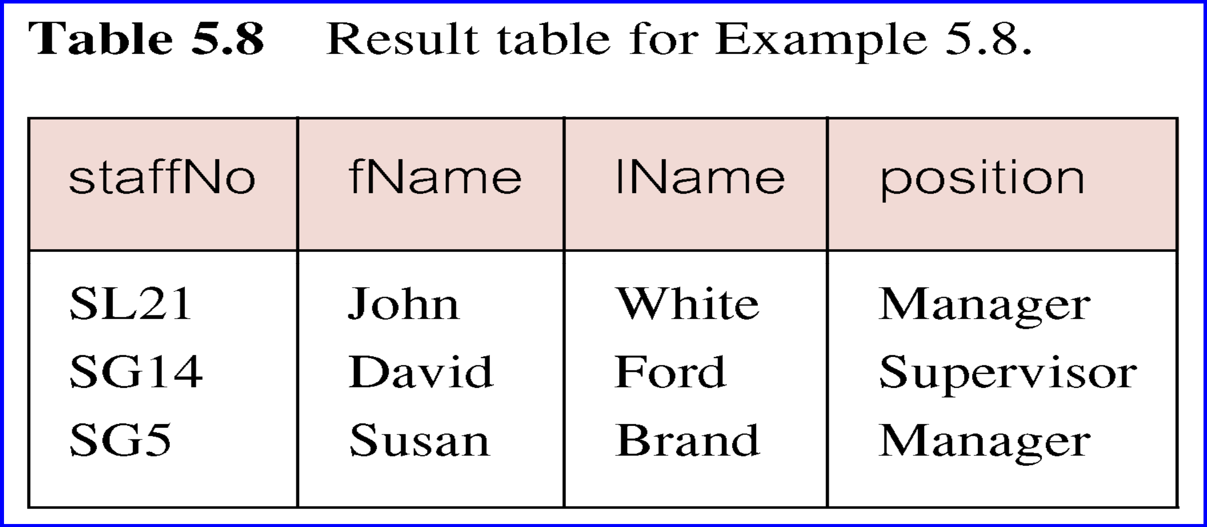


Table 5.8 Result table for Example 5.8.

staffNo	fName	lName	position
SL21	John	White	Manager
SG14	David	Ford	Supervisor
SG5	Susan	Brand	Manager

Example 5.8 Set Membership

- There is a negated version (NOT IN).
- IN does not add much to SQL's expressive power. Could have expressed this as:

```
 SELECT staffNo, fName, lName, position
FROM Staff
WHERE position='Manager' OR
             position='Supervisor';
```

- IN is more efficient when set contains many values.

Example 5.9 Pattern Matching

Find all owners with the string ‘Glasgow’ in their address.

```
SELECT ownerNo, fName, lName, address, telNo
FROM PrivateOwner
WHERE address LIKE ‘%Glasgow%’;
```

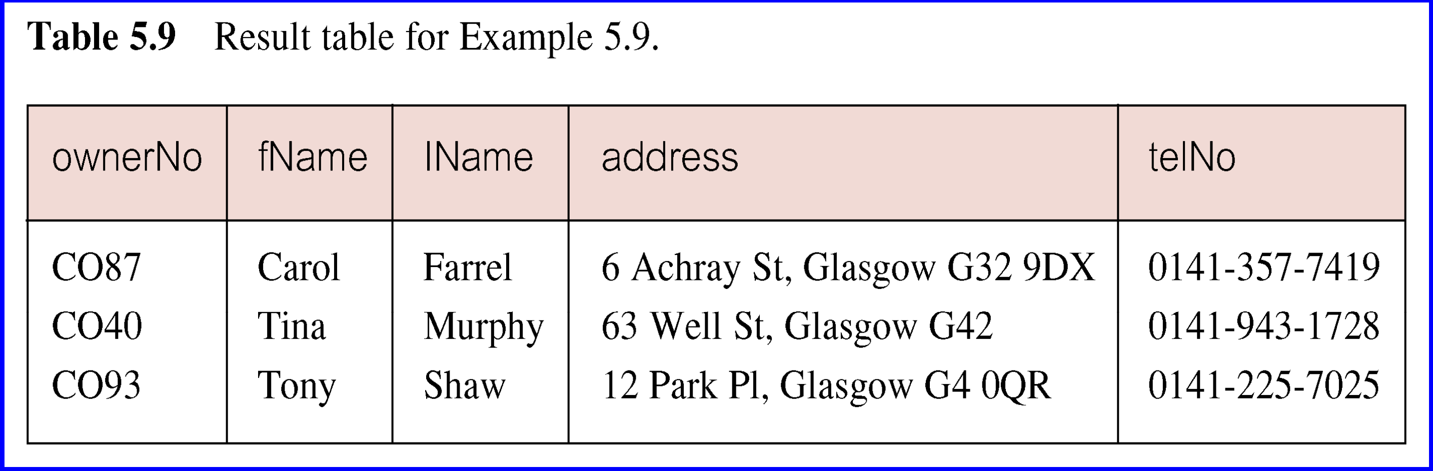


Table 5.9 Result table for Example 5.9.

ownerNo	fName	lName	address	telNo
CO87	Carol	Farrel	6 Achray St, Glasgow G32 9DX	0141-357-7419
CO40	Tina	Murphy	63 Well St, Glasgow G42	0141-943-1728
CO93	Tony	Shaw	12 Park Pl, Glasgow G4 0QR	0141-225-7025

Example 5.9 Pattern Matching

- SQL has two special pattern matching symbols:
  - %: sequence of zero or more characters;
  - _ (underscore): any single character.
- LIKE '%Glasgow%' means a sequence of characters of any length containing '*Glasgow*'.

Example 5.11 Single Column Ordering

List salaries for all staff, arranged in descending order of salary.

```
SELECT staffNo, fName, lName, salary
FROM Staff
ORDER BY salary DESC;
```

Example 5.11 Single Column Ordering

Table 5.11 Result table for Example 5.11.

staffNo	fName	lName	salary
SL21	John	White	30000.00
SG5	Susan	Brand	24000.00
SG14	David	Ford	18000.00
SG37	Ann	Beech	12000.00
SA9	Mary	Howe	9000.00
SL41	Julie	Lee	9000.00

Example 5.12 Multiple Column Ordering

Produce abbreviated list of properties in order of property type.

```
SELECT propertyNo, type, rooms, rent
FROM PropertyForRent
ORDER BY type;
```

Example 5.12 Multiple Column Ordering

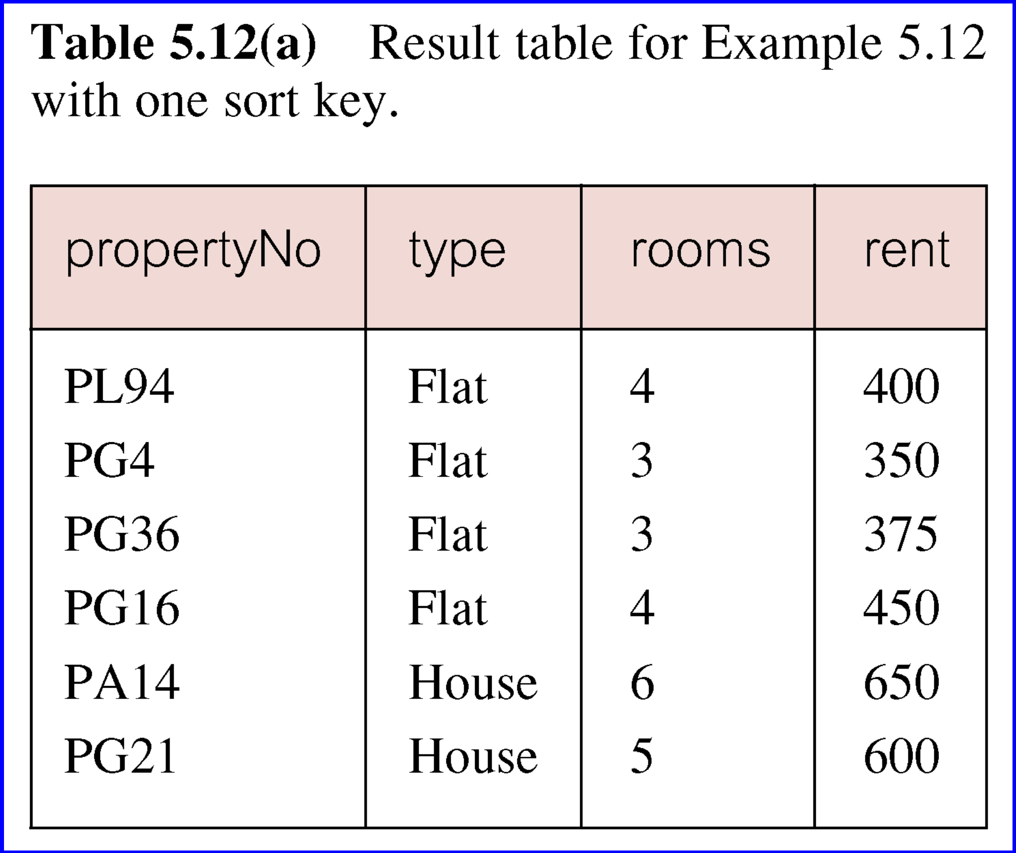


Table 5.12(a) Result table for Example 5.12 with one sort key.

propertyNo	type	rooms	rent
PL94	Flat	4	400
PG4	Flat	3	350
PG36	Flat	3	375
PG16	Flat	4	450
PA14	House	6	650
PG21	House	5	600

Example 5.12 Multiple Column Ordering

- Four flats in this list - as no minor sort key specified, system arranges these rows in any order it chooses.
- To arrange in order of rent, specify minor order:

```
SELECT propertyNo, type, rooms, rent
FROM PropertyForRent
ORDER BY type, rent DESC;
```

Example 5.12 Multiple Column Ordering

Table 5.12(b) Result table for Example 5.12 with two sort keys.

propertyNo	type	rooms	rent
PG16	Flat	4	450
PL94	Flat	4	400
PG36	Flat	3	375
PG4	Flat	3	350
PA14	House	6	650
PG21	House	5	600

SELECT Statement - Aggregates

- ISO standard defines five aggregate functions:

COUNT	returns number of values in specified column.
SUM	returns sum of values in specified column.
AVG	returns average of values in specified column.
MIN	returns smallest value in specified column.
MAX	returns largest value in specified column.

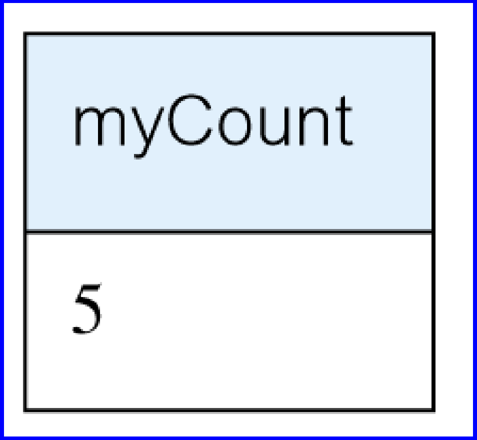
SELECT Statement - Aggregates

- Each operates on a single column of a table and returns a single value.
- COUNT, MIN, and MAX apply to numeric and non-numeric fields, but SUM and AVG may be used on numeric fields only.

Example 5.13 Use of COUNT(*)

How many properties cost more than £350 per month to rent?

```
SELECT COUNT(*) AS myCount
FROM PropertyForRent
WHERE rent > 350;
```

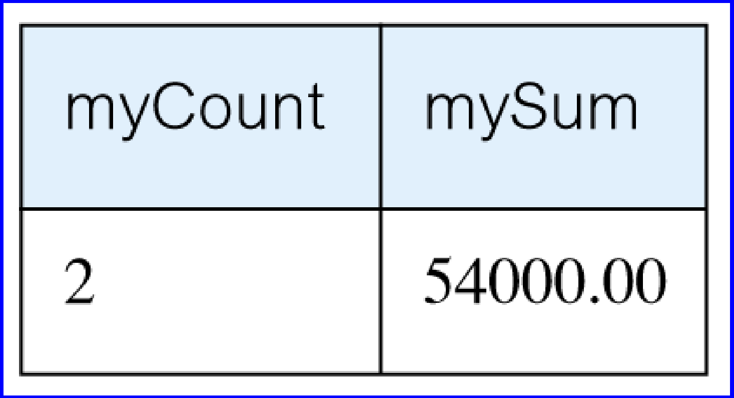


myCount
5

Example 5.15 Use of COUNT and SUM

Find number of Managers and sum of their salaries.

```
SELECT COUNT(staffNo) AS myCount,
            SUM(salary) AS mySum
FROM Staff
WHERE position = ‘Manager’;
```

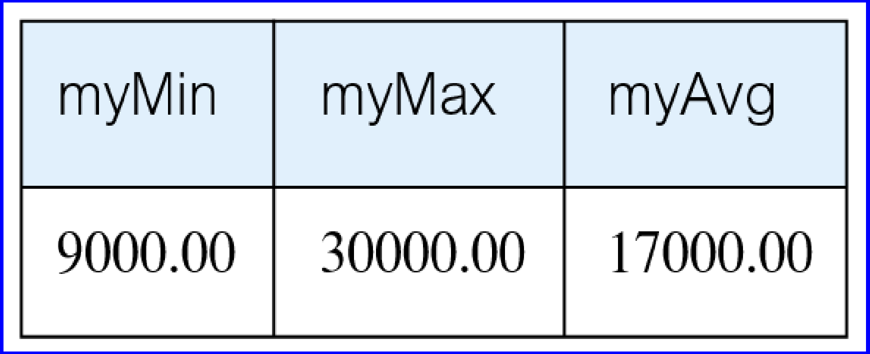


myCount	mySum
2	54000.00

Example 5.16 Use of MIN, MAX, AVG

Find minimum, maximum, and average staff salary.

```
SELECT MIN(salary) AS myMin,
  MAX(salary) AS myMax,
   AVG(salary) AS myAvg
FROM Staff;
```



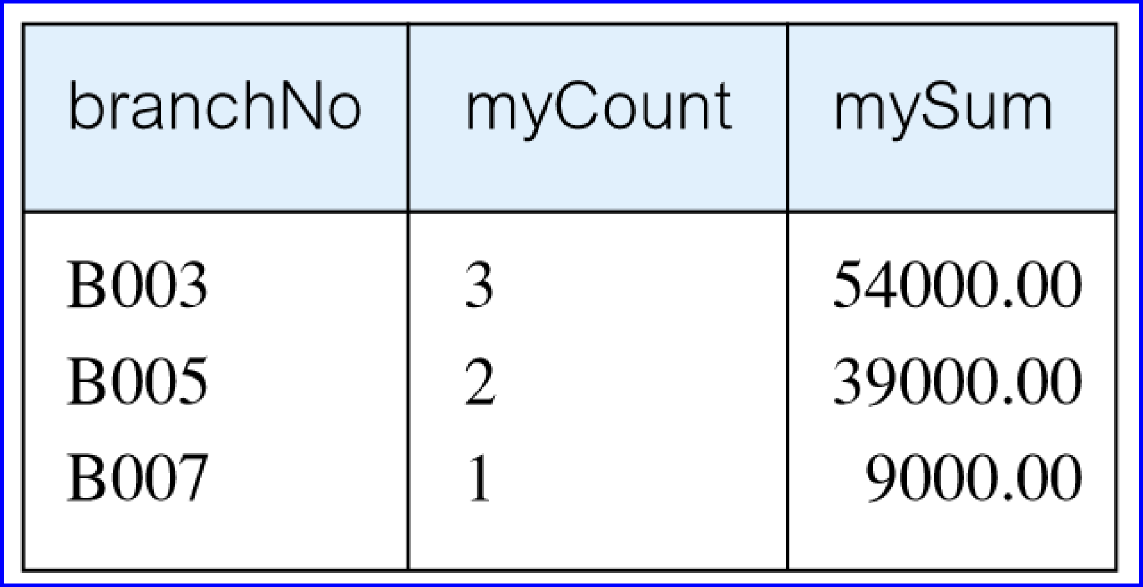
myMin	myMax	myAvg
9000.00	30000.00	17000.00

Example 5.17 Use of GROUP BY

Find number of staff in each branch and their total salaries.

```
SELECT    branchNo,
          COUNT(staffNo) AS myCount,
          SUM(salary) AS mySum
FROM Staff
GROUP BY branchNo
ORDER BY branchNo;
```

Example 5.17 Use of GROUP BY



branchNo	myCount	mySum
B003	3	54000.00
B005	2	39000.00
B007	1	9000.00

Restricted Groupings – HAVING clause

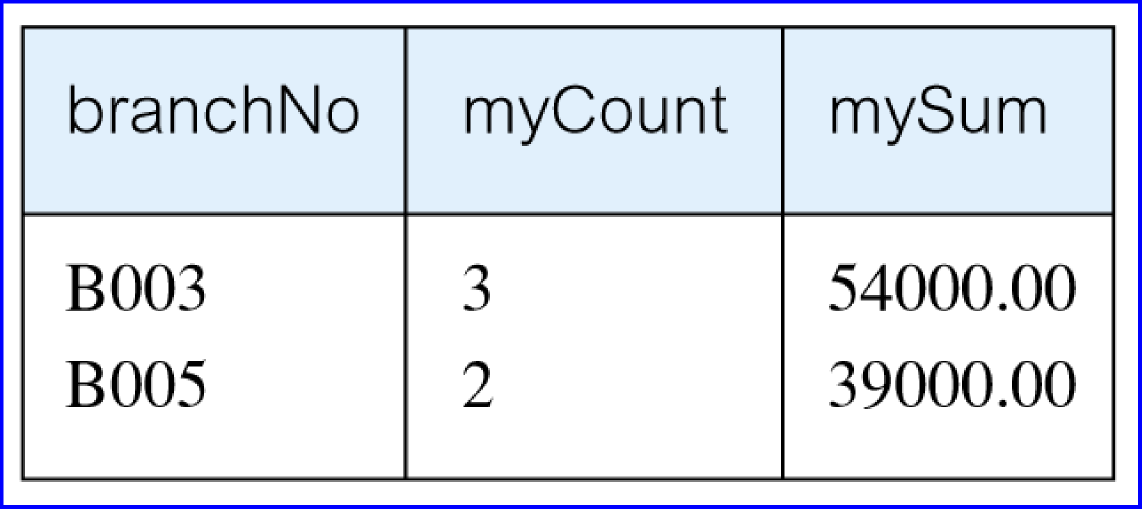
- **HAVING clause is designed for use with GROUP BY to restrict groups that appear in final result table.**
- **Similar to WHERE, but WHERE filters individual rows whereas HAVING filters groups.**

Example 5.18 Use of HAVING

For each branch with more than 1 member of staff, find number of staff in each branch and sum of their salaries.

```
SELECT branchNo,
            COUNT(staffNo) AS myCount,
            SUM(salary) AS mySum
FROM Staff
GROUP BY branchNo
HAVING COUNT(staffNo) > 1
ORDER BY branchNo;
```

Example 5.18 Use of HAVING



branchNo	myCount	mySum
B003	3	54000.00
B005	2	39000.00

Subqueries

- Some SQL statements can have a SELECT embedded within them.
- A subselect can be used in WHERE and HAVING clauses of an outer SELECT, where it is called a *subquery* or *nested query*.
- Subselects may also appear in INSERT, UPDATE, and DELETE statements.

Example 5.19 Subquery with Equality

List staff who work in branch at '163 Main St'.

```
SELECT staffNo, fName, lName, position
FROM Staff
WHERE branchNo =
          (SELECT branchNo
           FROM Branch
           WHERE street = '163 Main St');
```

Example 5.19 Subquery with Equality

- Inner SELECT finds branch number for branch at ‘163 Main St’ (‘B003’).
- Outer SELECT then retrieves details of all staff who work at this branch.
- Outer SELECT then becomes:

```
SELECT staffNo, fName, lName, position
FROM Staff
WHERE branchNo = ‘B003’;
```

Example 5.19 Subquery with Equality

Table 5.19 Result table for Example 5.19.

staffNo	fName	lName	position
SG37	Ann	Beech	Assistant
SG14	David	Ford	Supervisor
SG5	Susan	Brand	Manager

Example 5.21 Nested subquery: use of IN

List properties handled by staff at ‘163 Main St’.

```
SELECT propertyNo, street, city, postcode, type, rooms, rent
FROM PropertyForRent
WHERE staffNo IN
     (SELECT staffNo
      FROM Staff
      WHERE branchNo =
           (SELECT branchNo
            FROM Branch
            WHERE street = ‘163 Main St’));
```

Example 5.21 Nested subquery: use of IN

Table 5.21 Result table for Example 5.21.

propertyNo	street	city	postcode	type	rooms	rent
PG16	5 Novar Dr	Glasgow	G12 9AX	Flat	4	450
PG36	2 Manor Rd	Glasgow	G32 4QX	Flat	3	375
PG21	18 Dale Rd	Glasgow	G12	House	5	600

Multi-Table Queries

- Can use subqueries provided result columns come from same table.
- If result columns come from more than one table must use a join.
- To perform join, include more than one table in FROM clause.
- Use comma as separator and typically include WHERE clause to specify join column(s).

Multi-Table Queries

- Also possible to use an alias for a table named in FROM clause.
- Alias is separated from table name with a space.
- Alias can be used to qualify column names when there is ambiguity.

Example 5.24 Simple Join

List names of all clients who have viewed a property along with any comment supplied.

```
SELECT c.clientNo, fName, lName,
          propertyNo, comment
FROM Client c, Viewing v
WHERE c.clientNo = v.clientNo;
```

Example 5.24 Simple Join

- Only those rows from both tables that have identical values in the clientNo columns (c.clientNo = v.clientNo) are included in result.
- Equivalent to equi-join in relational algebra.

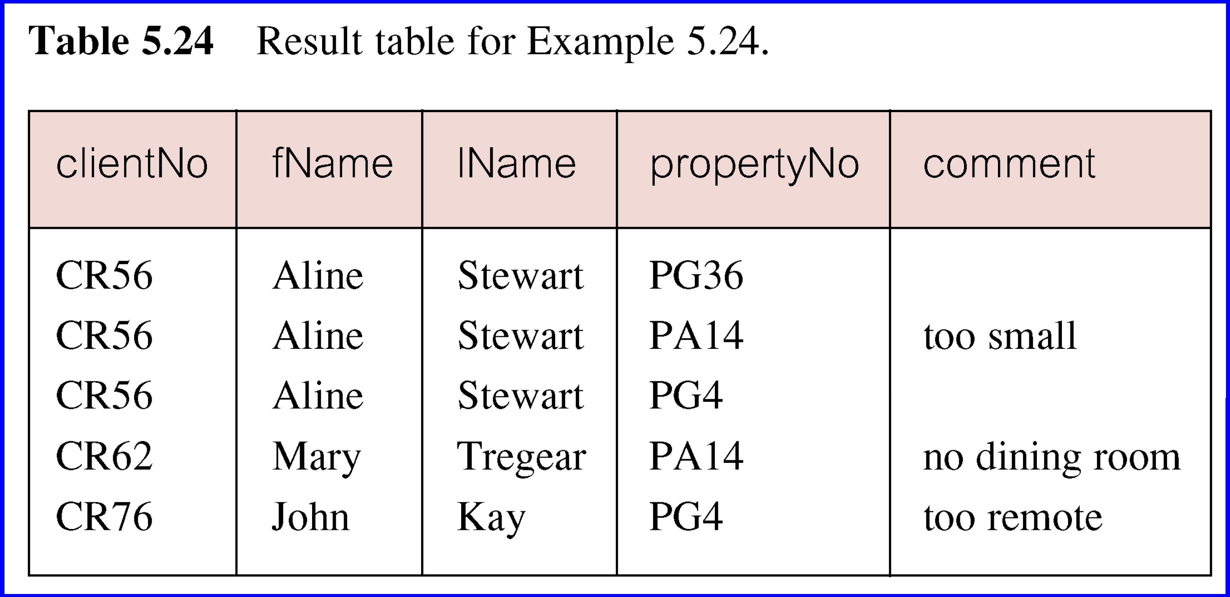


Table 5.24 Result table for Example 5.24.

clientNo	fName	lName	propertyNo	comment
CR56	Aline	Stewart	PG36	
CR56	Aline	Stewart	PA14	too small
CR56	Aline	Stewart	PG4	
CR62	Mary	Tregear	PA14	no dining room
CR76	John	Kay	PG4	too remote

Alternative JOIN Construct used in SQL Server

- **SQL provides alternative ways to specify joins:**

  FROM Client c JOIN Viewing v ON c.clientNo = v.clientNo

- **FROM replaces original FROM and WHERE.**

Example 5.25 Sorting a join

For each branch, list numbers and names of staff who manage properties, and properties they manage.

```
SELECT s.branchNo, s.staffNo, fName, lName,
            propertyNo
FROM Staff s, PropertyForRent p
WHERE s.staffNo = p.staffNo
ORDER BY s.branchNo, s.staffNo, propertyNo;
```

Example 5.25 Sorting a join

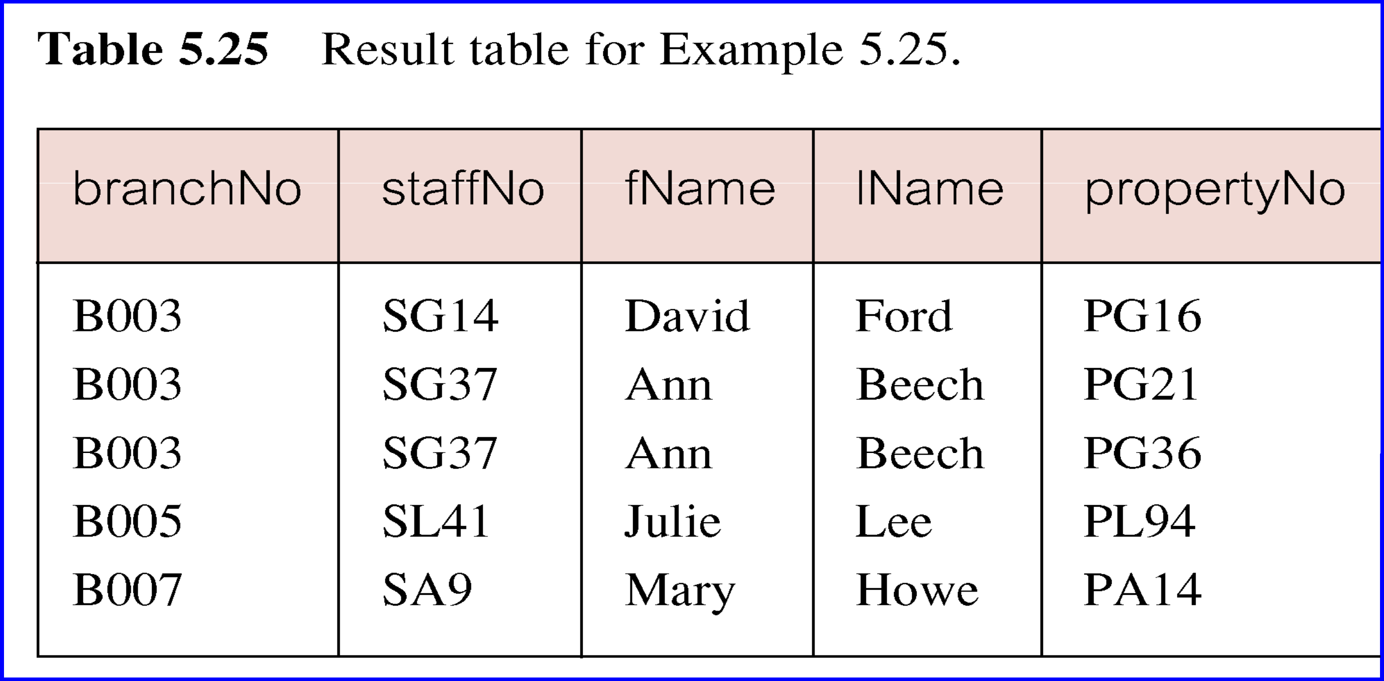


Table 5.25 Result table for Example 5.25.

branchNo	staffNo	fName	lName	propertyNo
B003	SG14	David	Ford	PG16
B003	SG37	Ann	Beech	PG21
B003	SG37	Ann	Beech	PG36
B005	SL41	Julie	Lee	PL94
B007	SA9	Mary	Howe	PA14

Example 5.26 Three Table Join

For each branch, list staff who manage properties, including city in which branch is located and properties they manage.

```
SELECT b.branchNo, b.city, s.staffNo, fName, lName,
        propertyNo
FROM Branch b, Staff s, PropertyForRent p
WHERE b.branchNo = s.branchNo AND
        s.staffNo = p.staffNo
ORDER BY b.branchNo, s.staffNo, propertyNo;
```

Example 5.26 Three Table Join

Table 5.26 Result table for Example 5.26.

branchNo	city	staffNo	fName	lName	propertyNo
B003	Glasgow	SG14	David	Ford	PG16
B003	Glasgow	SG37	Ann	Beech	PG21
B003	Glasgow	SG37	Ann	Beech	PG36
B005	London	SL41	Julie	Lee	PL94
B007	Aberdeen	SA9	Mary	Howe	PA14

Computing a Join

Procedure for generating results of a join are:

1. Form Cartesian product of the tables named in FROM clause.
2. If there is a WHERE clause, apply the search condition to each row of the product table, retaining those rows that satisfy the condition.
3. For each remaining row, determine value of each item in SELECT list to produce a single row in result table.

Computing a Join

4. If DISTINCT has been specified, eliminate any duplicate rows from the result table.

5. If there is an ORDER BY clause, sort result table as required.

Outer Joins

- If one row of a joined table is unmatched, row is omitted from result table.
- Outer join operations retain rows that do not satisfy the join condition.
- Consider following tables:

Branch1

branchNo	bCity
B003	Glasgow
B004	Bristol
B002	London

PropertyForRent1

propertyNo	pCity
PA14	Aberdeen
PL94	London
PG4	Glasgow

Outer Joins

- The (inner) join of these two tables:

```
SELECT b.*, p.*
FROM Branch1 b, PropertyForRent1 p
WHERE b.bCity = p.pCity;
```

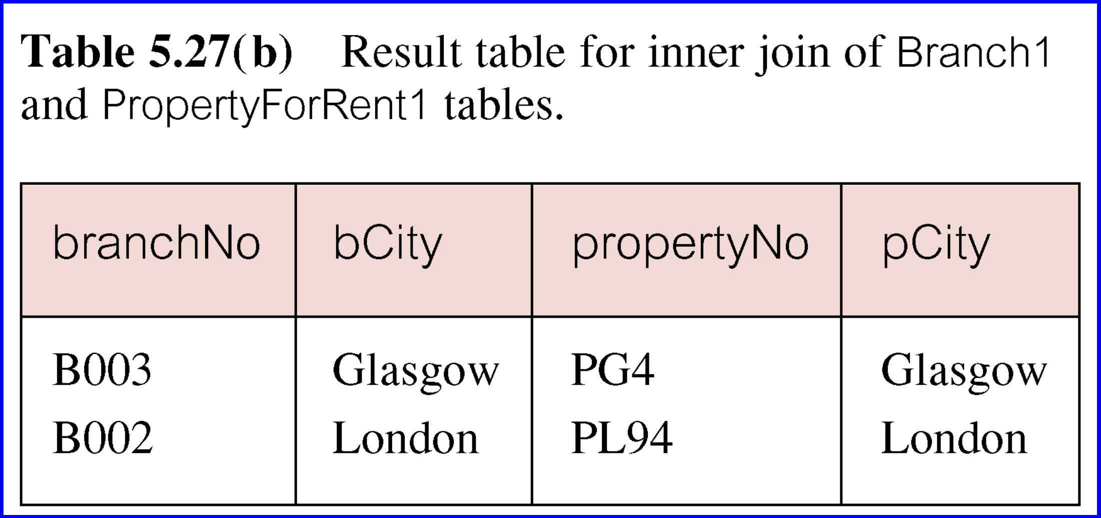


Table 5.27(b) Result table for inner join of Branch1 and PropertyForRent1 tables.

branchNo	bCity	propertyNo	pCity
B003	Glasgow	PG4	Glasgow
B002	London	PL94	London

Outer Joins

- Result table has two rows where cities are same.
- There are no rows corresponding to branches in Bristol and Aberdeen.
- To include unmatched rows in result table, use an Outer join.

Example 5.28 Left Outer Join

List branches and properties that are in same city along with any unmatched branches.

```
SELECT b.*, p.*
FROM Branch1 b LEFT JOIN
     PropertyForRent1 p ON b.bCity = p.pCity;
```

Example 5.28 Left Outer Join

- Includes those rows of first (left) table unmatched with rows from second (right) table.
- Columns from second table are filled with NULLs.

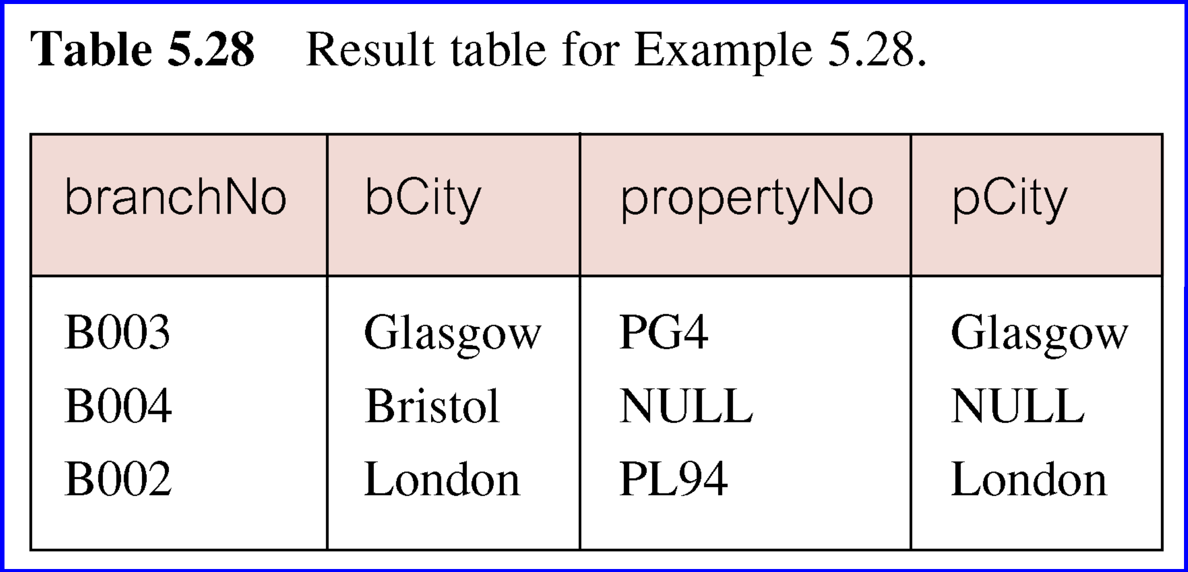


Table 5.28 Result table for Example 5.28.

branchNo	bCity	propertyNo	pCity
B003	Glasgow	PG4	Glasgow
B004	Bristol	NULL	NULL
B002	London	PL94	London

Example 5.29 Right Outer Join

List branches and properties in same city and any unmatched properties.

```
SELECT b.*, p.*
 FROM Branch1 b RIGHT JOIN
   PropertyForRent1 p ON b.bCity = p.pCity;
```

Example 5.29 Right Outer Join

- Right Outer join includes those rows of second (right) table that are unmatched with rows from first (left) table.
- Columns from first table are filled with NULLs.

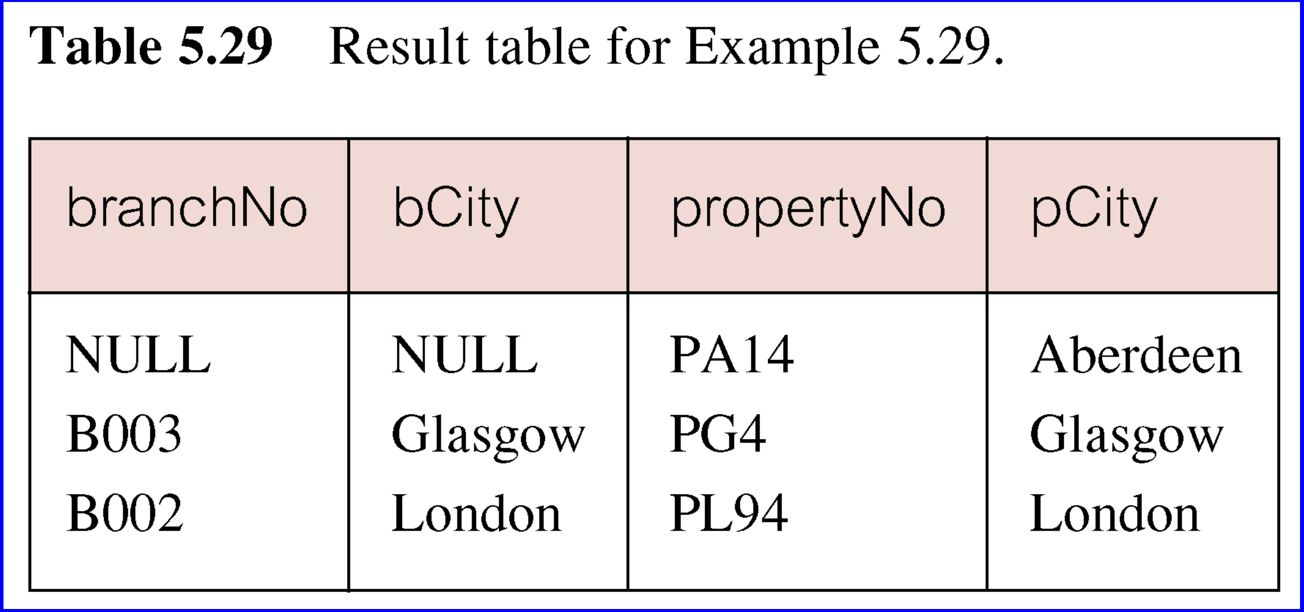


Table 5.29 Result table for Example 5.29.

branchNo	bCity	propertyNo	pCity
NULL	NULL	PA14	Aberdeen
B003	Glasgow	PG4	Glasgow
B002	London	PL94	London

Example 5.30 Full Outer Join

List branches and properties in same city and any unmatched branches or properties.

```
SELECT b.*, p.*
 FROM Branch1 b FULL JOIN
   PropertyForRent1 p ON b.bCity = p.pCity;
```

Example 5.30 Full Outer Join

- Includes rows that are unmatched in both tables.
- Unmatched columns are filled with NULLs.

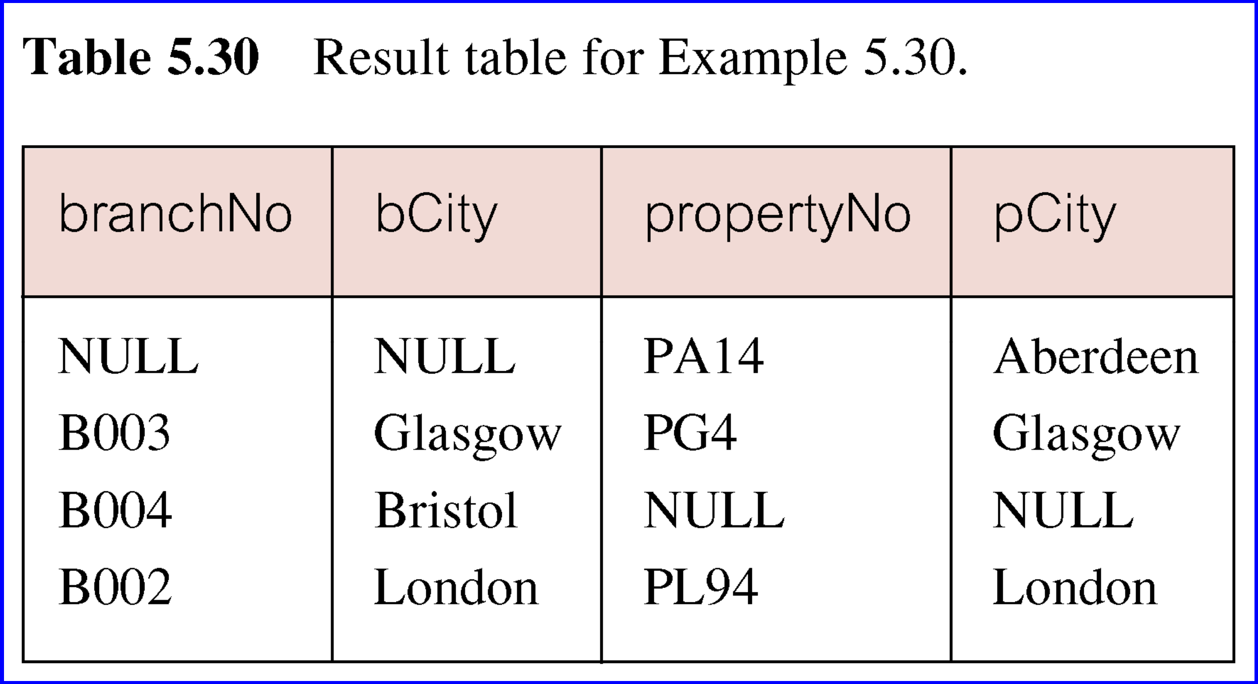


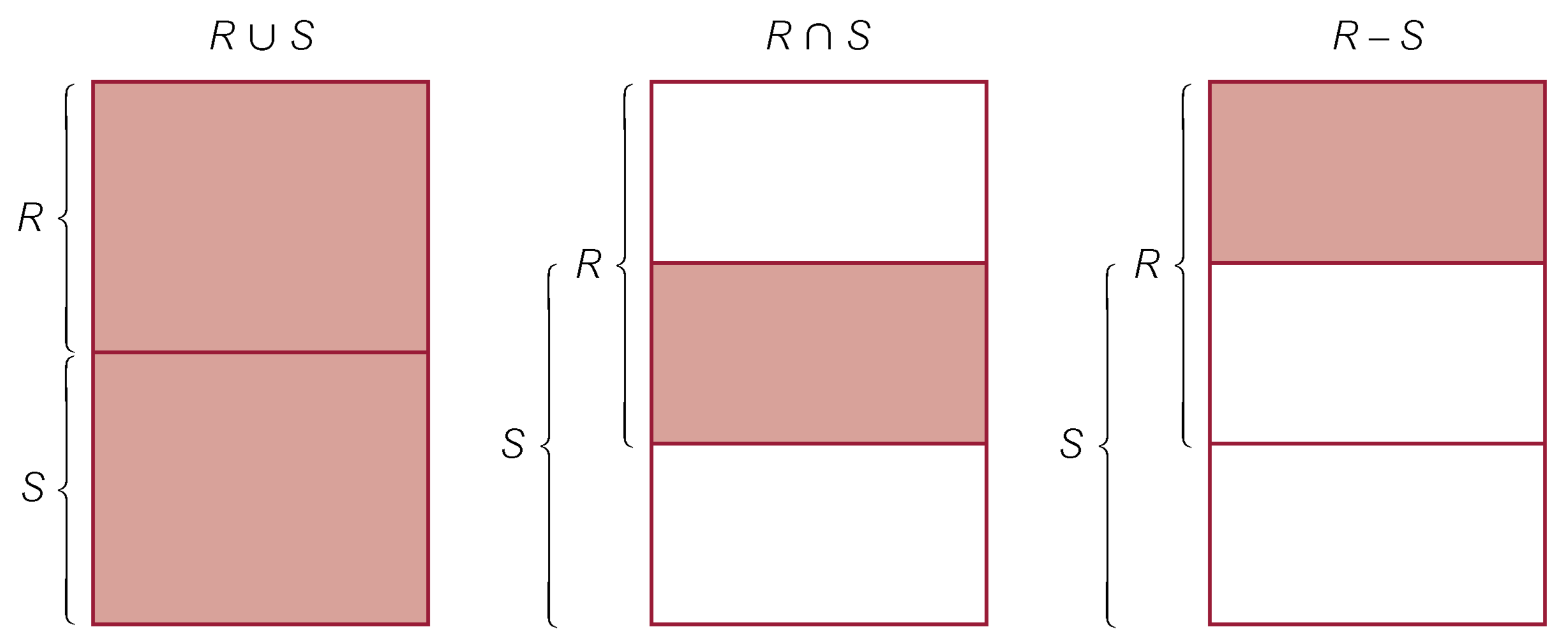
Table 5.30 Result table for Example 5.30.

branchNo	bCity	propertyNo	pCity
NULL	NULL	PA14	Aberdeen
B003	Glasgow	PG4	Glasgow
B004	Bristol	NULL	NULL
B002	London	PL94	London

Union, Intersect, and Difference (Except)

- Can use normal set operations of Union, Intersection, and Difference to combine results of two or more queries into a single result table.
- Union of two tables, A and B, is table containing all rows in either A or B or both.
- Intersection is table containing all rows common to both A and B.
- Difference is table containing all rows in A but not in B.
- Two tables must be *union compatible*.

Union, Intersect, and Difference (Except)



(a) Union (b) Intersection (c) Difference

Example 5.32 Use of UNION

List all cities where there is either a branch office or a property.

```
(SELECT city
FROM Branch)
UNION
(SELECT city
FROM PropertyForRent);
```

Example 5.32 Use of UNION

- Produces result tables from both queries and merges both tables together.

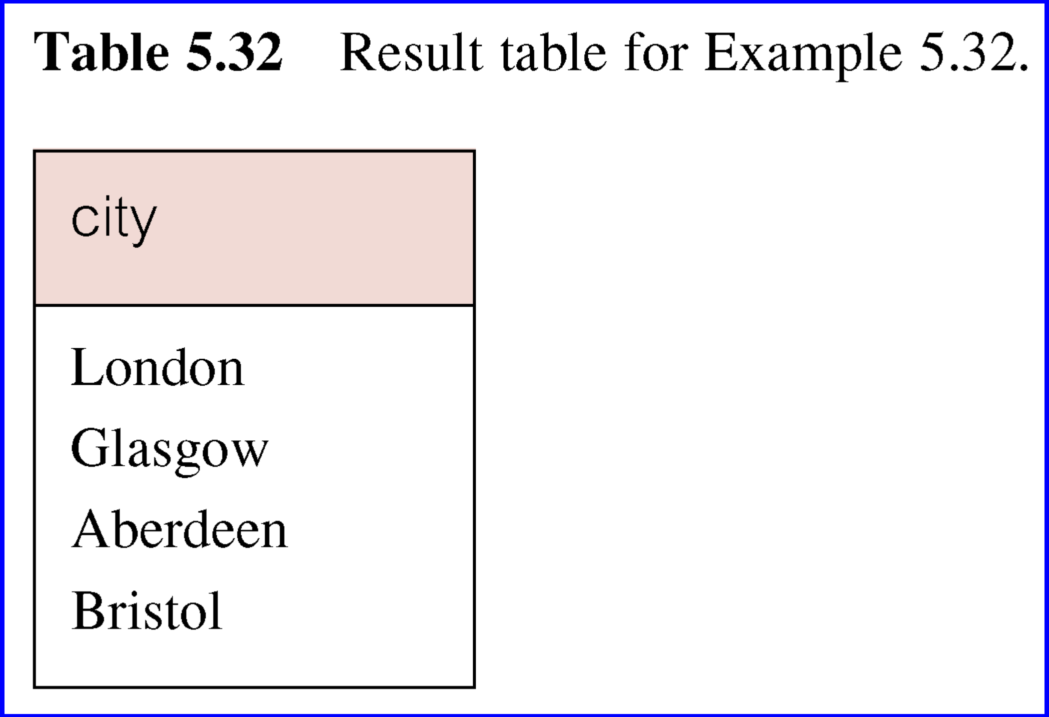


Table 5.32 Result table for Example 5.32.

city
London
Glasgow
Aberdeen
Bristol

Example 5.33 Use of INTERSECT

List all cities where there is both a branch office and a property.

```
(SELECT city FROM Branch)
INTERSECT
(SELECT city FROM PropertyForRent);
```

Example 5.33 Use of INTERSECT

- Could rewrite this query without INTERSECT operator:

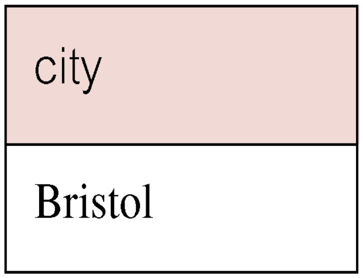
```
SELECT b.city
FROM Branch b PropertyForRent p
WHERE b.city = p.city;
```

Example 5.34 Use of EXCEPT

List of all cities where there is a branch office but no properties.

```
(SELECT city FROM Branch)
EXCEPT
(SELECT city FROM PropertyForRent);
```

Table 5.34 Result table for Example 5.34.



city
Bristol

Example 5.34 Use of EXCEPT

- Could rewrite this query without EXCEPT:

```
SELECT DISTINCT city FROM Branch
WHERE city NOT IN
  (SELECT city FROM PropertyForRent);
```

INSERT

```
INSERT INTO TableName [ (columnList) ]
VALUES (dataValueList)
```

- *columnList* is optional; if omitted, SQL assumes a list of all columns in their original CREATE TABLE order.

Example 5.35 INSERT … VALUES

Insert a new row into Staff table supplying data for all columns.

```
INSERT INTO Staff
VALUES ('SG16', 'Alan', 'Brown', 'Assistant',
   'M', Date'1957-05-25', 8300, 'B003');
```

INSERT … SELECT

- Second form of INSERT allows multiple rows to be copied from one or more tables to another:

```
INSERT INTO TableName [ (columnList) ]
    SELECT ...
```

Example 5.37 INSERT … SELECT

Assume there is a table StaffPropCount that contains names of staff and number of properties they manage:

StaffPropCount(<u>staffNo</u>, fName, lName, propCnt)

Populate StaffPropCount using Staff and PropertyForRent tables.

Example 5.37 INSERT … SELECT

```
INSERT INTO StaffPropCount
  (SELECT s.staffNo, fName, lName,
  COUNT(*)
  FROM Staff s, PropertyForRent p
  WHERE s.staffNo = p.staffNo
  GROUP BY s.staffNo, fName, lName);
```

Example 5.37 INSERT … SELECT

Table 5.35 Result table for Example 5.37.

staffNo	fName	lName	propCount
SG14	David	Ford	1
SL21	John	White	0
SG37	Ann	Beech	2
SA9	Mary	Howe	1
SG5	Susan	Brand	0
SL41	Julie	Lee	1

UPDATE

```
UPDATE TableName
SET columnName1 = dataValue1
    [, columnName2 = dataValue2...]
[WHERE searchCondition]
```

- *TableName* can be name of a base table or an updatable view.
- SET clause specifies names of one or more columns that are to be updated.

UPDATE

- WHERE clause is optional:
  - if omitted, named columns are updated for all rows in table;
  - if specified, only those rows that satisfy *searchCondition* are updated.
- New *dataValue(s)* must be compatible with data type for corresponding column.

Example 5.38/39 UPDATE All Rows

Give all staff a 3% pay increase.

```
UPDATE Staff
SET salary = salary*1.03;
```

Give all Managers a 5% pay increase.

```
UPDATE Staff
SET salary = salary*1.05
WHERE position = ‘Manager’;
```

Example 5.40 UPDATE Multiple Columns

Promote David Ford (staffNo='SG14') to Manager and change his salary to £18,000.

```
UPDATE Staff
SET position = 'Manager', salary = 18000
WHERE staffNo = 'SG14';
```

DELETE

```
DELETE FROM TableName
[WHERE searchCondition]
```

- *TableName* can be name of a base table or an updatable view.
- *searchCondition* is optional; if omitted, all rows are deleted from table. This does not delete table. If *search_condition* is specified, only those rows that satisfy condition are deleted.

Example 5.41/42 DELETE Specific Rows

Delete all viewings that relate to property PG4.

```
DELETE FROM Viewing
WHERE propertyNo = ‘PG4’;
```

Delete all records from the Viewing table.

```
DELETE FROM Viewing;
```