CS 422 - DBMS

Lesson 3 - Chapters 6

WHOLENESS OF THE LESSON

SQL is a non-procedural language that can be used by professionals and non-professionals alike. It is both a formal and de facto standard language for defining and manipulating relational databases. Science & Technology of Consciousness: TM is a simple, effortless mental technique that can be used by anyone, no matter what their lifestyle. It promotes spontaneous fulfillment of desires, by bringing the desires of the individual into accord with Natural Law, without the individual having to know the underlying mechanism.

History of SQL (Structured Query Language)

- IBM developed the 1st database language in mid 1970 based on Dr. E.F. Codd's relational model research paper and at that time it was called SEQUEL (Structured English QUEry Language) which was later changed to SQL.
- A DBMS named System-R was also developed during this time followed by DB2 and Sybase.
- In 1979, Relational Software, Inc. (now Oracle Corp.) introduced the first commercially available implementation of SQL called as Oracle V2.
- MS SQL Server was introduced in 1989.

History of SQL (Structured Query Language) contd..

- An ISO and ANSI standard now exists for SQL, making it both the formal and de facto standard language for relational databases. (More than 100 DBMSs now support SQL, running on various h/w platforms)
- The first ANSI standard was given to SQL in 1986 and ISO standard in 1987.
- The latest SQL standard is → SQL:2023
- ISO SQL Standard has 2 major components:
  - A DDL for defining database structure
  - A DML for retrieving and updating data

Introduction to SQL

- SQL is a ***transform-oriented language*** meaning a language designed to use relations to transform inputs into required outputs.
- 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
- Can be used by range of users including DBAs, management, application developers, and other types of end users.

Introduction to SQL contd..

- SQL consists of standard English words.
  Some SQL statement examples are as follows:

1) CREATE TABLE Staff(staffNo VARCHAR(5), lastName VARCHAR(15),
   salary DECIMAL(7,2));

2) INSERT INTO Staff VALUES ('SG16', 'Brown', 8300);

3) SELECT staffNo, lastName, salary
   FROM Staff
   WHERE salary > 10000;

Data Manipulation Language (DML) Statements

- **SELECT –** to query data in the database
- **INSERT –** to insert data into a table
- **UPDATE –** to update data in a table
- **DELETE –** to delete data from a table

SELECT Statement

- The purpose of the SELECT statement is to retrieve and display data from one or more database tables.
- It’s an extremely powerful and most used command capable of performing the equivalent of the relational algebra’s *Selection*, *Projection* and *Join* operations in a single statement!

General Form of SELECT Statement

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

- Only SELECT and FROM are mandatory.

Order of the clauses in a SELECT statement cannot be changed.

Example 6.1 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;**

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 6.2 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;
```

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 6.3 Use of DISTINCT

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

```
SELECT propertyNo
FROM Viewing;
```

Viewing

clientNo	propertyNo	viewDate	comment
CR56	PA14	24-May-13	too small
CR76	PG4	20-Apr-13	too remote
CR56	PG4	26-May-13	
CR62	PA14	14-May-13	no dining room
CR56	PG36	28-Apr-13	

propertyNo
PA14
PG4
PG4
PA14
PG36

- Use DISTINCT to eliminate duplicates
- DISTINCT can be specified only once in a query.

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

propertyNo
PA14
PG4
PG36

Sequence of Processing in a SELECT Statement

FROM **Specifies table(s) to be used**
(Produces result set which is Cartesian product of tables listed in FROM clause)

WHERE **Filters rows subject to some condition**
(Produces result set consisting of rows that satisfy the given condition)

GROUP BY **Forms groups of rows with same column value**

HAVING **Filters the groups subject to some condition**

SELECT **Specifies which columns are to appear in the output**

ORDER BY **Specifies the order of the output**

Example 6.4 Calculated Fields

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

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

Staff

staffNo	fName	lName	position	sex	DOB	salary	branchNo
SL21	John	White	Manager	M	1-Oct-45	30000	B005
SG37	Ann	Beech	Assistant	F	10-Nov-60	12000	B003
SG14	David	Ford	Supervisor	M	24-Mar-58	18000	B003
SA9	Mary	Howe	Assistant	F	19-Feb-70	9000	B007
SG5	Susan	Brand	Manager	F	3-Jun-40	24000	B003
SL41	Julie	Lee	Assistant	F	13-Jun-65	9000	B005

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

- To name column, use AS clause:

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

staffNo	fName	lName	sal
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 6.5 Comparison Search Condition

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

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

Staff

staffNo	fName	lName	position	sex	DOB	salary	branchNo
SL21	John	White	Manager	M	1-Oct-45	30000	B005
SG37	Ann	Beech	Assistant	F	10-Nov-60	12000	B003
SG14	David	Ford	Supervisor	M	24-Mar-58	18000	B003
SA9	Mary	Howe	Assistant	F	19-Feb-70	9000	B007
SG5	Susan	Brand	Manager	F	3-Jun-40	24000	B003
SL41	Julie	Lee	Assistant	F	13-Jun-65	9000	B005

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 6.6 Compound Comparison Search Condition

List addresses of all branch offices in London or Glasgow.

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

Branch

branchNo	street	city	postcode
B005	22 Deer Rd	London	SW1 4EH
B007	16 Argyll St	Aberdeen	AB2 3SU
B003	163 Main St	Glasgow	G11 9QX
B004	32 Manse Rd	Bristol	BS99 1NZ
B002	56 Clover Dr	London	NW10 6EU

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 6.7 Range Search Condition

List all staff with a salary between 20,000 and 30,000.

```
SELECT staffNo, fName, lName, position, salary
FROM Staff
WHERE salary BETWEEN 20000 AND 30000;
```

- **BETWEEN test includes the endpoints of range.**

Staff

staffNo	fName	lName	position	sex	DOB	salary	branchNo
SL21	John	White	Manager	M	1-Oct-45	30000	B005
SG37	Ann	Beech	Assistant	F	10-Nov-60	12000	B003
SG14	David	Ford	Supervisor	M	24-Mar-58	18000	B003
SA9	Mary	Howe	Assistant	F	19-Feb-70	9000	B007
SG5	Susan	Brand	Manager	F	3-Jun-40	24000	B003
SL41	Julie	Lee	Assistant	F	13-Jun-65	9000	B005

staffNo	fName	lName	position	salary
SL21	John	White	Manager	30000.00
SG5	Susan	Brand	Manager	24000.00

Example 6.8 Set Membership (search condition)

List all managers and supervisors.

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

OR

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

There is a negated version (NOT IN).

Staff

staffNo	fName	lName	position	sex	DOB	salary	branchNo
SL21	John	White	Manager	M	1-Oct-45	30000	B005
SG37	Ann	Beech	Assistant	F	10-Nov-60	12000	B003
SG14	David	Ford	Supervisor	M	24-Mar-58	18000	B003
SA9	Mary	Howe	Assistant	F	19-Feb-70	9000	B007
SG5	Susan	Brand	Manager	F	3-Jun-40	24000	B003
SL41	Julie	Lee	Assistant	F	13-Jun-65	9000	B005

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

Example 6.9 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 6.9 Pattern Matching (search condition)

Find all owners with the string 'Glasgow' in their address.

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

PrivateOwner

ownerNo	fName	lName	address	telNo	branchNo
CO46	Joe	Keogh	2 Fergus Dr, Aberdeen AB2 7SX	01224-861212	B007
CO87	Carol	Farrel	6 Achray St, Glasgow G32 9DX	0141-357-7419	B003
CO40	Tina	Murphy	63 Well St, Glasgow G42	0141-943-1728	B003
CO93	Tony	Shaw	12 Park Pl, Glasgow G4 0QR	0141-225-7025	B003

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 6.10 NULL Search Condition

- **List details of all viewings on property PG4 where a comment has not been supplied.**
- There are 2 viewings for property PG4, one with and one without a comment.
- Have to test for null explicitly using special keyword *IS NULL*:

SELECT clientNo, viewDate FROM Viewing
WHERE propertyNo = 'PG4' AND comment IS NULL;

Viewing

clientNo	propertyNo	viewDate	comment
CR56	PA14	24-May-13	too small
CR76	PG4	20-Apr-13	too remote
CR56	PG4	26-May-13	
CR62	PA14	14-May-13	no dining room
CR56	PG36	28-Apr-13	

clientNo	viewDate
CR56	26-May-04

Negated version (IS NOT NULL) can test for non-null values.

Example 6.11 Single Column Ordering (Sorting)

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

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

Staff

staffNo	fName	lName	position	sex	DOB	salary	branchNo
SL21	John	White	Manager	M	1-Oct-45	30000	B005
SG37	Ann	Beech	Assistant	F	10-Nov-60	12000	B003
SG14	David	Ford	Supervisor	M	24-Mar-58	18000	B003
SA9	Mary	Howe	Assistant	F	19-Feb-70	9000	B007
SG5	Susan	Brand	Manager	F	3-Jun-40	24000	B003
SL41	Julie	Lee	Assistant	F	13-Jun-65	9000	B005

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 6.12 Multiple Column Ordering

Produce abbreviated list of properties in order of property type.

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

PropertyForRent

propertyNo	street	city	postcode	type	rooms	rent	ownerNo	staffNo	branchNo
PA14	16 Holhead	Aberdeen	AB7 5SU	House	6	650	CO46	SA9	B007
PL94	6 Argyll St	London	NW2	Flat	4	400	CO87	SL41	B005
PG4	6 Lawrence St	Glasgow	G11 9QX	Flat	3	350	CO40		B003
PG36	2 Manor Rd	Glasgow	G32 4QX	Flat	3	375	CO93	SG37	B003
PG21	18 Dale Rd	Glasgow	G12	House	5	600	CO87	SG37	B003
PG16	5 Novar Dr	Glasgow	G12 9AX	Flat	4	450	CO93	SG14	B003

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 6.12 Multiple Column Ordering

- Four flats in this list - as no minor sort key specified, system arranges these rows in any order it chooses.

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

- **To arrange in order of rent, specify minor order:**

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

PropertyForRent

propertyNo	street	city	postcode	type	rooms	rent	ownerNo	staffNo	branchNo
PA14	16 Holhead	Aberdeen	AB7 5SU	House	6	650	CO46	SA9	B007
PL94	6 Argyll St	London	NW2	Flat	4	400	CO87	SL41	B005
PG4	6 Lawrence St	Glasgow	G11 9QX	Flat	3	350	CO40		B003
PG36	2 Manor Rd	Glasgow	G32 4QX	Flat	3	375	CO93	SG37	B003
PG21	18 Dale Rd	Glasgow	G12	House	5	600	CO87	SG37	B003
PG16	5 Novar Dr	Glasgow	G12 9AX	Flat	4	450	CO93	SG14	B003

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

- While retrieving rows and columns from the database, we often want to perform summation or aggregation of data, similar to totals at the bottom of a report.
- 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 contd…

- 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.
- COUNT(*) counts all rows of a table, regardless of whether nulls or duplicate values occur.
- Apart from COUNT(*), each function eliminates nulls first and operates only on remaining non-null values.
- Can use DISTINCT before column name to eliminate duplicates.
- DISTINCT has no effect with MIN/MAX, but may have with SUM/AVG.

Example 6.13 Use of COUNT(*)

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

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

PropertyForRent

propertyNo	street	city	postcode	type	rooms	rent	ownerNo	staffNo	branchNo
PA14	16 Holhead	Aberdeen	AB7 5SU	House	6	650	CO46	SA9	B007
PL94	6 Argyll St	London	NW2	Flat	4	400	CO87	SL41	B005
PG4	6 Lawrence St	Glasgow	G11 9QX	Flat	3	350	CO40		B003
PG36	2 Manor Rd	Glasgow	G32 4QX	Flat	3	375	CO93	SG37	B003
PG21	18 Dale Rd	Glasgow	G12	House	5	600	CO87	SG37	B003
PG16	5 Novar Dr	Glasgow	G12 9AX	Flat	4	450	CO93	SG14	B003

myCount
5

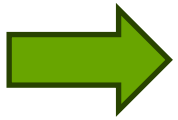
Example 6.14 Use of COUNT(DISTINCT)

How many different properties viewed in May'13?

```
SELECT COUNT(DISTINCT propertyNo) AS myCount
FROM Viewing
WHERE viewDate BETWEEN '1-May-13'
                   AND '31-May-13';
```

Viewing

clientNo	propertyNo	viewDate	comment
CR56	PA14	24-May-13	too small
CR76	PG4	20-Apr-13	too remote
CR56	PG4	26-May-13	
CR62	PA14	14-May-13	no dining room
CR56	PG36	28-Apr-13	



myCount
2

Example 6.15 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';
```

Staff

staffNo	fName	lName	position	sex	DOB	salary	branchNo
SL21	John	White	Manager	M	1-Oct-45	30000	B005
SG37	Ann	Beech	Assistant	F	10-Nov-60	12000	B003
SG14	David	Ford	Supervisor	M	24-Mar-58	18000	B003
SA9	Mary	Howe	Assistant	F	19-Feb-70	9000	B007
SG5	Susan	Brand	Manager	F	3-Jun-40	24000	B003
SL41	Julie	Lee	Assistant	F	13-Jun-65	9000	B005

myCount	mySum
2	54000.00

Example 6.16 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;
```

Staff

staffNo	fName	lName	position	sex	DOB	salary	branchNo
SL21	John	White	Manager	M	1-Oct-45	30000	B005
SG37	Ann	Beech	Assistant	F	10-Nov-60	12000	B003
SG14	David	Ford	Supervisor	M	24-Mar-58	18000	B003
SA9	Mary	Howe	Assistant	F	19-Feb-70	9000	B007
SG5	Susan	Brand	Manager	F	3-Jun-40	24000	B003
SL41	Julie	Lee	Assistant	F	13-Jun-65	9000	B005

myMin	myMax	myAvg
9000.00	30000.00	17000.00

Example 6.17 Use of GROUP BY

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

```
SELECT branchNo,
    COUNT(*) AS staffCount,
    SUM(salary) AS sumOfSalary
FROM Staff
GROUP BY branchNo
ORDER BY branchNo;
```

Staff

staffNo	fName	lName	position	sex	DOB	salary	branchNo
SL21	John	White	Manager	M	1-Oct-45	30000	B005
SG37	Ann	Beech	Assistant	F	10-Nov-60	12000	B003
SG14	David	Ford	Supervisor	M	24-Mar-58	18000	B003
SA9	Mary	Howe	Assistant	F	19-Feb-70	9000	B007
SG5	Susan	Brand	Manager	F	3-Jun-40	24000	B003
SL41	Julie	Lee	Assistant	F	13-Jun-65	9000	B005

branchNo	staffCount	sumOfSalary
B003	3	62400
B005	2	39800
B007	1	9800

Use GROUP BY clause to get sub-totals in reports.

SELECT Statement - Grouping

- SELECT and GROUP BY are closely integrated. When GROUP BY is used, each item in the SELECT list must be "single-valued per group”.
- All column names in SELECT list must appear in GROUP BY clause unless that column name is used only in an aggregate function.
- When GROUP BY is used, the SELECT clause may only contain:
  - column names
  - aggregate functions
  - constants
  - expression involving combinations of the above
- If WHERE is used with GROUP BY, WHERE is applied first, then groups are formed from remaining rows satisfying predicate.
- If the GROUP BY clause is omitted when an aggregate function is used, then the entire table is considered as one group, and the aggregate function displays a single value for the entire table.

Example 6.18 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;
```

Staff

staffNo	fName	lName	position	sex	DOB	salary	branchNo
SL21	John	White	Manager	M	1-Oct-45	30000	B005
SG37	Ann	Beech	Assistant	F	10-Nov-60	12000	B003
SG14	David	Ford	Supervisor	M	24-Mar-58	18000	B003
SA9	Mary	Howe	Assistant	F	19-Feb-70	9000	B007
SG5	Susan	Brand	Manager	F	3-Jun-40	24000	B003
SL41	Julie	Lee	Assistant	F	13-Jun-65	9000	B005

branchNo	myCount	mySum
B003	3	54000.00
B005	2	39000.00

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.**
- Column names in HAVING clause must also appear in the GROUP BY list or they should be contained within an aggregate function.
- Search condition in the HAVING clause always includes at least one aggregate function; otherwise the search condition could be moved to the WHERE clause and applied to individual rows.

SELECT Statement - Aggregates

- Aggregate functions "cannot" be used in the WHERE clause. (WHERE sal > AVG(sal) is wrong!)
- **Aggregate functions can be used only in SELECT list and in HAVING clause.**
- If SELECT list includes an aggregate function and there is no GROUP BY clause, then SELECT list **cannot** include some other column as well as that aggregate function.
  - For example, the following is illegal:

```
SELECT staffNo, COUNT(salary)  FROM Staff;
```

X

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 6.19 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');
```

Branch

branchNo	street	city	postcode
B005	22 Deer Rd	London	SW1 4EH
B007	16 Argyll St	Aberdeen	AB2 3SU
B003	163 Main St	Glasgow	G11 9QX
B004	32 Manse Rd	Bristol	BS99 1NZ
B002	56 Clover Dr	London	NW10 6EU

Staff

staffNo	fName	lName	position	sex	DOB	salary	branchNo
SL21	John	White	Manager	M	1-Oct-45	30000	B005
SG37	Ann	Beech	Assistant	F	10-Nov-60	12000	B003
SG14	David	Ford	Supervisor	M	24-Mar-58	18000	B003
SA9	Mary	Howe	Assistant	F	19-Feb-70	9000	B007
SG5	Susan	Brand	Manager	F	3-Jun-40	24000	B003
SL41	Julie	Lee	Assistant	F	13-Jun-65	9000	B005

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

Example 6.19 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';
```

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

Example 6.20 Subquery with Aggregate

List all staff whose salary is greater than the average salary and show by how much.

```
SELECT staffNo, fName, lName, position,
  (salary - (SELECT AVG(salary) FROM Staff)) As SalDiff
FROM Staff
WHERE salary > (SELECT AVG(salary) FROM Staff);
```

staffNo	fName	lName	position	salDiff
SL21	John	White	Manager	13000.00
SG14	David	Ford	Supervisor	1000.00
SG5	Susan	Brand	Manager	7000.00

Example 6.20 Subquery with Aggregate

- Cannot write 'WHERE salary > AVG(salary)'
- Instead, use subquery to find average salary (17000), and then use outer SELECT to find those staff with salary greater than this:

```
SELECT staffNo, fName, lName, position,
    salary – 17000 As salDiff
FROM Staff
WHERE salary > 17000;
```

staffNo	fName	lName	position	salDiff
SL21	John	White	Manager	13000.00
SG14	David	Ford	Supervisor	1000.00
SG5	Susan	Brand	Manager	7000.00

Example 6.21 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'));
```

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

Example 6.22 Use of ANY/SOME

Find staff whose salary is larger than salary of at least one member of staff at branch B003.

```
SELECT staffNo, fName, lName,
       position, salary
FROM Staff
WHERE salary > ANY
      (SELECT salary
       FROM Staff
       WHERE branchNo = 'B003');
```

Staff

staffNo	fName	lName	position	sex	DOB	salary	branchNo
SL21	John	White	Manager	M	1-Oct-45	30000	B005
SG37	Ann	Beech	Assistant	F	10-Nov-60	12000	B003
SG14	David	Ford	Supervisor	M	24-Mar-58	18000	B003
SA9	Mary	Howe	Assistant	F	19-Feb-70	9000	B007
SG5	Susan	Brand	Manager	F	3-Jun-40	24000	B003
SL41	Julie	Lee	Assistant	F	13-Jun-65	9000	B005

staffNo	fName	lName	position	salary
SL21	John	White	Manager	30000.00
SG14	David	Ford	Supervisor	18000.00
SG5	Susan	Brand	Manager	24000.00

Inner query produces set {12000, 18000, 24000} and outer query selects those staff whose salaries are greater than any of the values in this set.

Multi-Table Queries

- Can use subqueries provided result columns come from same table.
- If result columns come from more than one table then 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).
- 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 6.24 Simple Join (Inner 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;
```

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

- 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.

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 Client c INNER JOIN Viewing v
                    ON c.clientNo = v.clientNo
```

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.
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.

Example 6.25 Sorting a join

- For each branch, list numbers and names of staff who manage properties, and properties that 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;
```

Staff

staffNo	fName	lName	position	sex	DOB	salary	branchNo
SL21	John	White	Manager	M	1-Oct-45	30000	B005
SG37	Ann	Beech	Assistant	F	10-Nov-60	12000	B003
SG14	David	Ford	Supervisor	M	24-Mar-58	18000	B003
SA9	Mary	Howe	Assistant	F	19-Feb-70	9000	B007
SG5	Susan	Brand	Manager	F	3-Jun-40	24000	B003
SL41	Julie	Lee	Assistant	F	13-Jun-65	9000	B005

PropertyForRent

propertyNo	street	city	postcode	type	rooms	rent	ownerNo	staffNo	branchNo
PA14	16 Holhead	Aberdeen	AB7 5SU	House	6	650	CO46	SA9	B007
PL94	6 Argyll St	London	NW2	Flat	4	400	CO87	SL41	B005
PG4	6 Lawrence St	Glasgow	G11 9QX	Flat	3	350	CO40		B003
PG36	2 Manor Rd	Glasgow	G32 4QX	Flat	3	375	CO93	SG37	B003
PG21	18 Dale Rd	Glasgow	G12	House	5	600	CO87	SG37	B003
PG16	5 Novar Dr	Glasgow	G12 9AX	Flat	4	450	CO93	SG14	B003

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 6.26 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;
```

Branch

branchNo	street	city	postcode
B005	22 Deer Rd	London	SW1 4EH
B007	16 Argyll St	Aberdeen	AB2 3SU
B003	163 Main St	Glasgow	G11 9QX
B004	32 Manse Rd	Bristol	BS99 1NZ
B002	56 Clover Dr	London	NW10 6EU

Staff

staffNo	fName	lName	position	sex	DOB	salary	branchNo
SL21	John	White	Manager	M	1-Oct-45	30000	B005
SG37	Ann	Beech	Assistant	F	10-Nov-60	12000	B003
SG14	David	Ford	Supervisor	M	24-Mar-58	18000	B003
SA9	Mary	Howe	Assistant	F	19-Feb-70	9000	B007
SG5	Susan	Brand	Manager	F	3-Jun-40	24000	B003
SL41	Julie	Lee	Assistant	F	13-Jun-65	9000	B005

PropertyForRent

propertyNo	street	city	postcode	type	rooms	rent	ownerNo	staffNo	branchNo
PA14	16 Holhead	Aberdeen	AB7 5SU	House	6	650	CO46	SA9	B007
PL94	6 Argyll St	London	NW2	Flat	4	400	CO87	SL41	B005
PG4	6 Lawrence St	Glasgow	G11 9QX	Flat	3	350	CO40		B003
PG36	2 Manor Rd	Glasgow	G32 4QX	Flat	3	375	CO93	SG37	B003
PG21	18 Dale Rd	Glasgow	G12	House	5	600	CO87	SG37	B003
PG16	5 Novar Dr	Glasgow	G12 9AX	Flat	4	450	CO93	SG14	B003

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

Example 6.27 Multiple Grouping Columns

Find number of properties handled by each staff member. Show the branch number as well.

```
SELECT s.branchNo, s.staffNo, COUNT(*) AS myCount
  FROM Staff s, PropertyForRent p
  WHERE s.staffNo = p.staffNo
  GROUP BY s.branchNo, s.staffNo
  ORDER BY s.branchNo, s.staffNo;
```

branchNo	staffNo	myCount
B003	SG14	1
B003	SG37	2
B005	SL41	1
B007	SA9	1

PropertyForRent

propertyNo	street	city	postcode	type	rooms	rent	ownerNo	staffNo	branchNo
PA14	16 Holhead	Aberdeen	AB7 5SU	House	6	650	CO46	SA9	B007
PL94	6 Argyll St	London	NW2	Flat	4	400	CO87	SL41	B005
PG4	6 Lawrence St	Glasgow	G11 9QX	Flat	3	350	CO40		B003
PG36	2 Manor Rd	Glasgow	G32 4QX	Flat	3	375	CO93	SG37	B003
PG21	18 Dale Rd	Glasgow	G12	House	5	600	CO87	SG37	B003
PG16	5 Novar Dr	Glasgow	G12 9AX	Flat	4	450	CO93	SG14	B003

Staff

staffNo	fName	lName	position	sex	DOB	salary	branchNo
SL21	John	White	Manager	M	1-Oct-45	30000	B005
SG37	Ann	Beech	Assistant	F	10-Nov-60	12000	B003
SG14	David	Ford	Supervisor	M	24-Mar-58	18000	B003
SA9	Mary	Howe	Assistant	F	19-Feb-70	9000	B007
SG5	Susan	Brand	Manager	F	3-Jun-40	24000	B003
SL41	Julie	Lee	Assistant	F	13-Jun-65	9000	B005

Outer Joins

- In Inner join, 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 these tables:
- The (inner) join of these two tables:

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

Branch1

branchNo	bCity
B003	Glasgow
B004	Bristol
B002	London

PropertyForRent1

propertyNo	pCity
PA14	Aberdeen
PL94	London
PG4	Glasgow

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 the branch in Bristol and the property in Aberdeen.
- To include unmatched rows in result table, use an Outer join.

Branch1

branchNo	bCity
B003	Glasgow
B004	Bristol
B002	London

PropertyForRent1

propertyNo	pCity
PA14	Aberdeen
PL94	London
PG4	Glasgow

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

Example 6.28 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;
```

Branch1

branchNo	bCity
B003	Glasgow
B004	Bristol
B002	London

PropertyForRent1

propertyNo	pCity
PA14	Aberdeen
PL94	London
PG4	Glasgow

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

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

Example 6.29 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;
```

Branch1

branchNo	bCity
B003	Glasgow
B004	Bristol
B002	London

PropertyForRent1

propertyNo	pCity
PA14	Aberdeen
PL94	London
PG4	Glasgow

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

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.

Example 6.30 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;
```

Branch1

branchNo	bCity
B003	Glasgow
B004	Bristol
B002	London

PropertyForRent1

propertyNo	pCity
PA14	Aberdeen
PL94	London
PG4	Glasgow

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

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

Example 6.31 Query using EXISTS

Find all staff who work in a London branch.

```
SELECT staffNo, fName, lName, position
FROM Staff s
WHERE EXISTS
    (SELECT * FROM Branch b
        WHERE s.branchNo = b.branchNo AND
                city = 'London');
```

staffNo	fName	lName	position
SL21	John	White	Manager
SL41	Julie	Lee	Assistant

EXISTS and NOT EXISTS

- EXISTS and NOT EXISTS are for use only with subqueries.
- Produce a simple true/false result.
  - True if and only if there exists at least one row in result table returned by subquery.
  - False if subquery returns an empty result table.
- NOT EXISTS is the opposite of EXISTS.
- As (NOT) EXISTS check only for existence or non-existence of rows in subquery result table, subquery can contain any number of columns.
- Common for subqueries following (NOT) EXISTS to be of form:
  (SELECT * ...)

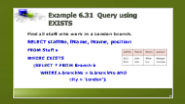
Example 6.31 Query using EXISTS

- Note, search condition s.branchNo = b.branchNo is necessary to consider correct branch record for each member of staff.
- If omitted, would get all staff records listed out because subquery:

```
SELECT * FROM Branch WHERE city='London'
```

would always be true and query would be:

```
SELECT staffNo, fName, lName, position FROM Staff
WHERE true;
```



Example 6.31 Query using EXISTS

- Could also write this query using join construct:

```
SELECT staffNo, fName, lName, position
FROM Staff s, Branch b
WHERE s.branchNo = b.branchNo AND
                   city = '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.

Example 6.32 Use of UNION

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

```
(SELECT city FROM Branch
WHERE city IS NOT NULL)
UNION
(SELECT city FROM PropertyForRent
WHERE city IS NOT NULL);
```

Branch

branchNo	street	city	postcode
B005	22 Deer Rd	London	SW1 4EH
B007	16 Argyll St	Aberdeen	AB2 3SU
B003	163 Main St	Glasgow	G11 9QX
B004	32 Manse Rd	Bristol	BS99 1NZ
B002	56 Clover Dr	London	NW10 6EU

city
London
Glasgow
Aberdeen
Bristol

PropertyForRent

propertyNo	street	city	postcode	type	rooms	rent	ownerNo	staffNo	branchNo
PA14	16 Holhead	Aberdeen	AB7 5SU	House	6	650	CO46	SA9	B007
PL94	6 Argyll St	London	NW2	Flat	4	400	CO87	SL41	B005
PG4	6 Lawrence St	Glasgow	G11 9QX	Flat	3	350	CO40		B003
PG36	2 Manor Rd	Glasgow	G32 4QX	Flat	3	375	CO93	SG37	B003
PG21	18 Dale Rd	Glasgow	G12	House	5	600	CO87	SG37	B003
PG16	5 Novar Dr	Glasgow	G12 9AX	Flat	4	450	CO93	SG14	B003

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

Example 6.34 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);
```

Branch

branchNo	street	city	postcode
B005	22 Deer Rd	London	SW1 4EH
B007	16 Argyll St	Aberdeen	AB2 3SU
B003	163 Main St	Glasgow	G11 9QX
B004	32 Manse Rd	Bristol	BS99 1NZ
B002	56 Clover Dr	London	NW10 6EU

PropertyForRent

propertyNo	street	city	postcode	type	rooms	rent	ownerNo	staffNo	branchNo
PA14	16 Holhead	Aberdeen	AB7 5SU	House	6	650	CO46	SA9	B007
PL94	6 Argyll St	London	NW2	Flat	4	400	CO87	SL41	B005
PG4	6 Lawrence St	Glasgow	G11 9QX	Flat	3	350	CO40		B003
PG36	2 Manor Rd	Glasgow	G32 4QX	Flat	3	375	CO93	SG37	B003
PG21	18 Dale Rd	Glasgow	G12	House	5	600	CO87	SG37	B003
PG16	5 Novar Dr	Glasgow	G12 9AX	Flat	4	450	CO93	SG14	B003

city
Bristol

Example 6.34 Use of EXCEPT

- Could rewrite this query without EXCEPT:

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

- Or

```
SELECT DISTINCT city FROM Branch b
WHERE NOT EXISTS
        (SELECT * FROM PropertyForRent p
                WHERE p.city = b.city);
```

Example 6.33 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);
```

city
Aberdeen
Glasgow
London

Example 6.33 Use of INTERSECT

- Could rewrite this query without INTERSECT operator:

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

- Or:

```
SELECT DISTINCT city FROM Branch b
WHERE EXISTS
  (SELECT * FROM PropertyForRent p
     WHERE p.city = b.city);
```