

# Where did SQL come from?

As mentioned earlier, SQL is an implementation of [Ed Codd's relational set operators](#):

1. SELECT [formerly known as RESTRICT]
2. PROJECT
3. JOIN
4. PRODUCT
5. UNION
6. INTERSECT
7. DIFFERENCE
8. DIVIDE

Interestingly, Ed's ideas were ignored by IBM, his employer. Only after Oracle debuted (with SQL support right off the bat!) did IBM create DB2, its first relational DB.

## Structured Query Language (SQL)

- Categories of SQL function
  - Data definition language (DDL)
  - Data manipulation language (DML)
- Nonprocedural language with basic command vocabulary set of less than 100 words
- Differences in SQL dialects are minor

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Table 7.1 - SQL Data Definition Command	
COMMAND OR OPTION	DESCRIPTION
CREATE SCHEMA AUTHORIZATION	Creates a database schema
CREATE TABLE	Creates a new table in the user's database schema
NOT NULL	Ensures that a column will not have null values
UNIQUE	Ensures that a column will not have duplicate values
PRIMARY KEY	Defines a primary key for a table
FOREIGN KEY	Defines a foreign key for a table
DEFAULT	Defines a default value for a column (when no value is given)
CHECK	Validates data in an attribute
CREATE INDEX	Creates an index for a table
CREATE VIEW	Creates a dynamic subset of rows and columns from one or more tables (see Chapter 8, Advanced SQL)
ALTER TABLE	Modifies a table's definition (adds, modifies, or deletes attributes or constraints)
CREATE TABLE AS	Creates a new table based on a query in the user's database schema
DROP TABLE	Permanently deletes a table (and its data)
DROP INDEX	Permanently deletes an index
DROP VIEW	Permanently deletes a view

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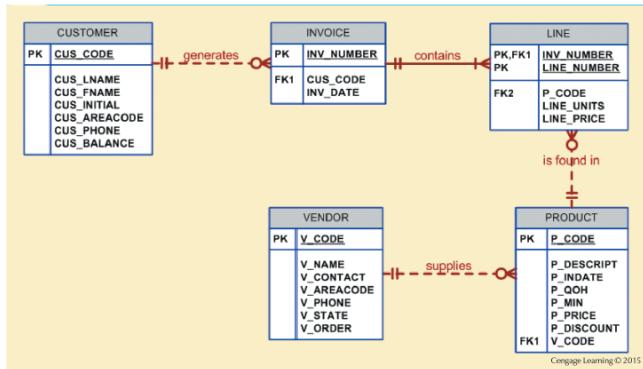
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## Table 7.2 - SQL Data Manipulation Commands

COMMAND OR OPTION	DESCRIPTION
INSERT	Inserts rows into a table
SELECT	Selects attributes from rows in one or more tables or views
WHERE	Restricts the selection of rows based on a conditional expression
GROUP BY	Groups the selected rows based on one or more attributes
HAVING	Restricts the selection of grouped rows based on a condition
ORDER BY	Orders the selected rows based on one or more attributes
UPDATE	Modifies an attribute's values in one or more table's rows
DELETE	Deletes one or more rows from a table
COMMIT	Permanently saves data changes
ROLLBACK	Restores data to their original values
<b>Comparison operators</b>	
=, <, >, <=, >=, <>	Used in conditional expressions
<b>Logical operators</b>	
AND/OR/NOT	Used in conditional expressions
<b>Special operators</b>	
BETWEEN	Checks whether an attribute value is within a range
IS NULL	Checks whether an attribute value is null
LIKE	Checks whether an attribute value matches a given string pattern
IN	Checks whether an attribute value matches any value within a value list
EXISTS	Checks whether a subquery returns any rows
DISTINCT	Limits values to unique values
<b>Aggregate functions</b>	
COUNT	Used with SELECT to return mathematical summaries on columns
MIN	Returns the number of rows with non-null values for a given column
MAX	Returns the minimum attribute value found in a given column
SUM	Returns the maximum attribute value found in a given column
AVG	Returns the sum of all values for a given column
	Returns the average of all values for a given column

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Figure 7.1 - The Database Model



## Common SQL Data Types

- Numeric
  - NUMBER(L,D) or NUMERIC(L,D)
- Character
  - CHAR(L)
  - VARCHAR(L) or VARCHAR2(L)
- Date
  - DATE

char vs VARCHAR (reserved for future use by SQL - so don't use!) vs VARCHAR2 [versus NVARCHAR2 (for Unicode)]:  
[http://www.orafaq.com/faq/what\\_is\\_the\\_difference\\_between\\_varchar\\_varchar2\\_and\\_nvarchar\\_nvarchar2](http://www.orafaq.com/faq/what_is_the_difference_between_varchar_varchar2_and_nvarchar_nvarchar2)

## Creating Table Structures

- Use one line per column (attribute) definition
- Use spaces to line up attribute characteristics and constraints
- Table and attribute names are capitalized
- Features of table creating command sequence
  - NOT NULL specification
  - UNIQUE specification
- Syntax to create table
  - CREATE TABLE tablename();

## Primary Key and Foreign Key

- Primary key attributes contain both a NOT NULL and a UNIQUE specification
- RDBMS will automatically enforce referential integrity for foreign keys
- Command sequence ends with semicolon
- ANSI SQL allows use of following clauses to cover CASCADE, SET NULL, or SET DEFAULT
  - ON DELETE and ON UPDATE

```
CREATE TABLE PRODUCT (
    P_CODE      VARCHAR(10)      NOT NULL      UNIQUE,
    P_DESCRPT  VARCHAR(35)      NOT NULL,
    P_INDATE   DATE            NOT NULL,
    P_QOH      SMALLINT        NOT NULL,
    P_MIN      SMALLINT        NOT NULL,
    P_PRICE    NUMBER(8,2)      NOT NULL,
    P_DISCOUNT NUMBER(5,2)      NOT NULL,
    V_CODE     INTEGER,
    PRIMARY KEY (P_CODE),
    FOREIGN KEY (V_CODE) REFERENCES VENDOR ON UPDATE
    CASCADE);
```

## SQL Constraints

### NOT NULL

- Ensures that column does not accept nulls

### UNIQUE

- Ensures that all values in column are unique

### DEFAULT

- Assigns value to attribute when a new row is added to table

### CHECK

- Validates data when attribute value is entered

Plus: ON UPDATE CASCADE and ON DELETE CASCADE - both affect [change] a secondary table (that has an FK), when a change is made in the primary table (with the corresponding PK). ON UPDATE will update the values in the secondary table when corresp. values in the primary table are changed; ON DELETE will delete rows in the secondary table, when linked rows are deleted in the primary table.

## Data Manipulation Commands

INSERT, SELECT, COMMIT, UPDATE, ROLLBACK, and DELETE.

### INSERT: Command to insert data into table

- Syntax - INSERT INTO tablename VALUES();
- Used to add table rows with NULL and NOT NULL attributes

### COMMIT: Command to save changes

- Syntax - COMMIT [WORK];
- Ensures database update integrity

```
INSERT INTO VENDOR VALUES (21225,'Bryson, Inc.');"Smithson'615';223-3234'TN'Y');
INSERT INTO VENDOR VALUES (21226,'Superloo, Inc.';'Flushing"904;"215-8995'FL'N');

INSERT INTO PRODUCT VALUES ('11QER/31'Power painter, 15 psi., 3-nozzle';03-Nov-13';8,5,109.99,0.00,25595);
INSERT INTO PRODUCT VALUES ('13-Q2/P2'7.25-in. pwr. saw blade';13-Dec-13';32,15,14.99,0.05, 21344);

INSERT INTO PRODUCT VALUES ('BRT-345';Titanium drill bit';18-Oct-13', 75, 10, 4.50, 0.06, NULL);

INSERT INTO PRODUCT(P_CODE, P_DESCRPT) VALUES ('BRT-345';Titanium drill bit');
```

Vaguely similar to parameter passing/matching during a function call [where arguments need to match in position, type, count].

## Data Manipulation Commands

### SELECT: Command to list the contents

- Syntax - `SELECT columnlist FROM tablename;`
- **Wildcard character(\*)**: Substitute for other characters/command

### UPDATE: Command to modify data

- Syntax - `UPDATE tablename SET columnname = expression [, columnname = expression] [WHERE conditionlist];`

```
SELECT * FROM
PRODUCT;

SELECT P.CODE, P_DESCRIPT, P_INDATE, P_QOH, P_MIN, P_PRICE, P_DISCOUNT,
V.CODE
FROM PRODUCT;

UPDATE PRODUCT
SET P_INDATE =
'18-JAN-2014'
WHERE P_CODE = '13-Q2/P2';

UPDATE PRODUCT
SET P_INDATE = '18-JAN-2014', P_PRICE = 17.99, P_MIN
= 10
WHERE P_CODE = '13-Q2/P2';
```

SELECT operates on 1 or more columns, and 0 or more rows from 1 or more tables - like many SQL commands, it is **set-oriented** and **non procedural**.

UPDATE modifies one or more columns of a table (on all rows, or on specific rows based on a condition specified by WHERE). [Here](#) is more.

## Data Manipulation Commands

### WHERE condition

- Specifies the rows to be selected

### ROLLBACK: Command to restore the database

- Syntax - ROLLBACK;
- Undoes the changes since last COMMIT command

### DELETE: Command to delete

- Syntax - DELETE FROM *tablename*
  - [WHERE *conditionlist*];

```
DELETE FROM PRODUCT  
WHERE P_CODE = 'BRT-345';
```

Another ex: DELETE FROM PRODUCT WHERE P\_MIN=5; (can be any condition on any attribute).

Q: what would DELETE do, if there isn't a WHERE condition?

## Inserting Table Rows with a SELECT Subquery

- Syntax
  - `INSERT INTO tablename SELECT columnlist FROM tablename`
- Used to add multiple rows using another table as source
- SELECT command - Acts as a subquery and is executed first
  - **Subquery:** Query embedded/nested inside another query

```
INSERT INTO      SELECT      FROM





```

## Selecting Rows Using Conditional Restrictions

- Following syntax enables to specify which rows to select
  - `SELECT columnlist`
  - `FROM tablelist`
  - `[WHERE conditionlist];`
- Used to select partial table contents by placing restrictions on the rows
- Optional WHERE clause
  - Adds conditional restrictions to the SELECT statement

```
SELECT    columnlist
FROM      tablelist
[WHERE    conditionlist
];

```

## Comparison Operators

- Add conditional restrictions on selected table contents
- Used on:
  - Character attributes
  - Dates

**Table 7.6 - Comparison Operators**

SYMBOL	MEANING
=	Equal to
<	Less than
<=	Less than or equal to
>	Greater than
>=	Greater than or equal to
<> or !=	Not equal to

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## Comparison Operators: Computed Columns and Column Aliases

- SQL accepts any valid expressions/formulas in the computed columns
- **Alias:** Alternate name given to a column or table in any SQL statement to improve the readability
- Computed column, an alias, and date arithmetic can be used in a single query

```
SELECT      P_DESCRIP, P_QOH, P_PRICE, P_QOH *  
            P_PRICE  
FROM        PRODUCT
```

P_DESCRIP	P_QOH	P_PRICE	Expr1
Power painter, 15 psi., 3-nozzle	8	109.99	879.92
7.25-in. pwr. saw blade	32	14.99	479.68
9.00-in. pwr. saw blade	18	17.49	314.82
Hrd. cloth, 1/4-in., 2x50	15	39.95	599.25
Hrd. cloth, 1/2-in., 3x50	23	43.99	1011.77
B&D jigsaw, 12-in. blade	8	109.92	879.36
B&D jigsaw, 8-in. blade	6	99.87	599.22
B&D cordless drill, 1/2-in.	12	38.95	467.40
Claw hammer	23	9.95	228.85
Sledge hammer, 12 lb.	8	14.40	115.20
Rat-tail file, 1/8-in. fine	43	4.99	214.57
Hicut chain saw, 16 in.	11	256.99	2826.89
PVC pipe, 3.5-in., 8-ft	188	5.87	1103.56
1.25-in. metal screw, 25	172	6.99	1202.28
2.5-in. wd. screw, 50	237	8.45	2002.65
Steel matting, 4'x8'x1/6", .5" mesh	18	119.95	2159.10

```
SELECT      P_DESCRIP, P_QOH, P_PRICE, P_QOH * P_PRICE AS TOTVALUE  
FROM        PRODUCT;
```

P_DESCRPT	P_QOH	P_PRICE	TOTVALUE
Power painter, 15 psi., 3-nozzle	8	109.99	879.92
7.25-in. pwr. saw blade	32	14.99	479.68
9.00-in. pwr. saw blade	18	17.49	314.82
Hrd. cloth, 1/4-in., 2x50	15	39.95	599.25
Hrd. cloth, 1/2-in., 3x50	23	43.99	1011.77
B&D jigsaw, 12-in. blade	8	109.92	879.36
B&D jigsaw, 8-in. blade	6	99.87	599.22
B&D cordless drill, 1/2-in.	12	38.95	467.40
Claw hammer	23	9.95	228.85
Sledge hammer, 12 lb.	8	14.40	115.20
Rat-tail file, 1/8-in. fine	43	4.99	214.57
Hicut chain saw, 16 in.	11	256.99	2826.89
PVC pipe, 3.5-in., 8-ft	188	5.87	1103.56
1.25-in. metal screw, 25	172	6.99	1202.28
2.5-in. wd. screw, 50	237	8.45	2002.65
Steel matting, 4'x8'x1/6", .5" mesh	18	119.95	2159.10

```
SELECT      P_CODE, P_INDATE, P_INDATE + 90 AS EXPDATE
FROM        PRODUCT;
```

## Arithmetic operators

- **The Rule of Precedence:** Establish the order in which computations are completed
- Perform:
  - Operations within parentheses
  - Power operations
  - Multiplications and divisions
  - Additions and subtractions

**Table 7.7 - The Arithmetic Operators**

ARITHMETIC OPERATOR	DESCRIPTION
+	Add
-	Subtract
*	Multiply
/	Divide
<sup>^</sup>	Raise to the power of (some applications use $\text{**}$ instead of $\wedge$ )

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Figure 7.12 - Selected PRODUCT Table  
Attributes: The logical OR

P_DESCRIP	P_INDATE	P_PRICE	V_CODE
7.25-in. pwr. saw blade	13-Dec-13	14.99	21344
9.00-in. pwr. saw blade	13-Nov-13	17.49	21344
B&D jigsaw, 12-in. blade	30-Dec-13	109.92	24288
B&D jigsaw, 8-in. blade	24-Dec-13	99.87	24288
Rat-tail file, 1/8-in. fine	15-Dec-13	4.99	21344
Hicut chain saw, 16 in.	07-Feb-14	256.99	24288

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```
SELECT P_DESCRIP, P_INDATE, P_PRICE, V_CODE
FROM   PRODUCT
WHERE  V_CODE = 21344 OR V_CODE = 24288;
```

Figure 7.13 - Selected PRODUCT Table  
Attributes: The Logical AND

P_DESCRIP	P_INDATE	P_PRICE	V_CODE
B&D cordless drill, 1/2-in.	20-Jan-14	38.95	25595
Claw hammer	20-Jan-14	9.95	21225
PVC pipe, 3.5-in., 8-ft	20-Feb-14	5.87	
1.25-in. metal screw, 25	01-Mar-14	6.99	21225
2.5-in. wd. screw, 50	24-Feb-14	8.45	21231

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```
SELECT      P_DESCRIP, P_INDATE, P_PRICE, V_CODE
FROM        PRODUCT
WHERE       P_PRICE < 50
AND         P_INDATE > '15-Jan-2014';
```

Figure 7.14 - Selected PRODUCT Table  
Attributes: The Logical AND and OR

P_DESCRPT	P_INDATE	P_PRICE	V_CODE
B&D jigsaw, 12-in. blade	30-Dec-13	109.92	24288
B&D jigsaw, 8-in. blade	24-Dec-13	99.87	24288
B&D cordless drill, 1/2-in.	20-Jan-14	38.95	25595
Claw hammer	20-Jan-14	9.95	21225
Hicut chain saw, 16 in.	07-Feb-14	256.99	24288
PVC pipe, 3.5-in., 8-ft	20-Feb-14	5.87	
1.25-in. metal screw, 25	01-Mar-14	6.99	21225
2.5-in. wd. screw, 50	24-Feb-14	8.45	21231

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```
SELECT      P_DESCRPT, P_INDATE, P_PRICE, V_CODE
FROM        PRODUCT
WHERE       (P_PRICE < 50 AND P_INDATE > '15-Jan-2014')
OR          V_CODE = 24288;
```

## Special Operators

### BETWEEN

- Checks whether attribute value is within a range

### IS NULL

- Checks whether attribute value is null

### LIKE

- Checks whether attribute value matches given string pattern

### IN

- Checks whether attribute value matches any value within a value list

### EXISTS

- Checks if subquery returns any rows

```
SELECT      *
FROM        PRODUCT
WHERE       P_PRICE BETWEEN 50.00 AND 100.00;
```

```
SELECT      P_CODE, P_DESCRIP, V_CODE
FROM        PRODUCT
WHERE       V_CODE IS NULL;
```

- % means any and all *following* or *preceding* characters are eligible. For example:  
'J%' includes Johnson, Jones, Jernigan, July, and J-231Q.  
'Jo%' includes Johnson and Jones.  
'%n' includes Johnson and Jernigan.
- \_ means any *one* character may be substituted for the underscore. For example:  
'\_23-456-6789' includes 123-456-6789, 223-456-6789, and 323-456-6789.  
'\_23-\_56-678\_' includes 123-156-6781, 123-256-6782, and 823-956-6788.  
'\_o\_es' includes Jones, Cones, Cokes, totes, and roles.

```
SELECT V_NAME, V_CONTACT, V_AREACODE, V_PHONE  
FROM VENDOR  
WHERE V_CONTACT LIKE 'Smith%';
```

Another example for pattern-matching: load [this](#) page, and enter and execute:

```
SELECT * FROM Customers WHERE CustomerName LIKE 'C%';
```

```
SELECT      *
FROM        PRODUCT
WHERE       V_CODE = 21344
OR          V_CODE = 24288;

SELECT      *
FROM        PRODUCT
WHERE       V_CODE IN (21344, 24288);

SELECT      V_CODE, V_NAME
FROM        VENDOR
WHERE       V_CODE IN (SELECT V_CODE FROM PRODUCT);
```

# 'EXISTS'

The EXISTS clause is used with a query, and returns TRUE if the subquery results in any output (non-zero # of rows being returned), or FALSE if the subquery results in no data. The rest of the query (the 'main' query) will (or will not) run, based on EXIST's output - if EXISTS returns false, the main query will get skipped.

You can loosely think of EXISTS as "ONLY WHEN". We use it to 'defensively' update (insert, modify, delete) parts of a table (after we determine it is updatable).

You can also think of 'WHERE EXISTS' as "such that there exists". Eg. in the first example below (SELECT \* FROM VENDOR..), it reads as "Find all vendors such that there exists records for them in the PRODUCT TABLE (via V\_CODE) where P\_QOH<=P\_MIN" [in other words, we are looking for vendors we need to re-order from].

In the second example (INSERT INTO CONTACTS..), read it as "get the supplier ID and name for all suppliers such that there exists order IDs for them, then insert them into the contacts table".

Exercise: what does #3 below do?

```
SELECT      *
FROM        VENDOR
WHERE       EXISTS (SELECT * FROM PRODUCT WHERE P_QOH <= P_MIN);
```

```
INSERT INTO contacts
(contact_id, contact_name)
SELECT supplier_id, supplier_name
FROM suppliers
WHERE EXISTS (SELECT *
              FROM orders
              WHERE suppliers.supplier_id = orders.supplier_id);
```

```
UPDATE suppliers
SET supplier_name = (SELECT customers.name
                      FROM customers
                      WHERE customers.customer_id = suppliers.supplier_id)
WHERE EXISTS (SELECT customers.name
              FROM customers
              WHERE customers.customer_id = suppliers.supplier_id);
```

```
DELETE FROM suppliers
WHERE EXISTS (SELECT *
              FROM orders
              WHERE suppliers.supplier_id = orders.supplier_id);
```

```
SELECT *
FROM suppliers
WHERE EXISTS (SELECT *
               FROM orders
              WHERE suppliers.supplier_id = orders.supplier_id);
```

This SQL EXISTS condition example will return all records from the suppliers table where there is at least one record in the orders table with the same supplier\_id.

```
SELECT *
FROM suppliers
WHERE NOT EXISTS (SELECT *
                     FROM orders
                    WHERE suppliers.supplier_id = orders.supplier_id);
```

This SQL EXISTS example will return all records from the suppliers table where there are **no** records in the orders table for the given supplier\_id.

## Advanced Data Definition Commands

- **ALTER TABLE** command: To make changes in the table structure
- Keywords use with the command
  - ADD - Adds a column
  - MODIFY - Changes column characteristics
  - DROP - Deletes a column
- Used to:
  - Add table constraints
  - Remove table constraints

## Changing Column's Data Type

- ALTER can be used to change data type
- Some RDBMSs do not permit changes to data types unless column is empty
- Syntax –
  - `ALTER TABLE tablename MODIFY  
(columnname(datatype));`

```
ALTER TABLE PRODUCT MODIFY (V_CODE CHAR(5));
```

## Changing Column's Data Characteristics

- Use ALTER to change data characteristics
- Changes in column's characteristics are permitted if changes do not alter the existing data type
- Syntax
  - `ALTER TABLE tablename MODIFY  
(columnname(characterstic));`

```
ALTER TABLE PRODUCT MODIFY (P_PRICE DECIMAL(9,2));
```

## Adding Column, Dropping Column

- Adding a column
  - Use ALTER and ADD
  - Do not include the NOT NULL clause for new column
- Dropping a column
  - Use ALTER and DROP
  - Some RDBMSs impose restrictions on the deletion of an attribute

```
ALTER TABLE PRODUCT ADD (P_SALECODE CHAR(1));
```

```
ALTER TABLE VENDOR DROP COLUMN V_ORDER;
```

## Advanced Data Updates

- UPDATE command updates only data in existing rows
- If a relationship is established between entries and existing columns, the relationship can assign values to appropriate slots
- Arithmetic operators are useful in data updates
- In Oracle, ROLLBACK command undoes changes made by last two UPDATE statements

```
UPDATE      PRODUCT
SET          P_SALECODE = '2'
WHERE        P_CODE = '1546-QQ2';

UPDATE      PRODUCT
SET          P_SALECODE = '1'
WHERE        P_CODE IN ('2232/QWE', '2232/QTY');

UPDATE      PRODUCT
SET          P_SALECODE = '1'
WHERE        P_INDATE >= '16-Jan-2014' AND P_INDATE <='10-Feb-2014';

UPDATE      PRODUCT
SET          P_PRICE = P_PRICE * 1.10
WHERE        P_PRICE < 50.00;
```

# Table update in 'bulk'

Sometimes we can update a table, by filling it with output from a query. The table to be filled in has to exist first (so we need to create it if necessary), and have type-compatible columns that can receive values from our data-fetching query.

The table creation and updating can happen in separate steps, or even be combined for compactness of expression.

## Copying Parts of Tables

- SQL permits copying contents of selected table columns
  - Data need not be reentered manually into newly created table(s)
- Table structure is created
- Rows are added to new table using rows from another table

```
CREATE TABLE PART(
    PART_CODE          CHAR(8),
    PART_DESCRPT      CHAR(35),
    PART_PRICE        DECIMAL(8,2),
    V_CODE            INTEGER,
    PRIMARY KEY (PART_CODE));

INSERT INTO PART      (PART_CODE, PART_DESCRPT, PART_PRICE, V_CODE)
SELECT              P_CODE, P_DESCRPT, P_PRICE, V_CODE FROM PRODUCT;

CREATE TABLE PART AS
SELECT    P_CODE AS PART_CODE, P_DESCRPT AS
          PART_DESCRPT, P_PRICE AS PART_PRICE,
          V_CODE
FROM     PRODUCT;
```

## Adding Primary and Foreign Key Designations

- **ALTER TABLE** command
  - Followed by a keyword that produces the specific change one wants to make
  - Options include ADD, MODIFY, and DROP
- Syntax to add or modify columns
  - **ALTER TABLE tablename**
    - {ADD | MODIFY} ( *columnname datatype* [ {ADD | MODIFY} *columnname datatype* ] ) ;
  - **ALTER TABLE tablename**
    - ADD *constraint* [ ADD *constraint* ] ;

```
ALTER TABLE PART
ADD PRIMARY KEY (PART_CODE);
```

```
ALTER TABLE PART
ADD FOREIGN KEY (V_CODE) REFERENCES VENDOR;
```

Oftentimes the need to do this occurs when a table (eg. PART) is created via bulk-update, from another table (eg. PRODUCT).

## Deleting a Table from the Database

- **DROP TABLE:** Deletes table from database
- Syntax - `DROP TABLE tablename;`
- Can drop a table only if it is not the one side of any relationship
- RDBMS generates a foreign key integrity violation error message if the table is dropped

# Ordering, unique entries, aggregate ops..

## Additional SELECT Query Keywords

- Logical operators work well in the query environment
- SQL provides useful functions that:
  - Counts
  - Find minimum and maximum values
  - Calculate averages
- SQL allows user to limit queries to entries:
  - Having no duplicates
  - Whose duplicates may be grouped

# ORDER BY

## Ordering a Listing

- **ORDER BY** clause is useful when listing order is important
- Syntax - `SELECT columnlist  
FROM tablelist  
[WHERE conditionlist]  
[ORDER BY columnlist [ASC | DESC]];`
- **Cascading order sequence:** Multilevel ordered sequence
  - Created by listing several attributes after the ORDER BY clause

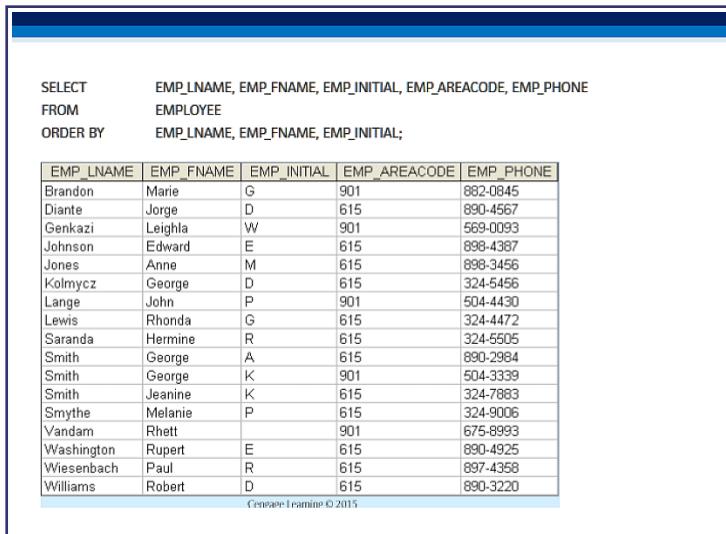
Below is an example of ORDER BY, where by default, values are listed (sorted) in ascending order. To list the values in descending order, we'd do this: ORDER BY P\_PRICE DESC;

```
SELECT      P_CODE, P_DESCRPT, P_INDATE, P_PRICE
FROM        PRODUCT
ORDER BY    P_PRICE;
```

P_CODE	P_DESCRPT	P_INDATE	P_PRICE
S4779-2T	Retail fls, 10-in. fine	15-Dec-13	4.99
PVC23DRT	PVC pipe, 3.5-in., 8-ft	20-Feb-14	5.87
SM-16277	1.25-in. metal screw, 25	01-Mar-14	6.99
SM-23116	2.5-in. wd. screw, 50	24-Feb-14	8.45
Z3109-HB	Claw hammer	20-Jan-14	9.95
Z3114-AH	Bridge hammer, 12 lb.	02-Jan-14	14.40
13-Q2P/L3	7.25-in. pwr. saw blade	13-Dec-13	14.99
14-Q2P/L3	9.00-in. pwr. saw blade	13-Nov-13	17.40
2236CPO	B&D cordless drill, 1/2-in.	20-Jan-14	39.95
1566-Q02	Hrd. cloth, 1/4-in., 2x50	15-Jan-14	39.95
1598-QW1	Hrd. cloth, 1/2-in., 3x50	15-Jan-14	43.99
2232QME	B&D jigsaw, 8-in. blade	24-Dec-13	99.87
2232QTY	B&D jigsaw, 12-in. blade	30-Dec-13	109.92
110ER/31	Power planer, 15 psi., 3-nozzle	03-Nov-13	109.99
WR3TT3	Steel matting, 4x8x16", 5 <sup>th</sup> mesh	17-Jan-14	119.95
89-WRE-Q	Hand chain saw, 16 in.	07-Feb-14	266.99

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The sequence (listing) obtained by specifying several comma-separated attributes for ORDER BY is called a cascading order sequence.



A screenshot of a computer screen showing a SQL query result. The query is:

```
SELECT      EMP_LNAME, EMP_FNAME, EMP_INITIAL, EMP_AREACODE, EMP_PHONE
FROM        EMPLOYEE
ORDER BY    EMP_LNAME, EMP_FNAME, EMP_INITIAL;
```

The result is a table with the following data:

EMP_LNAME	EMP_FNAME	EMP_INITIAL	EMP_AREACODE	EMP_PHONE
Brandon	Marie	G	901	882-0845
Dianite	Jorge	D	615	890-4567
Genkazi	Leighla	W	901	569-0093
Johnson	Edward	E	615	898-4387
Jones	Anne	M	615	896-3456
Kolmycz	George	D	615	324-5456
Lange	John	P	901	504-4430
Lewis	Rhonda	G	615	324-4472
Saranda	Hermine	R	615	324-5505
Smith	George	A	615	890-2984
Smith	George	K	901	504-3339
Smith	Jeanine	K	615	324-7883
Smythe	Melanie	P	615	324-9006
Vandam	Rhett		901	675-8993
Washington	Rupert	E	615	890-4925
Wiesenbach	Paul	R	615	897-4358
Williams	Robert	D	615	890-3220

# DISTINCT

The 'DISTINCT' keyword is used to count unique/distinct occurrences of an attribute:

## Listing Unique Values

- **DISTINCT** clause: Produces list of values that are unique
- Syntax - `SELECT DISTINCT columnlist  
FROM tablelist;`
- Access places nulls at the top of the list
  - Oracle places it at the bottom
  - Placement of nulls does not affect list contents

# Example of 'DISTINCT' usage

```
SELECT      DISTINCT V_CODE  
FROM        PRODUCT;
```

V_CODE
21225
21231
21344
23119
24288
25595

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# AGGREGATE functions

COUNT, MIN, MAX, SUM, AVG are all functions that operate on a numerical attr/column, and produce a single scalar result (not a table).

Table 7.8 - Some Basic SQL Aggerate Functions

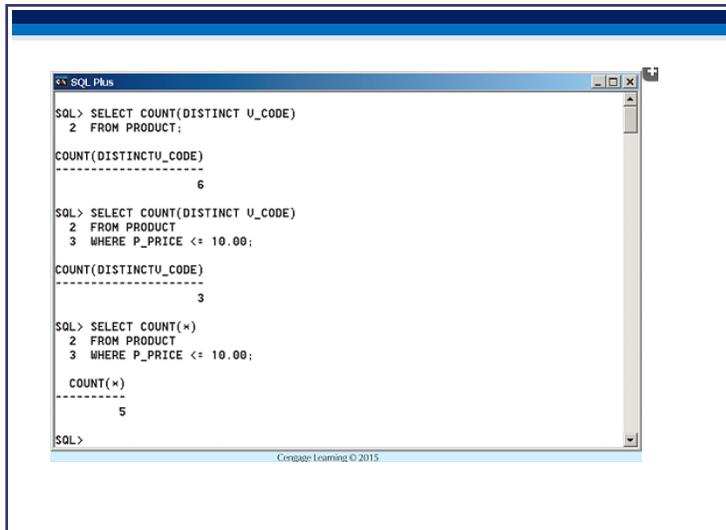
FUNCTION	OUTPUT
COUNT	The number of rows containing non-null values
MIN	The minimum attribute value encountered in a given column
MAX	The maximum attribute value encountered in a given column
SUM	The sum of all values for a given column
AVG	The arithmetic mean (average) for a specified column

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# Aggregate function examples

How many different vendors supply our products? How many supply cheap (PRICE < 10) products?

Note the third query below: COUNT(\*) counts the # of rows returned by a query (rows where the product costs < 10 units). In contrast, count() counts the # of non-null values of the column.



The screenshot shows a window titled "SQL\*Plus" with three SQL queries entered and their results displayed:

```
SQL> SELECT COUNT(DISTINCT V_CODE)
  2  FROM PRODUCT;
COUNT(DISTINCTV_CODE)
-----
6

SQL> SELECT COUNT(DISTINCT V_CODE)
  2  FROM PRODUCT
  3  WHERE P_PRICE <= 10.00;
COUNT(DISTINCTV_CODE)
-----
3

SQL> SELECT COUNT(*)
  2  FROM PRODUCT
  3  WHERE P_PRICE <= 10.00;
COUNT(*)
-----
5

SQL>
```

The window has a status bar at the bottom that reads "Cengage Learning © 2015".

# MAX, MIN

What is the value for the most expensive item in the product table? Least expensive?

What is the most expensive item (details)? We can't do: WHERE P\_PRICE = MAX(P\_PRICE). This is because MAX() can only be used in a SELECT statement.

The screenshot shows the Oracle SQL Plus interface. The command window contains the following SQL statements:

```
SQL> SELECT MAX(P_PRICE)
  2  FROM PRODUCT;
MAX(P_PRICE)
-----
256.99

SQL> SELECT MIN(P_PRICE)
  2  FROM PRODUCT;
MIN(P_PRICE)
-----
4.99

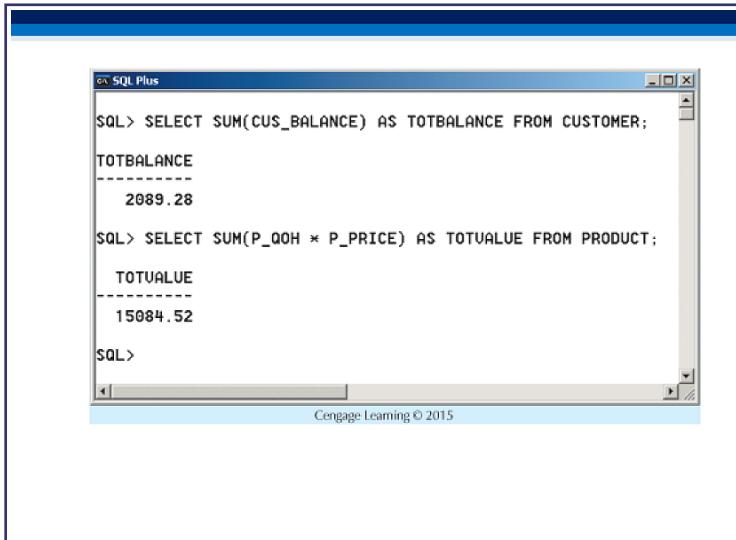
SQL> SELECT P_CODE, P_DESCRIP, P_PRICE
  2  FROM PRODUCT
  3  WHERE P_PRICE = (SELECT MAX(P_PRICE) FROM PRODUCT);
P_CODE          P_DESCRIP          P_PRICE
-----  -----
89-WRE-Q  Hicut chain saw, 16 in.      256.99

SQL>
```

In the bottom-left corner, there is a small preview window showing a partial query:

```
SELECT *
  FROM PRODUCT
 WHERE P_QOH*P_PRICE = (SELECT MAX(P_QOH*P_PRICE) FROM PRODUCT);
```

# SUM



The screenshot shows an Oracle SQL Plus window with a blue header bar. The main area contains the following SQL statements and their results:

```
SQL> SELECT SUM(CUS_BALANCE) AS TOTBALANCE FROM CUSTOMER;
TOTBALANCE
-----
2089.28

SQL> SELECT SUM(P_QOH * P_PRICE) AS TOTVALUE FROM PRODUCT;
TOTVALUE
-----
15084.52

SQL>
```

In the bottom right corner of the window, there is a small watermark that reads "Cengage Learning © 2015".

# AVG

The screenshot shows a Windows application window titled "SQL Plus". Inside, there are two SQL queries and their results.

```
SQL> SELECT AVG(P_PRICE) FROM PRODUCT;
AVG(P_PRICE)
-----
56.42125

SQL> SELECT P_CODE, P_DESCRIP, P_QOH, P_PRICE, V_CODE
  2  FROM PRODUCT
  3 WHERE P_PRICE > (SELECT AVG(P_PRICE) FROM PRODUCT)
  4 ORDER BY P_PRICE DESC;

P_CODE      P_DESCRIP          P_QOH    P_PRICE     V_CODE
-----  -----
89-WRE-Q   Hicut chain saw, 16 in.      11    256.99    24288
W3/TT3     Steel matting, 4'x8'x1/6", .5" mesh    18    119.95    25595
110ER/31   Power painter, 15 psi., 3-nozzle      8    109.99    25595
2232/DTY   B&D jigsaw, 12-in. blade      8    109.92    24288
2232/QME   B&D jigsaw, 8-in. blade      6    99.87    24288
```

At the bottom of the window, it says "Cengage Learning © 2015".

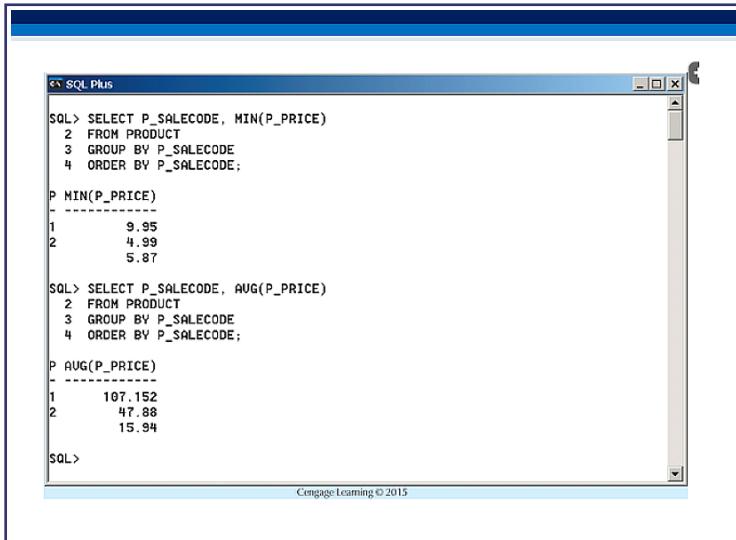
# GROUP BY (itemizing)

## Grouping Data

- Frequency distributions created by **GROUP BY** clause within SELECT statement
- GROUP BY can **only** be used in concert with an aggregate function
- Syntax - SELECT *columnlist*

```
FROM tablelist
[WHERE conditionlist]
[GROUP BY columnlist]
[HAVING conditionlist]
[ORDER BY columnlist [ASC | DESC]]; ..
```

# 'GROUP BY' example



The screenshot shows a Windows-style window titled "SQL Plus". Inside, two SQL queries are run against a "PRODUCT" table. The first query uses MIN() to find the lowest price for each sale code, resulting in three rows with prices 9.95, 4.99, and 5.87. The second query uses AVG() to find the average price for each sale code, resulting in three rows with averages 107.152, 47.88, and 15.94. The SQL prompt "SQL>" appears at the bottom of the window.

```
SQL> SELECT P_SALECODE, MIN(P_PRICE)
  2  FROM PRODUCT
  3  GROUP BY P_SALECODE
  4  ORDER BY P_SALECODE;

P MIN(P_PRICE)
-----
1      9.95
2      4.99
3      5.87

SQL> SELECT P_SALECODE, AVG(P_PRICE)
  2  FROM PRODUCT
  3  GROUP BY P_SALECODE
  4  ORDER BY P_SALECODE;

P AVG(P_PRICE)
-----
1    107.152
2     47.88
3     15.94

SQL>
```

You can think of 'GROUP BY' to mean "CATEGORIZE BY" or "ITEMIZE BY": rather than just a single MIN, MAX, SUM, COUNT or AVG, we're asking for a value PER OCCURRENCE of a GROUP BY value, eg. minimum price PER VENDOR, max GPA PER DEPARTMENT, average earnings PER MAJOR, etc. Specifically, when used with SUM(), GROUP BY is used to request subtotals.

The screenshot shows a window titled "SQL Plus" with the following content:

```
SQL> SELECT U_CODE, P_CODE, P_DESCRPT, P_PRICE
  2  FROM PRODUCT
  3 GROUP BY U_CODE;
SELECT U_CODE, P_CODE, P_DESCRPT, P_PRICE
      *
ERROR at line 1:
ORA-00979: not a GROUP BY expression

SQL> SELECT U_CODE, COUNT(DISTINCT P_CODE)
  2  FROM PRODUCT
  3 GROUP BY U_CODE;

U_CODE COUNT(DISTINCTP_CODE)
-----
21225          2
21231          1
21344          3
23119          2
24286          3
25595          3
                  2

7 rows selected.

SQL>
```

'GROUP BY' used without an aggregate function is meaningless, since there is no aggregate value (MIN, COUNT etc.) to itemize.

## Store receipt

Here is a grocery store receipt where subtotals are displayed itemized, aggregated by product types DELI, GROCERY, MIXED NUTS and PRODUCE (presumably using SUM(), together with GROUP BY):

**SK**  
**SUPER KING**  
**MARKETS**  
**SUPER KING**

Join "Royal Rewards" today  
 and Start Earning Points!

2716 N. San Fernando Rd.  
 Los Angeles, CA, 90065  
 (323) 225-0044  
 Store Hours 7 am - 9 pm  
[www.SuperKingMarkets.com](http://www.SuperKingMarkets.com)

Purchase \$ 8.74 PIN Used  
 Debit Card #SXXXXXXXXXXXXX4428  
 Auth # 568771 Payment from primary  
 Lane # 06 Cashier # 766  
 01/29/16 09:34 Ref/Seq # 065808  
 Mrch=912871 Term=001 IC=DC  
 EPS Sequence # 065808

DELI

SHAMROCK 2% STRAWBER 1.89 \*

GROCERY

DORITOS SPICY NACHO  
 1 @ 2 FOR 5.00 2.50 \*

MIXED NUTS

FRIED RED SKIN PEANU  
 0.66 1b @ 1.99/ 1b 1.31 \*

PRODUCE

BLACKBERRIES BERRY L V 1.99 \*  
 CACAHUATE QUEMADO  
 0.53 1b @ 1.99/ 1b 1.05 \*

BALANCE DUE 8.74  
 Debit Card 8.74  
 Auth Code = 568771

CHANGE 0.00

Total number of items sold = 5

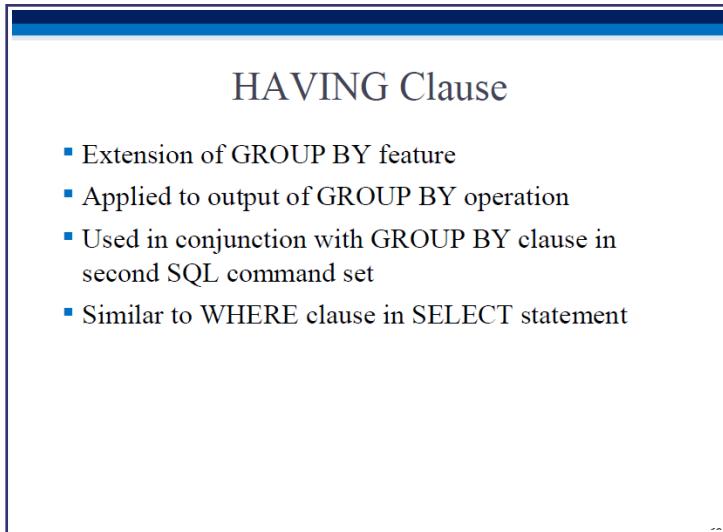
CASHIER NAME: JULIA P.  
 STORE:00002 REGISTER:006 CASHIER:0766  
 TICKET#:4826 29JAN2016 9:34:32  
 \*ALL RETURNS AND EXCHANGES CAN ONLY BE  
 ACCEPTED WITHIN 2 DAYS FROM THE DATE OF  
 PURCHASE AND MUST BE WITH RECEIPT.  
 \*RETURNS OR EXCHANGES OF NON-FOOD ITEMS  
 SHALL BE IN ORIGINAL PACKAGE \*NO CASH  
 REFUND ON ITEMS PAID BY CREDIT CARD  
 \*NO RETURNS ON BABYFOOD AND FORMULA  
 ALL SALES ARE FINAL ON ALL  
 ALCOHOLIC BEVERAGES & TOBACCO  
 LA County State Tax Rate of 9.00%

While you're at it, see what other DATA you can spot in the receipt! Even a single trip to the store can generate a LOT of data.

# HAVING

The HAVING clause is used to filter rows in a GROUP BY specification (only those rows HAVING met the specified condition will appear in the result).

Note that HAVING can only occur in a query that has a GROUP BY, which in turn can only occur when there is an aggregate function (MIN, MAX, SUM, COUNT or AVG).



```
SQL> SELECT U_CODE, COUNT(DISTINCT P_CODE), AVG(P_PRICE)
  2  FROM PRODUCT
  3  GROUP BY U_CODE;
 
  U_CODE COUNT(DISTINCTP_CODE) AVG(P_PRICE)
  -----  -----
  21225      2      8.47
  21231      1      8.45
  21344      3     12.49
  23119      2     41.97
  24288      3  155.593333
  25595      3     89.63
          2     10.135

7 rows selected.

SQL> SELECT U_CODE, COUNT(DISTINCT P_CODE), AVG(P_PRICE)
  2  FROM PRODUCT
  3  GROUP BY U_CODE
  4  HAVING AVG(P_PRICE) < 10;
 
  U_CODE COUNT(DISTINCTP_CODE) AVG(P_PRICE)
  -----  -----
  21225      2      8.47
  21231      1      8.45

SQL>
```

# Table joins

## Joining Database Tables

- Performed when data are retrieved from more than one table at a time
  - Equality comparison between foreign key and primary key of related tables
- Tables are joined by listing tables in FROM clause of SELECT statement
  - DBMS creates Cartesian product of every table in the FROM clause

## Joining Tables With an Alias

- Alias identifies the source table from which data are taken
- Any legal table name can be used as alias
- Add alias after table name in FROM clause
  - FROM tablename alias, eg. 'FROM PRODUCT P'

P_DESCRIPTOR	P_PRICE	V_NAME	V_CONTACT	V_AREACODE	V_PHONE
Claw hammer	9.95	Bryson, Inc.	Smithson	615	223-3234
1.25-in. metal screw, 25	6.99	Bryson, Inc.	Smithson	615	223-3234
2.5-in. wd. screw, 50	8.45	D&E Supply	Singh	615	228-3245
7.25-in. pwr. saw blade	14.99	Gomez Bros.	Ortega	615	889-2546
9.00-in. pwr. saw blade	17.49	Gomez Bros.	Ortega	615	889-2546
Rat-tail file, 1/8-in. fine	4.99	Gomez Bros.	Ortega	615	889-2546
Hrd. cloth, 1/4-in., 2x50	39.95	Randssets Ltd.	Anderson	901	678-3998
Hrd. cloth, 1/2-in., 3x50	43.99	Randssets Ltd.	Anderson	901	678-3998
B&D jigsaw, 12-in. blade	109.92	ORDVA, Inc.	Hakford	615	898-1234
B&D jigsaw, 8-in. blade	99.87	ORDVA, Inc.	Hakford	615	898-1234
Hicut chain saw, 16 in.	256.99	ORDVA, Inc.	Hakford	615	898-1234
Power painter, 15 psi., 3-nozzle	109.99	Rubicon Systems	Orton	904	456-0092
B&D cordless drill, 1/2-in.	38.95	Rubicon Systems	Orton	904	456-0092
Steel matting, 4x6'x1/8", .5" mesh	119.85	Rubicon Systems	Orton	904	456-0092

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ORDER BY PRODUCT.P\_PRICE;

```
SELECT      CUS_LNAME, INVOICE.INV_NUMBER, INV_DATE, P_DESCRPT
FROM        CUSTOMER, INVOICE, LINE, PRODUCT
WHERE       CUSTOMER.CUS_CODE = INVOICE.CUS_CODE
AND         INVOICE.INV_NUMBER = LINE.INV_NUMBER
AND         LINE.P_CODE = PRODUCT.P_CODE
AND         CUSTOMER.CUS_CODE = 10014
ORDER BY    INV_NUMBER;
```

Joining n tables will need (n-1) join conditions.

# 'Recursive join' example

Need different aliases for the table being queried so that we can use such aliases as namespaces for attributes.

## Recursive Joins

- **Recursive query:** Table is joined to itself using alias
- Use aliases to differentiate the table from itself

EMP_NUM	EMP_TITLE	EMP_LNAME	EMP_FNAME	EMP_INITIAL	EMP_DOB	EMP_HIRE_DATE	EMP_AREA_CODE	EMP_PHONE	EMP_MGR
100 Mr.	Kolmycz	George	D		15-Jun-42	15-Mar-85 615	324-5456		
101 Ms.	Lewis	Rhonda	G		19-Mar-65	25-Apr-86 615	324-4472		100
102 Mr.	Vandam	Rhett			14-Nov-58	20-Dec-90 901	675-3993		100
103 Ms.	Jones	Anne	M		16-Oct-74	28-Aug-94 615	698-3456		100
104 Mr.	Lange	John	P		08-Nov-71	20-Oct-94 901	504-4430		105
105 Mr.	Williams	Robert	D		14-Mar-75	06-Nov-96 615	690-3220		
106 Mrs.	Smith	Jeanine	K		12-Feb-68	05-Jan-89 615	324-7803		105
107 Mr.	Dante	Jorge	D		21-Aug-74	02-Jul-94 615	690-4567		105
108 Mr.	vLesenbach	Paul	R		14-Feb-66	18-Nov-92 615	697-4358		
109 Mr.	Smith	George	K		18-Jun-61	14-Apr-89 901	504-3339		108
110 Mrs.	Genkozi	Leighla	W		19-May-70	01-Dec-90 901	659-0093		108
111 Mr.	Washington	Rupert	E		03-Jan-66	21-Jan-93 615	690-4925		105
112 Mr.	Johnson	Edward	E		14-May-61	01-Dec-83 615	698-4387		100
113 Ms.	Smythe	Melanie	P		15-Sep-70	11-May-99 615	324-9006		105
114 Ms.	Brandon	Marie	G		02-Nov-55	15-Nov-79 901	682-0845		108
115 Mrs.	Saranda	Hermine	R		25-Jul-72	23-Apr-93 615	324-5505		105
116 Mr.	Smith	George	A		08-Nov-65	10-Dec-88 615	690-2984		108

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```
SELECT      E.EMP_NUM, E.EMP_LNAME, E.EMP_MGR, M.EMP_LNAME
FROM        EMP E, EMP M
WHERE       E.EMP_MGR=M.EMP_NUM
ORDER BY    E.EMP_MGR;
```

EMP_NUM	E.EMP_LNAME	EMP_MGR	M.EMP_LNAME
112	Johnson	100	Kolmycz
103	Jones	100	Kolmycz
102	Vandam	100	Kolmycz
101	Lewis	100	Kolmycz
115	Saranda	105	Williams
113	Smythe	105	Williams
111	Washington	105	Williams
107	Dante	105	Williams
106	Smith	105	Williams
104	Lange	105	Williams
116	Smith	108	Wiesenbach
114	Brandon	108	Wiesenbach
110	Gentazi	108	Wiesenbach
109	Smith	108	Wiesenbach

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Sooo... are joins 'evil'? Not really :)

# SQL is declarative, not imperative

Now that you're familiar with SQL syntax, you will appreciate knowing how it compares with a regular programming language such as C++. Shown below is such a comparison, using C# which lets us write code in an imperative (command-oriented) manner as well a declarative (result-oriented) one [this is from a book on functional programming]:

## **Listing 1.3 Imperative data processing (C#)**

```
List<string> res = new List<string>(); #1
foreach(Product p in Products) {
    if (p.UnitPrice > 75.0M) {
        res.Add(String.Format("{0} - ${1}",
            p.ProductName, p.UnitPrice)); #3
    }
}
return res;
#1 Create resulting list
#2 Iterate over products
#3 Add information to list of results
```

You'll probably need to read the code carefully to understand what it does, but that's not the only aspect we want to improve. The code is written as a sequence of some basic imperative commands. For example, the first statement creates new list (#1), the second iterates over all products (#2) and a later one adds element to the list (#3). However, we'd like to be able to describe the problem at a higher level. In more abstract terms, the code just filters a collection and returns some information about every returned product.

In C# 3.0, we can write the same code using query expression syntax. This version is closer to our real goal—it uses the same idea of filtering and transforming the data. You can see the code in listing 1.4.

## **Listing 1.4 Declarative data processing (C#)**

```
var res = from p in Products
          where p.UnitPrice > 75.0M
          select string.Format("{0} - ${1}",
            p.ProductName, p.UnitPrice); #1
#2
return res;
#1 Filter products using predicate
#2 Return information about product
```

The expression that calculates the result (`res`) is composed from basic operators such as `where` or `select`. These operators take other expressions as an argument, because they need to know exactly what we want to filter or select as a result.

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# Ways to 'do' SQL..

SQL is a data creation+manipulation language, so it's best learned HANDS ON (not just by looking at slides and reading about the syntax) - you need access to a relational database where you can **create tables, enter data in them and do queries on the data** (tables ← data ← queries).

There are three ways to get your hands on a DB: use a browser page [a server runs the DB software, you simply access it from a page]; install a DB locally on your laptop/tablet/phone; use a 'cloud-based' DB [this is similar to, but more powerful than, accessing a DB via a web page].

## 1. Browser-based SQL IDEs

An easy way to practice running SQL queries is to use browser-based interfaces (nothing to download, no login needed) to create/query databases. Here are some sites that provide this form of access:

- \* SQL Tutorial: <http://www.w3schools.com/sql/default.asp>
- \* ideone: <http://www.ideone.com>
- \* sqlfiddle: <http://sqlfiddle.com/>
- \* Code School's Try SQL: <http://campus.codeschool.com/courses/try-sql/contents>
- \* SQLZOO: <http://sqlzoo.net/> - has extensive tutorials
- \* another tutorial: <http://www.sqltutorial.org/>
- \* w3resource: <http://www.w3resource.com/sql-exercises/> - more tutorials
- \* Khan Academy: <https://www.khanacademy.org/computer-programming/new/sql>
- \* 'Online SQL interpreter': <https://sql-js.github.io/sql.js/examples/GUI/> - JavaScript-based!

Below are examples for three of the above links.

Bring up the w3schools [Tryit Editor](#), enter and run the following pair of sql command sets one at a time (these commands run on a set of pre-installed (by w3schools.com) [collection of tables](#) called the [Northwind database](#)):

```
SELECT City FROM Customers  
WHERE Country="Germany";
```

```
SELECT City, CustomerID FROM Customers  
WHERE Country="Germany" AND CustomerID>60;
```

In [ideone](#), select SQLite (for the choice of language), then enter and run this:

```
-- warmup
create table tble(str varchar(20));
insert into tble values ('Hello world!'),('SQL is fun!!');
select * from tble;
```

```
-- recipes
CREATE TABLE recipes (
recipe_id INT NOT NULL,
recipe_name VARCHAR(30) NOT NULL,
PRIMARY KEY (recipe_id),
UNIQUE (recipe_name)
);
```

```
INSERT INTO recipes
(recipe_id, recipe_name)
VALUES
(1, "Tacos"),
(2, "Tomato Soup"),
(3, "Grilled Cheese");
```

```
-- quick check
SELECT recipe_name
FROM recipes;
```

```
-- ingredients
CREATE TABLE ingredients (
ingredient_id INT NOT NULL,
ingredient_name VARCHAR(30) NOT NULL,
ingredient_price INT NOT NULL,
PRIMARY KEY (ingredient_id),
UNIQUE (ingredient_name)
);
```

```
INSERT INTO ingredients
(ingredient_id, ingredient_name, ingredient_price)
VALUES
(1, "Beef", 5),
```

```
(2, "Lettuce", 1),
(3, "Tomatoes", 2),
(4, "Taco Shell", 2),
(5, "Cheese", 3),
(6, "Milk", 1),
(7, "Bread", 2);

-- recipe_ingredients
CREATE TABLE recipe_ingredients (
recipe_id int NOT NULL,
ingredient_id INT NOT NULL,
amount INT NOT NULL,
PRIMARY KEY (recipe_id,ingredient_id)
);

INSERT INTO recipe_ingredients
(recipe_id, ingredient_id, amount)
VALUES
(1,1,1),
(1,2,2),
(1,3,2),
(1,4,3),
(1,5,1),
(2,3,2),
(2,6,1),
(3,5,1),
(3,7,2);

SELECT *
FROM recipes
ORDER BY recipe_id;
```

Here is the recipes db table and its queries again, this time in sqlfiddle. After the page loads (with our SQL commands above, filled in!), click 'Build Schema' on the left, then click 'Run SQL' on the right [and wait for a few seconds for the output].

## 2. Locally installed DBs

You can install Oracle on your machine, or install the light-weight but powerful DB Browser for SQLite, aka SQLite Browser. On Windows, this offers a 'notebook'

environment: <https://sqlnotebook.com/> [a mix of SQL and non-SQL commands]. It is also OK to use Postgres, or MySQL; or you could use [some other DB...](#)

Here is a quickstart guide for SQLite Browser - we create a table called CosineTable, and fill it with rows containing [angle, cos(angle)] pairs. And [here](#) is another clip that shows how to create a simple sqlite DB and query it.

The second clip above, also shows that the .db file that is created, contains data in a SQLite-native binary format [which is [public and well-documented](#)]. FYI, there are sqlite API calls in multiple languages that let you access the (binary) data using functions/methods that accept SQL commands as regular strings. This is mixed-language programming that lets us accomplish a lot, because we leverage the power of Java, Python etc., as well as that of SQL. Eg. here's how it works in Python:

```
>>> for row in c.execute('SELECT * FROM stocks ORDER BY price'):
    print row # or we could email this, put it up on an LED
display, buy/sell the cheap/pricey stocks..

(u'2006-01-05', u'BUY', u'RHAT', 100, 35.14)
(u'2006-03-28', u'BUY', u'IBM', 1000, 45.0)
(u'2006-04-06', u'SELL', u'IBM', 500, 53.0)
(u'2006-04-05', u'BUY', u'MSFT', 1000, 72.0)
```

You could also write a binary reader+parser in C++, Java etc. and extract the sqlite-native data that way - in other words, you'd never lose your data if you store it in a sqlite .db file!

As you can see, sqlite is [very](#) popular :)

### 3. Cloud-based DBs

You can also work with a relational DB via the cloud, eg. using Amazon's [RDS](#) offering. RDS offers a way to create databases such as Amazon's own Aurora, Oracle, SQL Server, MariaDB, MySQL, Postgres.