DATA 301
Introduction to Data Analytics
Relational Databases

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Why Relational Databases?

Relational databases allow for the storage and analysis of large amounts of data.

Relational databases are the most common form of database used by companies and organizations for data management.

Since a significant amount of data is stored in relational databases, understanding how to create and query these databases using the SQL standard is a very valuable skill.

What is a database?

A ***database*** is a collection of logically related data for a particular domain.

A ***database management system*** (***DBMS***) is software designed for the creation and management of databases.

- e.g. Oracle, DB2, Microsoft Access, MySQL, SQL Server, MongoDB

Bottom line: A ***database*** is the *data* stored and a ***database system*** is the *software* that manages the data.

Databases in the Real-World

Databases are everywhere in the real-world even though you do not often interact with them directly.

- $40 billion dollar annual industry

Examples:

- Retailers manage their products and sales using a database.
  - Wal-Mart has one of the largest databases in the world!
- Online web sites such as Amazon, eBay, and Expedia track orders, shipments, and customers using databases.
- The university maintains all your registration information and marks in a database that is accessible over the Internet.

Can you think of other examples?

What data do you have?

Database System Properties

A database system provides *efficient*, *convenient*, and *safe multi-user* storage and access to *massive* amounts of *persistent* data.

Efficient - Able to handle large data sets and complex queries without searching all files and data items.

Convenient - Easy to write queries to retrieve data.

Safe - Protects data from system failures and hackers.

Massive - Database sizes in gigabytes, terabytes and petabytes.

Persistent - Data exists even if have a power failure.

Multi-user - More than one user can access and update data at the same time while preserving consistency.

The Relational Model: Terminology

The ***relational model*** organizes data into tables called relations.

- Developed by E. F. Codd in 1970 and used by most database systems.

Terminology:

A ***relation*** is a table with columns and rows.

An ***attribute*** is a named column of a relation.

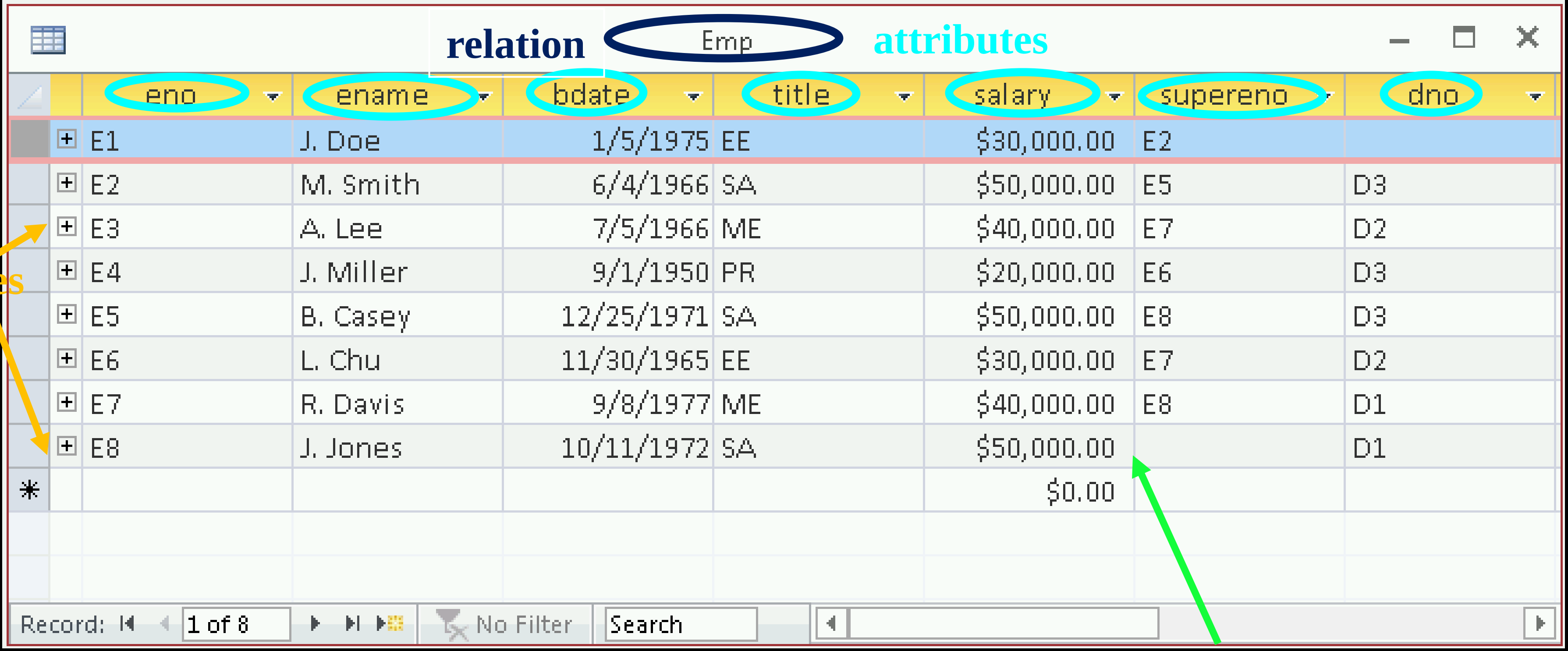
A ***tuple*** is a row of a relation.

A ***domain*** is a set of allowable values for one or more attributes.

The ***degree*** of a relation is the number of attributes it contains.

The ***cardinality*** of a relation is the number of tuples it contains.

Relation Example



relation Emp attributes

eno	ename	bdate	title	salary	supereno	dno
E1	J. Doe	1/5/1975	EE	$30,000.00	E2	
E2	M. Smith	6/4/1966	SA	$50,000.00	E5	D3
E3	A. Lee	7/5/1966	ME	$40,000.00	E7	D2
E4	J. Miller	9/1/1950	PR	$20,000.00	E6	D3
E5	B. Casey	12/25/1971	SA	$50,000.00	E8	D3
E6	L. Chu	11/30/1965	EE	$30,000.00	E7	D2
E7	R. Davis	9/8/1977	ME	$40,000.00	E8	D1
E8	J. Jones	10/11/1972	SA	$50,000.00		D1
				$0.00		

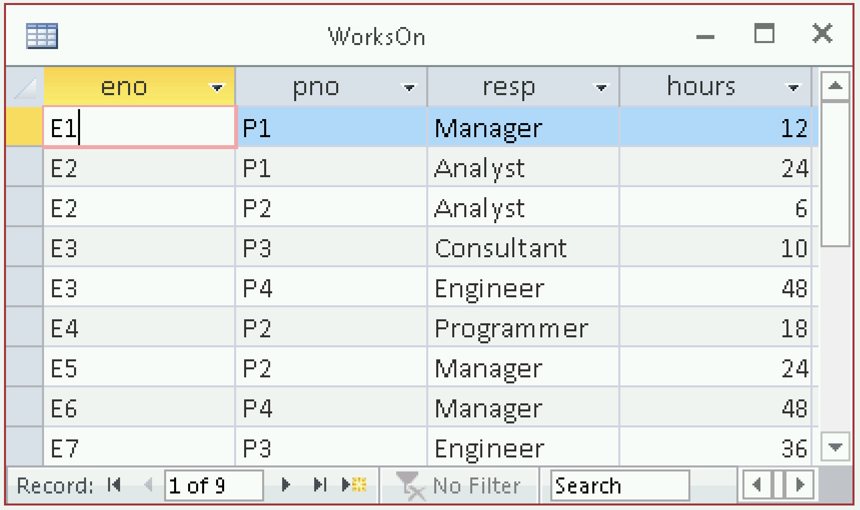
tuples

Degree =7

Cardinality = 8

Domain of salary is *currency*

Relation Practice Questions



eno	pno	resp	hours
E1	P1	Manager	12
E2	P1	Analyst	24
E2	P2	Analyst	6
E3	P3	Consultant	10
E3	P4	Engineer	48
E4	P2	Programmer	18
E5	P2	Manager	24
E6	P4	Manager	48
E7	P3	Engineer	36

1) What is the name of the relation?

2) What is the cardinality of the relation?

3) What is the degree of the relation?

4) What is the domain of `resp`? What is the domain of `hours`?

Creating and Using a Database

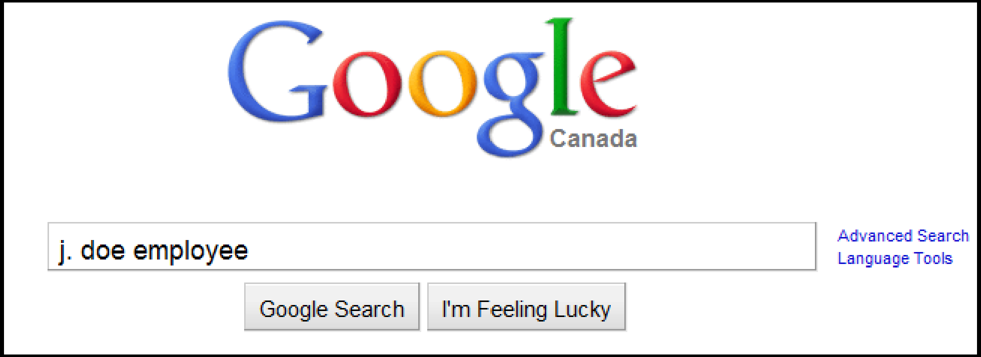
Typically, a data analyst will use an existing database. The database will already be created on a database system and contain data that was inserted and updated previously.

To use an existing database, the data analyst must be able to use the tools and languages to query the database. The standard is SQL.

Creating a large database is outside of the scope of this class, but we will learn how to create individual tables and load data into them which is a common data analysis task.

A Simple Query Language: Keyword Searching

Keyword (or English-language) ***search*** allows a user to type keywords or phrases and returns a best answer estimate.



This works fairly well for web searches, although we lack precision. Precision is required for many applications.

- Example: How would you return all employees with salary greater than 30,000 using keyword search?

SQL Overview

Structured Query Language or SQL is the standard database query language to retrieve *exact answers*.

- A SQL query specifies *what* to retrieve but not *how* to retrieve it.
- SQL is used by Microsoft Access and almost all other database systems.

Some basic rules for SQL statements:

- 1) There is a set of *reserved words* that cannot be used as names for database fields and tables.
  - SELECT, FROM, WHERE, etc.
- 2) SQL is generally *case-insensitive*.
  - Only exception is string constants. 'FRED' not the same as 'fred'.
- 3) SQL is *free-format* and white-space is ignored.

SQL CREATE TABLE

The **CREATE TABLE** command is used to create a table in the database. A table consists of a table name and a set of fields with their names and data types.

Example:

```
CREATE TABLE emp (
        eno      CHAR(5),
        ename    VARCHAR(30) NOT NULL,
        bdate    DATE,
        title    CHAR(2),
        salary   DECIMAL(9,2),
        supereno CHAR(5),
        dno      CHAR(5),
        PRIMARY KEY (eno)
)
```

field must always have a value

Data Types:

CHAR(5)	– always 5 chars long
VARCHAR(30)	– up to 30 chars long
DECIMAL(9,2)	– e.g. 1234567.99
DATE	– e.g. 1998/01/18

What is a key?

A ***key*** is a set of attributes that uniquely identifies a tuple in a relation.

A key helps to identify a particular row (data item) and find it faster.

In the `emp` table, the key was `eno`. It was called the `primary key` because it was the main key used to find an employee in the table.

Question:

- What is a key to identify a student in this class?

Try it: `CREATE TABLE`

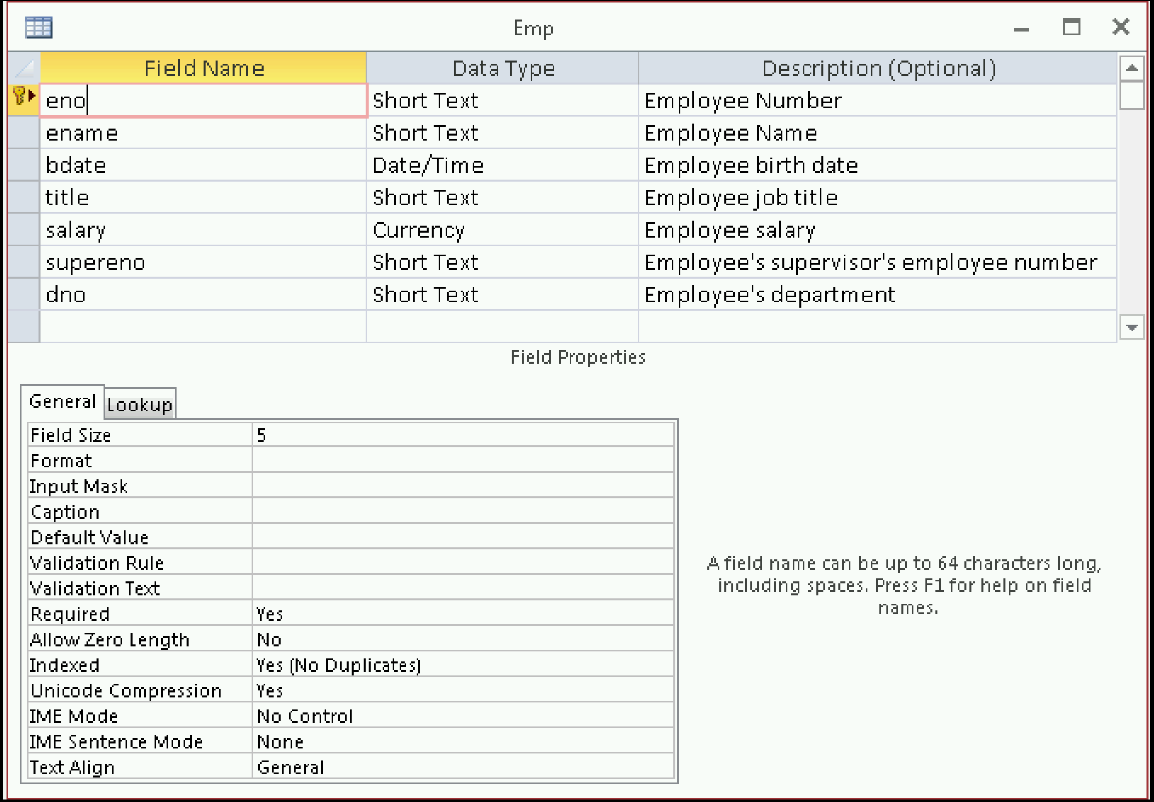
Question: Create a table called `mydata` that has three fields:

- `num` – that will store a number (use `int` as data type)
- `message` – that will store a string up to 50 characters (`varchar` data type)
- `amount` – that stores a decimal number with 8 total digits and 2 decimal digits (`decimal` data type)

Use the website **sqlfiddle.com** to try your table creation.

CREATE TABLE in Microsoft Access

In Microsoft Access, use `Create` -> `Table` to build a table.



Field Name	Data Type	Description (Optional)
eno	Short Text	Employee Number
ename	Short Text	Employee Name
bdate	Date/Time	Employee birth date
title	Short Text	Employee job title
salary	Currency	Employee salary
supereno	Short Text	Employee's supervisor's employee number
dno	Short Text	Employee's department

Field Properties

Field Size	5
Format	
Input Mask	
Caption	
Default Value	
Validation Rule	
Validation Text	
Required	Yes
Allow Zero Length	No
Indexed	Yes (No Duplicates)
Unicode Compression	Yes
IME Mode	No Control
IME Sentence Mode	None
Text Align	General

A field name can be up to 64 characters long, including spaces. Press F1 for help on field names.

Schemas and Metadata

Creating tables defines the structure of the database.

The description of the structure of the database is called a ***schema***.

The schema is a type of ***metadata***.

DROP TABLE

The command **DROP TABLE** is used to delete the table and *all its data* from the database:

Example: `DROP TABLE emp;`

- Note: The database does not confirm if you really want to drop the table and delete its data. The effect of the command is immediate.

Adding Data using INSERT

Insert a row using the INSERT command:

```
INSERT INTO emp VALUES ('E9','S. Smith','1975-03-05',
                        'SA',60000,'E8','D1')
```

Fields: eno, ename, bdate, title, salary, supereno, dno

If you do not give values for all fields in the order they are in the table, you must list the fields you are providing data for:

```
INSERT INTO emp(eno, ename, salary)
        VALUES ('E9','S. Smith',60000)
```

Note: If any columns are omitted from the list, they are set to NULL (empty).

Try it: INSERT

Question: Using the `mydata` table insert three rows:

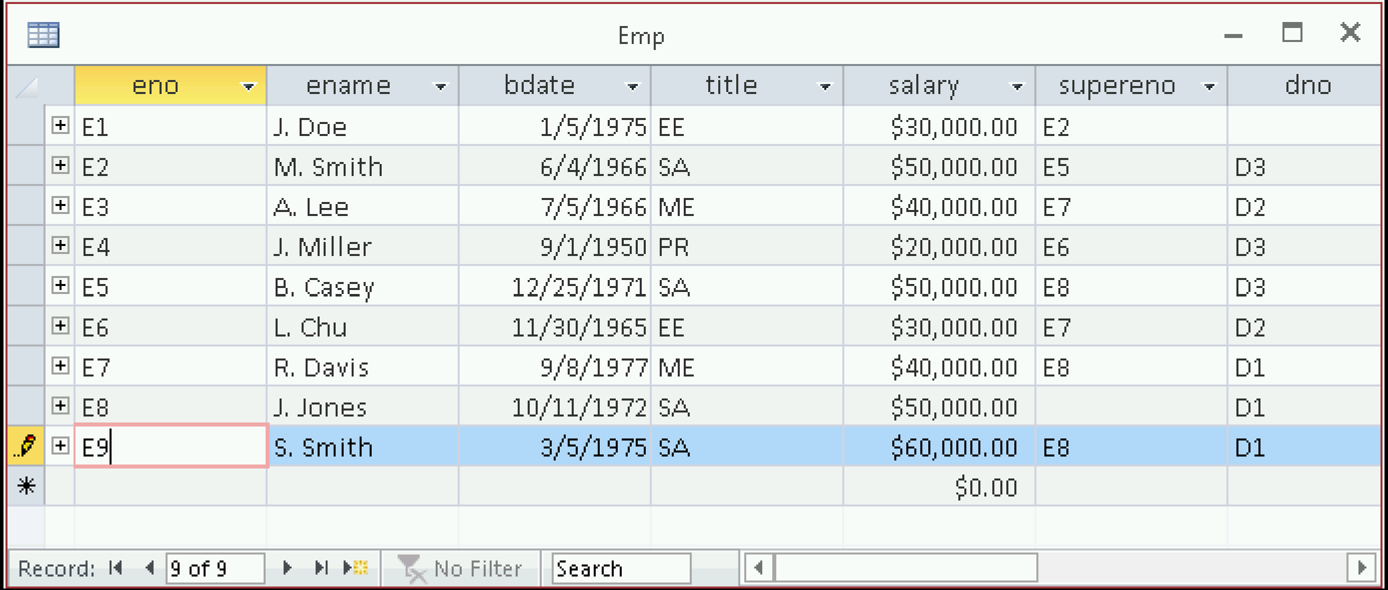
- `(1, 'Hello', 99.45)`
- `(2, 'Goodbye', 55.99)`
- `(3, 'No Amount')`

Use the web site **sqlfiddle.com** to try your table creation.

- Hint: You will need to create the table first and then insert the data

Adding Data using INSERT in Microsoft Access

In Microsoft Access, insert a new row by entering data into the last row of the table when in data view.



Emp

eno	ename	bdate	title	salary	supereno	dno
E1	J. Doe	1/5/1975	EE	$30,000.00	E2	
E2	M. Smith	6/4/1966	SA	$50,000.00	E5	D3
E3	A. Lee	7/5/1966	ME	$40,000.00	E7	D2
E4	J. Miller	9/1/1950	PR	$20,000.00	E6	D3
E5	B. Casey	12/25/1971	SA	$50,000.00	E8	D3
E6	L. Chu	11/30/1965	EE	$30,000.00	E7	D2
E7	R. Davis	9/8/1977	ME	$40,000.00	E8	D1
E8	J. Jones	10/11/1972	SA	$50,000.00		D1
E9	S. Smith	3/5/1975	SA	$60,000.00	E8	D1
				$0.00		

UPDATE Statement

Updating existing rows using the UPDATE statement. Examples:

- 1) Increase all employee salaries by 10%.

```
UPDATE emp SET salary = salary*1.10;
```

- 2) Increase salary of employee E2 to $1 million and change his name:

```
UPDATE emp SET salary = 1000000, name='Rich Guy'
WHERE eno = 'E2';
```

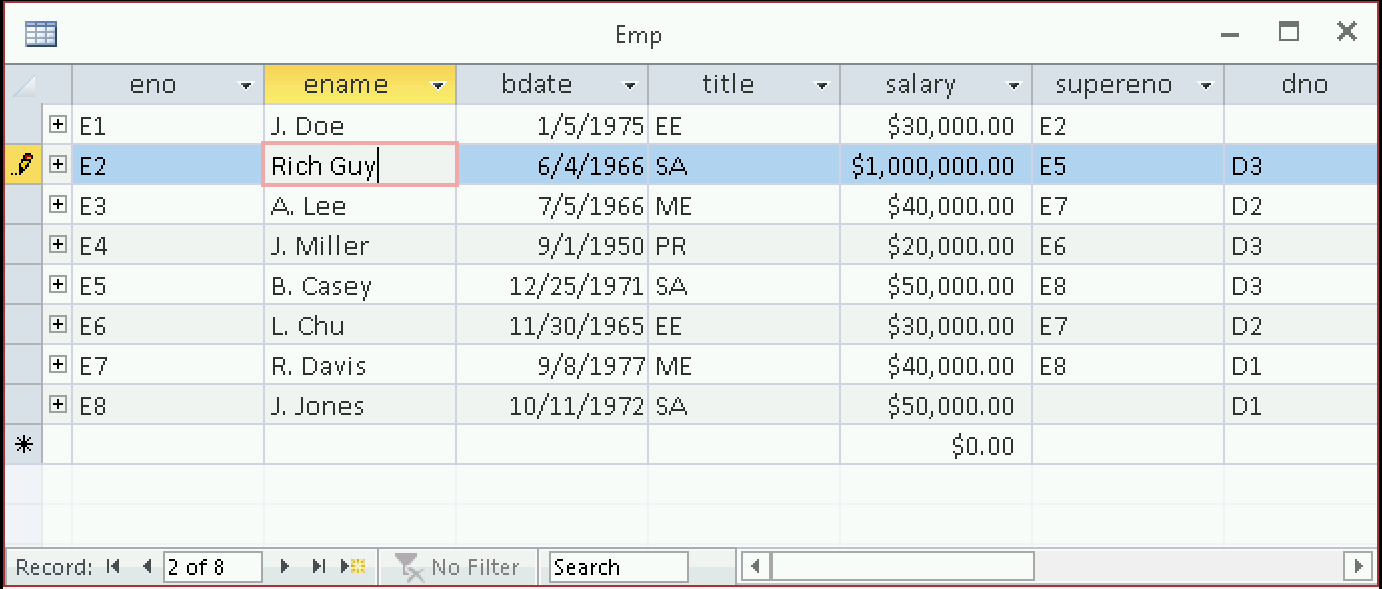
Notes:

- May change (SET) more than one value at a time. Separate by commas.
- Use WHERE to filter only the rows to update.

Updating Data in Microsoft Access

UPDATE command supported by Microsoft Access.

To modify individual data items, select the row and cell to update and change the data. Data is saved when you leave the row.



Emp

eno	ename	bdate	title	salary	supereno	dno
E1	J. Doe	1/5/1975	EE	$30,000.00	E2	
E2	Rich Guy	6/4/1966	SA	$1,000,000.00	E5	D3
E3	A. Lee	7/5/1966	ME	$40,000.00	E7	D2
E4	J. Miller	9/1/1950	PR	$20,000.00	E6	D3
E5	B. Casey	12/25/1971	SA	$50,000.00	E8	D3
E6	L. Chu	11/30/1965	EE	$30,000.00	E7	D2
E7	R. Davis	9/8/1977	ME	$40,000.00	E8	D1
E8	J. Jones	10/11/1972	SA	$50,000.00		D1
				$0.00		

Try it: UPDATE

Question: Using the `mydata` table and the three rows previously inserted do these updates:

- Update all `amount` fields to be `99.99`.
- Update the `num` field and set it to 10 for the record with `num = 1`.
- Update the `message` field to `'Changed'` for the record with `num = 2`.

Use sqlfiddle.com

DELETE Statement

Rows are deleted using the DELETE statement. Examples:

- 1) Fire everyone in the company.

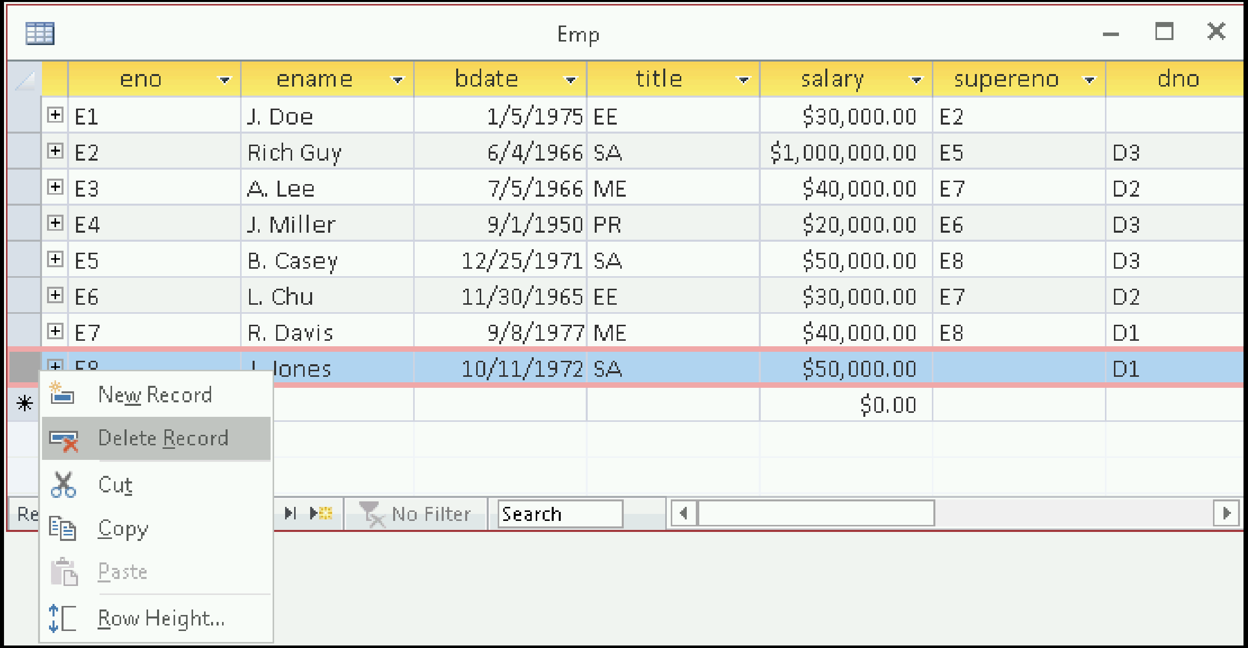
```
DELETE FROM emp;
```

- 2) Fire everyone making over $35,000.

```
DELETE FROM emp
WHERE salary > 35000;
```

Deleting Data in Microsoft Access

DELETE command supported by Microsoft Access. To delete an individual row, select the row to delete and press `Delete` key or select `Delete Record` from pop-up menu.



Emp

eno	ename	bdate	title	salary	supereno	dno
E1	J. Doe	1/5/1975	EE	$30,000.00	E2	
E2	Rich Guy	6/4/1966	SA	$1,000,000.00	E5	D3
E3	A. Lee	7/5/1966	ME	$40,000.00	E7	D2
E4	J. Miller	9/1/1950	PR	$20,000.00	E6	D3
E5	B. Casey	12/25/1971	SA	$50,000.00	E8	D3
E6	L. Chu	11/30/1965	EE	$30,000.00	E7	D2
E7	R. Davis	9/8/1977	ME	$40,000.00	E8	D1
E8	J. Jones	10/11/1972	SA	$50,000.00		D1
				$0.00		

Try it: DELETE

Question: Using the `mydata` table and the three rows previously inserted do these deletes:

- Delete the row with `num = 1`.
- Delete the row(s) with `message > 'C'`.
- Delete all rows.

Use sqlfiddle.com

★

SQL Queries using SELECT

A query in SQL has the form:

SELECT (list of columns or expressions)

FROM (list of tables)

WHERE (filter *conditions*)

GROUP BY (columns)

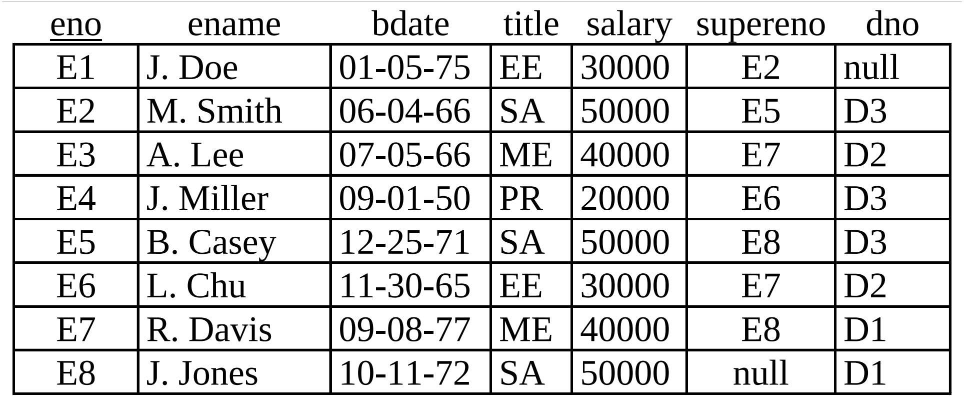
ORDER BY (columns)

Notes:

- 1) Separate the list of columns/expressions and list of tables by **commas**.
- 2) The "*" is used to select all columns.
- 3) Only SELECT required. FROM, WHERE, GROUP BY, ORDER BY are optional.

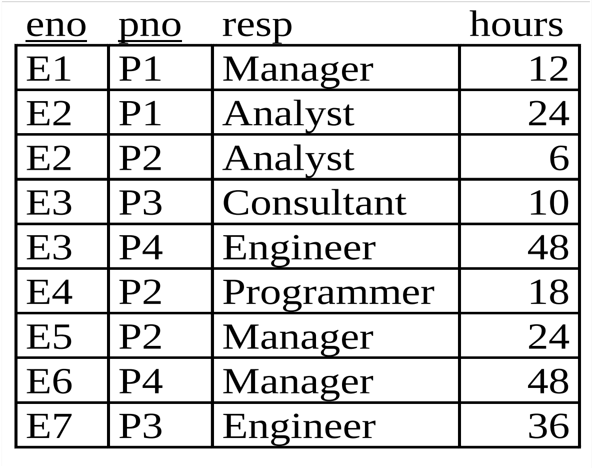
Example Data

emp Table



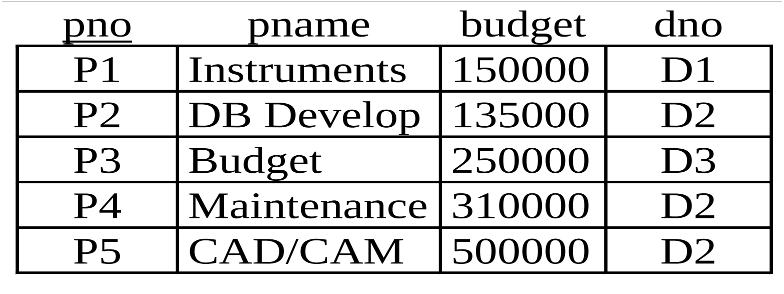
eno	ename	bdate	title	salary	supereno	dno
E1	J. Doe	01-05-75	EE	30000	E2	null
E2	M. Smith	06-04-66	SA	50000	E5	D3
E3	A. Lee	07-05-66	ME	40000	E7	D2
E4	J. Miller	09-01-50	PR	20000	E6	D3
E5	B. Casey	12-25-71	SA	50000	E8	D3
E6	L. Chu	11-30-65	EE	30000	E7	D2
E7	R. Davis	09-08-77	ME	40000	E8	D1
E8	J. Jones	10-11-72	SA	50000	null	D1

workson Table



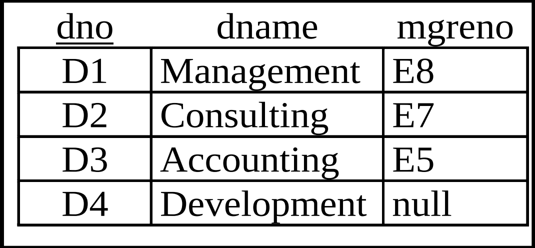
eno	pno	resp	hours
E1	P1	Manager	12
E2	P1	Analyst	24
E2	P2	Analyst	6
E3	P3	Consultant	10
E3	P4	Engineer	48
E4	P2	Programmer	18
E5	P2	Manager	24
E6	P4	Manager	48
E7	P3	Engineer	36

proj Table



pno	pname	budget	dno
P1	Instruments	150000	D1
P2	DB Develop	135000	D2
P3	Budget	250000	D3
P4	Maintenance	310000	D2
P5	CAD/CAM	500000	D2

dept Table



dno	dname	mgreno
D1	Management	E8
D2	Consulting	E7
D3	Accounting	E5
D4	Development	null

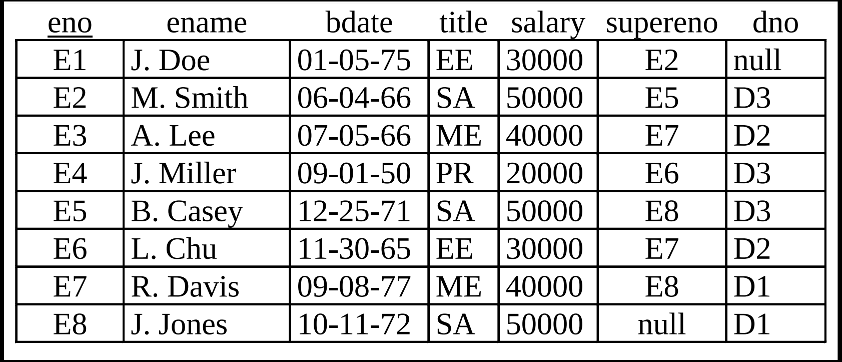
SQL: Retrieving Only Some of the Columns

The ***projection operation*** creates a new table that has some of the columns of the input table. In SQL, provide the table in the FROM clause and the fields in the output in the SELECT.

Example: Return only the eno field from the Emp table:

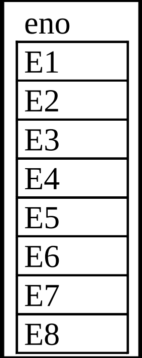
```
SELECT  eno
FROM    emp
```

emp Table



eno	ename	bdate	title	salary	supereno	dno
E1	J. Doe	01-05-75	EE	30000	E2	null
E2	M. Smith	06-04-66	SA	50000	E5	D3
E3	A. Lee	07-05-66	ME	40000	E7	D2
E4	J. Miller	09-01-50	PR	20000	E6	D3
E5	B. Casey	12-25-71	SA	50000	E8	D3
E6	L. Chu	11-30-65	EE	30000	E7	D2
E7	R. Davis	09-08-77	ME	40000	E8	D1
E8	J. Jones	10-11-72	SA	50000	null	D1

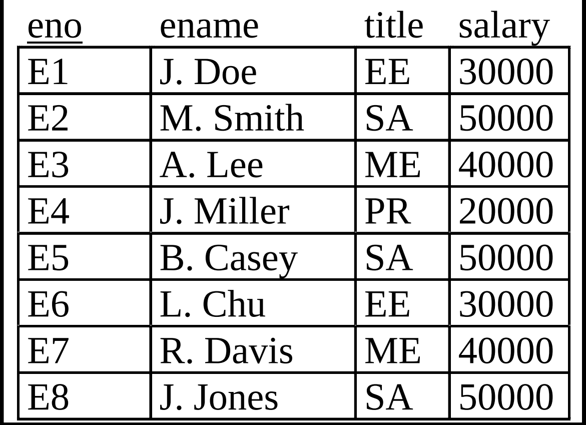
Result



eno
E1
E2
E3
E4
E5
E6
E7
E8

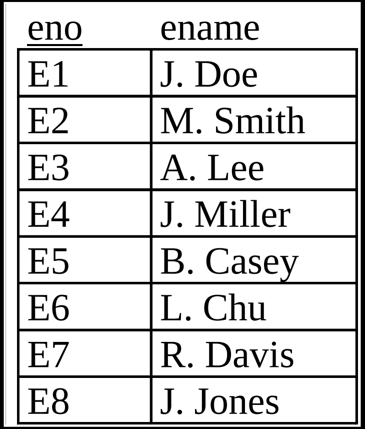
SQL Projection Examples

emp Table



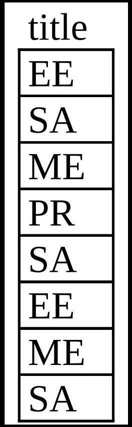
eno	ename	title	salary
E1	J. Doe	EE	30000
E2	M. Smith	SA	50000
E3	A. Lee	ME	40000
E4	J. Miller	PR	20000
E5	B. Casey	SA	50000
E6	L. Chu	EE	30000
E7	R. Davis	ME	40000
E8	J. Jones	SA	50000

```
SELECT eno,ename
FROM   emp
```



eno	ename
E1	J. Doe
E2	M. Smith
E3	A. Lee
E4	J. Miller
E5	B. Casey
E6	L. Chu
E7	R. Davis
E8	J. Jones

```
SELECT title
FROM   emp
```

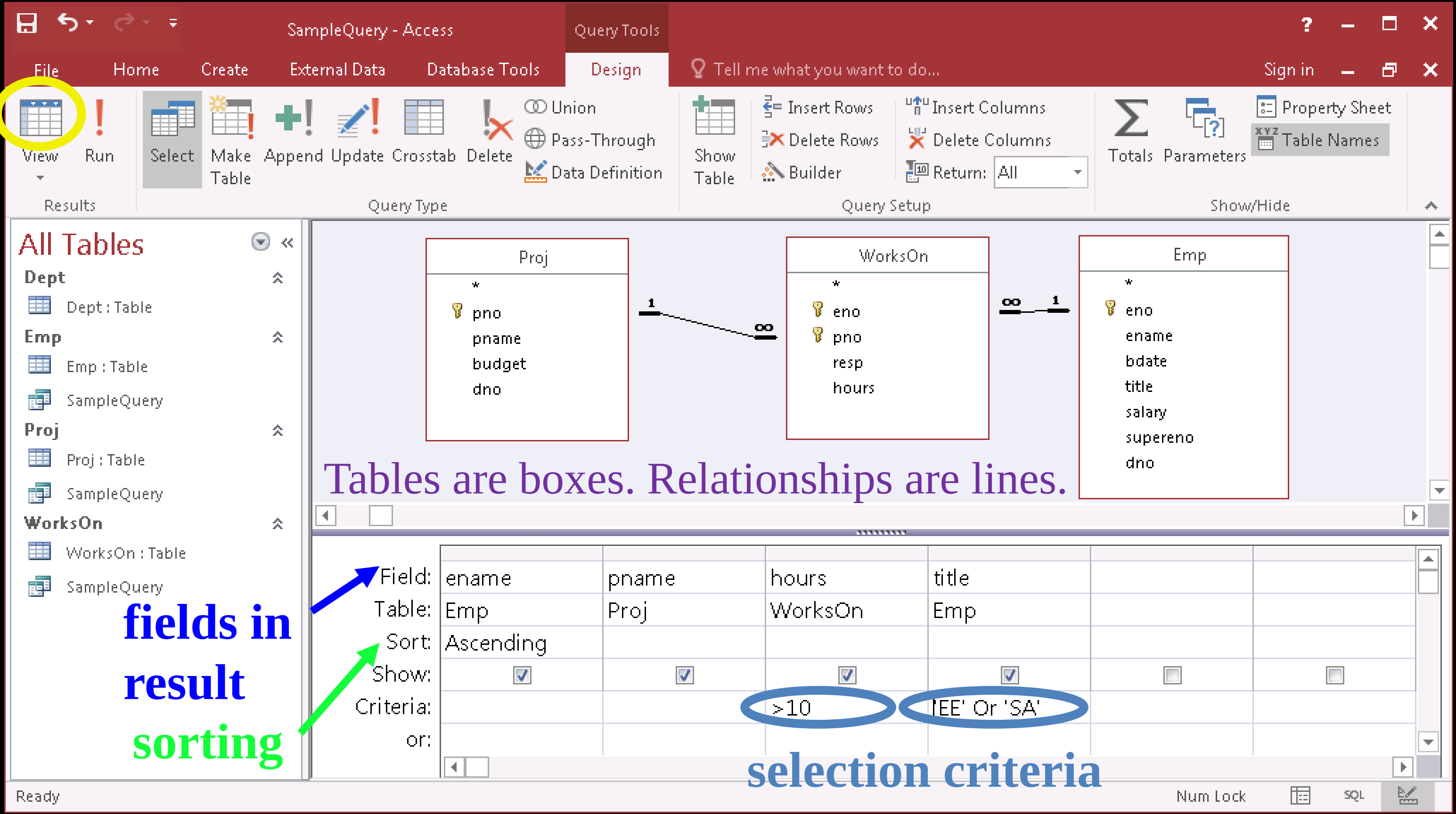


title
EE
SA
ME
PR
SA
EE
ME
SA

Notes: 1) Duplicates are not removed during SQL projection.
2) SELECT * will return all columns.

Microsoft Access Query Interface

switch view button



Tables are boxes. Relationships are lines.

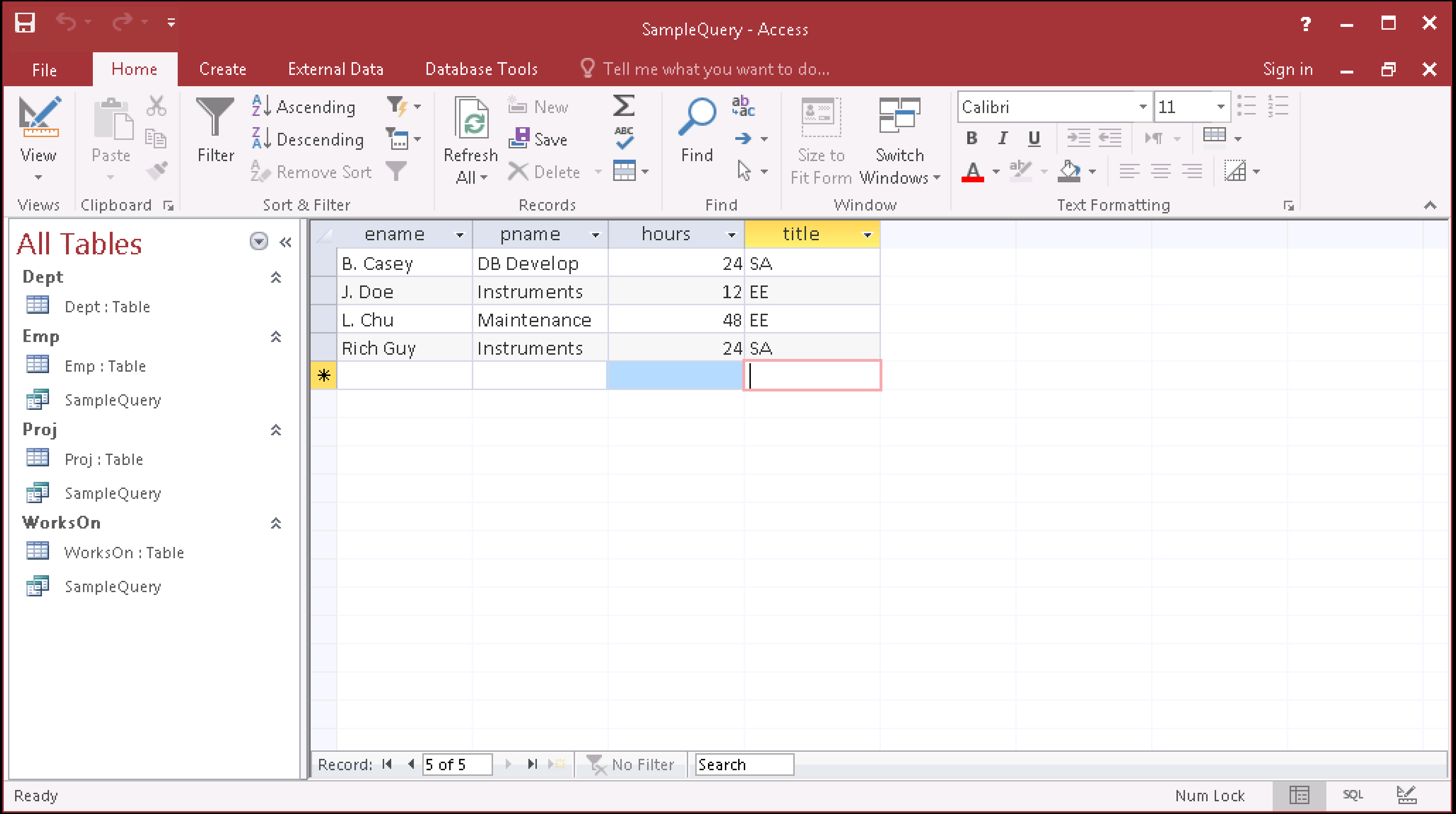
Field:	ename	pname	hours	title		
Table:	Emp	Proj	WorksOn	Emp		
Sort:	Ascending					
Show:	☑	☑	☑	☑	☐	☐
Criteria:			>10	'EE' Or 'SA'		
or:						

fields in result

sorting

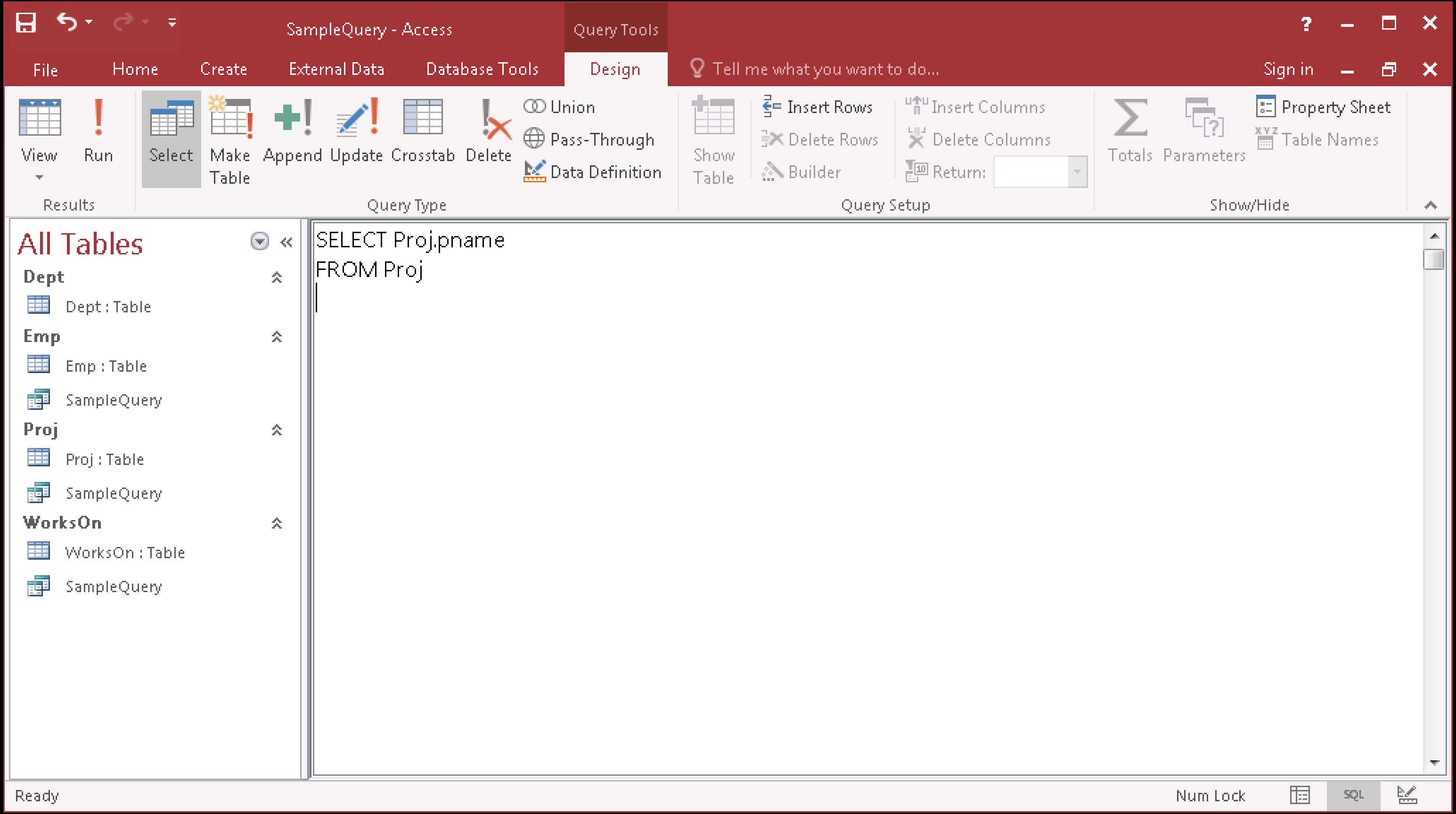
selection criteria

Microsoft Access Data Sheet View



ename	pname	hours	title
B. Casey	DB Develop	24	SA
J. Doe	Instruments	12	EE
L. Chu	Maintenance	48	EE
Rich Guy	Instruments	24	SA

Microsoft Access SQL Design View



```
SELECT Proj.pname
FROM Proj
```

Try it: SQL SELECT and Projection

Question: Using the `proj` table, write these three queries:

- Show all rows and all columns.
- Show all rows but only the `pno` column.
- Show all rows but only the `pno` and `budget` columns.

Use sqlfiddle.com

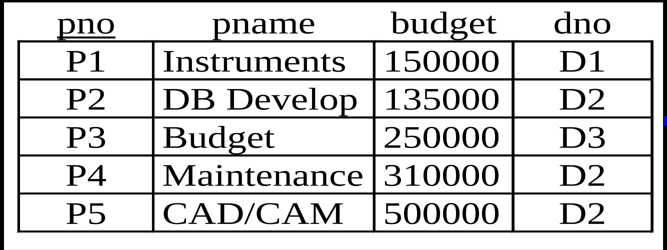
Retrieving Only Some of the Rows

The ***selection operation*** creates a new table with some of the rows of the input table. A condition specifies which rows are in the new table. The condition is similar to an `if` statement.

Example: Return the projects in department `'D2'`:

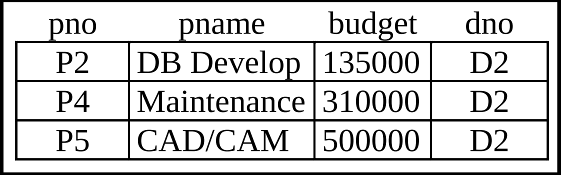
```
SELECT pno, pname, budget, dno
FROM   proj
WHERE  dno = 'D2';
```

`proj` Table



pno	pname	budget	dno
P1	Instruments	150000	D1
P2	DB Develop	135000	D2
P3	Budget	250000	D3
P4	Maintenance	310000	D2
P5	CAD/CAM	500000	D2

Result



pno	pname	budget	dno
P2	DB Develop	135000	D2
P4	Maintenance	310000	D2
P5	CAD/CAM	500000	D2

Algorithm: Scan each tuple and check if matches condition in WHERE clause.

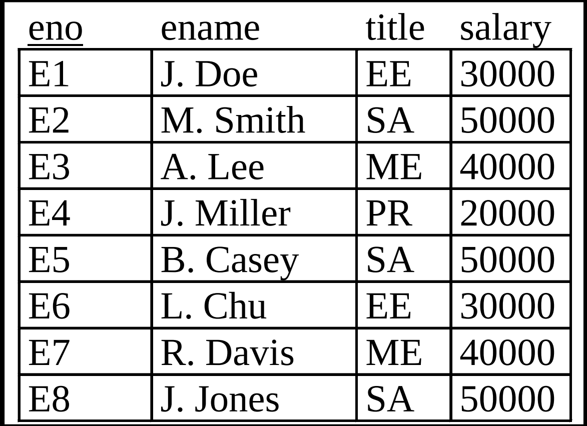
Selection Conditions

The condition in a selection statement specifies which rows are included. It has the general form of an if statement.

The condition may consist of attributes, constants, comparison operators (<, >, =, != , <=, >=), and logical operators (AND, OR, NOT).

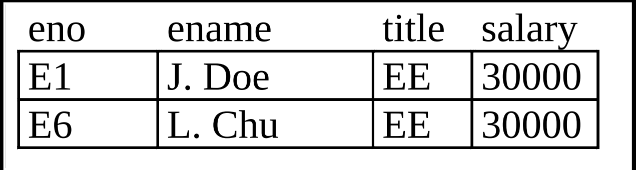
SQL Selection Examples

emp Table



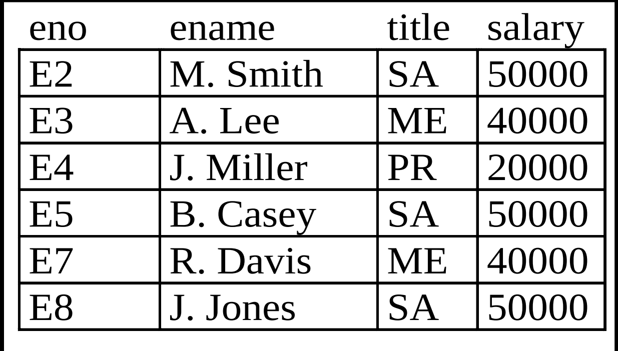
eno	ename	title	salary
E1	J. Doe	EE	30000
E2	M. Smith	SA	50000
E3	A. Lee	ME	40000
E4	J. Miller	PR	20000
E5	B. Casey	SA	50000
E6	L. Chu	EE	30000
E7	R. Davis	ME	40000
E8	J. Jones	SA	50000

```
SELECT *
FROM   emp
WHERE  title = 'EE'
```



eno	ename	title	salary
E1	J. Doe	EE	30000
E6	L. Chu	EE	30000

```
SELECT eno, ename, title, salary
FROM   emp
WHERE  salary > 35000 OR
          title = 'PR'
```



eno	ename	title	salary
E2	M. Smith	SA	50000
E3	A. Lee	ME	40000
E4	J. Miller	PR	20000
E5	B. Casey	SA	50000
E7	R. Davis	ME	40000
E8	J. Jones	SA	50000

Try it: SQL SELECT and Filtering Rows

Question: Using the `proj` table, write these three queries:

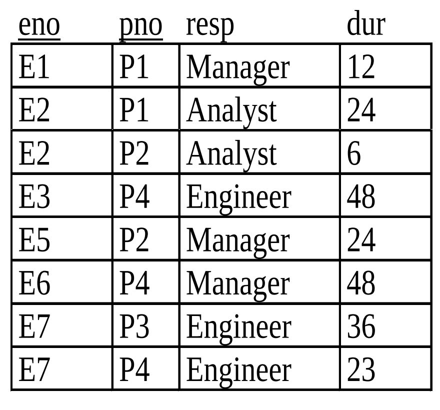
- Return all projects with `budget >$250000`.
- Show the `pno` and `pname` for projects in `dno = 'D1'`.
- Show `pno` and `dno` for projects in `dno='D1'` or `dno='D2’`.

Use sqlfiddle.com

Join Example for Combining Tables

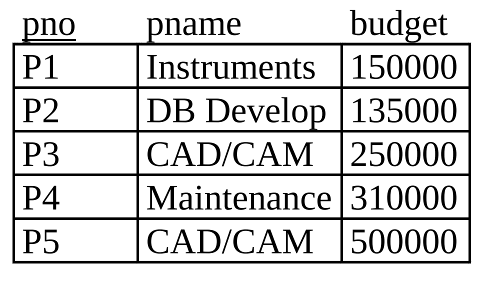
A ***join*** combines two tables by matching columns in each table.

workson Table



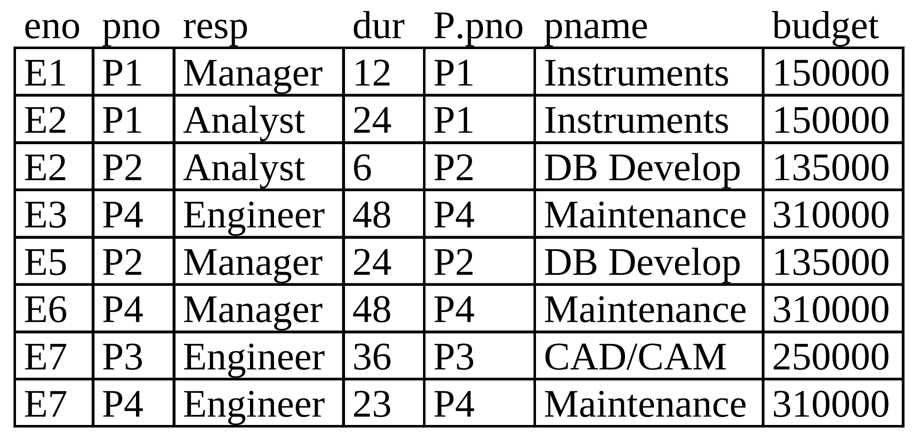
eno	pno	resp	dur
E1	P1	Manager	12
E2	P1	Analyst	24
E2	P2	Analyst	6
E3	P4	Engineer	48
E5	P2	Manager	24
E6	P4	Manager	48
E7	P3	Engineer	36
E7	P4	Engineer	23

proj Table



pno	pname	budget
P1	Instruments	150000
P2	DB Develop	135000
P3	CAD/CAM	250000
P4	Maintenance	310000
P5	CAD/CAM	500000

```
SELECT *
FROM   WorksOn INNER JOIN Proj
   ON  WorksOn.pno = Proj.pno
```



eno	pno	resp	dur	P.pno	pname	budget
E1	P1	Manager	12	P1	Instruments	150000
E2	P1	Analyst	24	P1	Instruments	150000
E2	P2	Analyst	6	P2	DB Develop	135000
E3	P4	Engineer	48	P4	Maintenance	310000
E5	P2	Manager	24	P2	DB Develop	135000
E6	P4	Manager	48	P4	Maintenance	310000
E7	P3	Engineer	36	P3	CAD/CAM	250000
E7	P4	Engineer	23	P4	Maintenance	310000

Join Query with Selection Example

You can use join, selection, and projection in the same query.

- Recall: Projection returns columns listed in SELECT, selection filters out rows using condition in WHERE, and join combines tables in FROM using a condition.

Example: Return the employee names who are assigned to the 'Management' department.

Projection: only name field in result

```
SELECT ename
FROM   emp INNER JOIN dept
         ON emp.dno = dept.dno
WHERE  dname = 'Management';
```

tables in query joined together

Selection: filter rows

Result

ename
R. Davis
J. Jones

Ordering Result Data

The query result returned is not ordered on any column by default. We can order the data using the **ORDER BY** clause:

```
SELECT   ename, salary, bdate
FROM     emp
WHERE    salary > 30000
ORDER BY salary DESC, ename ASC;
```

- 'ASC' sorts the data in ascending order, and 'DESC' sorts it in descending order. The default is 'ASC'.
- The order of sorted attributes is significant. The first column specified is sorted on first, then the second column is used to break any ties, etc.

LIMIT and OFFSET

If you only want the first *N* rows, use a **LIMIT** clause:

```
SELECT   ename, salary FROM emp
ORDER BY salary DESC LIMIT 5
```

To start from a row besides the first, use **OFFSET**:

```
SELECT   eno, salary FROM emp
ORDER BY eno DESC
LIMIT 3  OFFSET 2
```

- LIMIT improves performance by reducing amount of data processed and sent by the database system.
- OFFSET 0 is first row, so OFFSET 2 would return the 3rd row.
- LIMIT/OFFSET syntax supported differently by systems.
- For Access, use `SELECT TOP 5 eno, salary FROM emp`

Try it: SQL SELECT with Joins and Ordering

Question: Write these three queries:

- Return all projects with `budget < $500000` sorted by `budget` descending.
- List only the top 5 employees by `salary` descending. Show only their `name` and `salary`.
- List each project `pno`, `dno`, `pname`, and `dname` ordered by `dno` ascending then `pno` ascending. Only show projects if department `name > 'D'`. Note: This query will require a join.

Use sqlfiddle.com

Aggregate Queries and Functions

Several queries cannot be answered using the simple form of the SELECT statement. These queries require a summary calculation to be performed. Examples:

- What is the maximum employee salary?
- What is the total number of hours worked on a project?
- How many employees are there in department 'D1'?

To answer these queries requires the use of aggregate functions. These functions operate on a single column of a table and return a single value.

Aggregate Functions

Five common aggregate functions are:

- COUNT - returns the # of values in a column
- SUM - returns the sum of the values in a column
- AVG - returns the average of the values in a column
- MIN - returns the smallest value in a column
- MAX - returns the largest value in a column

Notes:

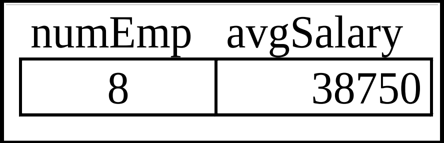
- 1) COUNT, MAX, and MIN apply to all types of fields, whereas SUM and AVG apply to only numeric fields.
- 2) Except for COUNT(*) all functions ignore nulls. COUNT(*) returns the number of rows in the table.
- 3) Use DISTINCT to eliminate duplicates.

Aggregate Function Example

Return the number of employees and their average salary.

```
SELECT COUNT(eno) AS numEmp, AVG(salary) AS avgSalary
FROM   emp
```

Result



numEmp	avgSalary
8	38750

Note: AS is used to rename a column in the output.

GROUP BY Clause

Aggregate functions are most useful when combined with the GROUP BY clause. The **GROUP BY** clause groups rows based on the values of the columns specified.

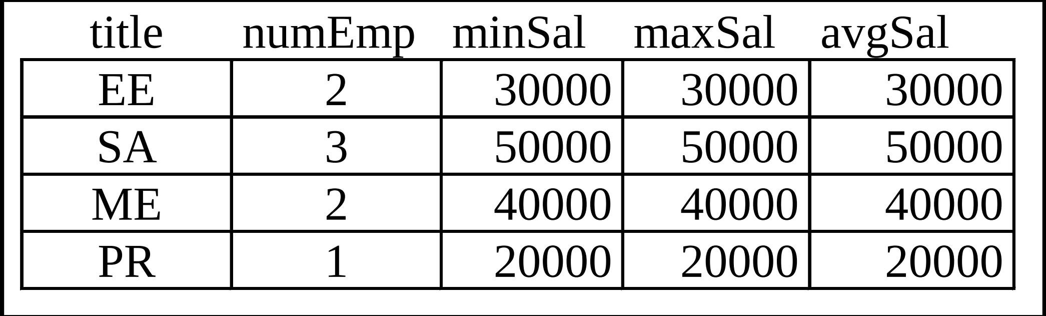
When used in combination with aggregate functions, the result is a table where each row consists of unique values for the group by attributes and the result of the aggregate functions applied to the rows of that group.

GROUP BY Example

For each employee title, return the number of employees with that title, and the minimum, maximum, and average salary.

```
SELECT   title, COUNT(eno) AS numEmp,
         MIN(salary) as minSal,
         MAX(salary) as maxSal, AVG(salary) AS avgSal
FROM     emp
GROUP BY title
```

Result



title	numEmp	minSal	maxSal	avgSal
EE	2	30000	30000	30000
SA	3	50000	50000	50000
ME	2	40000	40000	40000
PR	1	20000	20000	20000

GROUP BY Facts

1) You can group by multiple attributes. To be in the same group, all attribute values must be the same.

2) Any WHERE conditions are applied before the GROUP BY and aggregate functions are calculated.

3) A column name cannot appear in the SELECT part of the query unless it is part of an aggregate function or in the list of group by attributes.

4) There is a HAVING clause that is applied *AFTER* the GROUP BY clause and aggregate functions are calculated to filter out groups. (We will not study that.)

Try it: GROUP BY

Question: Use GROUP BY and aggregation functions to answer these queries.

1) Output the number of projects in the database.
2) Return the sum of the budgets for all projects.
3) For each department (dno), return the department number (dno) and the average budget of projects in that department.
4) For each project (pno), return the project number (pno) and the sum of the number of hours employees have worked on that project.
   - Challenge: Show the project name (pname) as well as the project number.
5) Challenge: Show the department name (dname), project name (pname), and sum of hours worked on that project as well as the number of employees working on the project.

Use sqlfiddle.com

Putting it All Together

The steps to write an English query in SQL are:

- 1) Find the columns that you need and put in SELECT clause.
- 2) List the tables that have the columns in the FROM clause. If there is more than one, join them together.
- 3) If you must filter rows, add a filter criteria in WHERE clause.
- 4) If you need to create an aggregate, use aggregation functions and GROUP BY.

Example: For each project name list the sum of the hours worked by employees working as a ‘Manager’ on the project.

```
SELECT pname, SUM(hours) as totalHours
FROM   workson INNER JOIN proj on workson.pno=proj.pno
WHERE  resp='Manager'
GROUP BY pname
```

Conclusion

A ***database*** is a collection of related data. A ***database system*** allows storing and querying a database.

SQL is the standard query language for databases, although Microsoft Access also provides a graphical user interface.

`CREATE TABLE` creates a table. `INSERT`, `DELETE`, and `UPDATE` commands modify the data stored within the database.

The basic query operations are selection (subset of rows), projection (subset of columns), join (combine two or more tables), and grouping and aggregation.

Objectives

- Define: database, database system, schema, metadata
- Define: relation, attribute, tuple, domain, degree, cardinality
- SQL properties: reserved words, case-insensitive, free-format
- Be able to create a table using CREATE TABLE command and in Microsoft Access.
- Explain what a key is and what it is used for.
- Use DROP TABLE to delete a table and its data.
- Use INSERT/UPDATE/DELETE to add/update/delete rows of a table and perform same actions using Microsoft Access user interface.
- Execute queries using SQL SELECT and using Microsoft Access user interface.
- Sort rows using ORDER BY. Use LIMIT to keep only the first (top) N rows.
- Use GROUP BY and aggregation functions for calculating summary data.

★ Given a small database write simple English queries in SQL.