

# INTRODUCTION To SQL

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*CS 564- Fall 2018*

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# ANNOUNCEMENTS

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- Enroll in Piazza!
- PS #1 will be posted tomorrow (due next Sunday)
- Group formation:
  - send an email to Ankur with:
  - 3 x (Student IDs + emails)
  - only one person from every team!

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# WHAT IS THIS LECTURE ABOUT

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- The Relational Model
- SQL: Basics
  - creating a table
  - primary keys
- SQL: Single-table queries
  - SELECT-FROM-WHERE structure
  - DISTINCT/ORDER BY/LIMIT
- SQL: Multi-table queries
  - foreign keys
  - joins

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# RELATIONAL MODEL

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# RELATIONAL MODEL

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- first proposed by Codd in 1969
- has just a single concept: **relation**
- the world is represented as a collection of tables
- well-suited for efficient manipulations on computers

# RELATION

The data is stored in **tables** (or **relations**)

**PRODUCT**

table name

attribute name

name	category	price	manufacturer
iPad	tablet	\$399.00	Apple
Surface	tablet	\$299.00	Microsoft
...	...	...	...

record/tuple

# DOMAINS

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- Each attribute has an **atomic type** called domain
- A **domain** specifies the set of values allowed
- **Examples:**
  - integer
  - string
  - real

**PRODUCT**(name: *string*,  
category: *string*,  
price: *real*,  
manufacturer: *string*)

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# SCHEMA

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The **schema** of a *relation*:

- relation name + attribute names
- **Product**(name, price, category, manufacturer)
- In practice we add the domain for each attribute

The **schema** of a *database*:

- a collection of relation schemas



# INSTANCE

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The **instance** of a *relation*:

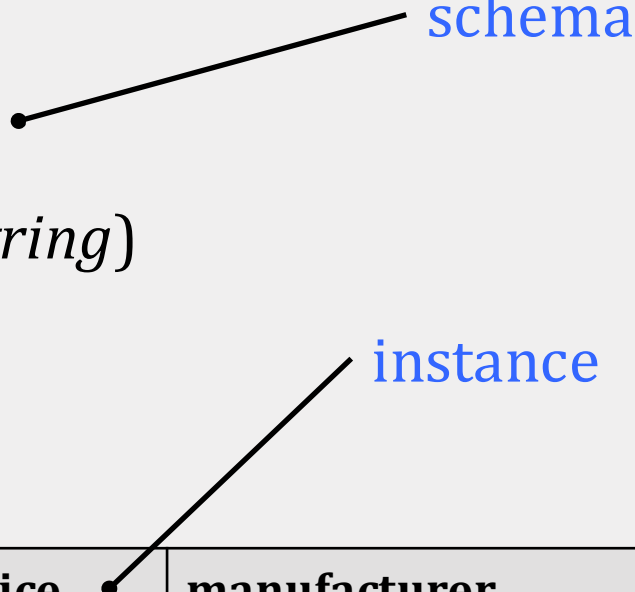
- a set of tuples or records

The **instance** of a *database*:

- a collection of relation instances

# EXAMPLE

**PRODUCT**(name: *string*,  
category: *string*,  
price: *real*,  
manufacturer: *string*)



name	category	price	manufacturer
iPad	tablet	\$399.00	Apple
Surface	tablet	\$299.00	Microsoft
...	...	...	...

# SCHEMA VS INSTANCE

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- Analogy with programming languages:
  - schema  $\sim$  type
  - instance  $\sim$  value
- Important distinction
  - schema: stable over long periods of time
  - instance: changes constantly, as data is inserted/updated/deleted

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# SQL: BASICS

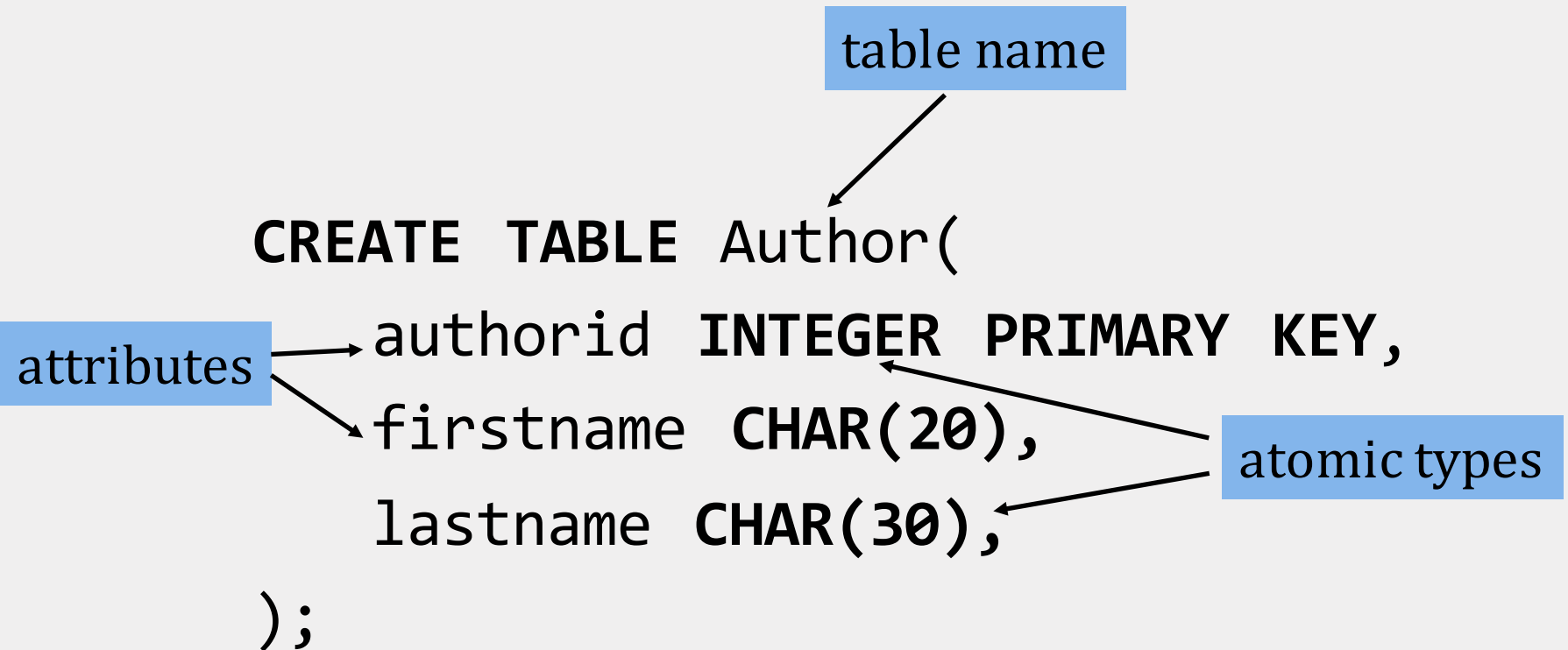
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# WHAT IS SQL?

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- The most widely used database language
- Used to **query** and **manipulate** data
- SQL stands for **S**tructured **Q**uery **L**anguage
  - many SQL standards: SQL-92, SQL:1999, SQL:2011
  - vendors support different subsets
  - we will discuss the common functionality

# CREATING A TABLE



# PRIMARY KEYS

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A primary key is a **minimal subset of attributes** that is a unique identifier of tuples in a relation

- A key is an implicit constraint on which tuples can be in the relation
- In SQL we specify that an attribute is the primary key with the keyword **PRIMARY KEY**

# UNIQUE KEYS

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- We can also define a **unique key**: a subset of attributes that uniquely defines a row:

```
CREATE TABLE Author(  
    authorid INTEGER UNIQUE,  
    firstname CHAR(20)) ;
```

- There can be only one primary key, but many unique keys!



# NULL VALUES

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- tuples in SQL relations can have **NULL** as a value for one or more attributes
- The meaning depends on context:
  - **missing value**: e.g. we know that Greece has some population, but we don't know what it is
  - **inapplicable**: e.g. the value of attribute *spouse* for an unmarried person

# NULL VALUES

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When creating a table in SQL, we can assert that a particular attribute takes no **NULL** values

```
CREATE TABLE Author(  
    authorid INTEGER PRIMARY KEY,  
    firstname CHAR(20) NOT NULL,  
    lastname CHAR(30)  
);
```

# POPULATING A TABLE

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- To insert a single tuple:

```
INSERT INTO <relation>  
VALUES ( <list of values> );
```

- We may add to the relation name a list of attributes (if we forget the order)

```
INSERT INTO Author  
VALUES(001, 'Dan', 'Brown');
```

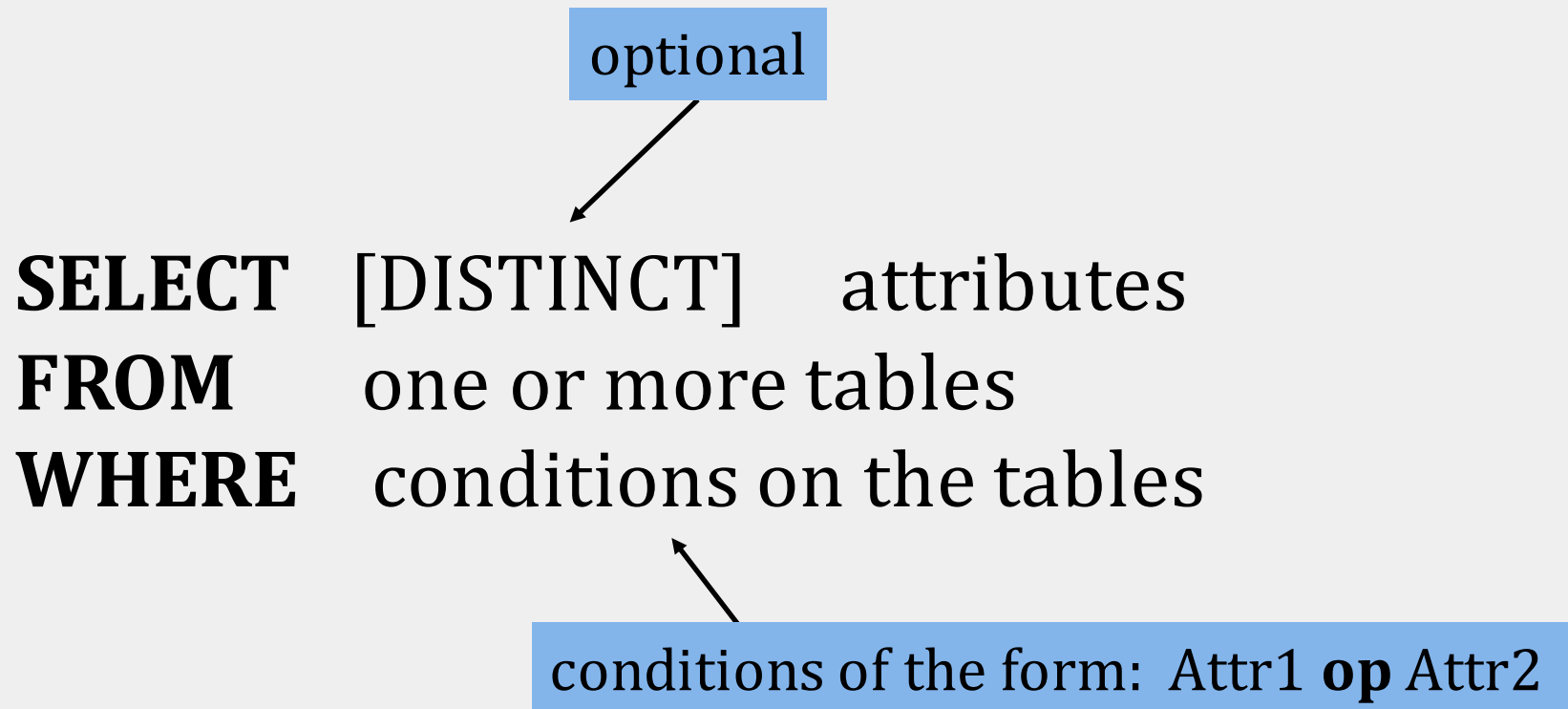
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# SQL: SINGLE-TABLE QUERIES

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# BASIC SQL QUERY

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# EXAMPLE

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What is the population of USA?

```
SELECT Population  
FROM Country  
WHERE Code = 'USA';
```

**PROJECTION:** keeps only the specified attributes



**SELECTION:** filters the tuples of the relation



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# SEMANTICS

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1. Think of a *tuple variable* ranging over each tuple of the relation mentioned in **FROM**
2. Check if the current tuple satisfies the **WHERE** clause
3. If so, compute the attributes or expressions of the **SELECT** clause using this tuple

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# \* IN SELECT CLAUSES

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When there is one relation in the **FROM** clause, \* in the **SELECT** clause stands for “*all attributes of this relation*”

```
SELECT *  
FROM City  
WHERE Population >= '1000000'  
AND CountryCode = 'USA';
```



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# RENAMING ATTRIBUTES

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If we want the output schema to have different attribute names, we can use **AS** *<new name>* to rename an attribute

```
SELECT Name AS LargeUSACity
FROM City
WHERE Population >= '1000000'
AND CountryCode = 'USA';
```

# ARITHMETIC EXPRESSIONS

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We can use any arithmetic expression (that makes sense) in the **SELECT** clause

```
SELECT Name,  
       (Population/ 1000000) AS PopulationInMillion  
FROM City  
WHERE Population >= '1000000' ;
```

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# WHAT CAN WE USE IN WHERE CLAUSES?

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- attribute names of the relations that appear in the **FROM** clause
- comparison operators: =, <>, <, >, <=, >=
- arithmetic operations (+, -, /, \*)
- **AND, OR, NOT** to combine conditions
- operations on strings (e.g. concatenation)
- pattern matching: *s* **LIKE** *p*
- special functions for comparing dates and times

# PATTERN MATCHING

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s **LIKE** p: pattern matching on strings

- % = any sequence of characters
- \_ = any single character

```
SELECT Name, GovernmentForm  
FROM Country  
WHERE GovernmentForm LIKE '%Monarchy%';
```

# USING DISTINCT

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- The default semantics of SQL is **bag** semantics (duplicate tuples are allowed in the output)
- The use of **DISTINCT** in the **SELECT** clause removes all duplicate tuples in the result, and returns a **set**

```
SELECT DISTINCT GovernmentForm  
FROM Country;
```

# ORDER BY

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The use of **ORDER BY** orders the tuples by the attribute we specify in **decreasing (DESC)** or **increasing (ASC)** order

```
SELECT Name, Population
FROM City
WHERE Population >= '1000000'
ORDER BY Population DESC;
```

---

# LIMIT

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- The use of **LIMIT** *<number>* limits the output to be only the specified number of tuples
- It can be used with **ORDER BY** to get the maximum or minimum value of an attribute!

```
SELECT Name, Population
FROM City
ORDER BY Population DESC
LIMIT 2;
```

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# SQL: MULTI-TABLE QUERIES

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# FOREIGN KEYS

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Suppose that we want to create a table Book, and make sure that *the author of the book exists in the table Author*

```
CREATE TABLE Book(  
    bookid INTEGER PRIMARY KEY,  
    title TEXT,  
    authorid INTEGER,  
    FOREIGN KEY (authorid) REFERENCES  
    Author(authorid));
```

# FOREIGN KEYS

---

- Use the keyword **REFERENCES**, as:

**FOREIGN KEY** ( *<list of attributes>* )  
**REFERENCES** *<relation>* ( *<attributes>* )

- Referenced attributes must be declared **PRIMARY KEY** or **UNIQUE**

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# ENFORCING FK CONSTRAINTS

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If there is a **foreign-key constraint** from attributes of relation  $R$  to the primary key of relation  $S$ , two violations are possible:

1. An insert or update to  $R$  introduces values not found in  $S$
2. A deletion or update to  $S$  causes some tuples of  $R$  to dangle

**There are 3 ways to enforce foreign key constraints!**

# ACTION 1: REJECT

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- The insertion/deletion/update query is **rejected** and not executed in the DBMS
- This is the **default action** if a foreign key constraint is declared

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# ACTION 2: CASCADE UPDATE

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When a tuple referenced is *updated*, the update **propagates** to the tuples that reference it

```
CREATE TABLE Book(  
    bookid INTEGER PRIMARY KEY,  
    title TEXT,  
    authorid INTEGER,  
    FOREIGN KEY (authorid) REFERENCES  
    Author(authorid)  
    ON UPDATE CASCADE);
```

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## ACTION 2: CASCADE DELETE

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When a tuple referenced is *deleted*, the deletion **propagates** to the tuples that reference it

```
CREATE TABLE Book(  
    bookid INTEGER PRIMARY KEY,  
    title TEXT,  
    authorid INTEGER,  
    FOREIGN KEY (authorid) REFERENCES  
    Author(authorid)  
    ON DELETE CASCADE);
```

---

## ACTION 3: SET NULL

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- When a delete/update occurs, the values that reference the deleted tuple are set to **NULL**

```
CREATE TABLE Book(  
    bookid INTEGER PRIMARY KEY,  
    title TEXT,  
    authorid INTEGER,  
    FOREIGN KEY (authorid) REFERENCES  
    Author(authorid)  
    ON UPDATE SET NULL);
```

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# WHAT SHOULD WE CHOOSE?

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- When we declare a foreign key, we may choose policies **SET NULL** or **CASCADE** *independently* for deletions and updates  
**ON [UPDATE, DELETE] [SET NULL, CASCADE]**
- Otherwise, the default policy (*reject*) is used



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# MULTIPLE RELATIONS

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- We often want to combine data from more than one relation
- We can address several relations in one query by listing them all in the **FROM** clause
- If two attributes from different relations have the same name, we can distinguish them by writing *<relation>.<attribute>*

# EXAMPLE

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*What is the name of countries that speak Greek?*

```
SELECT Name
FROM Country, CountryLanguage
WHERE Code = CountryCode
      AND Language = 'Greek';
```

This is **BAD** style!!

# EXAMPLE: GOOD STYLE

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```
SELECT Country.Name
FROM Country, CountryLanguage
WHERE Country.Code=CountryLanguage.CountryCode
AND CountryLanguage.Language = 'Greek';
```

```
SELECT C.Name
FROM Country C, CountryLanguage L
WHERE C.Code = L.CountryCode
AND L.Language = 'Greek';
```

# VARIABLES

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Variables are necessary when we want to use two copies of the same relation in the **FROM** clause

```
SELECT C.Name
FROM Country C, CountryLanguage L1,
CountryLanguage L2
WHERE  C.Code = L1.CountryCode
      AND C.Code = L2.CountryCode
      AND L1.Language = 'Greek'
      AND L2.Language = 'English';
```

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# SEMANTICS: SELECT-FROM-WHERE

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1. Start with the cross product of all the relations in the **FROM** clause
2. Apply the conditions from the **WHERE** clause
3. Project onto the list of attributes and expressions in the **SELECT** clause
4. If **DISTINCT** is specified, eliminate duplicate rows

# SEMANTICS OF SQL: EXAMPLE

**SELECT** R.D  
**FROM** R, S  
**WHERE** R.A = S.B AND S.C = 'e' ;

A	D
1	a
2	b
2	c

B	C
1	d
2	e

cross product

A	D	B	C
1	a	1	d
1	a	2	e
2	b	1	d
2	b	2	e
2	c	1	d
2	c	2	e

select

A	D	B	C
2	b	2	e
2	c	2	e

project

D
b
c

# SEMANTICS OF SQL: NESTED LOOP

**SELECT**  $a_1, a_2, \dots, a_k$   
**FROM**  $R_1$  **AS**  $x_1, R_2$  **AS**  $x_2, \dots, R_n$  **AS**  $x_n$   
**WHERE** Conditions

*answer* := {}  
**for**  $x_1$  **in**  $R_1$  **do**  
    **for**  $x_2$  **in**  $R_2$  **do**  
        .....  
            **for**  $x_n$  **in**  $R_n$  **do**  
                **if** Conditions  
                    **then** *answer* := *answer*  $\cup \{(a_1, \dots, a_k)\}$   
**return** *answer*

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# SEMANTICS OF SQL

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- The query processor will **almost never** evaluate the query this way
- SQL is a **declarative** language
- The DBMS figures out the most efficient way to compute it (we will discuss this later in the course when we talk about *query optimization*)