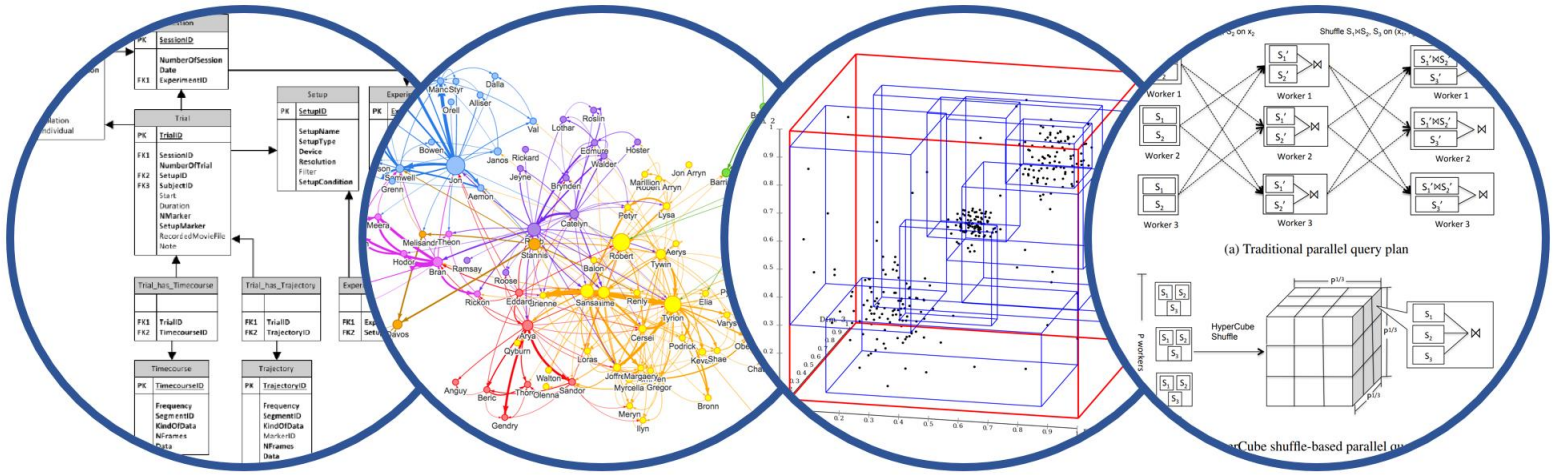


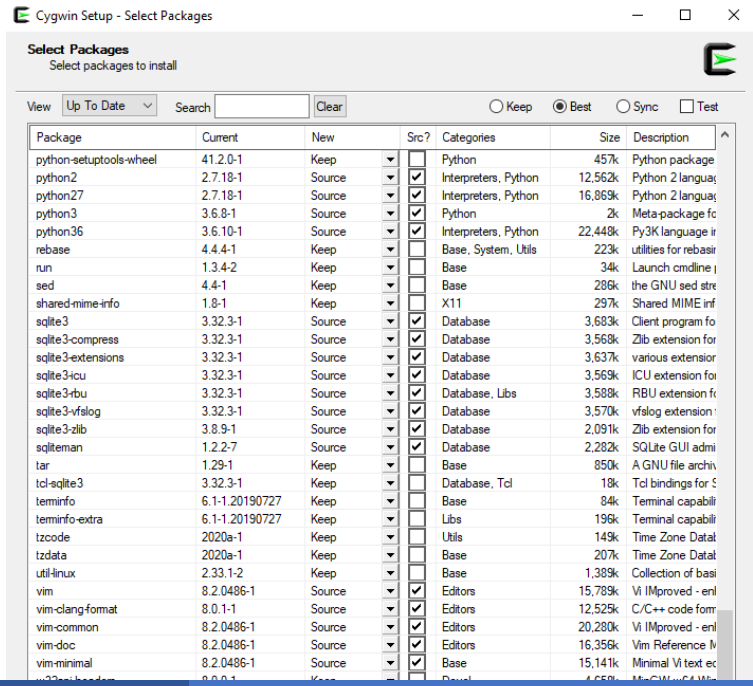
Data Management for Data Science

SQL Basics

Paul G. Allen School of Computer Science and Engineering
University of Washington, Seattle

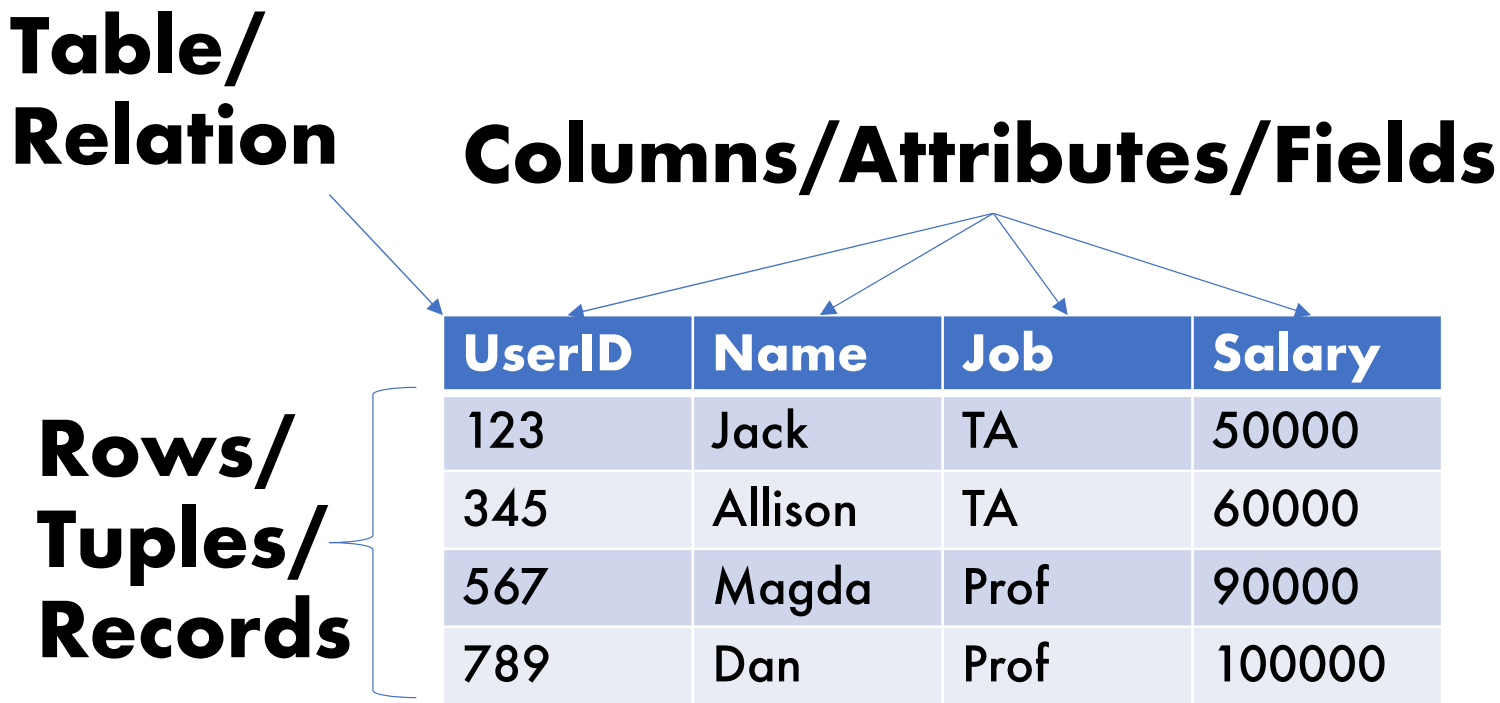
Announcements

- HW 1 released!
  - Released and collected via Gradescope
  - Your @uw user account has been added to gradescope.com
  - Lightweight, due Tuesday Jan. 12
- Note for Windows users:
  - Check boxes for sqlite3 in Cygwin



Recap – The Relational Model

- Flat tables, static and typed attributes, etc.
  - "It's a spreadsheet with rules"



UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

Structured Query Language - SQL

- **Declarative** query language
  - Tell the computer what you want, not how to get it
- Languages like Java/Python are procedural
- Declarative query language allows **physical data independence**

Recap - Basic SQL query

Payroll

UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

```
SELECT *
  FROM Payroll
```

Recap - Basic SQL query

Payroll

UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

```
SELECT  *
  FROM  Payroll
```

UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

Recap - Basic SQL query

Payroll

UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

```
SELECT P.Name, P.UserID
  FROM Payroll AS P
 WHERE P.Job = 'TA';
```

Recap - Basic SQL query

Payroll

UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

Name	UserID
Jack	123
Allison	345

```
SELECT P.Name, P.UserID
  FROM Payroll AS P
 WHERE P.Job = 'TA';
```

Recap - Basic SQL query

Payroll

UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

Name	UserID
Jack	123
Allison	345

```
SELECT  P.Name, P.UserID
  FROM  Payroll AS P
 WHERE  P.Job = 'TA';
```

"Payroll AS P" makes P an alias. This lets us specify that the attributes come from Payroll

Wait!

How does a computer understand abstract SQL text?

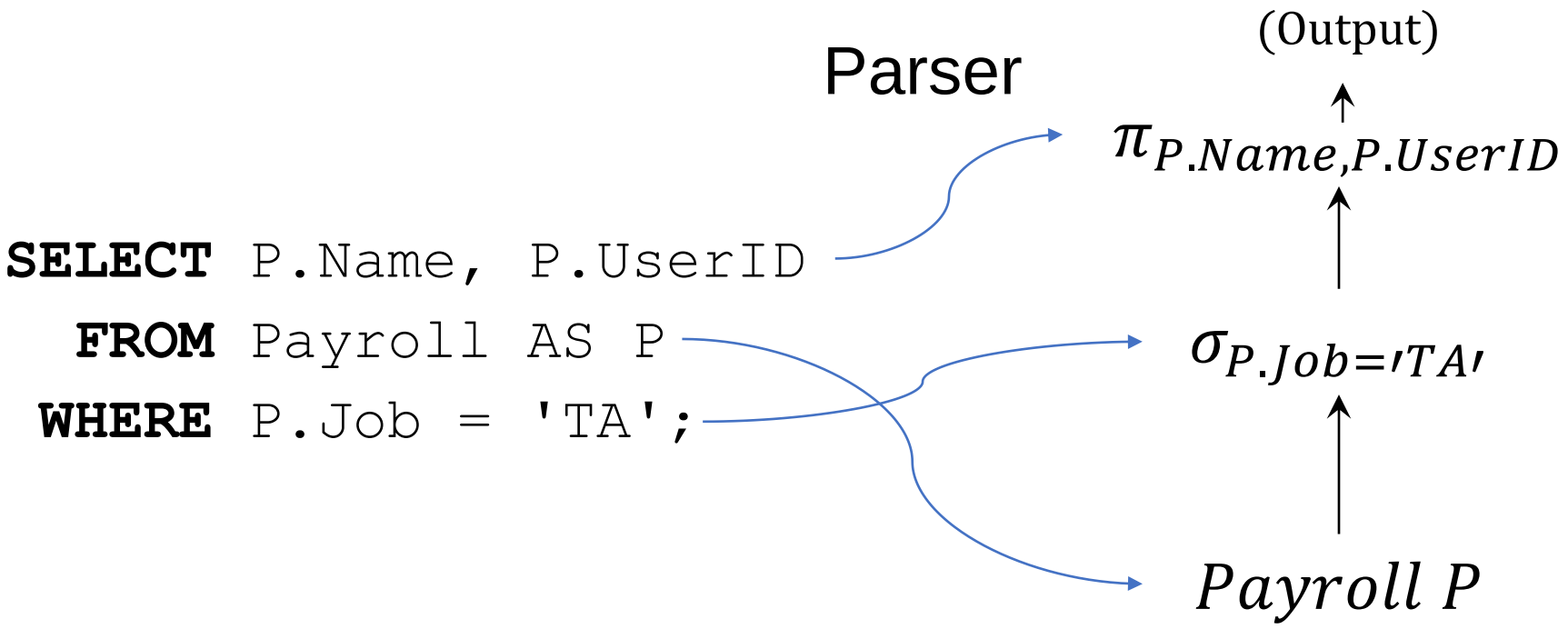
Database Internals

- Code has to boil down to instructions at some point
- Relational Database Management Systems (RDBMSs) use **Relational Algebra** (RA)

```
SELECT P.Name, P.UserID
  FROM Payroll AS P
 WHERE P.Job = 'TA';
```

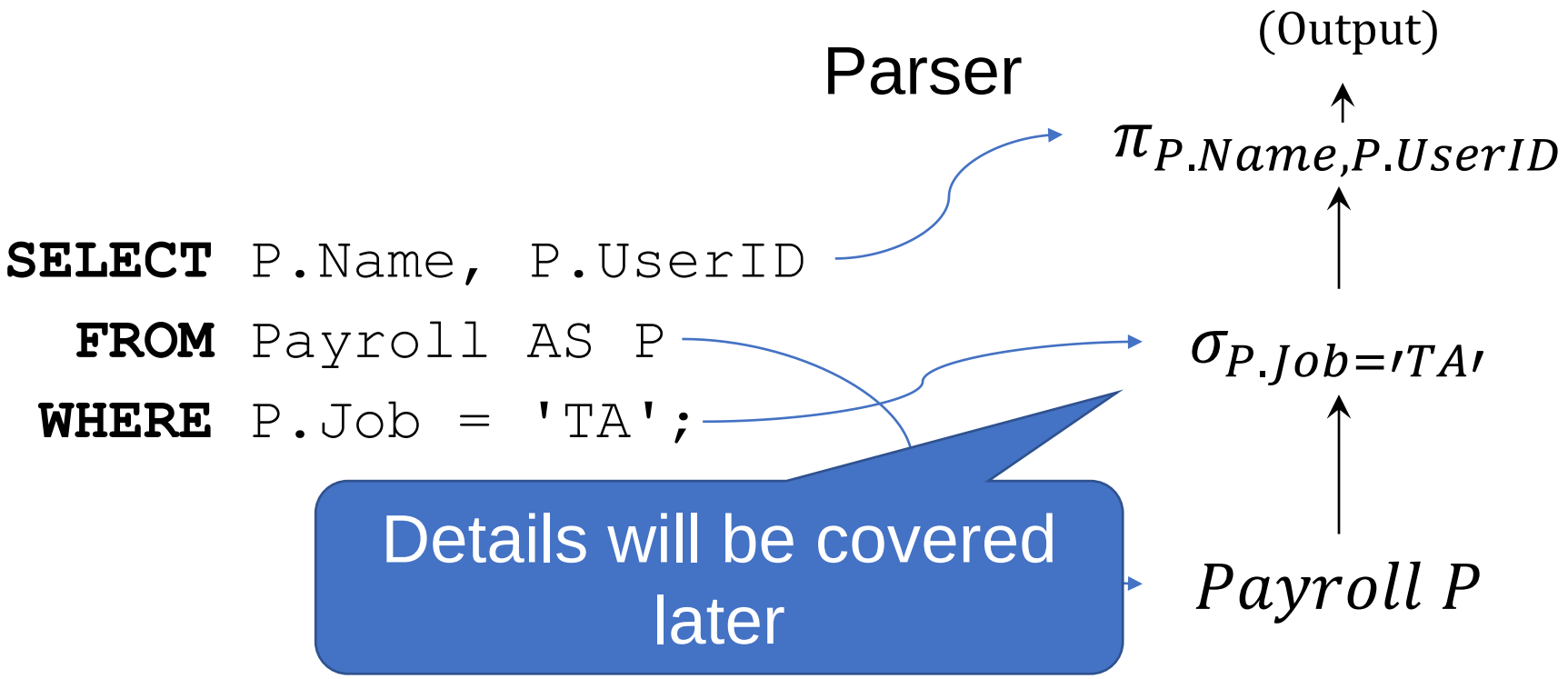
Database Internals

- Code has to boil down to instructions at some point
- Relational Database Management Systems (RDBMSs) use **Relational Algebra** (RA).



Database Internals

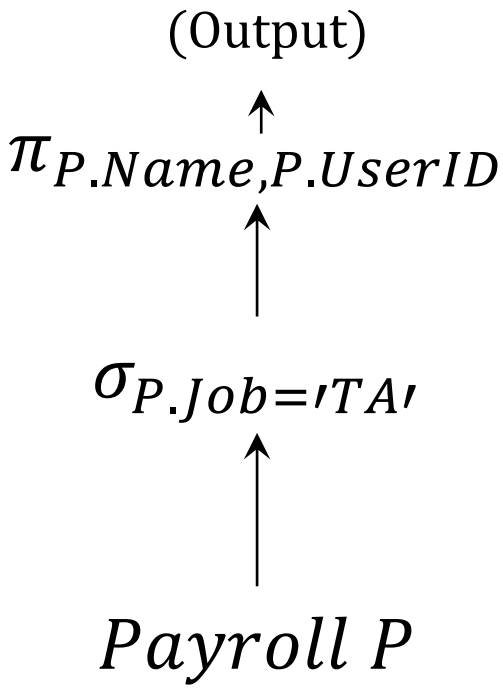
- Code has to boil down to instructions at some point
- Relational Database Management Systems (RDBMSs) use **Relational Algebra** (RA).



Database Internals

- It's important to define the semantics (meaning) of a query

```
SELECT P.Name, P.UserID
  FROM Payroll AS P
 WHERE P.Job = 'TA';
```

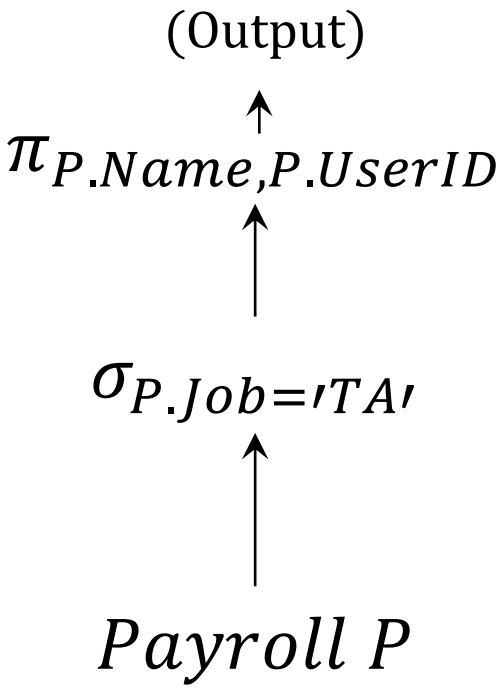


For-each semantics

Database Internals

- It's important to define the semantics (meaning) of a query

```
SELECT P.Name, P.UserID
  FROM Payroll AS P
 WHERE P.Job = 'TA';
```



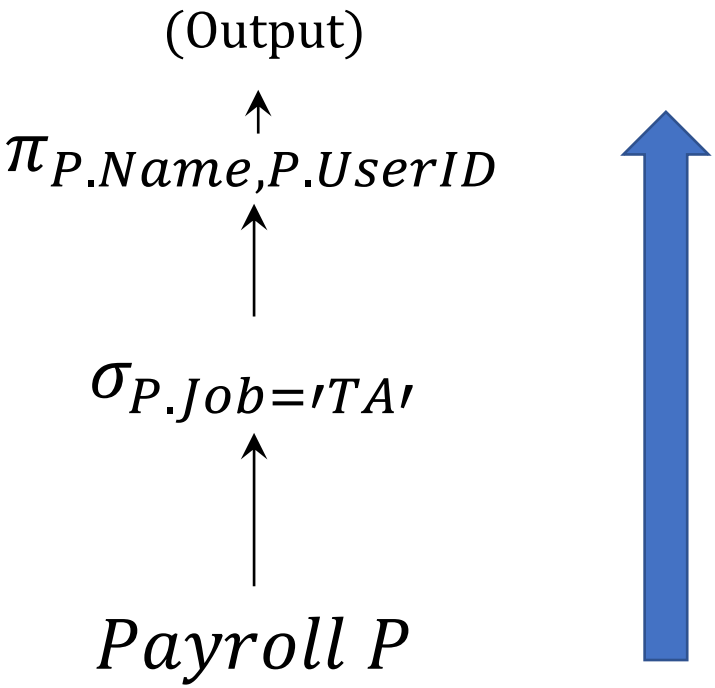
For-each semantics

```
for each row in P:
  if (row.Job == 'TA'):
    output (row.Name, row.UserID)
```

Database Internals

- It's important to define the semantics (meaning) of a query

```
SELECT P.Name, P.UserID
  FROM Payroll AS P
 WHERE P.Job = 'TA';
```



Tuples “flow” up the query plan, getting filtered and modified

For-each semantics

Payroll

UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

```
for each row in P:
  if (row.Job == 'TA'):
    output (row.Name, row.UserID)
```

Name	UserID

```
SELECT P.Name, P.UserID
  FROM Payroll AS P
 WHERE P.Job = 'TA';
```

For-each semantics

Payroll

UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

```
for each row in P:
  if (row.Job == 'TA'):
    output (row.Name, row.UserID)
```

Name	UserID
Jack	123

```
SELECT P.Name, P.UserID
  FROM Payroll AS P
 WHERE P.Job = 'TA';
```

For-each semantics

Payroll

UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

```
for each row in P:
  if (row.Job == 'TA'):
    output (row.Name, row.UserID)
```

Name	UserID
Jack	123

```
SELECT P.Name, P.UserID
  FROM Payroll AS P
 WHERE P.Job = 'TA';
```

For-each semantics

Payroll

UserID	Name	Job	Salary
123	Jack	TA	50000
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```
for each row in P:
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```

Name	UserID
Jack	123
Allison	345

```
SELECT P.Name, P.UserID
  FROM Payroll AS P
 WHERE P.Job = 'TA';
```

For-each semantics

Payroll

UserID	Name	Job	Salary
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For-each semantics

Payroll

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For-each semantics

Payroll

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```
for each row in P:
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```

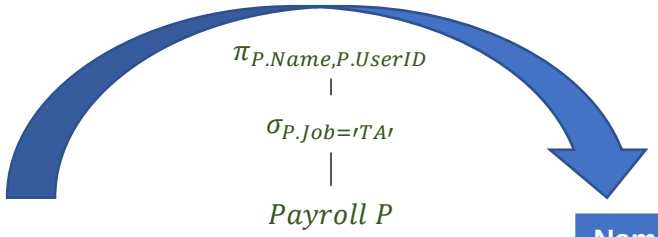
Name	UserID
Jack	123
Allison	345

```
SELECT P.Name, P.UserID
  FROM Payroll AS P
 WHERE P.Job = 'TA';
```

Recap – SQL and RA

- SQL (Next few lectures)
  - "What data do I want"
- RA (After SQL)
  - "How do I get the data"

UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000




```
SELECT P.Name, P.UserID
  FROM Payroll AS P
 WHERE P.Job = 'TA';
```

Name	UserID
Jack	123
Allison	345

What's Next?

- Creating tables
- Keys → Identification
- Foreign Keys → Relationships
- Joins in SQL and RA
  - Inner joins
  - Outer joins
  - Self joins

Create Table Statement

Payroll(UserId, Name, Job, Salary)

```
CREATE TABLE Payroll (
  UserID INT,
  Name VARCHAR(100),
  Job VARCHAR(100),
  Salary INT);
```

Data types

- Each attribute has a type.
  - Examples types:
    - Strings: CHAR(20), VARCHAR(50), TEXT
    - Numbers: INT, SMALLINT, FLOAT
    - MONEY, DATETIME, …
    - Few more that are DBMS specific
  - Statically and strictly enforced

Data types

- Generally you will use:
  - **VARCHAR(N)** for strings where N is the maximum character length
    - Generally set this to as large as you need, like 256 or 1000.
  - **INT**, **FLOAT** for numbers (INTEGER works in SQLite)
  - **DATETIME** for dates
    - Can use VARCHAR(N) in SQLite

Create Table Statement

Payroll(UserId, Name, Job, Salary)

```
CREATE TABLE Payroll (
  UserID INT,
  Name VARCHAR(100),
  Job VARCHAR(100),
  Salary INT);
```

Create Table Statement

Payroll(UserId, Name, Job, Salary)

```
CREATE TABLE Payroll (
  UserID INT,
  Name VARCHAR(100),
  Job VARCHAR(100),
  Salary INT);
```

Everything is case-insensitive, but having your own guidelines is useful for readability

Keys

Key

A **Key** is one or more attributes that uniquely identify a row.

UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

Keys

Key

A **Key** is one or more attributes that uniquely identify a row.

UserID	Name	Job	Salary
123	Jack	TA	50000
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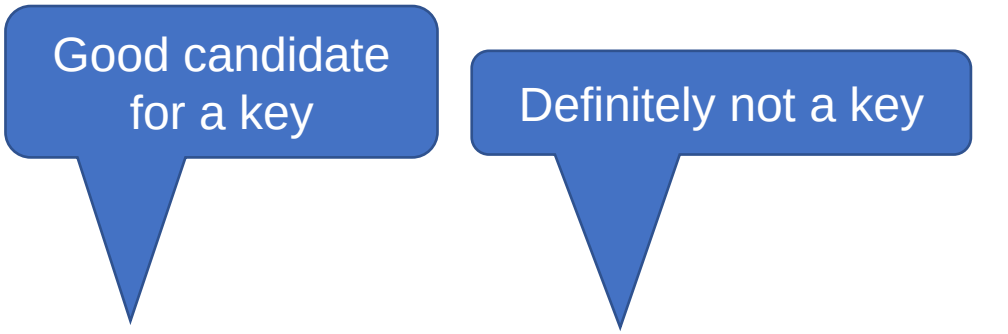

UserID	Name	Job	Salary
123	Jack	TA	50000
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567	Magda	Prof	90000
789	Dan	Prof	100000

Keys

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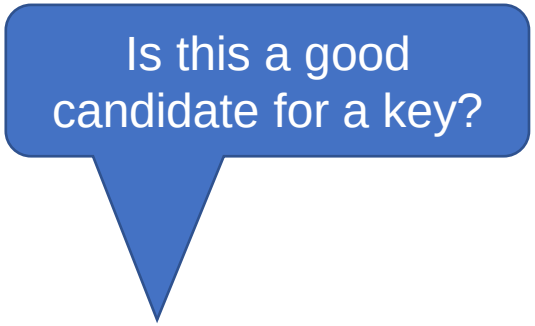
A **Key** is one or more attributes that uniquely identify a row.



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123	Jack	TA	50000
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Keys

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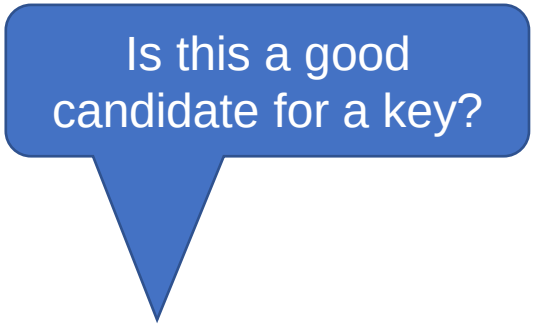


UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

Keys

Key

A **Key** is one or more attributes that uniquely identify a row.

Is this a good candidate for a key?

UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000
913	Peter	TA	60000

Keys

Key

A **Key** is one or more attributes that uniquely identify a row.

Data comes from the real world
so models ought to reflect that

UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000
913	Peter	TA	60000

Keys

```
CREATE TABLE Payroll (
  UserID INT,
  Name VARCHAR(100),
  Job VARCHAR(100),
  Salary INT);
```

Payroll(UserId, Name, Job, Salary)

Keys


```
CREATE TABLE Payroll (
  UserID INT,
  Name VARCHAR(100),
  Job VARCHAR(100),
  Salary INT);
```

Payroll(UserId, Name, Job, Salary)

Keys


```
CREATE TABLE Payroll (
  UserID INT PRIMARY KEY,
  Name VARCHAR(100),
  Job VARCHAR(100),
  Salary INT);
```

Payroll(UserId, Name, Job, Salary)

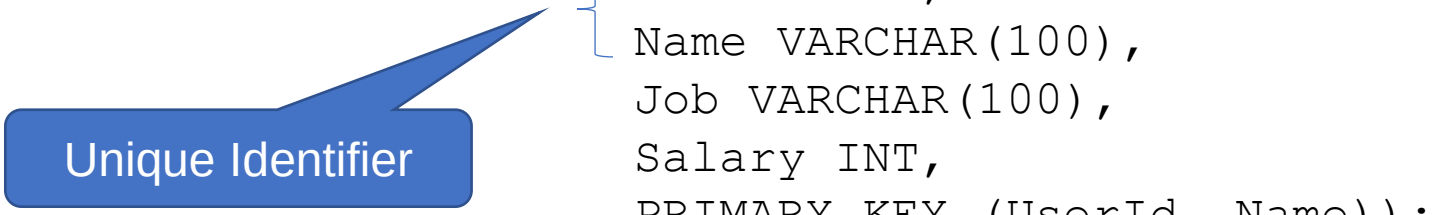
Keys

```
CREATE TABLE Payroll (
  UserID INT,
  Name VARCHAR(100),
  Job VARCHAR(100),
  Salary INT);
```

Unique Identifier

Payroll(UserId, Name, Job, Salary)

Keys




```
CREATE TABLE Payroll (
  UserID INT,
  Name VARCHAR(100),
  Job VARCHAR(100),
  Salary INT,
  PRIMARY KEY (UserId, Name));
```

Payroll(UserId, Name, Job, Salary)

Foreign Keys

- Databases can hold multiple tables
- How do we capture relationships *between* tables?

Payroll

UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

Regist

UserID	Car
123	Charger
567	Civic
567	Pinto

Foreign Keys

- Databases can hold multiple tables
- How do we capture relationships *between* tables?

UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

Foreign Key

UserID	Car
123	Charger
567	Civic
567	Pinto

Foreign Keys

- Databases can hold multiple tables
- How do we capture relationships *between* tables?

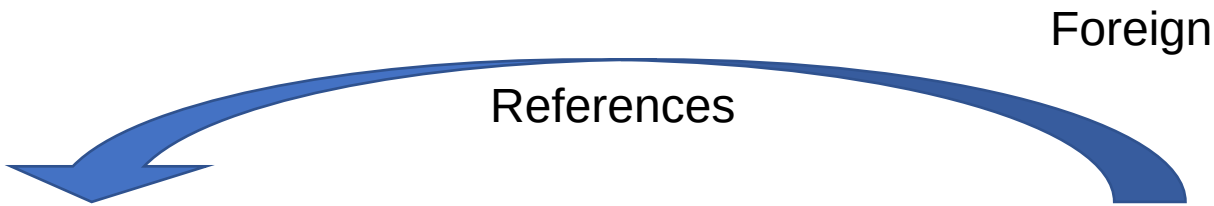
UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

UserID	Car
123	Charger
567	Civic
567	Pinto

Foreign Keys

Foreign Key

A **Foreign Key** is one or more attributes that uniquely identify a row in *another table*.



UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

UserID	Car
123	Charger
567	Civic
567	Pinto

Foreign Keys

Foreign Key

A **Foreign Key** is one or more attributes that uniquely identify a row in *another table*.

UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

UserID	Car
123	Charger
567	Civic
567	Pinto

Foreign Keys

Foreign Key

A **Foreign Key** is one or more attributes that uniquely identify a row in *another table*.

Is this valid?
Nope, 567 is not unique in Regist table

UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

UserID	Car
123	Charger
567	Civic
567	Pinto

Foreign Keys

```
CREATE TABLE Payroll (
  UserID INT PRIMARY KEY,
  Name VARCHAR(100),
  Job VARCHAR(100),
  Salary INT);
```

```
CREATE TABLE Regist (
  UserID INT,
  Car VARCHAR(100));
```

Payroll(<u>UserId</u>, Name, Job, Salary)

Regist(UserId, Car)

Foreign Keys

```
CREATE TABLE Payroll (
  UserID INT PRIMARY KEY,
  Name VARCHAR(100),
  Job VARCHAR(100),
  Salary INT);
```

```
CREATE TABLE Regist (
  UserID INT REFERENCES Payroll,
  Car VARCHAR(100));
```

Payroll(UserId, Name, Job, Salary)

Regist(UserId, Car)

Foreign Keys

```
CREATE TABLE Payroll (
  UserID INT PRIMARY KEY,
  Name VARCHAR(100),
  Job VARCHAR(100),
  Salary INT);
```

```
CREATE TABLE Regist (
  UserID INT REFERENCES Payroll(UserID),
  Car VARCHAR(100));
```

or, when attribute name is the same:

```
CREATE TABLE Regist (
  UserID INT REFERENCES Payroll,
  Car VARCHAR(100));
```

Payroll(UserId, Name, Job, Salary)

Regist(UserId, Car)

Foreign Keys

```
CREATE TABLE Payroll (
  UserID INT,
  Name VARCHAR(100),
  Job VARCHAR(100),
  Salary INT,
  PRIMARY KEY(UserID,
       Name)
  );
```

Payroll(<u>UserID</u>, <u>Name</u>, Job, Salary)

Alternatively, if your foreign key is also more than one attribute:

```
CREATE TABLE Regist (
  UserID INT,
  Name VARCHAR(100),
  Car VARCHAR(100),
  FOREIGN KEY (UserID, Name)
       REFERENCES Payroll);
```

Regist(UserID, Name, Car)

The Relational Model Revisited

- More complete overview of the Relational Model:
  - Database → collection of tables
  - All tables are flat
  - Keys uniquely ID rows
  - Foreign keys act as a “semantic pointer”
  - **Physical data independence**

Joins

- Foreign keys are able to *describe* a relationship between tables
- Joins are able to realize combinations of data

Inner Joins

- Bread and butter of SQL queries
  - “Inner join” is often interchangeable with just “join”

Nested-Loop Semantics

UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

UserID	Car
123	Charger
567	Civic
567	Pinto

```
SELECT P.Name, R.Car
  FROM Payroll AS P JOIN Regist AS R
       ON P.UserID = R.UserID;
```

How do we algorithmically get our results?

Name	Car
Jack	Charger
Magda	Civic
Magda	Pinto

Nested-Loop Semantics

UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

UserID	Car
123	Charger
567	Civic
567	Pinto

```
SELECT P.Name, R.Car
  FROM Payroll AS P JOIN Regist AS R
       ON P.UserID = R.UserID;
```

```
for each row1 in Payroll:
   for each row2 in Regist:
      if (row1.UserID = row2.UserID):
         output (row1.Name, row2.Car)
```

Nested-Loop Semantics

UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

UserID	Car
123	Charger
567	Civic
567	Pinto

Name	Car

```
for each row1 in Payroll:
   for each row2 in Regist:
      if (row1.UserID = row2.UserID):
         output (row1.Name, row2.Car)
```

Nested-Loop Semantics

UserID	Name	Job	Salary
123	Jack	TA	50000
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567	Magda	Prof	90000
789	Dan	Prof	100000

UserID	Car
123	Charger
567	Civic
567	Pinto

Name	Car
Jack	Charger

```
for each row1 in Payroll:
   for each row2 in Regist:
      if (row1.UserID = row2.UserID):
         output (row1.Name, row2.Car)
```

Nested-Loop Semantics

UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

UserID	Car
123	Charger
567	Civic
567	Pinto

Name	Car
Jack	Charger

```
for each row1 in Payroll:
   for each row2 in Regist:
      if (row1.UserID = row2.UserID):
         output (row1.Name, row2.Car)
```

Nested-Loop Semantics

UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

UserID	Car
123	Charger
567	Civic
567	Pinto

Name	Car
Jack	Charger

```
for each row1 in Payroll:
   for each row2 in Regist:
      if (row1.UserID = row2.UserID):
         output (row1.Name, row2.Car)
```

Nested-Loop Semantics

UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

UserID	Car
123	Charger
567	Civic
567	Pinto

Name	Car
Jack	Charger

```
for each row1 in Payroll:
   for each row2 in Regist:
      if (row1.UserID = row2.UserID):
         output (row1.Name, row2.Car)
```

Nested-Loop Semantics

UserID	Name	Job	Salary
123	Jack	TA	50000
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567	Magda	Prof	90000
789	Dan	Prof	100000

UserID	Car
123	Charger
567	Civic
567	Pinto

Name	Car
Jack	Charger

```
for each row1 in Payroll:
   for each row2 in Regist:
      if (row1.UserID = row2.UserID):
         output (row1.Name, row2.Car)
```

Nested-Loop Semantics

UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

UserID	Car
123	Charger
567	Civic
567	Pinto

Name	Car
Jack	Charger

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567	Pinto

Name	Car
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UserID	Car
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567	Civic
567	Pinto

Name	Car
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567	Pinto

Name	Car
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Magda	Civic
Magda	Pinto

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567	Pinto

Name	Car
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Magda	Civic
Magda	Pinto

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123	Charger
567	Civic
567	Pinto

Name	Car
Jack	Charger
Magda	Civic
Magda	Pinto

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Name	Car
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Magda	Pinto

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Name	Car
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Magda	Pinto

```
for each row1 in Payroll:
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```

Inner Joins

UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

UserID	Car
123	Charger
567	Civic
567	Pinto

Explicit

```
SELECT P.Name, R.Car
  FROM Payroll AS P JOIN Regist AS R
       ON P.UserID = R.UserID;
```

Implicit

```
SELECT P.Name, R.Car
  FROM Payroll AS P, Regist AS R
 WHERE P.UserID = R.UserID;
```

Outer Joins

Now I want to include everyone, even if they don't drive.

UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

UserID	Car
123	Charger
567	Civic
567	Pinto

Outer Joins

Now I want to include everyone, even if they don't drive.

UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

UserID	Car
123	Charger
567	Civic
567	Pinto

```
SELECT P.Name, R.Car
  FROM Payroll AS P LEFT OUTER JOIN Regist AS R
       ON P.UserID = R.UserID;
```

Outer Joins

UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

UserID	Car
123	Charger
567	Civic
567	Pinto

Name	Car
Jack	Charger
Allison	NULL
Magda	Civic
Magda	Pinto
Dan	NULL

Outer Joins

UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

UserID	Car
123	Charger
567	Civic
567	Pinto

Name	Car
Jack	Charger
Allison	NULL
Magda	Civic
Magda	Pinto
Dan	NULL

NULL is a value placeholder. Depending on context, it may mean unknown, not applicable, etc.

Outer Joins

- LEFT OUTER JOIN
  - All rows in left table are preserved
- RIGHT OUTER JOIN
  - All rows in right table are preserved
- FULL OUTER JOIN
  - All rows are preserved

Announcements

- HW 1 is out
  - https://www.gradescope.com/courses/142747/assignments/543000
  - Lightweight, due Tuesday 6/30 at **11:00 PM**
  - Note the time, late days are assigned automatically in Gradescope if you submit after the deadline.

Self Joins

Find all people who drive a Civic and Pinto

UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

UserID	Car
123	Charger
567	Civic
567	Pinto

```
SELECT P.Name, R.Car
  FROM Payroll AS P, Regist AS R
 WHERE P.UserID = R.UserID AND
       R.Car = 'Civic';
```

Self Joins

Find all people who drive a Civic and Pinto

UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

UserID	Car
123	Charger
567	Civic
567	Pinto

```
SELECT P.Name, R.Car
  FROM Payroll AS P, Regist AS R
 WHERE P.UserID = R.UserID AND
       R.Car = 'Civic' AND
       R.Car = 'Pinto';
```

Will this work?

Self Joins

Find all people who drive a Civic and Pinto

UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

UserID	Car
123	Charger
567	Civic
567	Pinto

```
SELECT P.Name, R.Car
  FROM Payroll AS P, Regist AS R
 WHERE P.UserID = R.UserID AND
       R.Car = 'Civic' AND
       R.Car = 'Pinto';
```

Will this work?

Nope, empty set is returned

Self Joins

Find all people who drive a Civic and Pinto

UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

UserID	Car
123	Charger
567	Civic
567	Pinto
789	Pinto

```
SELECT P.Name, R.Car
  FROM Payroll AS P, Regist AS R
 WHERE P.UserID = R.UserID AND
       R.Car = 'Civic' AND
       R.Car = 'Pinto';
```

Discuss with the people around you how you would solve this.

Self Joins

Find all people who drive a Civic and Pinto

UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

UserID	Car
123	Charger
567	Civic
567	Pinto

```
SELECT P.Name, R1.Car
  FROM Payroll AS P, Regist AS R1, Regist AS R2
 WHERE P.UserID = R1.UserID AND
       P.UserID = R2.UserID AND
       R1.Car = 'Civic' AND
       R2.Car = 'Pinto';
```

Self Joins

Find all people who drive a Civic and Pinto

UserID	Name	Job	Salary
123	Jack	TA	50000
345	Allison	TA	60000
567	Magda	Prof	90000
789	Dan	Prof	100000

UserID	Car
123	Charger
567	Civic
567	Pinto

All pairs of cars a person can drive

```
SELECT P.Name, R1.Car
  FROM Payroll AS P, Regist AS R1, Regist AS R2
 WHERE P.UserID = R1.UserID AND
       P.UserID = R2.UserID AND
       R1.Car = 'Civic' AND
       R2.Car = 'Pinto';
```

A little extra SQL

- ORDER BY – Orders result tuples by specified attributes (default ascending)

```
SELECT P.Name, P.UserID
  FROM Payroll AS P
 WHERE P.Job = 'TA'
 ORDER BY P.Salary, P.Name;
```

- DISTINCT – Deduplicates result tuples

```
SELECT DISTINCT P.Job
  FROM Payroll AS P
 WHERE P.Salary > 70000;
```

Takeaways

- We can describe relationships between tables with keys and foreign keys
- Different joining techniques can be used to achieve particular goals

- Our SQL toolbox is growing!
  - Not just reading and filtering data anymore
  - Starting to answer complex questions