Monday, November 17
Announcements

- Project 4 due Friday 11/21 @ 11:59pm
  - Project party Monday 11/17 6:30pm – 8:30pm in 10 Evans
  - Early submission point #2: Questions 1–16 by Tuesday 11/18 @ 11:59pm
  - Early submission point #3: Submit by Thursday 11/20 @ 11:59pm
- Homework 9 (6 pts) due Wednesday 11/26 @ 11:59pm
Declarative Languages
Database Management Systems

Database management systems (DBMS) are important, heavily used, and interesting!

A table is a collection of records, which are rows that have a value for each column

<table>
<thead>
<tr>
<th>Latitude</th>
<th>Longitude</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>38</td>
<td>122</td>
<td>Berkeley</td>
</tr>
<tr>
<td>42</td>
<td>71</td>
<td>Cambridge</td>
</tr>
<tr>
<td>45</td>
<td>93</td>
<td>Minneapolis</td>
</tr>
</tbody>
</table>

The Structured Query Language (SQL) is perhaps the most widely used programming language. SQL is a declarative programming language.
Declarative Programming

In **declarative languages** such as SQL & Prolog:

- A "program" is a description of the desired result
- The interpreter figures out how to generate the result

In **imperative languages** such as Python & Scheme:

- A "program" is a description of computational processes
- The interpreter carries out execution/evaluation rules

```sql
create table cities as
    select 38 as latitude, 122 as longitude, "Berkeley" as name union
    select 42, 71, "Cambridge" union
    select 45, 93, "Minneapolis";

select "west coast" as region, name from cities where longitude >= 115 union
select "other", name from cities where longitude < 115;
```

<table>
<thead>
<tr>
<th>Latitude</th>
<th>Longitude</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>38</td>
<td>122</td>
<td>Berkeley</td>
</tr>
<tr>
<td>42</td>
<td>71</td>
<td>Cambridge</td>
</tr>
<tr>
<td>45</td>
<td>93</td>
<td>Minneapolis</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Region</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>west coast</td>
<td>Berkeley</td>
</tr>
<tr>
<td>other</td>
<td>Minneapolis</td>
</tr>
<tr>
<td>other</td>
<td>Cambridge</td>
</tr>
</tbody>
</table>
Structured Query Language (SQL)
The SQL language is an ANSI and ISO standard, but DBMS's implement custom variants

- A **select** statement creates a new table, either from scratch or by projecting a table
- A **create table** statement gives a global name to a table
- Lots of other statements exist: **analyze**, **delete**, **explain**, **insert**, **replace**, **update**, etc.
- Most of the important action is in the **select** statement
- The code for executing **select** statements fits on a single sheet of paper (next lecture)

*Today's theme:*
Getting Started with SQL

Install sqlite (version 3.8.3 or later): http://sqlite.org/download.html

Use sqlite online: http://kripken.github.io/sql.js/GUI/

Use the SQL example from the textbook: http://composingprograms.com/examples/sql/sql.zip
Selecting Value Literals

A `select` statement always includes a comma-separated list of column descriptions.

A column description is an expression, optionally followed by `as` and a column name:

```
select [expression] as [name], [expression] as [name]; ...
```

Selecting literals creates a one-row table.

The union of two select statements is a table containing the rows of both of their results:

```
select "abraham" as parent, "barack" as child; union
select "abraham" , "clinton" union
select "delano" , "herbert" union
select "fillmore" , "abraham" union
select "fillmore" , "delano" union
select "fillmore" , "grover" union
select "eisenhower" , "fillmore";
```
Naming Tables

SQL is often used as an interactive language. The result of a `select` statement is displayed to the user, but not stored. A `create table` statement gives the result a name:

```
create table [name] as [select statement];
```

```sql
create table parents as
select "abraham" as parent, "barack" as child union
select "abraham", "clinton" union
select "delano", "herbert" union
select "fillmore", "abraham" union
select "fillmore", "delano" union
select "fillmore", "grover" union
select "eisenhower", "fillmore";
```

Parents:

<table>
<thead>
<tr>
<th>Parent</th>
<th>Child</th>
</tr>
</thead>
<tbody>
<tr>
<td>abraham</td>
<td>barack</td>
</tr>
<tr>
<td>abraham</td>
<td>clinton</td>
</tr>
<tr>
<td>delano</td>
<td>herbert</td>
</tr>
<tr>
<td>fillmore</td>
<td>abraham</td>
</tr>
<tr>
<td>fillmore</td>
<td>delano</td>
</tr>
<tr>
<td>fillmore</td>
<td>grover</td>
</tr>
<tr>
<td>eisenhower</td>
<td>fillmore</td>
</tr>
</tbody>
</table>
Projecting Tables
Select Statements Project Existing Tables

A **select** statement can specify an input table using a **from** clause
A subset of the rows of the input table can be selected using a **where** clause
An ordering over the remaining rows can be declared using an **order by** clause
Column descriptions determine how each input row is projected to a result row

```sql
select [expression] as [name], [expression] as [name], ...;
select [columns] from [table] where [condition] order by [order];
select child from parents where parent = "abraham";
select parent from parents where parent > child;
```

<table>
<thead>
<tr>
<th>Child</th>
<th>Parent</th>
</tr>
</thead>
<tbody>
<tr>
<td>barack</td>
<td>fillmore</td>
</tr>
<tr>
<td>clinton</td>
<td>fillmore</td>
</tr>
</tbody>
</table>
Joining Tables
Joining Two Tables

Two tables A & B are joined by a comma to yield all combos of a row from A & a row from B

```sql
create table dogs as
    select "abraham" as name, "long" as fur union
    select "barack" , "short" union
    select "clinton" , "long" union
    select "delano" , "long" union
    select "eisenhower" , "short" union
    select "fillmore" , "curly" union
    select "grover" , "short" union
    select "herbert" , "curly";

create table parents as
    select "abraham" as parent, "barack" as child union
    select "abraham" , "clinton" union
    select "abraham" , "clinton" union
...;
```

Select the parents of curly-furred dogs

```sql
select parent from parents, dogs
    where child = name and fur = "curly";
```
Aliases and Dot Expressions
Joining a Table with Itself

Two tables may share a column name; dot expressions and aliases disambiguate column values

```
select [columns] from [table] where [condition] order by [order];
```

[table] is a comma-separated list of table names with optional aliases

Select all pairs of siblings

```
select a.child as first, b.child as second
from parents as a, parents as b
where a.parent = b.parent and a.child < b.child;
```

<table>
<thead>
<tr>
<th>First</th>
<th>Second</th>
</tr>
</thead>
<tbody>
<tr>
<td>barack</td>
<td>clinton</td>
</tr>
<tr>
<td>abraham</td>
<td>delano</td>
</tr>
<tr>
<td>abraham</td>
<td>grover</td>
</tr>
<tr>
<td>delano</td>
<td>grover</td>
</tr>
</tbody>
</table>
Joining Multiple Tables

Multiple tables can be joined to yield all combinations of rows from each

```
create table grandparents as
    select a.parent as granddog, b.child as granpup
    from parents as a, parents as b
    where b.parent = a.child;
```

Select all grandparents with the same fur as their grandchildren

```
select granddog from grandparents, dogs as c, dogs as d
    where granddog = c.name and
    granpup = d.name and
    c.fur = d.fur;
```

Which tables need to be joined together?