Announcements
Declarative Languages
Database Management Systems
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The Structured Query Language (SQL) is perhaps the most widely used programming language.
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.

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

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Declarative Programming
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Declarative Programming

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- A "program" is a description of the desired result
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```sql
create table cities as
```
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In imperative languages such as Python & Scheme:
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create table cities as
  select 38 as latitude, 122 as longitude, "Berkeley" as name union

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In **imperative languages** such as Python & Scheme:
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```sql
create table cities as
    select 38 as latitude, 122 as longitude, "Berkeley" as name union
    select 42, 71, "Cambridge" union
```

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```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";
```

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### Cities:

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</table>

```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;
```
Declarative Programming

In **declarative languages** such as SQL & Prolog:
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In **imperative languages** such as Python & Scheme:
- A "program" is a description of computational processes
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```
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;
```

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<table>
<thead>
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<th>Region</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>west coast</td>
<td>Berkeley</td>
</tr>
<tr>
<td>other</td>
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Structured Query Language (SQL)
SQL Overview
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The SQL language is an ANSI and ISO standard, but DBMS's implement custom variants.
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• A `select` statement creates a new table, either from scratch or by projecting a table
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**SQL Overview**

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.
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- Lots of other statements exist: **analyze**, **delete**, **explain**, **insert**, **replace**, **update**, etc.
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
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- Most of the important action is in the **select** statement
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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

Today's theme:
SQL Overview

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

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/
Selecting Value Literals
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A `select` statement always includes a comma-separated list of column descriptions.
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A column description is an expression, optionally followed by `as` and a column name.
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:

```sql
select [expression] as [name]
```
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 Value Literals

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select [expression] as [name], [expression] as [name], ...
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A column description is an expression, optionally followed by `as` and a column name

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

Selecting literals creates a one-row table.
Selecting Value Literals

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

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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.
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

```sql
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

```sql
select "delano" as parent, "herbert" as child;
```
Selecting Value Literals

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

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select [expression] as [name], [expression] as [name];
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```sql
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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];
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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 "delano" as parent, "herbert" as child union
select "abraham" , "barack"  union
```
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:

```sql
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:

```sql
select "delano" as parent, "herbert" as child union
select "abraham" , "barack" union
select "abraham" , "clinton" union
```
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];
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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 "delano" as parent, "herbert" as child union
select "abraham", "barack" union
select "abraham", "clinton" union
select "fillmore", "abraham" union
```
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];
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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 "delano" as parent, "herbert" as child union
select "abraham", "barack" union
select "abraham", "clinton" union
select "fillmore", "abraham" union
select "fillmore", "delano" union
```
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```
select "delano" as parent, "herbert" as child union
select "abraham", "barack" union
select "abraham", "clinton" union
select "fillmore", "abraham" union
select "fillmore", "delano" union
select "fillmore", "grover" union
```
Selecting Value Literals

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```
select [expression] as [name], [expression] as [name];
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The union of two select statements is a table containing the rows of both of their results:

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

```sql
select "delano" as parent, "herbert" as child union
select "abraham", "barack" union
select "abraham", "clinton" 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

```sql
select "delano" as parent, "herbert" as child union
select "abraham", "barack" union
select "abraham", "clinton" 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

```
select "delano" as parent, "herbert" as child union
select "abraham", "barack" union
select "abraham", "clinton" 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.

```sql
select "delano" as parent, "herbert" as child union
select "abraham", "barack" union
select "abraham", "clinton" 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

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

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

```
Eisenhower
|
|-- Fillmore
|   |
|   | Abraham
|   | Delano
|   | Grover
|   |
|   | Barack
|   | Clinton
|   | Herbert
```
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];
```

```
create table parents as
select "delano" as parent, "herbert" as child union
select "abraham", "barack" union
select "abraham", "clinton" 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];
```

create table parents as
```
select "delano" as parent, "herbert" as child union
select "abraham", "barack" union
select "abraham", "clinton" 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];
```

create table parents as
  select "delano" as parent, "herbert" as child union
  select "abraham" , "barack" union
  select "abraham" , "clinton" 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>
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</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>
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Projecting Tables
Select Statements Project Existing Tables
Select Statements Project Existing Tables

A `select` statement can specify an input table using a `from` clause.
Select Statements Project Existing Tables

A `select` statement can specify an input table using a `from` clause

```
select [expression] as [name], [expression] as [name], ... ;
```
Select Statements Project Existing Tables

A `select` statement can specify an input table using a `from` clause.

```
select [expression] as [name], [expression] as [name], ...;
select [columns] ;
```
Select Statements Project Existing Tables

A `select` statement can specify an input table using a `from` clause

```
select [expression] as [name], [expression] as [name], ...;
select [columns] from [table] ;
```
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.

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

```
select [columns] from [table];
```
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.

- `select [expression] as [name], [expression] as [name], ...;`
- `select [columns] from [table] where [condition] ;`
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.

```sql
select [expression] as [name], [expression] as [name], ...;
select [columns] from [table] where [condition] ;
```
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.

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

select [columns] from [table] where [condition] order by [order];
```
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 Statements Project Existing Tables

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

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

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

- `select {expression} as [name], {expression} as [name], ...;`
- `select [columns] from [table] where [condition] order by [order];`
- `select child from parents where parent = "abraham";`
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select {expression} as [name], {expression} as [name], ...;
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```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>
</tr>
</thead>
<tbody>
<tr>
<td>barack</td>
</tr>
<tr>
<td>clinton</td>
</tr>
</tbody>
</table>
Select Statements Project Existing Tables

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(Demo)
Arithmetic
Arithmetic in Select Expressions
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In a select expression, column names evaluate to row values.

Arithmetic expressions can combine row values and constants.
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```sql
create table lift as
    select 101 as chair, 2 as single, 2 as couple union
    select 102 , 0 , 3 union
    select 103 , 4 , 1;
```
Arithmetic in Select Expressions

In a select expression, column names evaluate to row values

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### Arithmetic in Select Expressions

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```sql
create table lift as
    select 101 as chair, 2 as single, 2 as couple union
    select 102, 0, 3 union
    select 103, 4, 1;
```

```sql
select chair, single + 2 * couple as total from lift;
```
Arithmetic in Select Expressions

In a select expression, column names evaluate to row values.

Arithmetic expressions can combine row values and constants.

```
create table lift as
    select 101 as chair, 2 as single, 2 as couple union
    select 102 , 0 , 3 union
    select 103 , 4 , 1;

select chair, single + 2 * couple as total from lift;
```

<table>
<thead>
<tr>
<th>chair</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>101</td>
<td>6</td>
</tr>
<tr>
<td>102</td>
<td>6</td>
</tr>
<tr>
<td>103</td>
<td>6</td>
</tr>
</tbody>
</table>
### Discussion Question

Given the table `ints` that describes how to sum powers of 2 to form various integers

```sql
create table ints as
    select "zero" as word, 0 as one, 0 as two, 0 as four, 0 as eight union
    select "one", 1, 0, 0, 0 union
    select "two", 0, 2, 0, 0 union
    select "three", 1, 2, 0, 0 union
    select "four", 0, 0, 4, 0 union
    select "five", 1, 0, 4, 0 union
    select "six", 0, 2, 4, 0 union
    select "seven", 1, 2, 4, 0 union
    select "eight", 0, 0, 0, 8 union
    select "nine", 1, 0, 0, 8;
```
Discussion Question

Given the table `ints` that describes how to sum powers of 2 to form various integers

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    select "zero" as word, 0 as one, 0 as two, 0 as four, 0 as eight union
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    select "three", 1, 2, 0, 0 union
    select "four", 0, 0, 4, 0 union
    select "five", 1, 0, 4, 0 union
    select "six", 0, 2, 4, 0 union
    select "seven", 1, 2, 4, 0 union
    select "eight", 0, 0, 0, 8 union
    select "nine", 1, 0, 0, 8;
```

(A) Write a select statement for a two-column table of the `word` and `value` for each integer
Discussion Question

Given the table `ints` that describes how to sum powers of 2 to form various integers

```sql
create table ints as
    select "zero" as word, 0 as one, 0 as two, 0 as four, 0 as eight union
    select "one"   , 1   , 0   , 0   , 0      union
    select "two"   , 0   , 2   , 0   , 0      union
    select "three" , 1   , 2   , 0   , 0      union
    select "four"  , 0   , 0   , 4   , 0      union
    select "five"  , 1   , 0   , 4   , 0      union
    select "six"   , 0   , 2   , 4   , 0      union
    select "seven" , 1   , 2   , 4   , 0      union
    select "eight" , 0   , 0   , 0   , 8      union
    select "nine"  , 1   , 0   , 0   , 8      union
;
```

(A) Write a select statement for a two-column table of the word and value for each integer

<table>
<thead>
<tr>
<th>word</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>zero</td>
<td>0</td>
</tr>
<tr>
<td>one</td>
<td>1</td>
</tr>
<tr>
<td>two</td>
<td>2</td>
</tr>
<tr>
<td>three</td>
<td>3</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>
Given the table \texttt{ints} that describes how to sum powers of 2 to form various integers

\begin{verbatim}
create table ints as
    select "zero" as word, 0 as one, 0 as two, 0 as four, 0 as eight union
    select "one" as one, 0 as two, 0 as four, 0 as eight union
    select "two" as two, 0 as one, 0 as four, 0 as eight union
    select "three" as three, 0 as two, 0 as four, 0 as eight union
    select "four" as four, 0 as three, 0 as eight union
    select "five" as five, 0 as four union
    select "six" as six, 0 as four union
    select "seven" as seven, 0 as six union
    select "eight" as eight, 0 union
    select "nine" as nine, 0;
\end{verbatim}

(A) Write a select statement for a two-column table of the \texttt{word} and \texttt{value} for each integer

<table>
<thead>
<tr>
<th>word</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>zero</td>
<td>0</td>
</tr>
<tr>
<td>one</td>
<td>1</td>
</tr>
<tr>
<td>two</td>
<td>2</td>
</tr>
<tr>
<td>three</td>
<td>3</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

(B) Write a select statement for the \texttt{word} names of the powers of two
Discussion Question

Given the table `ints` that describes how to sum powers of 2 to form various integers

```sql
create table ints as
    select "zero" as word, 0 as one, 0 as two, 0 as four, 0 as eight union
    select "one", 1, 0, 0, 0 union
    select "two", 0, 2, 0, 0 union
    select "three", 1, 2, 0, 0 union
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    select "six", 0, 2, 4, 0 union
    select "seven", 1, 2, 4, 0 union
    select "eight", 0, 0, 0, 8 union
    select "nine", 1, 0, 0, 8;
```

(A) Write a select statement for a two-column table of the `word` and `value` for each integer

<table>
<thead>
<tr>
<th>word</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>zero</td>
<td>0</td>
</tr>
<tr>
<td>one</td>
<td>1</td>
</tr>
<tr>
<td>two</td>
<td>2</td>
</tr>
<tr>
<td>three</td>
<td>3</td>
</tr>
</tbody>
</table>

... ... ...

(B) Write a select statement for the `word` names of the powers of two

<table>
<thead>
<tr>
<th>word</th>
</tr>
</thead>
<tbody>
<tr>
<td>one</td>
</tr>
<tr>
<td>two</td>
</tr>
<tr>
<td>four</td>
</tr>
<tr>
<td>eight</td>
</tr>
</tbody>
</table>
Discussion Question

Given the table **ints** that describes how to sum powers of 2 to form various integers

```sql
create table ints as
  select "zero" as word, 0 as one, 0 as two, 0 as four, 0 as eight union
  select "one"     , 1 , 0 , 0 , 0          union
  select "two"     , 0 , 2 , 0 , 0          union
  select "three"   , 1 , 2 , 0 , 0          union
  select "four"    , 0 , 0 , 4 , 0          union
  select "five"    , 1 , 0 , 4 , 0          union
  select "six"     , 0 , 2 , 4 , 0          union
  select "seven"   , 1 , 2 , 4 , 0          union
  select "eight"   , 0 , 0 , 0 , 8          union
  select "nine"    , 1 , 0 , 0 , 8          union
;
```

**(A)** Write a select statement for a two-column table of the **word** and **value** for each integer

<table>
<thead>
<tr>
<th>word</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>zero</td>
<td>0</td>
</tr>
<tr>
<td>one</td>
<td>1</td>
</tr>
<tr>
<td>two</td>
<td>2</td>
</tr>
<tr>
<td>three</td>
<td>3</td>
</tr>
</tbody>
</table>

**(B)** Write a select statement for the **word** names of the powers of two

<table>
<thead>
<tr>
<th>word</th>
</tr>
</thead>
<tbody>
<tr>
<td>one</td>
</tr>
<tr>
<td>two</td>
</tr>
<tr>
<td>four</td>
</tr>
<tr>
<td>eight</td>
</tr>
</tbody>
</table>