Announcements
Databases
Database Management Systems
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Database management systems (DBMS) are important, heavily used, and interesting!
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<tr>
<td>38</td>
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The Structured Query Language (SQL) is perhaps the most widely used programming language.
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SQL is a declarative programming language.
Declarative Programming
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In **declarative languages** such as SQL & Prolog:
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```SQL
create table cities as
```
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create table cities as
   select 38 as latitude, 122 as longitude, "Berkeley" as name union

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>latitude</td>
<td>longitude</td>
<td>name</td>
</tr>
<tr>
<td>38</td>
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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
```

<table>
<thead>
<tr>
<th>Cities:</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>latitude</td>
<td>longitude</td>
<td>name</td>
<td></td>
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**create table cities as**

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

**Cities:**

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- 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;
```

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```sql
create table cities as
    select 38 as latitude, 122 as longitude, "Berkeley" as name union
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select "west coast" as region, name from cities where longitude >= 115 union
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<tbody>
<tr>
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<td>Berkeley</td>
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<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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**SQL Overview**

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*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: code.cs61a.org/sql
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.
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```
select [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]
```
Selecting Value Literals

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

```
Abraham  Delano
Barack    Herbert
```
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];
```

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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
```
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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];
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```sql
select "delano" as parent, "herbert" as child union
select "abraham", "barack" union
select "abraham", "clinton" union
select "fillmore", "abraham" union
```
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A `select` statement always includes a comma-separated list of column descriptions.

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

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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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
select "fillmore", "grover" union
select "eisenhower", "fillmore";
```
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

```
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.

```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
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];
```

```
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
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.

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

create table parents as

```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

```
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>
</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>
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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], ... ;
```
A `select` statement can specify an input table using a `from` clause:

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

```sql
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] 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.

```
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.

```
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], ... ;
```

```sql
select [columns] from [table] where [condition] order by [order];
```
A `select` statement can specify an input table using a `from` clause.

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```

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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";
```
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";
```
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.
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- `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>
Arithmetic
Arithmetic in Select Expressions
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In a select expression, column names evaluate to row values

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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;
```
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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;

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.

```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;

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 \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"    , 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;
\end{verbatim}

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

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

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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;
```

(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>
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;
```

(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>
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</tr>
<tr>
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<td>2</td>
</tr>
<tr>
<td>three</td>
<td>3</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>
Discussion Question

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" , 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
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    select "seven" , 1 , 2 , 4 , 0 union
    select "eight" , 0 , 0 , 0 , 8 union
    select "nine" , 1 , 0 , 0 , 8;
\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

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

(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

<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>

(Demo)