Announcements

Integer Examples (continued)

A Very Interesting Number

The mathematician G. H. Hardy once remarked to the mathematician Srinivasa Ramanujan...

Aggregate Functions

So far, all SQL expressions have referred to the values in a single row at a time

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

An aggregate function in the [columns] clause computes a value from a group of rows

```
create table animals as
select "dog" as kind, 4 as legs, 20 as weight union
select "cat" , 4 , 18 union
select "ferret" , 4 , 18 union
select "parrot" , 2 , 6 union
select "penguin" , 2 , 10 union
select "t-rex" , 2 , 12000;
```

```
select max(legs) from animals;
```

```
animals:

<table>
<thead>
<tr>
<th>kind</th>
<th>legs</th>
<th>weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>dog</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>cat</td>
<td>4</td>
<td>18</td>
</tr>
<tr>
<td>ferret</td>
<td>4</td>
<td>18</td>
</tr>
<tr>
<td>parrot</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>penguin</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>t-rex</td>
<td>2</td>
<td>12000</td>
</tr>
</tbody>
</table>
```

Mixing Aggregate Functions and Single Values

An aggregate function also selects a row in the table, which may be meaningful

```
select max(weight), kind from animals;
select max(legs), kind from animals;
select min(kind), kind from animals;
select avg(weight), kind from animals;
```

```
create table animals as
select "dog" as kind, 4 as legs, 20 as weight union
select "cat" , 4 , 18 union
select "ferret" , 4 , 18 union
select "parrot" , 2 , 6 union
select "penguin" , 2 , 10 union
select "t-rex" , 2 , 12000;
```

```
animals:

<table>
<thead>
<tr>
<th>animal</th>
<th>kind</th>
<th>legs</th>
<th>weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>dog</td>
<td>4</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>cat</td>
<td>4</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>ferret</td>
<td>4</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>parrot</td>
<td>2</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>penguin</td>
<td>2</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>t-rex</td>
<td>2</td>
<td>12000</td>
<td></td>
</tr>
</tbody>
</table>
```

Groups
Grouping Rows

Rows in a table can be grouped, and aggregation is performed on each group:

```
select [columns] from [table] group by [expression] having [expression];
```

The number of groups is the number of unique values of an expression:

```
select [column] as [name], [column] as [name], ... from [table] group by [expression];
```

Example:

<table>
<thead>
<tr>
<th>legs</th>
<th>max(weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>12000</td>
</tr>
</tbody>
</table>

Selecting Groups

Rows in a table can be grouped, and aggregation is performed on each group:

```
select [columns] from [table] group by [expression] having [expression];
```

A having clause filters the set of groups that are aggregated:

```
select [column] from [table] group by [expression] having [expression];
```

```
select weight/legs, count(*) from animals group by weight/legs having count(*)>1;
```

<table>
<thead>
<tr>
<th>weight/legs</th>
<th>count(*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>6000</td>
<td>1</td>
</tr>
</tbody>
</table>

Discussion Question

What's the maximum difference between leg count for two animals with the same weight?