Announcements

- WQ1 due on Tuesday
  - No late days allowed
- HW1 due on Tuesday
  - Submit using script in repo
- WQ2 and HW2 will be out tomorrow
  - Both are 1 week assignments
- Check website for up to date OHs

**Joins in SQL**

Retrieve all Japanese products that cost < $150

<table>
<thead>
<tr>
<th>pname</th>
<th>price</th>
<th>category</th>
<th>manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>MultiTouch</td>
<td>199.99</td>
<td>gadget</td>
<td>Canon</td>
</tr>
<tr>
<td>SingleTouch</td>
<td>49.99</td>
<td>photography</td>
<td>Canon</td>
</tr>
<tr>
<td>Gizmon</td>
<td>50</td>
<td>gadget</td>
<td>GizmoWorks</td>
</tr>
<tr>
<td>SuperGizmo</td>
<td>250.00</td>
<td>gadget</td>
<td>GizmoWorks</td>
</tr>
</tbody>
</table>

```
SELECT P.pname, P.price FROM Product as P, Company as C 
WHERE P.manufacturer = C.cname AND C.country = 'Japan' AND C.price < 150
```

**Joins in SQL**

Retrieve all USA companies that manufacture "gadget" products

<table>
<thead>
<tr>
<th>cname</th>
<th>country</th>
</tr>
</thead>
<tbody>
<tr>
<td>MultiTouch</td>
<td>GizmoWorks USA</td>
</tr>
<tr>
<td>SingleTouch</td>
<td>Canon Japan</td>
</tr>
<tr>
<td>Gizmon</td>
<td>Hitachi Japan</td>
</tr>
<tr>
<td>SuperGizmo</td>
<td>GizmoWorks</td>
</tr>
</tbody>
</table>

```
SELECT DISTINCT C.cname FROM Product as P, Company as C WHERE C.country = 'USA' AND P.category = 'gadget' AND P.manufacturer = C.cname
```

**Joins in SQL**

Retrieve all USA companies that manufacture "gadget" products

<table>
<thead>
<tr>
<th>cname</th>
<th>country</th>
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</thead>
<tbody>
<tr>
<td>MultiTouch</td>
<td>GizmoWorks USA</td>
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<td>Hitachi Japan</td>
</tr>
<tr>
<td>SuperGizmo</td>
<td>GizmoWorks</td>
</tr>
</tbody>
</table>

```
SELECT DISTINCT C.cname FROM Product, Company WHERE C.country = 'USA' AND C.category = 'gadget' AND C.manufacturer = C.cname
```
(Inner) joins

```
SELECT DISTINCT cname
FROM Product, Company
WHERE country='USA' AND category = 'gadget'
AND manufacturer = cname
```
**Inner Joins**

\[
\text{SELECT DISTINCT } c_{\text{name}} \\
\text{FROM Product, Company} \\
\text{WHERE country='USA' AND category = 'gadget' AND manufacturer = c_{\text{name}}}
\]

\[
\text{SELECT DISTINCT } c_{\text{name}} \\
\text{FROM Product JOIN Company ON country='USA' AND category = 'gadget' AND manufacturer = c_{\text{name}}}
\]

---

**Another Example**

Product\( (p_{\text{name}}, \text{price}, \text{category}, \text{manufacturer}) \)  
Company\( (c_{\text{name}}, \text{country}) \)  
-- manufacturer is foreign key to Company

Find US companies that manufacture both 'gadgets' and 'photo' products

\[
\text{SELECT DISTINCT } z_{\text{c.name}} \\
\text{FROM Product x, Company z} \\
\text{WHERE z.country = 'USA' AND x.manufacturer = z.cname AND x.category = 'gadget' AND x.category = 'photography;}
\]

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**Another Example**

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---

This is called nested loop semantics since we are interpreting what a join means using a nested loop.
Self-Joins and Tuple Variables

Find US companies that manufacture both 'gadgets' and 'photo' products

• Joining Product with Company is insufficient: need to join Product, with Product, and with Company

• When a relation occurs twice in the FROM clause we call it a self-join; in that case we must use tuple variables (aka table aliases) (why?)

```
SELECT DISTINCT z.cname
FROM Product x, Product y, Company z
WHERE z.country = 'USA'
    AND x.category = 'gadget'
    AND y.category = 'photo'
    AND x.manufacturer = z.cname
    AND y.manufacturer = z.cname;
```

Product

<table>
<thead>
<tr>
<th>pname</th>
<th>category</th>
<th>manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gizmo</td>
<td>gadget</td>
<td>GizmoWorks</td>
</tr>
<tr>
<td>SingleTouch</td>
<td>photo</td>
<td>Hitachi</td>
</tr>
<tr>
<td>MultiTouch</td>
<td>Photo</td>
<td>GizmoWorks</td>
</tr>
</tbody>
</table>

Company

<table>
<thead>
<tr>
<th>cname</th>
<th>country</th>
</tr>
</thead>
<tbody>
<tr>
<td>GizmoWorks</td>
<td>USA</td>
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<tr>
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</table>

Self-joins

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SELECT DISTINCT z.cname
FROM Product x, Product y, Company z
WHERE z.country = 'USA'
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Self-joins

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Self-joins

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<tbody>
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<td>USA</td>
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<td>Hitachi</td>
<td>Japan</td>
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\text{SELECT DISTINCT } z.\text{cname} \\
\text{FROM } \text{Product } x, \text{Product } y, \text{Company } z \\
\text{WHERE} \\
\phantom{xx} z.\text{country} = '\text{USA}' \\
\phantom{xx} \text{AND } x.\text{category} = '\text{gadget}' \\
\phantom{xx} \text{AND } y.\text{category} = '\text{photo}' \\
\phantom{xx} \text{AND } x.\text{manufacturer} = z.\text{cname} \\
\phantom{xx} \text{AND } y.\text{manufacturer} = z.\text{cname}; \\
\]

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\text{FROM } \text{Product } x, \text{Product } y, \text{Company } z \\
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\phantom{xx} \text{AND } x.\text{manufacturer} = z.\text{cname} \\
\phantom{xx} \text{AND } y.\text{manufacturer} = z.\text{cname}; \\
\]

Joins in SQL

• The join we have just seen is sometimes called an inner join
  – Each row in the result must come from both tables in the join
• Sometimes we want to include rows from only one of the two table: outer join
Retrieve employees and their sales

### Inner Join

<table>
<thead>
<tr>
<th>Employee</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>id</td>
<td>name</td>
</tr>
<tr>
<td>1</td>
<td>Joe</td>
</tr>
<tr>
<td>2</td>
<td>Jack</td>
</tr>
<tr>
<td>3</td>
<td>Jill</td>
</tr>
</tbody>
</table>

**SELECT** *
FROM Employee E, Sales S
WHERE E.id = S.employeeID

### Outer Join

<table>
<thead>
<tr>
<th>Employee</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>id</td>
<td>name</td>
</tr>
<tr>
<td>1</td>
<td>Joe</td>
</tr>
<tr>
<td>2</td>
<td>Jack</td>
</tr>
<tr>
<td>3</td>
<td>Jill</td>
</tr>
<tr>
<td>3</td>
<td>Jill</td>
</tr>
</tbody>
</table>

**SELECT** *
FROM Employee E
LEFT OUTER JOIN Sales S
ON E.id = S.employeeID
WHERE E.id = S.employeeID
### Outer joins

```sql
SELECT Product.name, Purchase.store
FROM Product
LEFT OUTER JOIN Purchase
ON Product.name = Purchase.prodName
```

-- `prodName` is foreign key

<table>
<thead>
<tr>
<th>Name</th>
<th>Category</th>
<th>ProdName</th>
<th>Store</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gizmo</td>
<td>gadget</td>
<td>Gizmo</td>
<td>Wiz</td>
</tr>
<tr>
<td>Camera</td>
<td>Photo</td>
<td>Camera</td>
<td>Ritz</td>
</tr>
<tr>
<td>OneClick</td>
<td>Photo</td>
<td>Camera</td>
<td>Wiz</td>
</tr>
</tbody>
</table>

### Output

<table>
<thead>
<tr>
<th>Name</th>
<th>Store</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gizmo</td>
<td>Wiz</td>
</tr>
</tbody>
</table>

---

```sql
SELECT Product.name, Purchase.store
FROM Product
JOIN Purchase
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<table>
<thead>
<tr>
<th>Name</th>
<th>Store</th>
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<tbody>
<tr>
<td>Gizmo</td>
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---

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```sql
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<tbody>
<tr>
<td>Gizmo</td>
<td>Wiz</td>
</tr>
</tbody>
</table>

---
```
SELECT Product.name, Purchase.store
FROM Product JOIN Purchase
ON Product.name = Purchase.prodName

SELECT Product.name, Purchase.store
FROM Product LEFT OUTER JOIN Purchase
ON Product.name = Purchase.prodName
```
SELECT Product.name, Purchase.store
FROM Product FULL OUTER JOIN Purchase ON
Product.name = Purchase.prodName

Output

<table>
<thead>
<tr>
<th>Name</th>
<th>Store</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gizmo</td>
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<td>Wiz</td>
</tr>
<tr>
<td>OneClick</td>
<td>NULL</td>
</tr>
<tr>
<td>NULL</td>
<td>Foo</td>
</tr>
</tbody>
</table>

Outer Joins

- **Left outer join**: Include tuples from tableA even if no match
- **Right outer join**: Include tuples from tableB even if no match
- **Full outer join**: Include tuples from both even if no match
- **In all cases**: Patch tuples without matches using NULL