### Possible Pitfalls

**Notation**: Here is the real symbol. Let “⊗” denote join (i.e., T ⊗)

- Theta join may not allow associative rewriting:
  - for R(a,b), S(b,c), T(c,d) the rhs is not defined:
    - \((R ⊗ S) ⊗ T) ≠ R ⊗ (S ⊗ T)\)
  - Laws for bags and sets can differ:
    - on bags: \(A \cap (B ∪ C) ≠ A \cap B ∪ A \cap C\) (consider \(A=B=C=\{x\}\))

### Algebraic Rewritings for Selection: Decomposition of Logical Connectives

**Question**: What about sets vs. bags? (hint: consider \(C_1\) and \(C_2\) hold)

### Algebraic Rewritings for Selection: Decomposition of Negation

<table>
<thead>
<tr>
<th>Question</th>
<th>Complete</th>
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<tbody>
<tr>
<td>(σ_{C_1 \text{ AND NOT } C_2})</td>
<td>(σ_{C_1 \text{ AND NOT } C_2})</td>
</tr>
<tr>
<td>(σ_{\text{NOT } C_2})</td>
<td>(σ_{\text{NOT } C_2})</td>
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<tr>
<td>(σ_{C_1 \text{ OR NOT } C_2})</td>
<td>(σ_{C_1 \text{ OR NOT } C_2})</td>
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Pushing Selections Through Binary Operators: Union and Difference

Q: How about intersection?

Pushing Selection Through Cartesian Product and Join

Exercise: Do the rule for theta join

Sometimes "Pushing Up" Can Help

if atts(c) \supseteq atts(R) \cap atts(S)
A projection is **simple** if it only consists of an attribute list

$$
\pi_A(R \cup S) = \pi_A(R) \cup \pi_A(S)
$$

**Q1**: Does this hold for bags and sets?

**Q2**: What about intersection and difference?

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**Pushing Projections**

- **Basic principle:**
  - A projection may be **introduced**, as long as it doesn’t eliminate attributes needed “above”

- $$\pi_A(R \otimes S) = \pi_A(\pi_B(R) \otimes \pi_C(S))$$
  (B,C contain all join atts and the input atts of A)

---

**Pushing Simple Projections Through Binary Operators: Join and Cartesian Product**

Where B is the list of R attributes that appear in A.
Similar for C.

**Question**: What is B and C?

**Exercise**: rule for “pushing” projection below theta join.
Using Equivalences to obtain "Better" Plans

$$\sigma_{C \land D} (R \otimes S) = \sigma_C (\sigma_D (R \otimes S))$$
$$= \sigma_C ((R \otimes \sigma_D (S))) \quad \text{(if atts(D) \subseteq atts(D))}$$
$$= (\sigma_C (R)) \otimes (\sigma_D (S)) \quad \text{(if atts(C) \subseteq atts(R))}$$

Pushing Projections: 2\(\pi\) or not 2\(\pi\)?

Consider \(R(a,b,x,y)\) with selection condition \(C := (a=a) \land (a=b)\) (for some given values \(a, b\))

\[\pi_x \{ \sigma_C (R) \} \quad \leq \quad \pi_x \{ \sigma_C (\pi_{ab} (R)) \} \]

Hint: \(R\) as an intermediate result vs. \(R\) as a stored relation (with indexes...)