Exercise 1 (Rule Transformation).

a) Determine the semantics $F^*$ of the following deductive database $D = (F, R)$:

<table>
<thead>
<tr>
<th>Rules R:</th>
<th>Facts F:</th>
</tr>
</thead>
<tbody>
<tr>
<td>$p(X) \leftarrow q(X, Y), r(Y)$</td>
<td>$s(1,2)$, $s(5,1)$, $q(1,2)$, $q(3,1)$</td>
</tr>
<tr>
<td>$r(Y) \leftarrow s(X, Y), \neg q(X, Y)$</td>
<td>$s(2,3)$, $s(5,2)$, $q(2,3)$, $q(3,4)$</td>
</tr>
<tr>
<td>$r(X, Y) \leftarrow q(X, Y)$</td>
<td></td>
</tr>
<tr>
<td>$r(X, Y) \leftarrow q(X, Z), r(Z, Y)$</td>
<td></td>
</tr>
</tbody>
</table>

b) Determine all propagation rules $R^\Delta$ which are necessary to compute true induced insertions $p^+$ and deletions $p^-$ with respect to relation p.

Exercise 2 (Update Propagation in SQL). Consider the following SQL view:

```sql
CREATE VIEW P AS
SELECT DISTINCT r.A
FROM r,t
WHERE r.B=t.C
```

Suppose there are insertions with respect to relation r and t. Determine a specialized version of the above view definition which allows for determining induced changes to p incrementally. To this end, translate the above SQL view into equivalent Datalog rules, at first.
Exercise 3 (Propagating Updates). Consider the following set of Datalog rules:

\[
\begin{align*}
p(X, Y) &\leftarrow sd(X, Y), \text{not } b(X, Y). \\
p(X, Y) &\leftarrow sd(X, Z), p(Z, Y). \\
sd(X, Y) &\leftarrow link(X, Y). \\
sd(X, Y) &\leftarrow up(X, Z), sd(Z, Z'), down(Z', Y).
\end{align*}
\]

1. Determine all propagation rules $R^{\Delta^+}$ which are necessary to compute true induced insertions $p^+$ with respect to relation $p$.

2. Given the following facts $F$ and base table updates

\[
\begin{align*}
\text{link}(1,a). &\quad \text{down}(a,b). \quad \text{up}(1,2). \quad \text{+b(b,1)!} \\
\text{link}(a,2). &\quad \text{down}(b,c). \quad \text{up}(3,4). \quad \text{+up(2,1)! +down(c,d)!} \\
\text{link}(b,1). &\quad \text{down}(e,f). \quad \text{up}(4,5).
\end{align*}
\]

Determine the induced changes with respect to $p$ using the equations in $R^{\Delta^+}$ with state relation facts.

3. Determine a reasonable and complete set of rules for determining potential updates for relation $sd$ resulting from the given base changes.

4. Determine true induced changes with respect to $p$ using the potential updates for $sd$ by mixing the propagation rules appropriately.