3.1 Relational Algebra
Given is the relational database schema from exercise 2.2. Define the queries from exercise 2.2 as expressions in Relational Algebra.

3.2 Tableau Optimization
a) Formulate the following tableau query in the domain calculus:

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>c</td>
<td>(R)</td>
<td></td>
</tr>
<tr>
<td>b</td>
<td>c</td>
<td>d</td>
<td>(S)</td>
</tr>
<tr>
<td>e</td>
<td>c</td>
<td>f</td>
<td>(S)</td>
</tr>
<tr>
<td>g</td>
<td>h</td>
<td>f</td>
<td>(S)</td>
</tr>
</tbody>
</table>

b) Optimize the tableaux query

c) Now assume an additional referential integrity constraint and redo the optimization: 
R[C] ⊆ S[C].

3.3 Tableau Optimization
Given are the following conjunctive queries, expressed in the relational domain calculus:

D1: \{a_1, a_2 \mid \exists b_1 \exists b_2 R(a_1,b_1) \land R(b_1,b_2) \land R(b_2,a_2) \}
D2: \{a_1, a_2 \mid \exists b_1 \exists b_2 \exists b_3 R(a_1,b_1) \land R(b_1,b_2) \land R(b_2,b_3) \land R(b_3,a_2) \}
D3: \{a_1, a_2 \mid \exists b_1 \exists b_2 \exists b_3 \exists b_4 R(a_1,b_2) \land R(b_3,b_4) \land R(b_1,a_2) \land R(a_1,b_3)
\land R(b_2,b_4) \land R(b_4,b_1) \}
D4: \{a_1, a_2 \mid \exists b_1 \exists b_2 R(a_1,b_1) \land R(b_1,c) \land R(c,b_2) \land R(b_2,a_2) \} \quad (c \text{ is some constant})

Construct the tableaus T_i (i=1,...,4) for these queries and check if T_i \subseteq T_j or T_i \equiv T_j for i \neq j. Remark: The constant c has to be replaced by an additional variable x and a condition x=c.

3.4 DPNF Transformation
Transform the following query in DPNF using the transformation rules given in the lecture notes (section 2.2.4). Then generate an expression in relational algebra from the DPNF:

\(<c.name> \text{ OF EACH } c \text{ in } \text{COURSE:} \text{ \land (c.quota } > 35) \text{ AND (SOME } p \text{ in } \text{PROF, SOME } s \text{ in } \text{STUDENT (c.teacher}=p) \text{ AND NOT (SOME a in ATTENDS (a.course}=c \text{ AND a.student}=s)))\)