Exercise 1 Given the following ALC TBox:

\[
\begin{align*}
A & \sqsubseteq \exists r.G \\
B \sqcap G & \sqsubseteq \exists r.E \\
C & \sqsubseteq F \\
D & \sqsubseteq \forall r.C \\
F & \sqsubseteq \neg G
\end{align*}
\]

(a) tell whether the TBox \( T \) is satisfiable, and if so, show a model for \( T \);
(b) tell whether the concept \( D \) is satisfiable with respect to \( T \), and if so, show a model for \( T \) where \( D \) is satisfiable;
(c) tell whether the concept \( A \sqcap D \) is satisfiable with respect to \( T \), and if so, show a model for \( T \) where \( A \sqcap D \) is satisfiable;
(d) given the ABox \( A = \{ D(a), r(a,b) \} \), use the tableau method to establish whether the knowledge base \( \langle T, A \rangle \) entails the assertion \( F(b) \).

Exercise 2 Given the following ASP program \( P \):

\[
\begin{align*}
xr(x,z) & : = q(x,y), p(y,z).
xs(x,z) & : = p(x,y), q(y,z).
x(t,y,z) & : = xry, xsyz.
x(u,y) & : = sxxy, ntrxy.
xv(x,y) & : = uyx.
xw(x,z) & : = xry, syz, ntvyz.
xw(y,z) & : = xry, syz, not uyxz.
xp(b,c) & : p(d,e) p(f,b).
q(a,b) & q(b,c) q(c,f) q(e,g).
\end{align*}
\]

(a) tell whether \( P \) is stratified;
(b) compute the answer sets of \( P \).

Exercise 3
We want to formalize knowledge about persons and kinship relationships. In particular, we want to formalize the following statements:

1. every mother is a person;
2. every father is a person;
3. for every \( x, y, z \), if \( x \) has child \( y \), then \( y \) has parent \( x \);
4. for every \( x, y, z \), if \( x \) has mother \( y \) and \( y \) has mother \( z \), then \( x \) has grandmother \( z \);
5. for every \( x, y, z, w \), if \( x \) has child \( w \) of \( z \) and \( x \) has child \( y \) of \( w \), then \( x \) and \( y \) are siblings;
6. for every \( x, y \), if \( x \) has child \( y \), then \( y \) does not have child \( x \).

(a) Choose the most appropriate knowledge representation language for expressing the above knowledge among the following ones: ALC, Datalog, Datalog with constraints, ASP, OWL, DL-Lite, EL, RL, RDFS, motivating your choice;
(b) express the above knowledge in the formalism chosen at the previous point.

Exercise 4
(a) Write an RDF/RDFS model representing the following statements about URIs Person, HasParent, HasMother, HasFather, Man, Woman, City, livesIn, Ann, Bob, Jane, Mary, Paul, Sandy, Rome, Milan,

1. Person, Man, Woman, and City are classes;
2. Man and Woman are subclasses of Person;
3. HasParent, HasMother, HasFather, livesIn, are properties;
4. IsMother and HasFather are subproperties of HasParent;
5. HasParent has domain Person and range Person;
6. HasMother has domain Person and range Woman;
7. HasFather has domain Person and range Man;
8. livesIn has domain Person and range City;
9. Jane is a woman;
10. Jane has father Bob;
11. Paul is the son of Ann;
12. Mary and Bob are the children of Paul and Sandy;

(b) Write SPARQL queries corresponding to the following requests: (b1) return all the grandparents (i.e., the persons who are parents of parents of someone); (b2) return all the aunts and uncles of Jane; (b3) return every grandchild of Sandy, and, optionally, the city where the grandchild lives.

Exercise 5
Given the RL knowledge base \( \langle T, A \rangle \), where \( T \) is the following TBox:

\[
\begin{align*}
&\text{hasMother} \sqsubseteq \text{hasParent} \\
&\text{hasFather} \sqsubseteq \text{hasParent} \\
&\text{hasParent}^- \sqsubseteq \text{hasChild} \\
&\exists\text{hasChild}.\top \sqsubseteq \text{PARENT} \\
&\exists\text{hasChild}.\text{PARENT} \sqsubseteq \text{GRANDPARENT} \\
&\exists\text{hasMother}^- . \top \sqsubseteq \text{WOMAN} \\
&\exists\text{hasFather}^- . \top \sqsubseteq \text{MAN} \\
&\text{WOMAN} \sqcap \text{GRANDPARENT} \sqsubseteq \text{GRANDMOTHER} \\
&\text{MAN} \sqcap \text{GRANDPARENT} \sqsubseteq \text{GRANDFATHER}
\end{align*}
\]

and \( A \) is the following ABox:

\[
\begin{align*}
&\text{hasMother}(\text{John, Ann}), \quad \text{hasFather}(\text{John, Bob}), \quad \text{hasMother}(\text{Ann, Mary}), \\
&\text{hasFather}(\text{Ann, Paul}), \quad \text{hasMother}(\text{Bob, Jane}), \quad \text{hasFather}(\text{Mary, Nick})
\end{align*}
\]

1. compute the materialization of the ABox \( A \) with respect to the TBox \( T \);
2. tell whether the concept assertion \( \text{GRANDMOTHER}(\text{Jane}) \) is entailed by \( \langle T, A \rangle \);
3. write a Datalog program corresponding to the above TBox.