Exercise 1
Given the following ALC TBox:

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

(a) tell whether the concept \( A \) is satisfiable with respect to \( T \), and if so, show a model for \( T \) where \( A \) is satisfiable, otherwise explain your answer;

(b) tell whether the concept \( A \sqcap F \sqcap G \) is satisfiable with respect to \( T \), and if so, show a model for \( T \) where \( A \sqcap F \sqcap G \) is satisfiable, otherwise explain your answer;

(c) given the ABox \( A = \{ A(a), F(a), r(a,b) \} \), tell whether the knowledge base \( \langle T, A \rangle \) entails the assertion \( \neg E(b) \), explaining your answer;

(d) given the ABox \( A = \{ A(a), G(a) \} \), tell whether the knowledge base \( \langle T, A \rangle \) entails the assertion \( H(a) \), explaining your answer.

Exercise 2
Given the following ASP program P:

\[
\begin{align*}
\text{r}(X,Z) & : \leftarrow \text{p}(X,Y), \text{q}(Y,Z). \\
\text{r}(X,Z) & : \leftarrow \text{q}(X,Y), \text{p}(Y,Z). \\
\text{r}(X,Z) & : \leftarrow \text{r}(X,Y), \text{r}(Y,Z). \\
\text{s}(X,Z) & : \leftarrow \text{p}(X,Y), \text{q}(Y,Z). \\
\text{t}(X,Y) & : \leftarrow \text{r}(X,Y), \text{not} \ \text{s}(X,Y). \\
\text{u}(X,Y) & : \leftarrow \text{s}(X,Y), \text{not} \ \text{r}(X,Y). \\
\text{v}(X,Y) & : \leftarrow \text{t}(X,Y), \text{not} \ \text{u}(X,Y). \\
\text{v}(X,Z) & : \leftarrow \text{t}(X,Y), \text{t}(Z,Y). \\
\text{w}(X,Y) & : \leftarrow \text{v}(X,Y), \text{not} \ \text{u}(X,Y), \text{not} \ \text{t}(X,Y), \text{not} \ \text{s}(X,Y), \text{not} \ \text{r}(X,Y). \\
\text{p}(a,b). \text{p}(b,c). \text{p}(d,e). \\
\text{q}(b,c). \text{q}(c,d).
\end{align*}
\]

(a) tell whether P is stratified;

(b) compute the answer sets of P;

(c) tell whether the fact \( w(c,a) \) is entailed by P.

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

1. every student is a person;
2. every worker is a person;
3. student and worker are disjoint classes;
4. every person has a father who is a person;
5. every person has a mother who is a person;
6. every student is either a bachelor student or a master student.
7. every student who is both a bachelor student and a master student is a special student.

(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-LiteR, 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 pairs of siblings (i.e., the pairs of persons who have the same parents); (b2) return the men who live in the cities where at least a grandchild of Paul lives; (b3) return all the descendants of Mary.

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

\[
\begin{align*}
A & \subseteq B \\
A \cap C \cap D & \subseteq \bot \\
B \cap \exists r.C & \subseteq D \\
B \cap \exists r^{-}C & \subseteq E \\
\exists s.T \cap \exists s^{-}T & \subseteq F \\
E \cap F \cap \exists r.A & \subseteq A
\end{align*}
\]

and \(A\) is the following ABox:

\[
A(a), \quad C(b), \quad C(c), \quad r(a, b), \quad r(c, a), \quad s(c, d), \quad s(e, c)
\]

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