Exercise 1  Given the following $\mathcal{ALC}$ TBox:

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

(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 $B \sqcap E$ is satisfiable with respect to $T$, and if so, show a model for $T$ where $B \sqcap E$ is satisfiable, otherwise explain your answer;

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

(d) given the ABox $A = \{C(a), r(a, b)\}$, tell whether the knowledge base $\langle T, A \rangle$ entails the assertion $\neg D(b)$, explaining your answer.

Exercise 2  Given the following ASP program $P$:

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

(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 employee is a person;
2. every manager is a person;
3. employee and manager are disjoint classes;
4. every project is either a research project or an industrial project;
5. the property “is manager of” has domain manager and range employee;
6. the property “is manager of” is a subproperty of the property “works with”.

(a) Choose the most appropriate knowledge representation language for expressing the above knowledge among the following ones: $\mathcal{ALC}$, Datalog, Datalog with constraints, ASP, OWL, DL-Lite$^R$, 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 $\text{Person}$, $\text{HasParent}$, $\text{HasMother}$, $\text{HasFather}$, $\text{Man}$, $\text{Woman}$, $\text{City}$, $\text{livesIn}$, $\text{Ann}$, $\text{Bob}$, $\text{Jane}$, $\text{Mary}$, $\text{Paul}$, $\text{Sandy}$, $\text{Rome}$, $\text{Milan}$,

1. $\text{Person}$, $\text{Man}$, $\text{Woman}$, and $\text{City}$ are classes;
2. $\text{Man}$ and $\text{Woman}$ are subclasses of $\text{Person}$;
3. $\text{HasParent}$, $\text{HasMother}$, $\text{HasFather}$, $\text{livesIn}$, are properties;
4. $\text{IsMother}$ and $\text{HasFather}$ are subproperties of $\text{HasParent}$;
5. $\text{HasParent}$ has domain $\text{Person}$ and range $\text{Person}$;
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 uncles of Bob (i.e., the men who have the same parents as one of Bob’s parents); (b2) return all the aunts of Mary (i.e., the women who have the same parents as one of Mary’s parents) and optionally the city where they live; (b3) return all the grandchildren of Paul.

**Exercise 5**

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

\[
F \sqcap A \sqsubseteq D \\
C \sqcap A \sqsubseteq B \\
r \sqsubseteq u \\
s \sqsubseteq u \\
u^{-} \sqsubseteq t \\
\exists t . T \sqsubseteq E \\
\exists t . E \sqsubseteq A \\
\exists s . \top \sqsubseteq F \\
\exists r . \top \sqsubseteq C
\]

and \(A\) is the following ABox:

\[
s(a_7, a_5), \ s(a_5, a_3), \ s(a_1, a_4), \ r(a_7, a_1), \ r(a_5, a_8), \ r(a_3, a_2), \ r(a_4, a_6)
\]

1. compute the materialization of the ABox \(A\) with respect to the TBox \(T\);
2. tell whether the concept assertion \(D(a_4)\) is entailed by \(\langle T, A \rangle\);
3. write a Datalog program corresponding to the above TBox.