Exercise 1 (Safeness of Datalog Rules). There are two syntactical conditions which have to be checked for distinguishing safe from unsafe Datalog rules. Are the following rules safe and if not, why?

a) \( p(X, Y) \leftarrow q(X), \neg s(X, Y), e(Y, Z) \)
b) \( p(X, Y) \leftarrow \neg r(X), q(X, Z) \)
c) \( p(X, X) \leftarrow \neg r(X), q(X, Z) \)
d) \( p(X, Y) \leftarrow q(X, Z), \neg r(X), \neg s \)

Exercise 2 (Datalog and SQL). Translate the following Datalog rules into SQL:

a) \( father(X, Y) \leftarrow mother(Z, Y), married(X, Z), male(X) \)
b) \( son(X, Y) \leftarrow father(Y, X), male(X) \)
\( son(X, Y) \leftarrow mother(Y, X), male(X) \)

You have to introduce attribute names for the employed base relations and may use the data type VARCHAR(max) for them.

Exercise 3 (CWA and NAF principle). Usually, the database does not store negative information. In order to determine the truth value of negated literals the closed world assumption (CWA) and the negation as failure principle (NAF principle) is typically applied.

1. What is the relationship between CWA and NAF?
2. Which of the following propositions represents the CWA:
   A) The database contains only true facts!
   B) Everything that is not in the DB, is false!
   C) Everything that is not in the DB, is assumed to be false!
   D) If something is not in the DB, I conclude that it is false!
Exercise 4 (Modelling in Datalog\textsuperscript{−}). The transitive closure of a path is usually modelled as follows:

\[ \text{path1}(X, Y) \leftarrow \text{edge}(X, Y) \]
\[ \text{path1}(X, Y) \leftarrow \text{edge}(X, Z), \text{path1}(Z, Y) \]

1. Define a relation \textit{one\_way/2} that indicates for a given place X all places Y reachable from X, such that X is not reachable from Y.

2. Define a relation \textit{long\_path/2} which contains all paths with a length more than two.

3. Compare the following definition of the transitive closure of a path

\[ \text{path2}(X, Y) \leftarrow \text{edge}(X, Y) \]
\[ \text{path2}(X, Y) \leftarrow \text{path2}(X, Z), \text{path2}(Z, Y) \]

with the definition above. Are they equivalent?
Compare the definitions concerning the efficiency of rule application.