Semantic and Declarative Technologies
Final exam sample – sit-in part
Time: 80 minutes.

This is an open book test, you can use the printed version of the slides and/or the textbook. You are not allowed to use electronic equipment (notebooks, phones, etc.)

1. Consider the interpretation $\mathcal{I} = \langle \Delta, I \rangle$, where

$$\begin{aligned} \Delta &= \{\texttt{Nick}, \texttt{Mary}, \texttt{Ann}, \texttt{Steve}, \texttt{John}\} \\ \mathsf{Female}^I &= \{\texttt{Mary}, \texttt{Ann}\} \\ \mathsf{hasChild}^I &= \{\langle \texttt{Nick}, \texttt{Ann} \rangle, \langle \texttt{Mary}, \texttt{Ann} \rangle, \\ &\quad \langle \texttt{Ann}, \texttt{John} \rangle, \langle \texttt{Steve}, \texttt{John} \rangle\} \\ \mathsf{Optimist}^I &= \{\texttt{Nick}, \texttt{Steve}, \texttt{Ann}\} \end{aligned}$$

   Consider also the TBox $\mathcal{T}$ consisting of the following three axioms:

$$\mathsf{Father} \equiv \neg\mathsf{Female} \sqcap \exists\mathsf{hasChild}.\top \quad (1)$$

$$\mathsf{FatherOfGirls} \equiv \mathsf{Father} \sqcap \forall\mathsf{hasChild}.\mathsf{Female} \quad (2)$$

$$\mathsf{FatherOfGirls} \sqsubseteq \mathsf{Optimist} \sqcup \exists\mathsf{hasChild}.\mathsf{Optimist}. \quad (3)$$

   Statements (1) and (2) are definitional axioms.

   (a) Extend the interpretation $\mathcal{I}$ to include the meaning of the concepts Father and FatherOfGirls so that axioms (1) and (2) hold, i.e. write down the subsets of Δ denoted by Father^I and $\mathsf{FatherOfGirls}^I$.

   (b) Evaluate the meaning of the concept expression on the right hand side of (3), i.e. provide the subset of Δ that corresponds to this concept expression in $\mathcal{I}$.

   (c) Decide if (3) holds in $\mathcal{I}$.

2. Build a $\mathcal{SHIQ}$ TBox, representing the statements below. You can only use the concept names shown in grotesque font, and the role names hasChild and hasFriend.

   A Person is Lucky if they have a Happy grandparent and have at least two Clever children. We know that lucky people (Persons) either have no friends or all their parents are not happy. We also know that no one can be both clever and lucky. Friendship is symmetric, i.e. if x has a friend y, then y is bound to have x as a friend. Parents are always befriended with their children.

3. Consider the following subsumption check task, with respect to an empty TBox:

$$\exists\mathsf{hC}.(\mathsf{B} \sqcap (\geqslant 1\,\mathsf{hF})) \sqcap \exists\mathsf{hC}.(\mathsf{B} \sqcap \forall\mathsf{hF}.\bot) \sqcap (\leqslant 2\mathsf{hC}) \sqsubseteq \forall\mathsf{hC}.\mathsf{B}.$$

   (a) Rewrite the above axiom to a sentence in English (hC stands for "has child", hF stands for "has friend" and B stands for "blonde").
   Use the following format: "If someone ... then ...".

   (b) Is the above statement true? (A "yes" or "no" answer is enough.)

   (c) Transform the above subsumption check to a concept satisfiability check for a concept, call it C_0.

   (d) Produce the negation normal form of C_0, call it C_1.

The following tasks are *optional*

4. Regarding task 1: Change the meaning of Optimist in interpretation $\mathcal{I}$ so that your answer to subquestion (3) changes to its opposite, i.e., if the answer was "yes", it changes to "no" and if the answer was "no", it changes to "yes".

5. Regarding task 1: Show that the axiom (4) below, is a consequence of $\mathcal{T}$, as defined by (1)–(3).

$$\mathsf{Father} \sqsubseteq \mathsf{Optimist} \sqcup \exists\mathsf{hasChild}.(\mathsf{Optimist} \sqcup \neg\mathsf{Female}). \quad (4)$$

   Hint: show that a counterexample for (4) is a counterexample for (3) as well.

6. Regarding task 3: Justify your answer to question (b).