Mock Examination in Knowledge Representation and Reasoning

This exam consists of *two* problems. For each of your solutions to these problems you can earn a maximum of *50* points. You are allowed to consult the slides presented during the lectures of the course as well as the Lecture Notes. However, it is *not allowed to consult the exercises made during the tutorials.* Finally, note that it is allowed to use Dutch for your solutions. Good luck!

Problem 1

a. Resolution is an efficient algorithm to reason with clauses in predicate logic. Now consider the following set of clauses:

$$\begin{aligned}\Sigma = \{&P(x) \vee Q(y) \vee \neg R(f(x,y)),\\ &R(f(a,z)) \vee R(w) \vee Q(z),\\ &\neg P(a),\\ &Q(h(b))\}\end{aligned}$$

Here x, y, z and w are variables; a and b are constants.

Is it possible to convert the given clause set to Horn clause syntax? If your answer is positive, give the conversion result; if your answer is negative, explain why this is not possible.

Determine the most general unifier of $R(f(x,y))$ and $R(f(a,z))$.

Show by means of resolution that $\Sigma \vDash Q(b)$, i.e. that $Q(b)$ can be derived from Σ.

b. The famous Spanish biologist Carlos Darwinguer came in 1870 with the following theory:

Birds are animals that can fly and lay eggs
A penguin is a bird that cannot fly
A canary is a bird
Tux is a penguin

Finally, in 1875 Carlos understood that it is possible to formally represent this knowledge in description logics as well as in frames. Advantage of these representations is that one can formally reason with the knowledge.

Represent the knowledge above in description logics as well as in frames. Derive for both cases the properties that hold for Tux. Which of the two representations has your preference? Explain your answer.

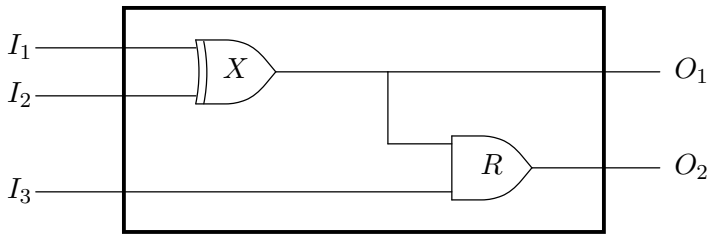

Figure 1: Logic circuit.

Problem 2

a. Consider the logic circuit depicted in Figure 1. The circuit consists of an XOR (exclusive OR) gate X and an OR gate R. The three inputs signals to the circuit are indicated by I_1, I_2 and I_3; O_1 and O_2 denote the two output signals.

Give the system description SYS for this circuit, assuming that only the XOR X and OR gate R can be faulty.

Next, consider the diagnostic problem DP = (SYS, OBS) with observations

$$\text{OBS} = \{I_1 = 1, I_2 = 0, I_3 = 0, O_1 = 1, O_2 = 0\}$$

Determine the set of conflict sets for this diagnostic problem. Use the hitting set algorithm to determine the set of minimal diagnoses.

b. Reconsider the system SYS as given above. Determine values for the inputs and outputs such that both components *must* be faulty. Motivate your solution.

c. Would it be possible to carry out consistency-based diagnosis without making use of the Ab literals in the logical representation of a system? Explain your answer.