ICS 271
Fall 2018
Instructor : Kalev Kask
Homework Assignment 6
Due Sunday November 25

1. (24 points) Problem 8.24 in RN.

2. (12) Problem 8.23 in RN.

3. (18) Say whether or not the following pairs of expressions are unifiable, and show the most general unifier for each unifiable pair:

   (a) $P(x)$ and $\neg P(A)$

   (b) $P(x, B, B)$ and $P(A, y, z)$

   (c) $Ancestor(x, father(x))$ and $Ancestor(David, George)$

   (d) $P(g(f(v)), g(u))$ and $P(x, x)$

   (e) $P(x, f(x)$ and $P(y, y)$

   (f) $P(y, y, B)$ and $P(z, x, z)$

4. (20) We are given the following paragraph:

   Tony, Mike, and John belong to the Alpine Club. Every member of the Alpine Club is either a skier or a mountain climber or both. No mountain climber likes rain and all skiers like snow. Mike dislikes whatever John likes and likes whatever John dislikes. John dislikes rain and snow.

   Represent this information by predicate-calculus sentences in such a way that you can represent the question "Who is a member of the Alpine Club and is a mountain climber but not a skier?" as a predicate-calculus expression. Use resolution refutation with answer extraction to answer it.

5. (9) Suppose a knowledge base contains just one sentence, $\exists x AsHighAs(x, Kilimanjaro)$. Which of the following are legitimate results of applying Existential Instantiation?

   (a) $AsHighAs(Everest, Kilimanjaro)$.

   (b) $AsHighAs(Kilimanjaro, Kilimanjaro)$.

   (c) $AsHighAs(Everest, Kilimanjaro) \wedge AsHighAs(BenNevis, Kilimanjaro)$ (after two applications).

6. (12) Write down FOL representations for the following sentences, suitable for use with Generalized Modus Ponens:

   (a) Horses, cows, and sheep are mammals.

   (b) An offspring of a pig is a pig.

   (c) Bluebeard is a pig.

(d) Bluebeard is Charlie's parent.

(e) Offspring and parent are inverse relations.

(f) Every mammal has a parent.

7. (10) In this exercise, use the sentences you wrote in the previous exercise to answer a question by using a backward-chaining algorithm. Draw the proof tree generated by an exhaustive backward-chaining algorithm for the query $\exists h Pig(h)$, where clauses are matched in the order given.

8. (20) Convert the following sentences to CNF form (note, if there is a non-quantified variable, you can assume it is universally quantified) :

   (a) $[\exists\, xP(x)\ \vee \exists\, x\ Q(x)]\ \Rightarrow\ \exists\, y[P(y)\ \vee\ Q(y)]$

   (b) $\forall\, x[P(x)\ \Rightarrow \forall\, y[Q(x,y)\ \Rightarrow \neg R(y,x)]]$

   (c) $\forall\, x[P(x)\ \Rightarrow \exists\, z[\forall\, xQ(x,z)\ \vee \forall\, x\ R(x,y,z)]]$

   (d) $\forall\, x[P(x)\ \Rightarrow\ Q(x,y)]\ \Rightarrow \exists\, y[P(y)\ \wedge \exists\, v[Q(y,v)]]$

9. (30) Given the of set sentences below, use resolution refutation to prove that there is a green object :

   - If pushable objects are blue, then nonpushable ones are green.
   - All objects are either blue or green but not both.
   - If there is a nonpushable object, then all pushable ones are blue.
   - Object 01 is not pushable.
   - Object 02 is pushable.

   (a) Convert these statements to sentences in first-order logic.

   (b) Convert the FOL expressions in (a) to CNF form.

   (c) Combine the CNF expressions in (b) with the clause form of the negation of the query, and then show the steps used in obtaining a resolution refutation. Provide an answer to the query, i.e. object that satisfies the required property.