Homework #4: Chapters 9 and 10

The following exercises are due at the beginning of class on Friday, March 24. Note, due to the length of this homework, it will count twice as much as your regular homeworks, but you also have additional time to complete it.

You must use SWI-Prolog to answer exercise 4. SWI-Prolog is free software and can be installed in a public Lehigh Lab via the "Install Software" feature or it can be downloaded from http://www.swi-prolog.org/ and installed on a personal machine. In addition to submitting your hardcopy homework, submit your Prolog program by e-mail to sml3@lehigh.edu. Please use "CSE327: HW #4" as your subject line and attach a file *userid*-hw4.pl where *userid* is your Lehigh user id. Also, attach a text file named *userid*-hw4-out.txt containing your output from 4(c).

1. *[10 points, 2 points each]* For each pair of atomic sentences, give the most general unifier if it exists. Assume that x, y, and z are variables, while other symbols are either predicates, constants, or functions as required by their use in the sentences. In order to avoid ambiguity, do not use a variable as a term if you have already specified a substitution for it.

   a) P(B,A,B), P(x,y,z)
   b) P(x,y), Q(A,B)
   c) Older(Father(y),y), Older(Father(x),John).
   d) Q(y,G(A,B)), Q(G(x,z),y)
   e) P(f(x), y, g(B)), P(f(y), A, g(y))

2. *[30 points total]* Consider the first-order logic sentences defined below.

   $\forall x,y\ P(x,y) \wedge Q(y,x) \Rightarrow R(x,y)$
   $\forall x,y\ S(x,Bob) \wedge S(y,x) \Rightarrow P(x,y)$
   $\forall x,y\ S(x,y) \Rightarrow Q(y,x)$
   $\forall x,y\ T(x,y,x) \Rightarrow Q(x,y)$
   $\forall x,y\ T(x,x,y) \Rightarrow Q(x,y)$
   T(Alice,Dawn,Alice)
   T(Eve,Carl,Eve)
   T(Alice,Bob,Dawn)
   T(Carl,Carl,Alice)
   S(Bob,Alice)
   S(Carl,Bob)
   S(Dawn,Carl)
   S(Carl,Dawn)
   S(Alice,Dawn)
   S(Eve,Carl)

   Use backward chaining to find **ALL** answers for the following queries. When matching rules, proceed from top to bottom, and evaluate subgoals from left to right. You must show your search tree using the same form I did in class (that is, each node should contain a list of subgoals remaining to be proven, and each child is a subsequent recursive call). Note, the form of the proof tree shown in Fig. 9.7 of the book (p. 288) is unacceptable, because it does not show when backtracking occurs.

   a) *[10 points]* $\exists x\ Q(Alice, x)$
   b) *[20 points]* $\exists x,y\ R(x,y)$.

3. *[10 points, 2 points each]* Translate the following first-order logic sentences into Prolog. Note, some sentences may require more than one Prolog statement.

   a) Knows(Sylvester,Tweetie)
   b) $\forall$x,y Friend(x,y) $\Rightarrow$ Knows(x,y)
   c) $\forall$x,y (Cat(x) $\wedge$ Bird(y)) $\Rightarrow$ LikesToEat(x,y)
   d) $\forall$x (Parakeet(x) $\vee$ Penguin(x)) $\Rightarrow$ Bird(x)
   e) $\forall$x Parakeet(x) $\Rightarrow$ (Flies(x) $\wedge$ Chirps(x))

4. *[30 points total]* In this exercise you will use Prolog to create a knowledge base for the family tree in Figure 8.5 of the book (p. 270) and then ask queries about the family tree. Assume the intended interpretation of all predicates of the form p(x,y) is that "*x* is the *p* of *y*". Parts (a) and (b) should be saved as a file named *userid*-hw4.pl. Please include an introductory comment with your name, the course number and date in it. As specified above, send an e-mail to the TA containing both your program and your output from part (c).

   a) *[5 points]* Enter the information from this family tree as a set of Prolog facts using only the three predicates **wife**, **son** and **daughter**. Note, the females are: Mum, Kydd, Elizabeth, Margaret, Diana, Anne, Sarah, Zara, Beatrice, and Eugenie.

   b) *[15 points]* Now add Prolog rules that will allow you to infer information for the predicates **husband, spouse, child, parent, grandChild, greatGrandParent, brother, sister, aunt, uncle, brotherInLaw, sisterInLaw** and **firstCousin**. You may not use any facts other than those from part (a), but you may create rules for additional predicates if you find that helpful. I recommend that you look up the definitions of terms like "aunt," "uncle," "brother-in-law," "sister-in-law," and "first cousin" in the dictionary, in order to be certain that you have captured their full meaning. Please attach a printout of your program to your hardcopy submission.

   c) *[10 points]* Test your Prolog program by asking it the following questions. Note, in some cases, it may be impossible to avoid getting the same answer more than once for a query.
      i) Who is Sarah's husband?
      ii) Who are Elizabeth's grandchildren?
      iii) Who are Zara's great-grandparents?
      iv) Who are Diana's sisters-in-law?
      v) Who are Beatrice's uncles?

      Include a printout that shows your query and the program's responses (you may simply copy this from SWI-Prolog's main window and paste it into a file for printing).

5. *[10 points, 2 points each]* For each of the following, determine which of the relations "Member" or "Subset" is being represented. Translate the statement into first order logic using the reified categories approach. Note, if you find a genuine ambiguity in a statement, then justify each of the possible interpretations.

   a) A parrot is a bird.
   b) Polly is a parrot.
   c) David Jones is a Jones
   d) "George Washington" is a great name.
   e) Artificial intelligence is a state of mind.

6. *[10 points, 5 points each]* Construct semantic network representations for the information below. See Figure 10.9 (p. 351) and Figure 10.10 (p. 352) of the book for examples.

   a) Richard Nixon is a Quaker and a Republican. Quakers and Republicans are Persons. Every Quaker follows the doctrine of pacifism.
   b) Mary gave the green flowered vase to her cousin.