# Homework #4: Chapters 9 and 12

The following exercises are due at the beginning of class on Thursday, March 30.

You must use SWI-Prolog to answer exercise 3. 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 me at heflin@cse.lehigh.edu. Please use "CSE327: HW #4" as your subject line and attach a file `userid-hw4.pl` where `userid` is your six character Lehigh user id such as `aaa999`. Also, attach a text file named `userid-hw4-out.txt` containing your output from 3(b).

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

    a)  P(B,A,B), P($x$,$y$,$z$)
    b)  P($x$,$x$), Q(A,A)
    c)  Q($y$,G(A,B)), Q(G($x$,$x$),$y$)
    d)  Older($y$,$x$), Older(Father($x$),John)
    e)  Q(G($y$,$x$),G($z$,$y$)), Q(G(B,$w$),G(A,B))

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

    $$\forall x,y \; P(x,y) \Rightarrow T(x,y)$$
    $$\forall x,y \; P(x,y) \Rightarrow T(y,x)$$
    $$\forall x,y,z \; T(x,y) \wedge Q(y,z) \wedge S(z,x) \Rightarrow R(x,y,z)$$
    P(Red,Blue)
    P(Green,Red)
    P(Blue,Green)
    Q(Blue,Green)
    Q(Green,Blue)
    Q(Red,Green)
    Q(Blue,Red)
    Q(Green,Red)
    S(Blue,Red)
    S(Green,Red)
    S(Green,Green)
    S(Green,Blue)

    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: Each node should contain a list of subgoals remaining to be proven, and each child is a subsequent recursive call. Also label each arc with the rule that was matched and give the substitutions that permit the match. Note, the form of the proof tree shown in Fig. 9.7 of the book (p. 338) is unacceptable, because it does not show when backtracking occurs.

    a)  *[10 points]* $\exists x \; T(x,\text{Blue}) \wedge Q(x,\text{Green})$
    b)  *[20 points]* $\exists x,y \; R(\text{Red},x,y)$

3. *[45 points total]* In this exercise you will use Prolog to create a knowledge base about a popular book series. Part (a) should be saved as a file named `userid-hw4.pl`. Include an introductory comment containing your name, the course number, and date. As specified at the beginning of the assignment, send an e-mail to me containing both your program and your output from part (b). You must also include hard copies of both files with your homework submission.

   a) *[30 points]* Create a Prolog program to reason with the knowledge provided below. Only include facts and rules that correspond to the information given here; do not encode any additional knowledge of the books that you may have. **Hint:** The Prolog program will be easier to write if you use unary predicates to represent categories.

   Hogwarts is a wizard academy. If someone teaches at a wizard academy, then they are a wizard. If someone is the head of a house, then they are a member of that house. Every child of a wizard is also a wizard. If someone is not a wizard, then they are a muggle. If someone is shifty, then they are in Slytherin house. If someone is brave, then they are in Gryffindor house. The head of a house teaches at the school the house belongs too. Any member of a house at a wizard academy is a wizard. Hermione is in the same house as Harry. James is a wizard. McGonagal is head of Gryffindor house. Snape teaches at Hogwarts. One of Ron's parents is Arthur. One of Harry's parents is James. Harry is brave. Draco is shifty. Gryffindor is part of Hogwarts.

   b) *[15 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) Is Harry a wizard?
      ii) Is Ron a muggle?
      iii) What house is Hermione in?
      iv) Who teaches at Hogwarts?
      v) Are Harry and McGonagal members of the same house?
      vi) Who is in Gryffindor house?

   Include a printout that shows your Prolog 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).

4. *[15 points]* Construct a semantic network representation for the following sentence: "Little Ben, an autonomous Toyota Prius, competed in the DARPA Urban Challenge in November 2007, and completed the course in 6 hours." Break the sentence down such that each object is represented by a separate bubble and each property of an object is represented by a different labeled link. See Figures 12.5 and 12.6 (p. 455) in the book for examples.