

Homework #4: Chapters 9 and 10

The following exercises are due at the beginning of class on Wednesday, March 24.

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 Lehigh user id. Also, attach a text file named *userid-hw4-out.txt* containing your output from 3(c).

1. [15 points, 3 points each] For each pair of atomic sentences, give the most general unifier if it exists. Do not standardize apart the sentences. 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) $P(x,x)$, $Q(A,A)$
 - c) $\text{Older}(\text{Father}(y),y)$, $\text{Older}(\text{Father}(x),\text{John})$.
 - d) $Q(y,G(A,B))$, $Q(G(x,z),y)$
 - e) $Q(G(y,z),G(z,y))$, $Q(G(x,x),G(A,B))$

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

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

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. 288) is unacceptable, because it does not show when backtracking occurs.

- a) [10 points] $\exists x Q(x,\text{Carl})$
- b) [20 points] $\exists x,y R(x,y)$.

3. *[40 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 at the beginning of the assignment, send an e-mail to me containing both your program and your output from part (c) (in files named *userid-hw4.pl* and *userid-hw4-out.txt*, respectively). You should also include hardcopies of both files with your homework submission.
- a) *[10 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) *[20 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. Where possible, optimize your program to avoid getting the same answer more than once for a query (but it may not always be possible to avoid some redundant answers).
 - i) Who is Sarah’s husband?
 - ii) Who are Philip’s grandchildren?
 - iii) Who are Peter’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).
4. *[15 points]* Construct semantic network representations for the following sentence: “In 1865, Asa Packer, an industrial pioneer, entrepreneur and philanthropist, founded Lehigh University.” 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 Figure 10.9 (p. 351) and Figure 10.10 (p. 352) of the book for examples.