CS 724 Assignment Three: First-Order Logic and Prolog

Dues on March 18. Total points: 70.

1. [25] Determine whether or not the following pairs of predicates are unifiable. If they are, give the most-general unifier and show the result of applying the substitution to each predicate. If they are not unifiable, indicate why. Assume that x, y, and z are variables, while other symbols are either predicates, constants, or functions.

a) P(B,A,B), P(x,y,z)

b) P(x,x), Q(A,A)

c) Older(Father(y),y), Older(Father(x),John).

d) Q(G(y,z),G(z,y)), Q(G(x,x),G(A,B)

e) P(f(x), x, g(x)), P(f(y), A, z)

2. [15] Given the following clauses as the knowledge base, show a proof by **resolution refutation** that kind(Tom):

$\forall x \neg old(x) \vee \neg smart(x) \vee kind(x)$
$\forall x \forall y\ old(x) \vee \neg tall(y) \vee \neg teach(x,y)$
$\forall x \neg pride(x) \vee smart(x)$
$tall(Eric)$
$teach(Tom,Eric)$
$teach(Eric,Sam)$
$pride(Tom)$

3. [10]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 query: $\exists x\ Q(Alice, x)$

When matching rules, proceed from top to bottom. You must show your search tree. Each node should contain a list of subgoals remaining to be proven. Also label each arc with the rule that was matched and give the substitutions that permit the match.

4. [20] Use Prolog (e.g., SWI-Prolog) to create a knowledge base for the family tree of Figure 1 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".

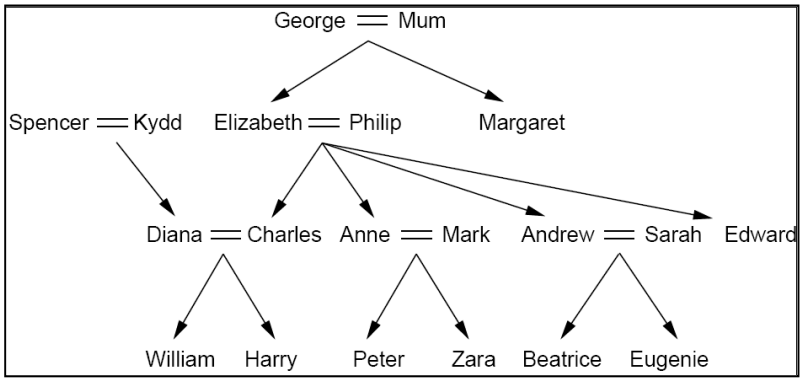

Figure 1. A typical family tree. The symbol = connects spouses and arrows point to children.

a) 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) 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. You may 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 submission.

c) 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).