Homework #4: Chapters 9 and 12

1. [10 points, 2 points each] For each pair of atomic sentences, give the most general unifier if it exists.
   a) \( P(B,A,B), P(x,y,z), \theta = \{x/B,y/A,z/B\} \)
   b) \( P(x,x), Q(A,A) \). Can’t unify \( P \) and \( Q \)
   c) \( Q(y,G(A,B)), Q(G(x,x),y) \). Can’t unify: \( y/G(A,B) \) but then need \( x/A \) and \( x/B \)
   d) \( \text{Older}(y,x), \text{Older}(\text{Father}(x),\text{John}) \), \( \theta = \{x/\text{John}, y/\text{Father(John)}\} \)
   e) \( Q(G(y,x),G(z,y)), Q(G(B,w),G(A,B)) \), \( \theta = \{w/x,y/B,z/A\} \)

2. [30 points total] Use backward chaining to find **ALL** answers for the following queries.
   a) [10 points] \( \exists x \, T(x, \text{Blue}) \land Q(x, \text{Green}) \)

   ![Diagram](image_url)

   **Answer**
   \( \{x_0/\text{Red}\} \)
b) [20 points] \( \exists x, y \, R(\text{Red}, x, y) \)

\[ \forall x, y, z \, T(x, y) \land Q(y, z) \land S(z, x) \Rightarrow R(x, y, z) \]
\[ \theta = \{ x/\text{Red}, y/x_0, z/y_0 \} \]

\( R(\text{Red}, x_0, y_0) \)

\( T(\text{Red}, x_0), Q(x_0, y_0), S(y_0, \text{Red}) \)

\( P(\text{Red}, x_0), Q(x_0, y_0), S(y_0, \text{Red}) \)

\( P(\text{Red}, \text{Blue}) \)
\[ \theta = \{ x_0/\text{Blue} \} \]

\( Q(\text{Blue}, x_0), S(x_0, y_0) \)

\( Q(\text{Blue}, y_0), S(y_0, \text{Red}) \)

\( Q(\text{Blue}, \text{Green}) \)
\[ \theta = \{ y_0/\text{Green} \} \]

\( S(\text{Green}, \text{Red}) \)
\[ \theta = \emptyset \]

\( \emptyset \)

answer
\( \{ x_0/\text{Blue}, y_0/\text{Green} \} \)

\( P(\text{Green}, \text{Red}) \)
\[ \theta = \{ x_0/\text{Green} \} \]

\( Q(\text{Green}, x_0), S(x_0, y_0) \)

\( Q(\text{Green}, y_0), S(y_0, \text{Red}) \)

\( Q(\text{Green}, \text{Blue}) \)
\[ \theta = \{ y_0/\text{Blue} \} \]

\( S(\text{Green}, \text{Red}) \)
\[ \theta = \emptyset \]

\( \emptyset \)

answer
\( \{ x_0/\text{Green}, y_0/\text{Blue} \} \)
3. **[45 points total]** Use Prolog to create a knowledge base about a popular book series.
   
   a) **[30 points]** Prolog program
      
      ```prolog
      wizard_academy(hogwarts).
      wizard(X) :- teaches_at(X, Y), wizard_academy(Y).
      wizard(X) :- child_of(X, Y), wizard(Y).
      wizard(X) :- member_of(X, Y), house_of(Y, Z), wizard_academy(Z).
      wizard(james).
      member_of(X, Y) :- head_of(X, Y).
      member_of(X, slytherin) :- shifty(X).
      member_of(X, gryffindor) :- brave(X).
      member_of(hermione, X) :- member_of(harry, X).
      muggle(X) :- \+ wizard(X).
      teaches_at(X, Y) :- head_of(X, Z), house_of(Z, Y).
      teaches_at(snape, hogwarts).
      head_of(mcgonagal, gryffindor).
      child_of(ron, arthur).
      child_of(harry, james).
      brave(harry).
      shifty(draco).
      house_of(gryffindor, hogwarts).
      
      ```
   
   b) **[15 points]** Test your Prolog program by asking it the following questions.
      
      i)  
      ```prolog
      wizard(harry).
      true.
      
      ```
      
      ii)  
      ```prolog
      muggle(ron).
      true.
      
      ```
      
      iii)  
      ```prolog
      member_of(hermione, X).
      X = gryffindor.
      
      ```
      
      iv)  
      ```prolog
      teaches_at(X, hogwarts).
      X = mcgonagal ;
      X = snape.
      
      ```
      
      v)  
      ```prolog
      Note, rather than creating a sameHouse predicate, you can simply use a conjunction of goals...
      member_of(harry, X), member_of(mcgonagal, X).
      X = gryffindor .
      
      ```
      
      vi)  
      ```prolog
      member_of(X, gryffindor).
      X = mcgonagal ;
      X = harry ;
      X = hermione.
      ```
4. **[15 points]** “Little Ben, an autonomous Toyota Prius, competed in the DARPA Urban Challenge in November 2007, and completed the course in 6 hours.”

This is just one of many possible correct answers. Note, on this problem, it is important to associate properties with the correct concepts. In particular, 6 hours is the length of a particular attempt by Little Ben to complete the DARPA Urban Challenge, and thus should be associated with a concept (e.g., Route) that connects these two concepts. Little Ben could have driven other routes that take more or less time, and there were other competitors in the challenge that took more or less time than Little Ben.