CS 540 HW5: Representation and Reasoning in FOPC

Asigned: **4/28/08**
Due: **5/7/08**
Value: **50 points**

1. Represent each of these sentences in first-order predicate calculus (FOPC).
    a. All basketballs are made of rubber.
    b. Every flower located in Sue's yard is red.
    c. At least one question on HW4 was hard.
    d. All birds can fly except for penguins and ostriches
       or unless they have a broken wing.
    e. John's boss is Mary.
    f. Selling a book changes who owns it but not who wrote it.
       [Use *situation calculus* here.]

2. Provide a formal *interpretation* that shows that the following translation from English to FOPC is *incorrect*. Be sure to *explain your answer formally* using the interpretation you provide.

   "A hat of Bob's is missing."

   $\forall$ x [hat(x) $\wedge$ owner(x, Bob)] $\rightarrow$ missing(x)

3. For each pair of FOPC wff's below, state its *most-general unifier* (mgu) or say none exists. Show your work. Universally quantified variables are indicated by ?'s.
    a. P(?x, 2) P(1, 2, 3)
    b. P(?x, ?y, ?z) P(1, f(2), f(g(a, b))
    c. P(?x, f(3), ?x) P(g(1,2), ?z, g(?z, 2))
    d. P(?x) Q(1)
    e. P(?x, ?y, ?x) P(f(?a, ?b), ?a, f(?b, ?b))

4. Starting with the following givens, formally prove (for simplicity, the predicate `state(s)` is not used in this question):

$$\exists\, s\ color(Box1, Red, s)$$

In other words, use logical reasoning to find a plan for painting Box 1 red.

You may use natural deduction or resolution theorem proving, but in either case report the state (i.e., the binding for *s*) where Box1 is Red and (informally) explain the plan represented by this state.

Number	WFF	Justification
1	box(Box1) ∧ box(Box2) ∧ (Box1 ≠ Box2) ∧ paint(Red) ∧ paint(Blue) ∧ (Red ≠ Blue) ∧ location(Loc1) ∧ location(Loc2) ∧ (Loc1 ≠ Loc2) *// Types of all our constants.*	given
2	at(Box1, Loc1, S0) ∧ at(Box2, Loc2, S0) ∧ color(Box1, Blue, S0) ∧ color(Box2, Red, S0) *// The initial state.*	given
3	∀ b,p,s box(b) ∧ paint(p) ∧ at(b, Loc2, s) → color(b, p, result(Paint(b, p), s)) *// In order to paint a box it must be at location 2.*	given
4	∀ b1,b2,p1,p2,s box(b1) ∧ box(b2) ∧ (b1 ≠ b2) paint(p1) ∧ paint(p2) ∧ color(b1, p1, s) ∧ → color(b1, p1, result(Paint(b2, p2), s)) *// Painting one box does not change the color of other boxes.*	given
5	∀ b,x,s box(b) ∧ location(x) → at(b, x, result(Move(b, x), s)) *// Moving a box changes where it is at.*	given
6	∀ b1,b2,x,y,s box(b1) ∧ box(b2) ∧ (b1 ≠ b2) ∧ location(x) ∧ location(y) ∧ at(b1, x, s) → at(b1, x, result(Move(b2, y), s)) *// Moving one box does not change where other boxes are at.*	given
7	∀ x,y (x ≠ y) → (y ≠ x) *// Inequality is symmetric.*	given