**Automated Reasoning 2012 (KB)  PROBLEMS 7**
**Equality in Resolution (Paramodulation) and Tableaux**

QUICKIES (and not so quick!)

***1. In how many ways can f(x)=g(x) be paramodulated into P(u,g(f(u)))? Show a simulation by resolution using EQAX for the case of matching f(x) with f(u).***

***2. Derive [] by (i) paramodulation and resolution and (ii) by RUE from***
***b(x)≠x,  s(x)≠x,  b(x)≠s(y),  x=x,  x=a ∨ y=a ∨ x=y ∨ x=u ∨ y=u ∨ u=a,***
***where b(x)≠x is ¬(b(x)=x) etc.***
***You may assume symmetry of =; e.g. a=b(a) resolves with b(a)≠a.***

***3. Repeat Q2 (i) using tableau, and (ii) using Otter.***

LONGER QUESTIONS.

1. (i) Paramodulate a=b into P(f(x), x) ∨ Q(x) in all possible ways.
(ii) Paramodulate f(u) = u ∨ R(u) into P(f(x), x) ∨ Q(x) in all possible ways.

2. For each of the following sets of clauses, derive the empty clause using

(a) ordinary unrestricted paramodulation,

(b) hyper-paramodulation

(c) The RUE approach

(i) x=x,  a=c,  b=c,  c=d,  c=e,  ¬P(d, x) ∨ ¬P(e, x),  P(a, y) ∨ P(b, y)

(ii) x=x,  x=a ∨ x=b,  g(x) =g(x),  ¬(g(x) =x),  R(a, b),  R(g(a), g(b) ),
¬R(a, g(a)) ∨ ¬R(b, g(b))

(iii) x=a ∨ x=b,  ¬(g(g(a)) =a),  x=y ∨ ¬(g(x) = g(y)),  x=x,  g(x) =g(x)

**Notes**: To use paramodulation in Otter, use `set(para_into).` and `set(para_from).`

Resolving an equality s=t with t≠s requirse an implicit use of symmetry. Without that, you must first use s=t in a paramodulation step on t≠s to obtain t≠t, and then resolve with x=x, or alternatively paramodulate s=t into x=x to get t=s and then resolve with t≠s.

**Question**: What does Otter do? **Answer**: Otter does not seem to want to, or be able to, paramodulate into x=x (or even into x=y or a=a, etc.)

3. Use method on Slide 13bi to find a closed tableau for the following sets of clauses
(i) x=x, a=c, b=c, c=d, c=e, ¬P(d, x) ∨¬P(e, x), P(a, y) ∨ P(b, y)
(ii) x=x, x=a ∨ x=b, ¬(g(x) =x), R(a, b), R(g(a), g(b) ), ¬R(a, g(a)) ∨¬R(b, g(b))

4. These clauses formalise the "Aunt Agatha" problem from Lecture 1.
K(d, a),  d=a ∨ d=b ∨ d=c.  H(b, d),  x=b ∨ H(b, x),  ¬ a=b,
¬ K(x, y) ∨ H(x, y),  ¬ H(x, f(x)),  ¬ H(c, x) ∨ x=b,  ¬ K(a, a),

Find a closed tableau using the given clauses by using the EQAX explicitly in the Model Elimination way. (**Hint**: start with clause d=a ∨ d=b ∨ d=c.)

(Using the RUE-tableau approach is much harder. You need a different top-clause. I managed by using K(d,a) as top clause, but the tableau is not made exactly in the ME way.) Instead, why not try Otter on this example as well?