**Homework -PL and FOL-**

1. Translate the following first-order sentences into English:
   1. ∀x (bird(x) ⇒ flies(x))
   2. ∀x ∃y (person(x) ⇒ mother(y; x))
   3. ∃x ∀y (person(x) mother(x; y))

Where:

bird(x) means “x is a bird"

flies(x) means “x flies"

person(x) means “x is a person"

mother(x; y) means “x is the mother of y"

1. Convert the following English sentences into sentences of first-order logic:
   1. All cats are mammals.
   2. No cat is a reptile.
   3. All computer scientists like some operating system.

Use meaningful predicate names or state the scheme of abbreviation that you are using.

1. Convert the following PL sentences into conjunctive normal form (CNF):
   1. A ⇒ B
   2. P∧((Q∧S) ⇒¬R)
2. Determine whether the following are valid inferences in first-order logic using resolution (all variables are supposed to be universally quantified):
   1. (P(x) ⇒Q(x)) ⊢(¬Q(y) ⇒ ¬P(y))
   2. Prove that syllogisms are valid inferences. In other words, show that (R(x) ⇒S(x)),R(c) ⊢S(c).
   3. (P(x) ⇒ Q(x)) ⊢ (¬Q(x) ⇒ ¬P(x))
   4. (P(x) ⇒ Q(x)) ,P(a) ⊢ Q(a)
   5. (P(x) ⇒ Q(x)), (Q(x) ⇒ R(x)) ⊢ (P(x) ⇒ R(x))
3. Consider the following three sentences:
   1. There is a student who likes every operating system.
   2. Windows is an operating system.
   3. Someone likes Windows.

We wish to investigate the relationship among these three sentences:

* 1. Write a formula in first-order logic expressing each of the given facts. Call them A, B and C.
  2. Write the set of clauses corresponding to A, B and ¬C.
  3. Derive the empty clause from this set of clauses using resolution. What can you conclude

1. Let P(x), Q(x), R(x), and S(x) be the statements “x is a duck”, “x is one of my poultry”, “x is an officer”, and “x is willing to walk”, respectively. Express each of these statements using quantifiers, logical connectives, and the predicates P(x), Q(x), R(x) and S(x).
   1. No ducks are willing to walk.
   2. No officers ever decline to walk.
   3. All my poultry are ducks.
   4. All My poultry are not officers.
   5. Does the fourth item follow from the first three taken together?