Homework #2: Chapters 6, 7, 8

The following exercises are due at the beginning of class on Wednesday, February 23.

1. *[20 points total]* This problem looks at playing the game tic-tac-toe. Assume that X is the MAX player. Let the utility of a win for X be 10, a loss for X be -10, and a draw be 0.
   a) Given the game board to the right with X's turn to play next, show the entire game tree. Mark the utilities of each terminal state and use the minimax algorithm to calculate the optimal move.

	X	
O	O	X
X	O	

   b) Given the game board to the right with X's turn to play next, show the game tree with a cut-off depth of two ply (i.e., stop after each player makes one move). Use the following evaluation function on all leaf nodes:
   $Eval(s) = 10X_3(s) + 3X_2(s) + X_1(s) – (10O_3(s) + 3O_2(s) + O_1(s))$
   where we define X_n as the number of rows, columns, or diagonals with exactly *n* X's and no O's, and similarly define O_n as the number of rows, columns, or diagonals with exactly *n* O's and no X's. Use the minimax algorithm to determine X's best move.

O	X	X
O		

2. *[25 points]* Consider a knowledge base *KB* that contains the following propositional logic sentences:

$$P \vee R \Rightarrow Q$$
$$\neg P \Rightarrow R$$
$$Q \vee R$$

   a) Construct a truth table that shows the truth value of each sentence in *KB* and indicate the models in which the *KB* is true.
   b) Does *KB* entail *R*? Use the definition of entailment to justify your answer.
   c) Does *KB* entail *Q*? Use the definition of entailment to justify your answer.
   d) Does *KB* entail $P \vee R$? Extend the truth table and use the definition of entailment to justify your answer.
3. *[10 points total]* Does an empty knowledge base (i.e., a knowledge base with no sentences in it) entail anything? Explain your answer.
4. *[20 points total]* Represent the following sentences in first order logic, assuming that the domain consists only of people. The only predicates you may use are *loves*(x,y), *knows*(x,y), and *avoids*(x,y), where a predicate of form *Predicate*(x,y) means that "x *Predicate* y." Choose meaningful constants where appropriate.
   a) Somebody knows and loves Tim.
   b) Everybody who knows Sue avoids Sue.
   c) There is somebody that everybody loves.
   d) Nobody knows everybody.
   e) There are some people who love nobody but themselves.
5. *[25 points]* Building on the kinship domain (p. 254), use first-order logic to write axioms defining the binary (i.e., having arity 2) predicates *Daughter*, *Son*, *Wife*, *GrandChild*, *GreatGrandParent*, *Brother*, *Sister*, *Aunt*, *Uncle*, and *FirstCousin*. Here, a predicate of form *Predicate*(x,y) should be read in English as "x is the *Predicate* of y." Only use these predicates and the predicates defined on p. 254-255 of the book in your definitions. Try to ensure that your definitions are as complete as possible without leading to false inferences.