Homework #2: Chapters 4 and 6

The following exercises are due at the beginning of class on **February 13.**

1. *[15 points]* Use greedy best-first search to find a path from Vaslui to Sibiu, assuming the roads between cities and their lengths are given by the map in Figure 3.2 of the book (p. 63). Use the straight-line distance from each node to Sibiu as your heuristic function, assuming these distances are given by the following table:

Arad	138	Mehadia	146
Bucharest	253	Neamt	237
Craiova	196	Oradea	148
Dobreta	183	Pitesti	162
Eforie	433	Rimnicu Vilcea	78
Fagaras	96	Sibiu	0
Giurgiu	272	Timisoara	141
Hirsova	385	Urziceni	302
Iasi	298	Vaslui	345
Lugoj	97	Zerind	146

Show your search tree, including the h(n) value for each node, and label each node with the order in which it is expanded (note, this may be different from the order it is generated). In order to reduce unnecessary search, you can ignore moves that return you to the state you just came from, however you must show any other repeated states.

2. *[15 points]* Now repeat the exercise above, but use A* instead of greedy best-first. Show your search tree, complete with f(n), g(n) and h(n) values for each node, and label each node with the order in which it is expanded. Once again, when expanding nodes, assume that you can ignore actions that return you to the previous state.

3. *[20 points]* Use A* to solve the 8-puzzle with the initial and goal states shown below. Assume that your path cost is 1 per move and that your heuristic function is the number of tiles that are out of place (note, the blank does not count as a tile). Show your search tree and label each node with the order in which it is expanded. Each node should show the position of all tiles in that state and the corresponding f(n), g(n) and h(n) values. Once again, when expanding nodes, assume that you can ignore actions that return you to the previous state.

Initial State

1		3
4	2	5
7	8	6

Goal State

1	2	3
4	5	6
7	8	

4. *[10 points]* Approximately how many possible games (i.e., sequences of moves) of tic-tac-toe can be played? Note, due to the variability in when a game ends it is difficult to provide an exact answer, but you should be able to provide reasonable upper and lower bounds with a few simple calculations. Be sure to explain how you derived your answer.

5. *[40 points]* 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 **board1** below where it is 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.

   b) Given the game board **board2** below where it is 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 $X_n(s)$ as the number of rows, columns, or diagonals in state s with exactly n X's and no O's, and similarly define $O_n(s)$ as the number of rows, columns, or diagonals in state s with exactly n O's and no X's. Use the minimax algorithm to determine X's best move.

board1

X	O	X
O		O
	X	

board2

O	X	X
O		