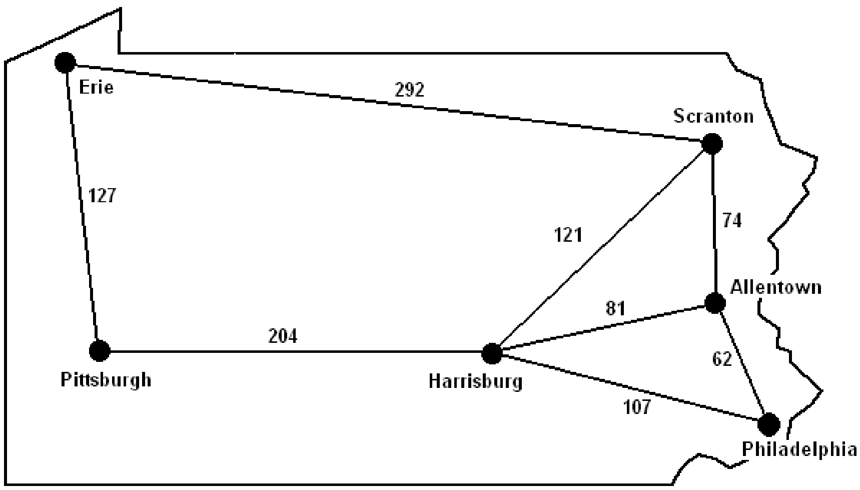
Homework #2: Chapters 4 and 6

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

1. *[15 points]* A hurried traveler is seeking an efficient route across Pennsylvania, from Philadelphia to Erie. Use greedy best-first search to find a path, assuming the roads between cities and their lengths are given by the map below. Use the straight-line distance from each node to Erie as your heuristic function, where these distances are given by the table to the right of the map.



Heuristic Estimates	
n	**h(*n*)**
Allentown	300
Erie	0
Harrisburg	225
Philadelphia	350
Pittsburgh	100
Scranton	250

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, complete with f(n), g(n) and h(n) values for each node. Also show that current game board at each node in the tree. Once again, when expanding nodes, assume that you can ignore actions that return you to the previous state.

Initial State

2	8	3
1	6	4
7		5

Goal State

1	2	3
8		4
7	6	5

4. *[10 points]* The book shows how to derive heuristics for the 8-puzzle problem from relaxed versions of the problem (p. 107-108). Consider a new heuristic h3, which is the minimum number of moves to solve the puzzle if any tile can move directly to the blank square. Explain why h3 is at least as accurate as h1 (the number of misplaced tiles). Give an example of a state where h3 is more accurate than both h1 and h2 (the sum of Manhattan distances of each tile to its goal location).

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, and 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, and 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	O
	O	X
	X	

board2

	X	
O		
X		O