Q1. State Space *[10 points]*

1. Answer the following questions. Assume a minimal state representation.

   (a) *[0.5 points]* Consider a M by N grid of squares, where $M, N \geq 1$. Let there be a king on one of the squares. In terms of the variables introduced, what is the size of the world state space?

   (b) *[0.5 points]* From now on, each square can have a pawn on it. The king and a pawn can be on the same square. In terms of the variables introduced, what is the size of the world state space?

   (c) *[1 point]* From now on, the king cannot be on the same square as a pawn. In terms of the variables introduced, what is the size of the world state space?

   (d) From now on, the king can either move to any of the 8 adjacent squares on the grid or attack a pawn in one of those squares to reduce its health point by 1. A pawn will be removed from its square if it loses all its health points. For the following questions, your answer should be a number and not an expression.

      i. *[1 point]* What is the maximum number of actions available for the king at any state?

      ii. *[1 point]* What is the maximum number of actions available for the king at any state, if $M, N \leq 2$?

      iii. *[1 point]* What is the minimum number of actions available for the king at any state?

      iv. *[1 point]* What is the minimum number of actions available for the king at any state, if $M, N \geq 3$?

(e) For this problem alone, the king wants to kill all pawns on the grid. Also assume that the king cannot move to any squares previously occupied by the pawns. In each of the following questions, **consider the following instance of the problem** where K represents the king and numbers represent the health points of the pawns at each square. A square with no numbers means there is no pawn present there:

K	4	2
	2	

In this instance we are considering a three by three board with three pawns, two of which start with health two and one of which starts with health four as well as one king.

i. *[1 point]* How many search states are there?

ii. *[1 point]* How many search states pass the goal test? That is, how many states are goal states?

(f) For this problem alone, the king wants to visit the maximum number of unique squares given the constraints of each sub-problem. In each of the following questions, consider the following instance of the problem where K represents the king and numbers represent the health points of the pawns at each square:

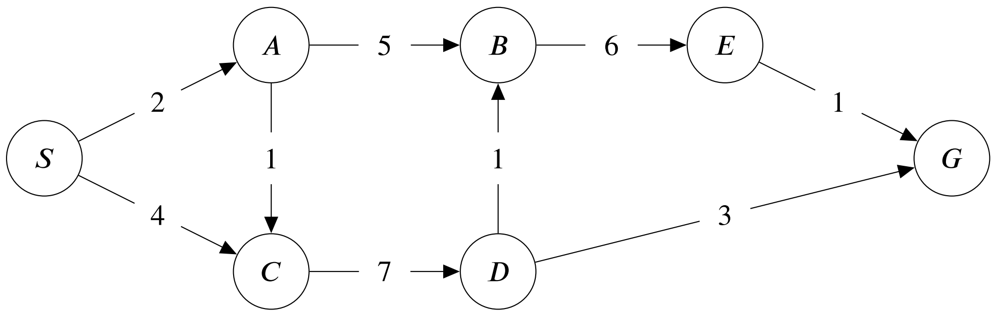
K		
1	1	
	1	

i. *[1 point]* How many search states are there, given that the king cannot attack the pawns?

ii. *[1 point]* How many search states pass the goal test, given that the king cannot attack the pawns?

Q2. Uninformed Search *[10 points]*

1. Answer the following questions about the below graph. Break any ties alphabetically (e.g., if two nodes are enqued at the same time or have the same priority, first deque the node that has the lowest value alphabetically). Consider all of these search algorithms to expand a node before checking the goal test.



   (a) *[1 point]* What path would depth first tree search from S to G produce? List the nodes in order.

   (b) *[1 point]* When depth first tree searching from S to G, which nodes are expanded? Provide them in the order they were expanded.

   (c) *[1 point]* What path would depth first tree search from S to G produce, given that an edge with weight 8 from *B* to *C* is added?

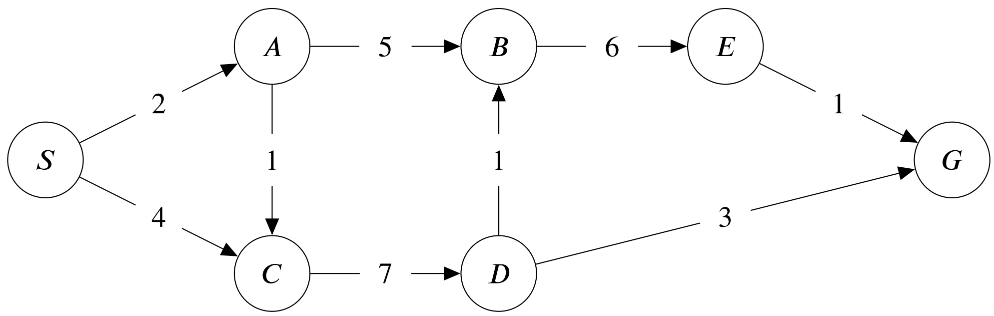
   (d) *[1 point]* What path would breadth first tree search from S to G produce? List the nodes in order.

   (e) *[2 points]* When breadth first tree searching from S to G, which nodes are expanded? Provide them in the order they were expanded.

   (f) *[2 points]* What path would uniform cost tree search from S to G produce? List the nodes in order.

   (g) *[2 points]* When uniform cost tree searching from S to G, which nodes are expanded? Provide them in the order they were expanded.

Q3. Informed Search *[10 points]*



State	h_1	h_2
S	7	12
A	8	10
B	6	5
C	9	8
D	4	3
E	1	1
G	0	0

1. Answer the following questions about the above heuristics for the above graph.

   (a) *[2 points]* Is h_1 admissible? If it is, circle "Yes". Otherwise, circle "No" and provide a state at which the heuristic is inadmissible.

   Yes | **No** **State:** ☐

   (b) *[2 points]* Is h_1 consistent? If it is, circle "Yes". Otherwise, circle "No" and provide an arc at which the heuristic is inconsistent.

   Yes | **No** **Arc:** ☐

   (c) *[2 points]* Is h_2 admissible? If it is, circle "Yes". Otherwise, circle "No" and provide a state at which the heuristic is inadmissible.

   Yes | **No** **State:** ☐

   (d) *[2 points]* Is h_2 consistent? If it is, answer "yes". Otherwise, circle "No" and provide an arc at which the heuristic is inconsistent.

   Yes | **No** **Arc:** ☐

   (e) *[2 points]* For this question, assume h_2 is *consistent* everywhere except at $h_2(C)$. What range of values can h_2 take on at node C to make h_2 *consistent*?

   ☐ $\leq h_2(C) \leq$ ☐

Q4. Hours Worked

(a) How many hours did you spend on this homework? Any reasonable answer (number greater than zero) will receive credit. This will not affect your score on any other problem.