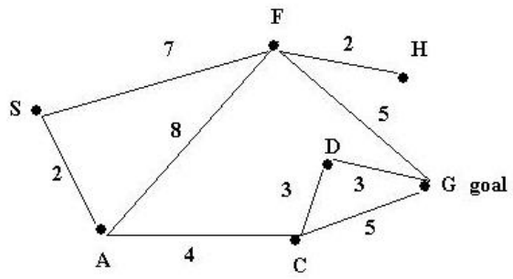
CSE 440: Artificial Intelligence
Midterm Assignment, Fall 2022
North South University
Full Marks: 50

Problem 1. Intelligent Agents and Search [10 Points]

Suppose that you need to find a path between S and G in the following graph. The number attached to each edge in the graph represents the **actual cost** of traversing the edge.



Assume also that the **heuristic** distances to the goal from each node are given by the following table:

Node	S	A	C	D	F	G	H
Heuristic dist. To G	10	5	4	3	4	0	2

For each of the following search methods, list the nodes in the order in which they are expanded by the search method while looking for a solution. **Show your work**. When everything else is equal, order the nodes in alphabetical order. (10 points)

i. Depth First Search
ii. Breadth First Search
iii. Uniform Cost Search
iv. Greedy Best First Search
v. A* search

Problem 2. Adversarial Search [15 points]

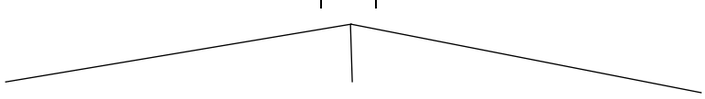
a) Suppose that you are playing a game of tic-tac-toe on a 3X3 board with your friend. You are the MAX player, and you are playing with "X". The current board configuration is depicted below and it is your turn to move.

Assume also that the utility function is given by:

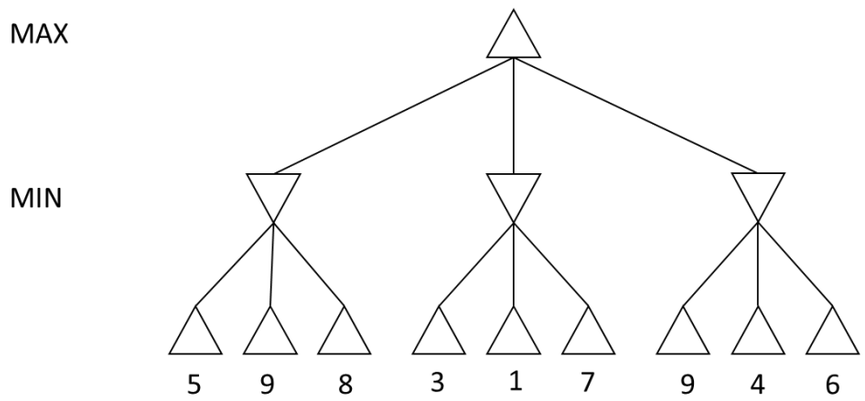
$$Utility\ of\ a\ terminal\ board\ configuration = \begin{cases} +1, & if\ 'X'\ wins \\ 0, & if\ it\ is\ a\ draw \\ -1, & if\ 'O'\ wins \end{cases}$$

Use the **minimax** procedure to select your next move. First, you must expand the game tree, which is rooted at the current board configuration below, until the terminal states are reached. Then use minimax algorithm to select your optimal next move. (5 points)

O	O	X
	X	
O	X	



b) An adversarial tree of a 2-ply turn-taking game is given below. The utility values at each leaf node is given in the tree. MAX is the first player, and it is MAX's turn to move. Using **minimax** algorithm with **alpha-beta pruning**, determine MAX's next move. **Show your steps** and clearly identify any node(s) that will be pruned by the alpha-beta pruning algorithm. (10 points)



Problem 3. Propositional Logic and Logical Inference [15 points]

a) The following statements are given:

"The humidity is high, or the sky is cloudy. If the sky is cloudy, then it will rain. If the humidity is high, then it is hot. It is not hot."

i. Write down each sentence in **propositional logic** (3 points)
ii. Now convert each of the sentences to **CNF** (3 points)
iii. From the above CNF clauses, use **Resolution** to prove (or disprove) the following statement – "It will rain" (3 points)

b) Consider the following knowledge base:

- If there is gas in the tank and the fuel line is okay, then there is gas in the engine;
- If there is gas in the engine and a good spark, the engine runs;
- If there is power to the plugs and the plugs are clean, a good spark is produced;
- If the battery is charged and the cables are okay, then there is power to the plugs.

Now write the four rules above as **Horn clauses** using proposition symbols such as *GasInTank*, *FuelLineOK*, etc (you can choose your own propositional symbol). Then construct an **AND-OR graph**, and prove using both **Forward Chaining** and **Backward Chaining** that the engine runs. Assume the following as ground truths: there is gas in tank, the fuel line is OK, the plugs are clean, the battery is charged, and the cables are okay. (6 points)

Problem 4. First Order Logic [10 points]

Assume we have a function *MapColor* and predicates *In(x, y)*, *Borders(x, y)*, and *Country(x)*, whose arguments are geographical regions (city, state, country, continent, etc.). *MapColor(x)* returns the map color for region x. *In(x, y)* means "region x is in region y". *Borders(x, y)* means that regions x and y have a common border. *Country(x)* means the region x is a country. Using these predicates, express Each of the following statements using First Order Logic:

i. Both Dhaka and Chittagong are in Bangladesh
ii. There is a country that borders both India and Pakistan.
iii. All countries that border Bangladesh are in Asia.
iv. No region in South America borders any region in Europe.
v. No two adjacent countries have the same map color.