Midterm 1: Rubric

CSCI 561 Fall 2022:

Foundation of Artificial Intelligence

Instructions:

1. Maximum credits/points for this midterm: 100 points.
2. No books (or any other material) are allowed.
3. Follow the instructions strictly and carefully to answer the questions.
4. Adhere to the Academic Integrity Code.

Problems	100 Percent Total
1 – General AI knowledge	20
2 – Search Algorithm Concepts	30
3 – CSP	10
4 – Game Playing	10
5 – Reinforcement Learning	20
6 – Multiple Choice from Discussion	10

For section 5, all students have been given 20 credits.

1. General AI Knowledge [20%]

For each of the statements below, select **True** if the statement is always and unconditionally true, or **False** if it is always false, sometimes false, or just does not make sense:

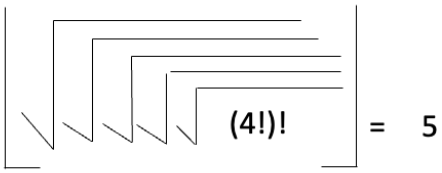
1. [2%] An agent that senses only partial information about the environmental state cannot be perfectly rational.

   FALSE: Perfect rationality refers to the ability to make good decisions given the sensor information received.

2. [2%] It is possible for a given agent to be perfectly rational in two distinct task environments.

   TRUE: We can arbitrarily modify the parts of the environment that are unreachable by any optimal policy as long as they stay unreachable.

3. [2%] Knuth conjectured that starting with the number 4, a sequence of factorial, square root, and floor operations will reach any desired positive integer. For example, we can reach 5 from 4 as follows:

   The above problem has a finite number of states.

   FALSE: There is no bound on how large a number might be constructed in the process of reaching a given target. There are infinitely many states for this problem.

   [ABOVE STATEMENT IS WRITTEN IN AIMA]

4. [2%] Breadth-first search is a special case of uniform-cost search.

   TRUE: When all step costs are equal, $g(n) \propto \text{depth}(n)$, so uniform-cost search reproduces breadth-first search

5. [2%] Both the learning element and performance element in a learning agent receive feedback from the critic.

   FALSE: Only the learning element receives the feedback.

6. [2%] It is not possible for an agent to get stuck at a local extreme while following the Hill Climbing Algorithm.

   FALSE

7. [2%] A purely random walk - that is, moving to a successor chosen uniformly at random from the set of successors is complete.

   TRUE: A purely random walk - that is, moving to a successor chosen uniformly at random from the set of successors is complete but extremely inefficient.

8. [2%] The map coloring problem discussed in the class can be solved by arc consistency using colors red and blue.

   FALSE: We need at least 3 colors to solve the problem using arc consistency.

9. [2%] It is not a good heuristic to choose the variable that is most constrained instead of choosing the value that is least constraining in a CSP search.

   FALSE

10. [2%] Policy Iteration has been empirically observed to converge more slowly than Value Iteration.

    FALSE

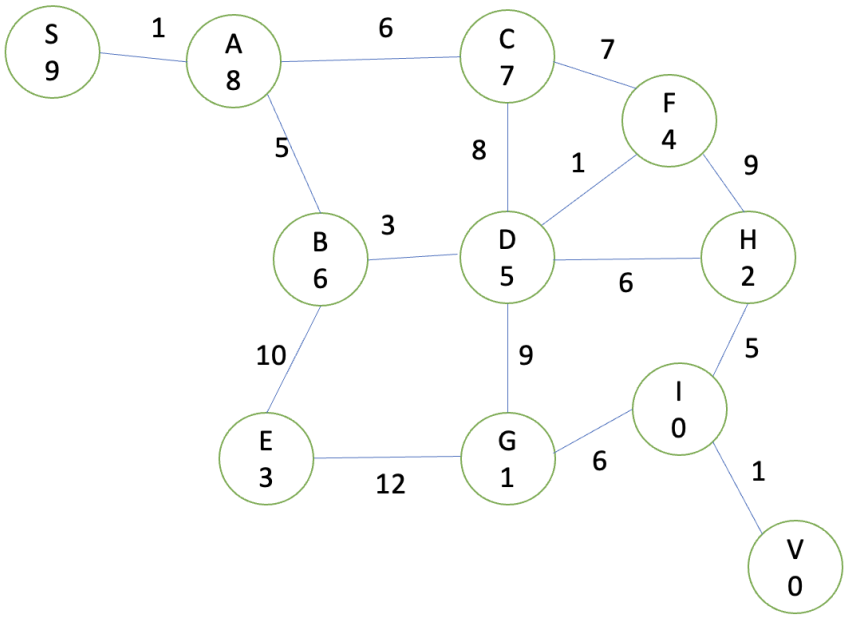
2. Search Algorithm Concepts [30%]

USC campus has been invaded by aliens, who think that the **Student Union (S)** contacted their mothership. Despite their realization that it did not, they went ahead with their invasion plan anyway. Advanced alien technology has disabled the use of phones and the internet, so you and your friends decide to go to the **Viterbi School of Engineering (V)** to get help and to tell everyone what's going on. You decide to use the secret underground network of tunnels underneath the campus to get from your **starting location at S, to the destination at V**.

You have the following graph of the underground tunnels. The edges are labeled with distances, and the nodes are labeled with a heuristically estimated to your destination at V.

When performing the search, ties are broken by choosing the node that is **alphabetically** first.

Please note that for DFS, you are supposed to run the **recursive** version of the algorithm.
For algorithms BFS and DFS, take the cost of each edge to be 1.



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The sequence of Nodes Explored, Solution Path by Algo, Solution Cost of the Path by Algo.

Each answer below should be a sequence of states, e.g., "S-A-B-C-D-E-V". Please follow this format only i.e. use '-' between any two nodes.

[6%] BFS:
Exploration Sequence: S-A-B-C-D-E-F-G-H-I-V
Path: S-A-B-D-G-I-V
Cost: 6

[6%] DFS (Recursive):
Exploration Sequence: S-A-B-D-C-F-H-I-G-E-V
Path: S-A-B-D-C-F-H-I-V
Cost: 8

[6%] UCS:
Exploration Sequence: S-A-B-C-D-F-H-E-G-I-V
Path: S-A-B-D-H-I-V
Cost: 21

[6%] A*:
Exploration Sequence: S-A-B-C-D-F-H-E-G-I-V
Path: S-A-B-D-H-I-V
Cost: 21

[6%] Greedy Best-First:
Exploration Sequence: S-A-B-E-G-I-V
Path: S-A-B-E-G-I-V
Cost: 35

Note: For each of the subparts:
Part a (popped off nodes): 3 marks
Part b (path): 2 marks
Part c (cost): 1 marks

3. Constraint Satisfaction Problem [10%]

A small school has only 2 classes and 4 teachers. On a particular day, both the classes have 4 lectures (1 hr each) from 9 AM to 1 PM. Each of the teachers teaches a different subject.
[T] Tom Cruise teaches Math
[J] Johnny Depp teaches English
[D] Dwayne Johnson teaches Science
[R] Ryan Reynolds teaches History

There are some constraints,

1. History cannot be taught as the first lecture in the classes as the school does not want students to be sleepy during the first lecture, even though Ryan is teaching.
2. Math requires a lot of mental strength, so Tom does not want to teach this as the last lecture of the day
3. All the teachers take only one lecture for each class
4. A teacher needs 1 hr of a break after every lecture he takes
5. Johnny Depp wants to take a class only when Tom Cruise is taking the other class.
6. Dwayne Johnson has a morning workout routine so he cannot take the first lecture for any class

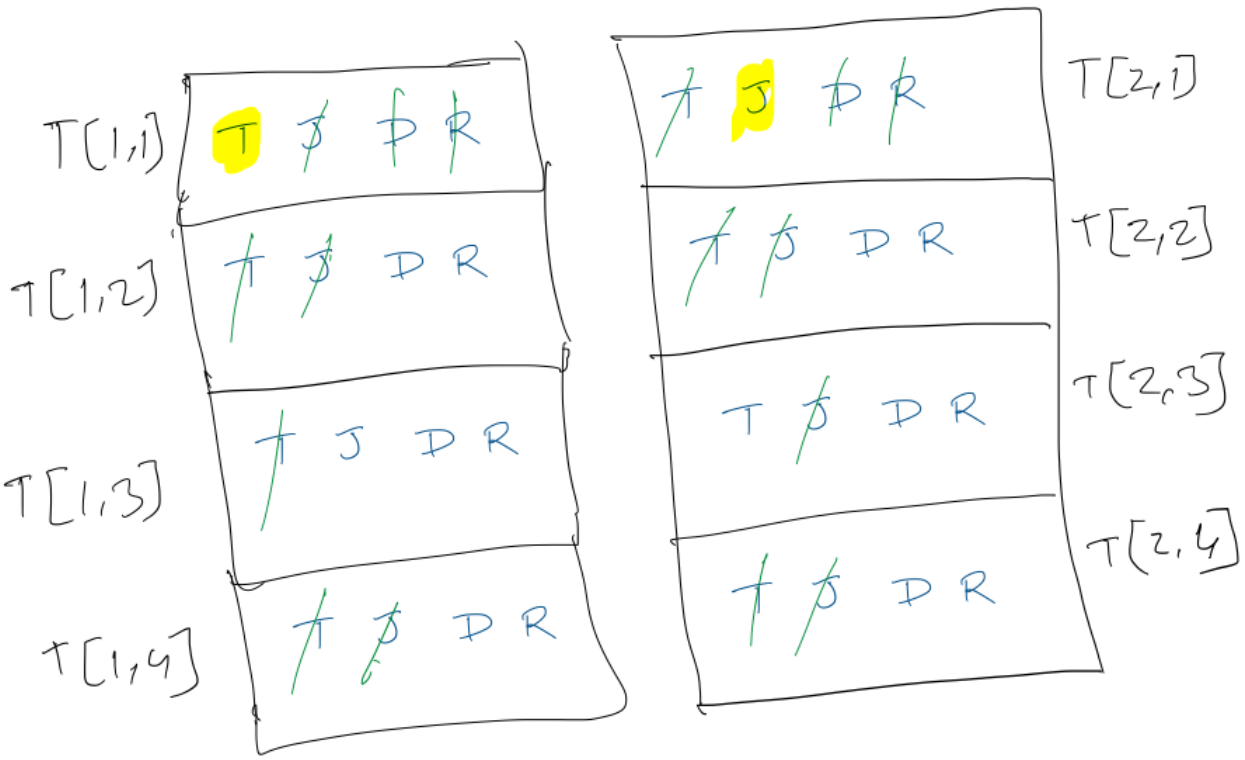
You have to design a timetable satisfying all the constraints.

Time Table is denoted in the format: T[i,j] where i is the class {1, 2} and j is the lecture number {1,2,3,4}.
So for example, 3rd lecture of the second class is denoted as T[2,3].

The timetable is the variable matrix and the domains are the teachers {T, J, D, R}
Answer the following questions:

1. [1%] How many unary constraints are there in this CSP?
   6
2. [4%] After resolving all the unary constraints, you assign Tom to take the first lecture for class 1 (i.e., T[1,1]=T) What is the final configuration after you run AC-3 (Arc consistency algorithm)

[ANS]

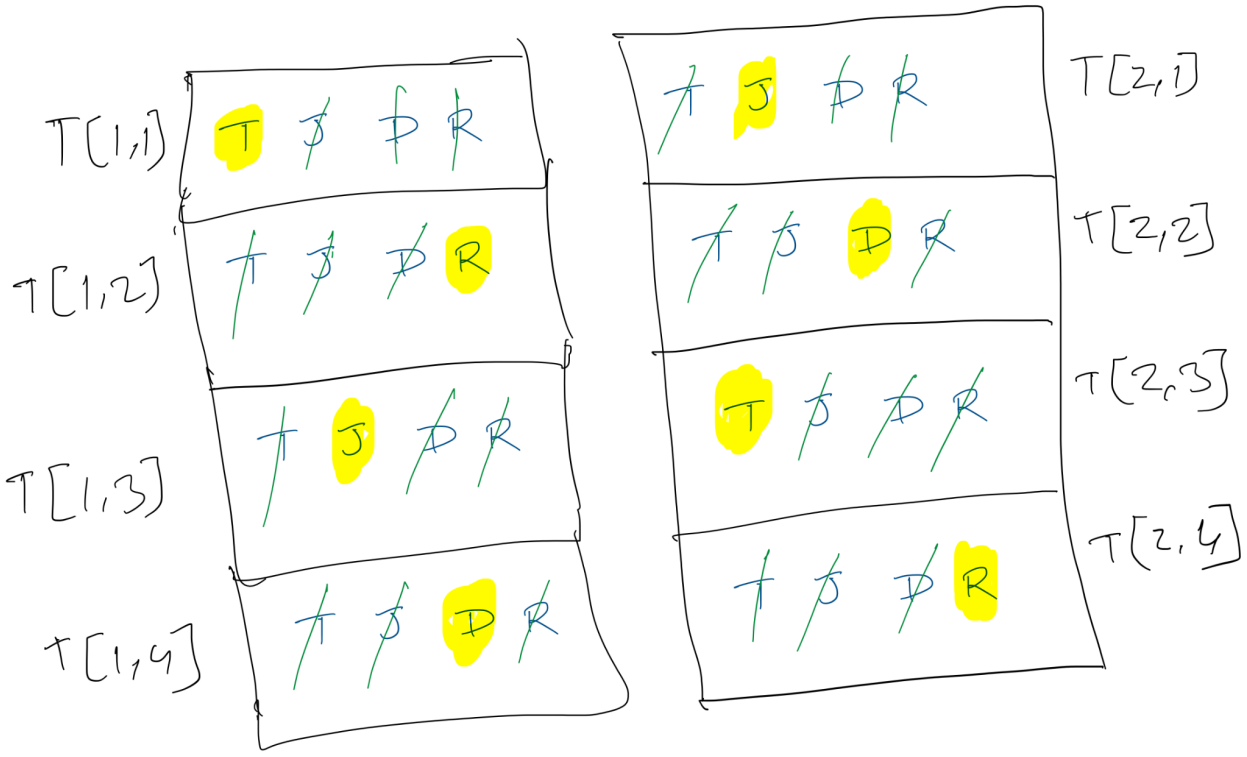


3. [1%] At this configuration which is the Most constrained variable? If there are multiple answers give any-one.

   T[2,1]

   Explanation: Only 1 value in the domain

4. [4%] Next you assign, Dwayne Johnson to take lecture 2 for class 2 (i.e. T[2,2] = D), After performing AC-3 what is the configuration?


T[1,1]
T[1,2]
T[1,3]
T[1,4]
T[2,1]
T[2,2]
T[2,3]
T[2,4]

4. Game Playing [10%]

1. Consider the following game tree.

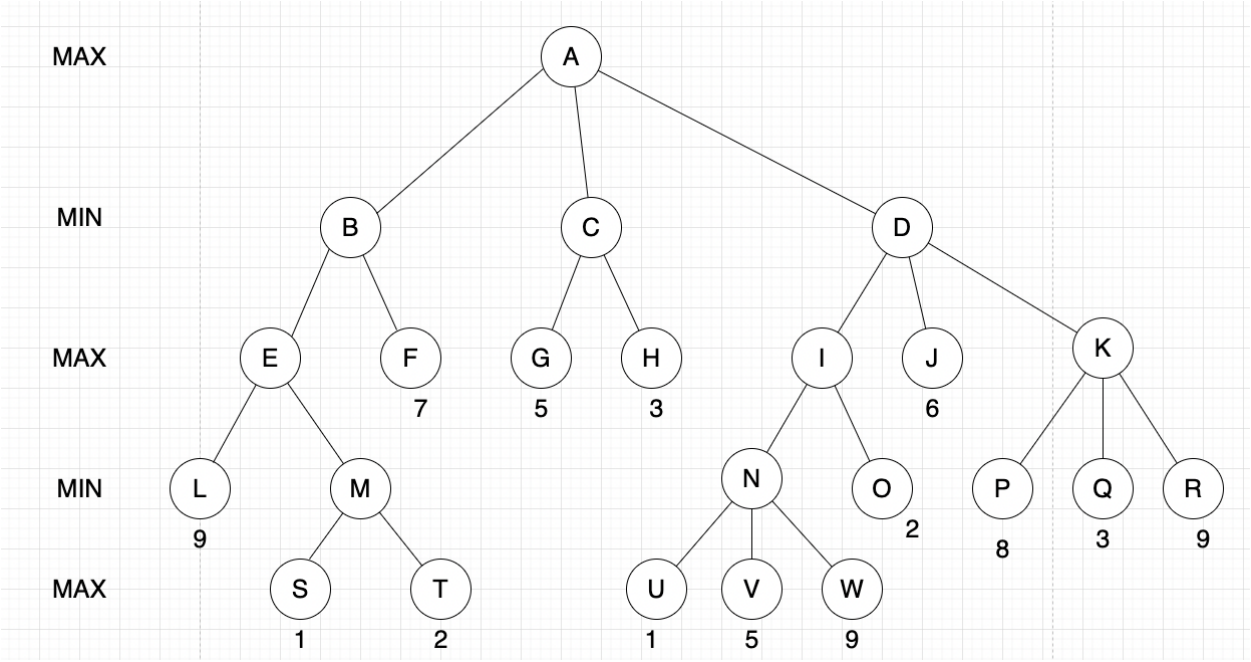


Figure 1

The values at the leaves of the tree are the utilities for each outcome of the game. The node names are labeled within each MIN/MAX node.Assume that the search always visits children left-to-right.

(a) [3%] Perform the MiniMax algorithm on the above tree. What will be the values at nodes B, I, and D? Write the answer comma separated. (For eg if B=1, I=3 and D=2 then write : 1,3,2)

B = 7

I = 2

D = 2

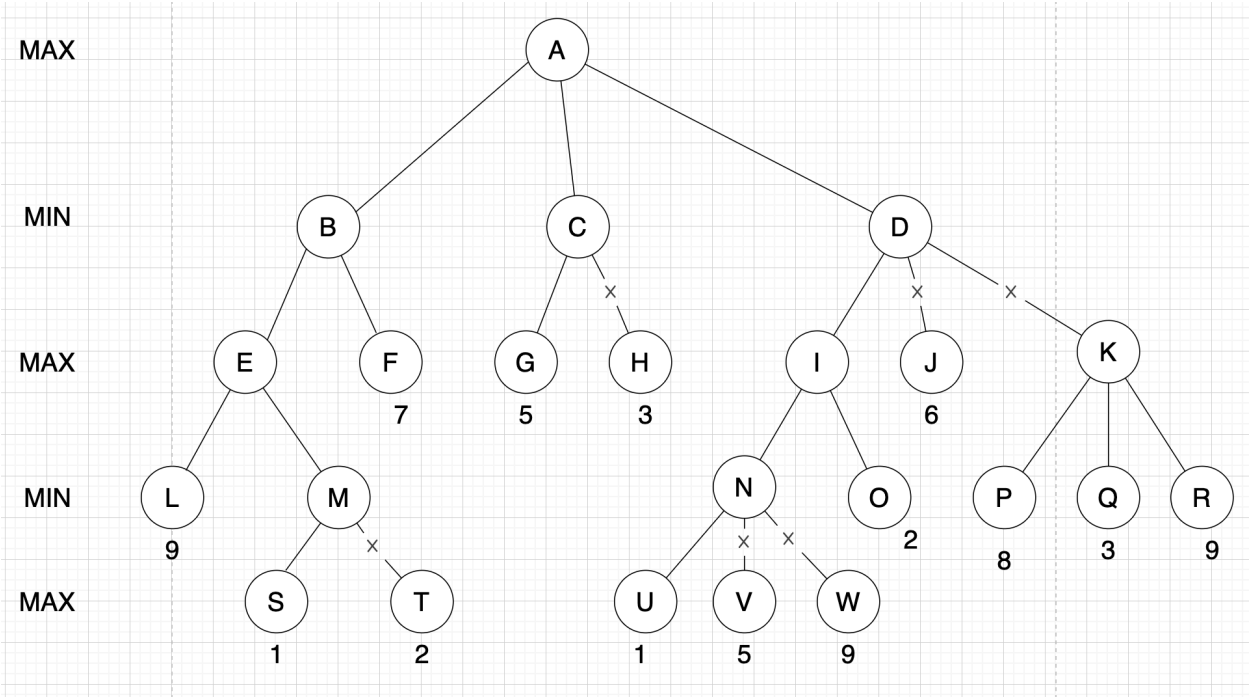
Ans: 7,2,2

(b) [3%] Perform the alpha-beta pruning algorithm on this game tree. After running

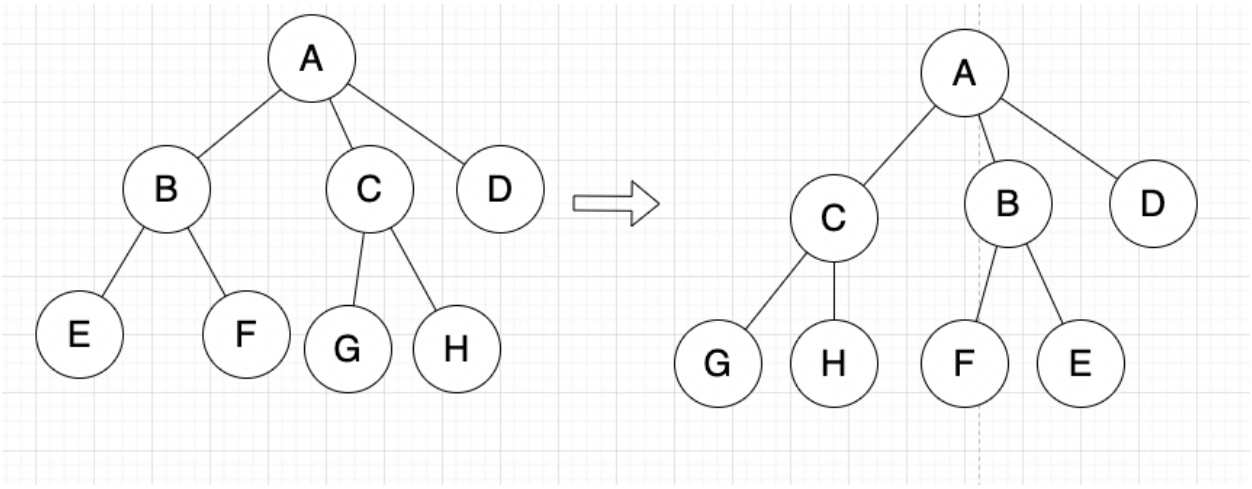
alpha-beta pruning on the given game tree, which nodes(including leaves) will **NOT** be visited during the search? The answer should be sorted in **alphabetical** order (Example : **A-B-C** Please follow this format only i.e. use '-' between any two nodes.). If all nodes will still be visited then answer NONE.

Ans: H-J-K-P-Q-R-T-V-W

Explanation:



(C) [4%] You are given the ability to swap the position of children for any number of nodes. Below is an example of such transitions.

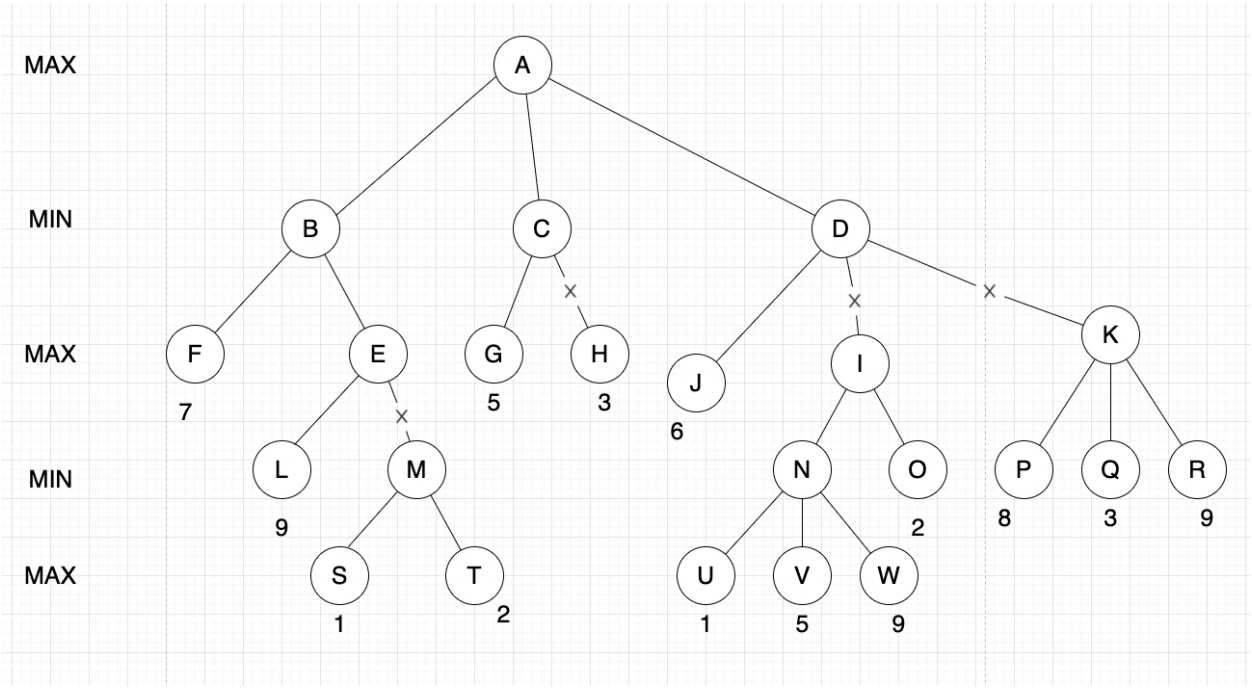


Perform such transitions in figure1. Give the minimum number of nodes that you must have to evaluate for calculating the value at A in the original tree. (Enter a number)

(Hint: For each node, think which subtree will give the results with minimum computations)

Ans: 9

Explanation: For each branching, we first evaluate the branch which gives us value such that we do not have to evaluate other siblings. For example, we evaluate node F first instead of E, as it results in less computation as compared to when we evaluate E first.



5. MDP [20%]

For section 5, all students have been given 20 credits.

6. Multiple choice from discussion [10%]

1. **[2%] Which of the following search algorithms are NOT complete? Select all that apply:**
    a. Breadth-first search
    b. Depth-first search
    c. Uniform-cost search
    d. Depth-limited search
    e. None of the above
2. **[2%] Which of the following are non-deterministic games? Select all that apply:**
    a. Checkers
    b. Backgammon
    c. Chess
    d. Go
3. **[2%] Which of the following is true about Monte Carlo RL (model-free)? Select all that apply:**
    a. The utility value of states U(s) is not fixed
    b. Works only in episodic problems
    c. Takes a very long time to converge as learning is from complete sample returns
    d. Wastes information as it figures out state values in isolation from other states
    e. None of the above
4. **Select all statements that are true about game-playing strategies:**
    a. α-β pruning can be used as a speed-up strategy in the Minimax algorithm
    b. Good move ordering improves the effectiveness of pruning
    c. Minimax uses a breadth-first technique
    d. None of the above

5. **During the discussion, we discussed the situations when it is suitable to use CSP (Constraint Satisfaction Problem) Techniques. Please select the options that are true:**
    a. When the problem can be expressed by a set of variables with constraints on their values
    b. When constraints are relatively simple (e.g., binary)
    c. When constraints propagate well (AC3 eliminates many values)
    d. Local Search: when the solutions are “densely” distributed in the space of possible assignments (change densely to sparsely)
    e. None of the above

** For part 5 (multiple select), +2 credits have been given to all the students.