Homework 02

***Submission Notices*:**

- *Conduct your homework by filling answers into the placeholders in this file (in Microsoft Word format). Questions are shown in black color, instructions/hints are shown in italics and blue color, and your content should use any color that is different from those.*
- *After completing your homework, prepare the file for submission by exporting the Word file (filled with answers) to a PDF file, whose filename follows the following format,*
  <StudentID-1>_<StudentID-2>_HW01.pdf (Student IDs are sorted in ascending order)
  E.g., ***2112001_2112002_HW02.pdf***
  and then submit the file to Moodle directly WITHOUT any kinds of compression (.zip, .rar, .tar, etc.).
- *Note that you will get zero credit for any careless mistake, including, but not limited to, the following things.*
  1. *Wrong file/filename format, e.g., not a pdf file, use "-" instead of "_" for separators, etc.*
  2. *Disorder format of problems and answers*
  3. *Conducted not in English*
  4. *Cheating, i.e., copying other students' works or letting other students copy your work.*

Problem 1. (2pt) Answer the following simple questions.

Please write your answer in the table

Questions (0.5pt each)	***Filling in the blanks***
What is the primary objective of local search?	*The primary objective of local search is to efficiently explore and exploit the search space to find a satisfactory solution within a local neighborhood, without considering the entire search space.*
How does local search differ from global search algorithms?	*Local search algorithms focus on finding satisfactory solutions within a local neighborhood, typically exploring a subset of the search space. These algorithms prioritize improving the current solution iteratively by making small modifications. In contrast, global search algorithms aim to explore the entire search space to find the optimal or near-optimal solution, often employing techniques like exhaustive search, genetic algorithms, or simulated annealing. The main difference lies in the scope and intensity of exploration: local search focuses on the immediate vicinity of the current solution, while global search explores a broader range of possibilities.*

What are the key components of a Constraint Satisfaction Problem (CSP)?	*The key components of a Constraint Satisfaction Problem (CSP) are:* • *Variables: The unknowns or entities to be assigned values. Each variable has a domain of possible values.* • *Domains: The set of possible values that each variable can take.* • *Constraints: The restrictions or conditions that define the relationships between variables. Constraints limit the combinations of variable assignments that are considered valid.* • *Solution: A valid assignment of values to variables that satisfies all the constraints.* *The goal of a CSP is to find a solution that satisfies all the constraints, considering the given variables, their domains, and the constraints imposed on them.*
In the context of hill-climbing, what is the role of the objective function or evaluation function?	*The objective function or evaluation function in hill-climbing is used to assess the quality or fitness of a potential solution. It provides a quantitative measure of how well a solution performs with respect to the desired outcome or goal. The role of the objective function is crucial in guiding the hill-climbing algorithm to make iterative improvements by selecting the next solution that maximizes or minimizes the objective function, depending on whether it is a maximization or minimization problem. The objective function acts as a guide for the search process, allowing the algorithm to climb towards better solutions within the search space.*

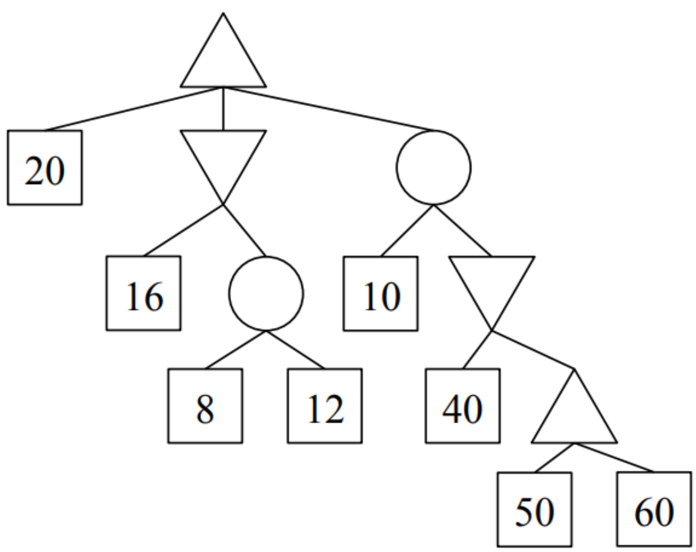
Problem 2. (1pt) For each of the following question, please choose either True or False and give a brief explanation.

Please write your answer in the table

Claims	**True/False**	**Explanation**
Hill-climbing algorithms with random restarts can overcome the issue of getting stuck in local optima and are guaranteed to find the global optimum solution.	False	Hill-climbing algorithms with random restarts can improve the chances of finding a better solution by performing multiple iterations from different starting points. However, they do not guarantee finding the global optimum solution in all cases. There is still a possibility of getting stuck in local

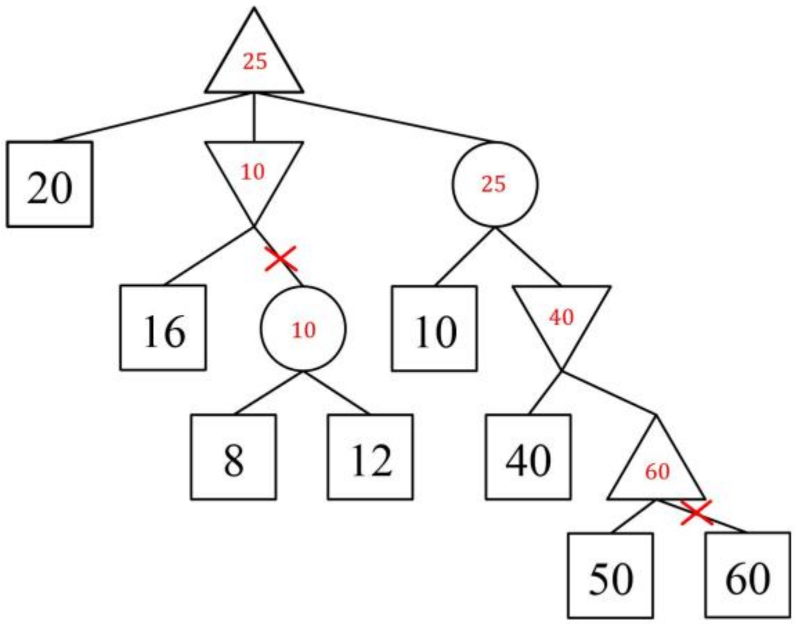
		optima, especially in complex and rugged search spaces where the global optimum may be difficult to reach. Random restarts increase the exploration capability of the algorithm but do not eliminate the risk of being trapped in local optima entirely.
Simulated annealing guarantees convergence to the global optimum solution if given enough computational resources and a properly designed cooling schedule.	False	Simulated annealing does not guarantee convergence to the global optimum solution, even with sufficient computational resources and a well-designed cooling schedule. While it has a higher probability of finding the global optimum compared to other local search algorithms, there is still a possibility of getting trapped in local optima or plateaus. The success of simulated annealing depends on the problem's characteristics, the choice of cooling schedule, and the exploration-exploitation balance. It is a probabilistic algorithm that explores the search space, allowing for occasional uphill moves, but it does not guarantee finding the global optimum in all cases.

Problem 3. (2pts) Consider the game tree below, which contains maximizer nodes, minimizer nodes, and chance nodes. For the chance nodes the probability of each outcome is equally likely.

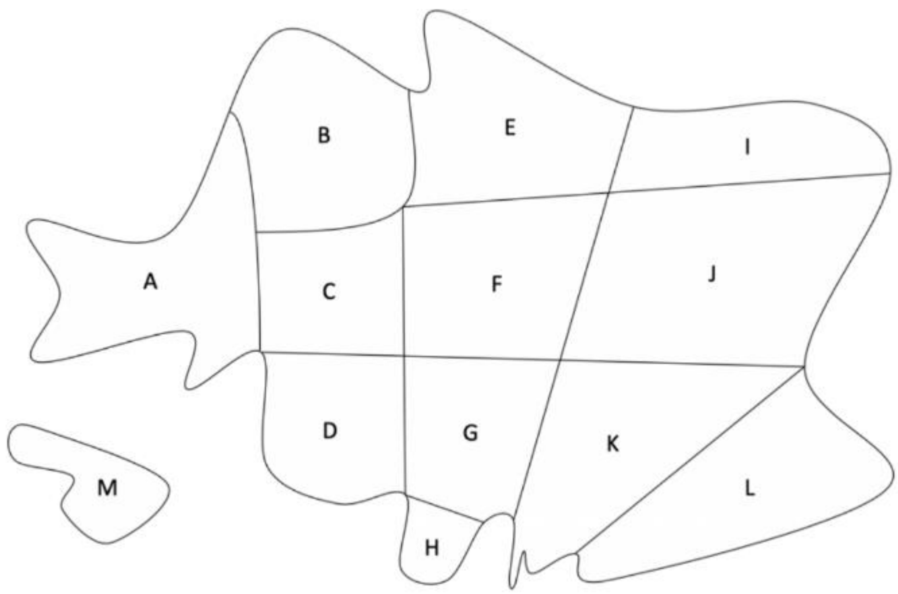


a) (1pt) Fill in the values of each of the nodes.
b) (1pt) Is pruning possible? If yes, please cross out the branches that can be pruned. If not, give a brief justification.

Please write your answer in the table



Problem 4. (2pts) Given *Constraint Satisfaction Problem*. In the given map below, there are 14 regions corresponding to 14 capital letters (from 'A' to 'M').



a) (1pt) Please find the minimum number of colors needed to color the regions with the constraint that no two adjacent regions have the same color. You just need to state the minimum number and give one sample of the colors assigned to each of the regions that satisfy the constraint.

Please present your work in the table

3 colors. Example: A=1, B=2, C=3, D=1, E=3, F=1, G=2, H=1, I=2, J=3, K=1, L=2.

b) (1pt) Assuming that there are three colors: red, blue, and green. Initially, we can give every region one of the colors. It means that the color domains of each of the regions are {red, blue, green}. Then, we assign the region F to have green color. What is the result of the Forward Checking algorithm?

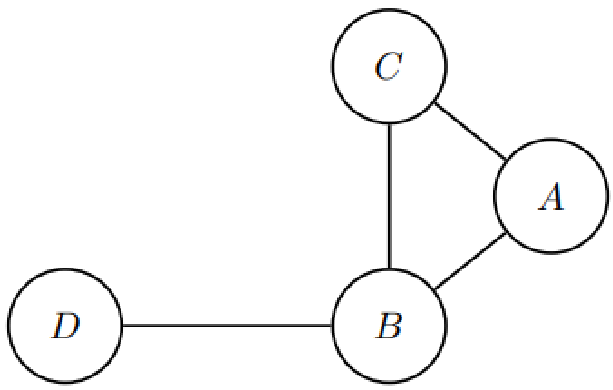
Please present your work in the table

F = {green}, C = {red, blue}, E = {red, blue}, J = {red, blue}, G = {red, blue} B = {green, red, blue}, D = {green, red, blue}, I = {green, red, blue}, K = {green, red, blue}, H = {green, red, blue} A = {green, red, blue}, H = {green, red, blue}, L = {green, red, blue}, M = {green, red, blue}.

Problem 5. (3pts) You are given a constraint graph for a Constraint Satisfaction Problem as follows. The domains of all variables are indicated in the table, and the binary constraints are as follows:

- $A > B$
- $A \neq C$
- $C > B$
- $D < B$

A	0	1	2	3
B	0	1	2	3
C	0	1	2	3
D	0	1	2	3



a) (1pt) Enforce arc consistency on this graph and indicate what the domains of all the variables are after arc consistency is enforced, in the table below by crossing out eliminated values from the domains.

A	~~0~~	~~1~~	2	3
B	~~0~~	1	2	~~3~~
C	~~0~~	~~1~~	2	3
D	0	1	~~2~~	~~3~~

b) (2pts) Now suppose you are given a different CSP with variables still being A, B, C, D, but you are not given the constraints. The domains of variables remaining after enforcing arc consistency for this CSP are given to you below.

A			2	3
B			2	3
C	0	1	2	
D			2	3

Select all of the following options which can be inferred given just this information.

- ☐ The CSP may have no solution.
- ☐ The CSP may have a solution.
- ☐ The CSP may have exactly one solution.
- ☐ The CSP may have more than one solution.
- ☐ The CSP must have more than one solution.
- ☐ None of the above.

Please give an explanation in this table

An example CSP that may have more than one solution with these domains is: $A > C$, $A \leq B$, $B \neq C$, $D=B$. You get solutions with $A=2$ and $B=3$, as well as solutions with $A=3$ and $B=2$. A CSP with no solution is with these domains is: $A \neq B$, $B \neq D$, $D \neq A$. There is a cycle between A, B, D and each arc is consistent but there is no overall consistent solution