1. Today is July 18. The CSE422 midterm exam is just seven days away.
Unfortunately, you have been procrastinating this entire semester and you still have a lab assignment (L) and a written assignment (W) left. You also have not yet come up with an idea for the project (P). Each of these things takes one day to do. In addition, you still need two days to study for the midterm (S1 and S2).
You decide to formulate the problem of managing all your tasks as a Constraint Satisfaction Problem. The details are as follows.

- Variables: L, W, P, S1, S2
- Domains: Each variable has the domain {1, 2, 3, 4, 5, 6, 7} where the numbers denote days of the week. For example, setting W = 2 means that you are deciding to do the written assignment on day 2.

You also have the following constraints.
(1) No two different tasks can be done on the same day.
(2) All the assignment and project-related tasks (L, W, P) must be completed before you start studying for the midterm (S1).
(3) The lab assignment (L) and the project idea submission (P) are both due in 4 days. So, they have to be completed in days 1, 2, 3, or 4.
(4) The first day of studying (S1) must come before the second day of studying (S2). Also, you like to take rests. So, no two study days in a row.
(5) The written assignment (W) cannot be done on an odd-numbered day.

Now answer the following questions:
a. You first decide to enforce the unary constraints (also called enforcing node consistency). **List** the values that remain in the domain of each variable. You should treat constraint (3) as a pair of unary constraints.

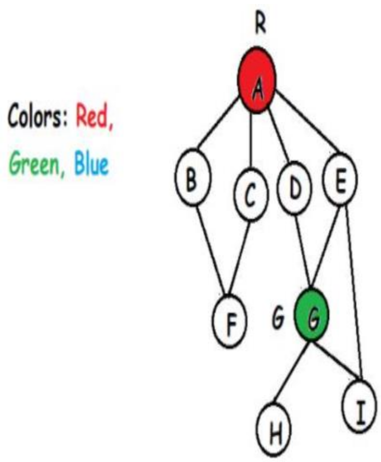
b. Continuing from (a), you now decide to enforce arc consistency for each arc. It turns out all of the arcs except S1 → L, S1 → W, S1 → P, S1 → S2 and S2 → S1 are already consistent. Enforce consistency of the arc S1 → S2 and **list** the values that remain in the domains of the variables S1 and S2.

c. Continuing from (b), **determine** the arcs that used to be consistent but need to be checked again after enforcing the consistency of the arc S1 → S2.

d. **Show** that at least one of the arcs you listed in (c) is not consistent anymore

2. **a) Explain** the concept of forward checking with an example.

b) Suppose, the following graph represents a map coloring CSP problem. You are trying to color the following graph with 3 colors: Red, Green and Blue such that no two adjacent node has the same color. Node A is already colored as **Red** (R) and node G is colored as **Green** (G). **Assess** which node will be visited in the following map coloring example if **i)** Degree heuristic is used. **Explain** your answer.**ii)** According to Least constraining value heuristic, which color will be chosen for node B in the given graph? **Explain** your answer.



3.

Assume [X1, X2, X3, X4, X5, X6, X7, X8] represents a set of 8 numbers where each number can be anything from 1 to 100. Now your task is to find such a set with a combination of numbers where the difference between sum of the even numbers and sum of the odd numbers is 30. And you have to solve this problem using Genetic Algorithm. So, for e.g., if D1 represents sum of the odd numbers and D2 represents sum of the even numbers then (D1 - D2) or (D2 - D1) will be equal to 30 for the solution.

a. Encode the problem and **deduce** two parent chromosomes, PC1 and PC2. But for PC1, the value of X1 should be 100, and for PC2 the value of X1 should be 1.

b. Define a suitable fitness function for the problem and calculate the fitness of PC1 and PC2.

c. Illustrate single point crossover after X4 between PC1 and PC2, and then perform mutation. You can mutate a number of your choosing. Finally, calculate fitness of the two newly formed child chromosomes and comment on which child is fitter.

4.

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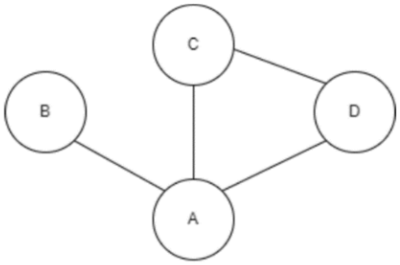


Consider the constraint graph of a problem above, where each region has to be filled up with either 1, 2, or 3. No two adjacent regions can have the same digit.

a. **Formulate** the variable, domain, constraint, and the goal of the problem

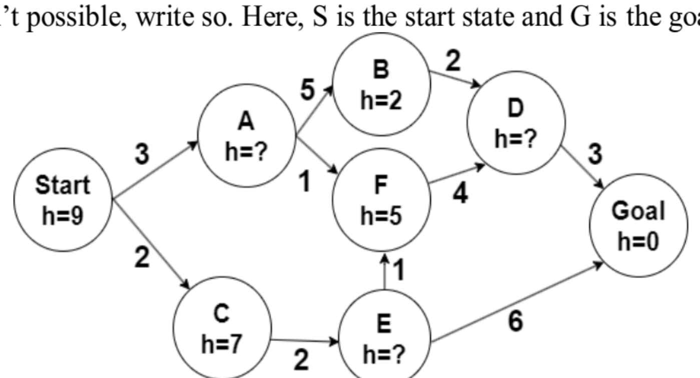
b. Based on the variable ordering procedure, mention the order of variables to be assigned with digit. **Provide** adequate explanation for your ordering.

c. Consider that node B already has digit 1 and all the other nodes are empty. If you are to provide digit to node D next, which digit should you pick? **Identify** your choice based on value selection procedure.

d. If node B has digit 1, node D has digit 2, and rest of the nodes are unassigned, does the constraint graph remain arc consistent? Why or why not? **Explain.**

5.

Consider the state space tree shown below in which some of the states are missing a heuristic value. Determine the possible range for each missing heuristic value so that the heuristic is admissible and consistent. If this isn't possible, write so. Here, S is the start state and G is the goal state.



a.

State	Lowest Possible Value for the State's Admissible and Consistent Heuristic	Highest Possible Value for the State's Admissible and Consistent Heuristic
A		
D		
E		

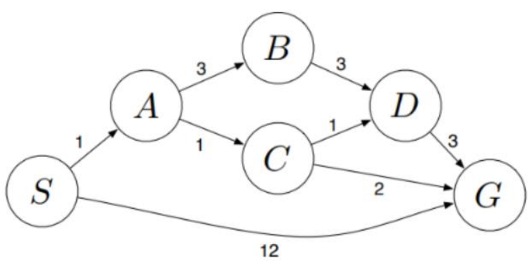
b. Assume the heuristics of A, D, and E are 6, 2, and 6 respectively. If you were to run the A* algorithm to find the shortest path from Start to Goal in this search space, **find** the length of the shortest path between them. Also, find what nodes will be explored in sequence.

6.

a) **Explain** population, selection, crossover, mutation and fitness function in light of 5-Queen problem.

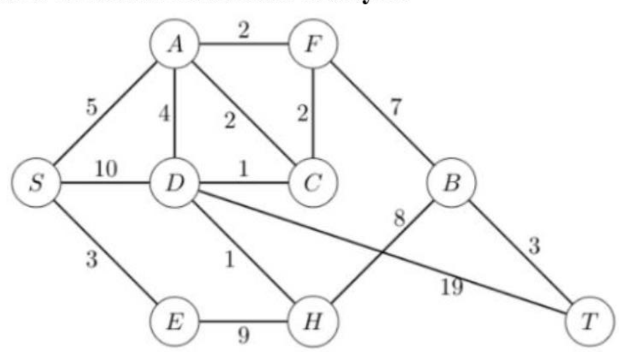
b) Consider two chromosomes. X1: 12256748 X2: 32828991.
Your job is to maximize the difference of sum of numbers in even positions and sum of numbers in odd positions. Now make a fitness function that is suitable for your job. **Evaluate** the chromosomes X1 and X2 in light of the fitness function that you just designed. **Apply** crossover between X1 and X2 at mid point and make two chromosomes X3 and X4 and **evaluate** X3 and X4 as well.

7.



Node	h1	h2
S	5	4
A	3	2
B	6	6
C	2	1
D	3	3
G	0	0

a) For the graph above, where S is the start node and G is the goal node, which of the two heuristic sets, h1 and h2, is admissible? Which of them is consistent? **Analyze**.



Node	S	A	B	C	D	E	F	H	T
$h(Node)$	19	12	3	2	18	15	9	10	1

b) For the graph above and the heuristic function given, **Use** A* algorithm on the graph. In what sequence will the nodes be explored? Which heuristics values in this table are inadmissible? Here, S is the starting node and T is the goal node. In case any tie occurs, expand the node that comes first alphabetically.