**Basic CSP Formulation Tasks**

**Each task below should be approached as:**

**🎯 Define the CSP by identifying:**

**Variables**

**Domains**

**Constraints (mention type: unary, binary, higher-order)**

**Task 1: Map Coloring (3-region map)**

Problem:

You have 3 countries: A, B, and C.

A borders B and C

B and C do not border each other

You must color the map using 3 colors (Red, Green, Blue), with no two adjacent regions having the same color.

What to do:

List variables

Assign domain

Define constraints (binary)



Variable : A, B, C

Domain : Red(R), Green(G), Blue(B)

Constraints are A border B and C but B and C do not border each other.

Then, A ≠ B and B ≠ C.

So, we can assign any color to A region like A = R (Red).

Now, A = R, for B cannot be Red now, we can go for Green or Blue.

So, B = G then C cannot be same as A and B.

Therefore C = B.

Final result is {A = Red, B = Green, C = Blue}

**Task 2: Simple Sudoku (2x2 mini-grid)**

Problem:

You are given a 2x2 Sudoku grid with 4 cells: A1, A2, B1, B2.

Each must contain a digit from 1 to 2

No digit repeats in any row or column

What to do:

Define the variables

What is the domain of each cell?

Write all constraints (all-diff style)



Variables = A1, A2, B1, B2

Domain = 1 or 2

A1 ≠ A2 and A1 ≠ B1, A2 ≠ A1 and A2 ≠ B2, B1 ≠ A1 and B1 ≠ B2, B2 ≠ B1 and B2 ≠ A2.

Constraints are each cell must contain a digit from 1 or 2 and it cannot be repeat in any row or column.

Let’s assign A1 as 1 then A2 should not be equal to 1 because A1 and A2 are in same rows.

So, A2 is 2. Now lets go for next row variables which are B1 and B2. B1 cannot be 1 because A1 is equal to 1 and both are in same column, so B1 should be 2. And then go for B2, B2 should be 1 because in its same column A2 is 2 and in same row B1 is 2.

**Task 3: Exam Scheduling**

Problem:

You must schedule exams for 3 subjects: Math, English, and Science.

Each exam must be scheduled in one of 2 time slots: Morning, Afternoon

The same teacher teaches Math and Science, so those exams cannot be at the same time

What to do:

Variables = subjects

Domains = time slots

Constraint = binary (Math ≠ Science)



Variables = Math, English and Science

Domains = Morning and Afternoon

Constraint = Math ≠ Science

So Math and English = Morning and Science = Afternoon OR Math and English = Afternoon and Science = Morning OR Science and English = Morning and Math = Afternoon OR Science and English = Afternoon and Math = Morning.

**Task 4: Cryptarithmetic Puzzle (SEND + MORE = MONEY)**

Problem:

In the puzzle SEND + MORE = MONEY, each letter stands for a unique digit from 0–9.

No leading digit (S or M) can be 0.

What to do:

Identify all letter variables

State domain for each

Define constraints:

AllDiff

Arithmetic equation holds

S ≠ 0, M ≠ 0



Variables in the puzzle are:

S, E, N, D, M, O, R, Y

Domain for Each Variable:

S: {1, 2, 3, 4, 5, 6, 7, 8, 9} (because S cannot be 0)

E: {0, 1, 2, 3, 4, 5, 6, 7, 8, 9}

N: {0, 1, 2, 3, 4, 5, 6, 7, 8, 9}

D: {0, 1, 2, 3, 4, 5, 6, 7, 8, 9}

M: {1, 2, 3, 4, 5, 6, 7, 8, 9} (because M cannot be 0)

O: {0, 1, 2, 3, 4, 5, 6, 7, 8, 9}

R: {0, 1, 2, 3, 4, 5, 6, 7, 8, 9}

Y: {0, 1, 2, 3, 4, 5, 6, 7, 8, 9}

Constraints

AllDiff: All variables must have unique values.

Arithmetic equation: SEND + MORE = MONEY

S ≠ 0: The leading digit S cannot be 0.

M ≠ 0: The leading digit M cannot be 0.

The solution to this puzzle can be found using constraint satisfaction techniques or search algorithms. One possible solution is:

S = 9, E = 5, N = 6, D = 7, M = 1, O = 0, R = 8, Y = 2

This solution satisfies all the constraints and the arithmetic equation:

9567 + 1085 = 10652