**🎓 Assignment: Understanding Constraint Satisfaction Problems (CSPs)**

**📌 Section A: Conceptual Understanding**

**Instructions**: Answer the following in your own words.

1. **What is a Constraint Satisfaction Problem (CSP)?** Give two real-life examples that can be modeled as CSPs.
2. **Explain the three main components of a CSP.**  
   Include a brief explanation of each with your own example (not covered in class).
3. **Differentiate between:**
   * Unary, Binary, and Higher-order constraints
   * Hard constraints vs Soft constraints
4. **What is a constraint graph?** Draw a sample constraint graph using the following constraint set:

A ≠ B, B ≠ C, A ≠ C, C ≠ D

**📌 Section B: Short Answer and Reasoning**

1. You are given:
   * Variables: X, Y
   * Domains: D(X) = {1, 2, 3}, D(Y) = {2, 3, 4}
   * Constraint: X < Y

a) Is the assignment X=3, Y=2 valid? Why or why not?  
b) List all valid (X, Y) pairs.

1. Consider a backtracking algorithm attempting to solve a CSP.  
   a) What happens if the algorithm chooses a value that leads to an inconsistency?  
   b) Why is backtracking inefficient in some cases?

**📌 Section C: Analytical Task – Backtracking Walkthrough**

1. Consider the following simple map coloring problem:
   * Variables: A, B, C
   * Domains: {Red, Green}
   * Constraints: A ≠ B, B ≠ C

a) Show step-by-step how backtracking search would work on this problem.  
b) How many assignments are tried before finding a solution?  
c) Write down a valid solution.

**📌 Section D: Forward Checking (Inference)**

1. **Explain in your own words** what forward checking is and how it helps during the CSP solving process.
2. Using the same map coloring problem as in Q7:
   * Variables: A, B, C
   * Domains: {Red, Green}
   * Constraints: A ≠ B, B ≠ C

a) If A is assigned **Red**, show the remaining domains of B and C after **forward checking**.  
b) Now if B is assigned **Green**, what is the domain of C after forward checking?

1. Consider:

* Variables: X, Y, Z
* Domains: {1, 2, 3} for each
* Constraints: X ≠ Y, Y ≠ Z

If X is assigned 2:  
a) Apply forward checking to update the domains of Y and Z.  
b) Which value assignment to Y would force backtracking in the next step?

**📌 Section E: Reflection**

1. In your own words, answer:

* What is the most important benefit of using **forward checking** in CSP solving?
* When might it not be sufficient on its own?