Assignment 4: Planning

Question 1

Consider the following Crypt-arithmetic problems, where all letters represent a different digit and the resulting sum is correct. **Write out all variables, domains and constraints of the problem.**

(a) SATURN + URANUS = PLANETS

- Variables: S, A, T, U, R, N, P, L.
- Domains: Each varialbe can have values: $\{0, 1, 2, 3, 4, 5, 6, 7, 8, 9\}$.
- Constraints:
  1. The arithmetic equation given.
  2. (Presumably) Each variable must have a unique digit assign to it.

(b) YES + SEND + ME + MORE = MONEY

- Variables: Y, E, S, N, D, M, O, R.
- Domains: Each varialbe can have values: $\{0, 1, 2, 3, 4, 5, 6, 7, 8, 9\}$.
- Constraints:
  1. The arithmetic equation given.
  2. (Presumably) Each variable must have a unique digit assign to it.

Question 2

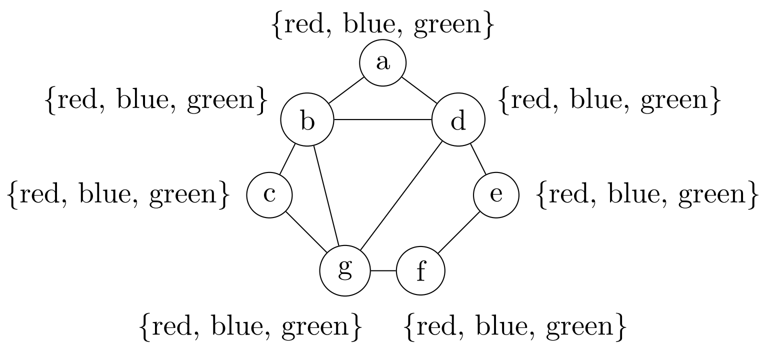
Consider the following set of edges between nodes. Find a coloring using colors red, blue, and green such that no two adjacent nodes are assigned the same color.

$$\{(a, b), (a, d), (b, c), (b, d), (b, g), (c, g), (d, e), (d, f), (d, g), (f, g)\}$$

(a) Define a Constraint Satisfaction Problem for this problem. Clearly define the variables, domains, and constraints.

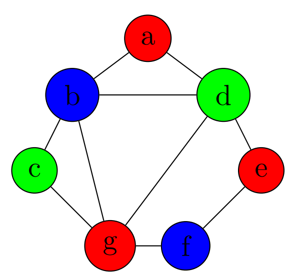
- Variables: The color of each of the nodes $\{a, b, c, d, e, f, g\}$
- Domains: For each node, the possible colors of the node. $\{red, blue, green\}$
- Constraints: The edges specified must exist and if two nodes are connected by an edge, they cannot be the same color.

(b) Draw the binary constraint graph for this Constraint Satisfaction Problem.



- $C_a \neq C_b$
- $C_a \neq C_d$
- $C_b \neq C_c$
- $C_b \neq C_d$
- $C_b \neq C_g$
- $C_c \neq C_g$
- $C_d \neq C_e$
- $C_d \neq C_f$
- $C_d \neq C_g$
- $C_f \neq C_g$

(c) Find at least one solution to the Constraint Satisfaction Problem.



Question 3

Consider a block stacking robot with the following actions:

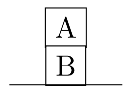
- Stack(x, y)
  - Preconditions: Clear(y), Holding(x)
  - Effects: armEmpty, On(x, y), ¬Clear(y), ¬Holding(x)
- Unstack(x, y)
  - Preconditions: Clear(x), On(x, y), armEmpty

– Effects: ¬armEmpty, ¬On(x, y), Clear(y), Holding(x)

- Pickup(x)
  - Preconditions: Clear(x), On(x, TABLE), armEmpty
  - Effects: ¬armEmpty, ¬On(x, TABLE), Holding(x)
- Putdown(x)
  - Preconditions: Holding(x)
  - Effects: armEmpty, On(x, TABLE), ¬Holding(x)

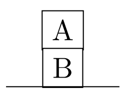
Create a plan for each of the initial state/goal pairs below. Assume armEmpty is in initial state and the table has infinite space.

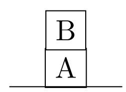
(a) Initial State: 

Goal State: 

Plan:

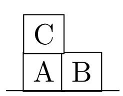
1. PickUp(A)
2. Stack(A, B)

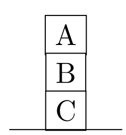
(b) Initial State: 

Goal State: 

Plan:

1. Unstack(A)
2. Putdown(A)
3. Pickup(B)
4. Stack(B, A)

(c) Initial State: 

Goal State: 

Plan:

1. Unstack(C, A)
2. Putdown(C)
3. Pickup(B)
4. Stack(B, C)
5. Pickup(A)
6. Stack(A, C)

Question 4

Consider the following simple planning problem in which the objective is to interchange the values of two variables v1 and v2

- Initial State: Value(v1, 3), Value(v2, 5), Value(v3, 0)
- Goal State: Value(v1, 5), Value(v2, 3)
- Actions:
  - Assign(V, W, X, Y)
    - Preconditions: Value(V, X), Value(W, Y)
    - Effects: Value(V, Y), ¬Value(W, X)