

## 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 variable 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 assigned to it.

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

- Variables: Y, E, S, N, D, M, O, R.
  - Domains: Each variable 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 assigned to it.
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**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 CSP for this problem. Clearly define the variables, domains, and constraints.
  - (b) Draw the binary constraint graph for this CSP.
  - (c) Find at least one solution to the CSP.
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### Question 3

Consider a block stacking robot with the following actions:

- Stack(x, y)
  - Preconditions: Clear(y), Holding(x)
  - Effects: armEmpty, On(x, y),  $\neg$ Clear(y),  $\neg$ Holding(x)
- Unstack(x, y)
  - Preconditions: Clear(x), On(x, y), armEmpty
  - Effects:  $\neg$ armEmpty,  $\neg$ On(x, y), Clear(y), Holding(x)
- Pickup(x)
  - Preconditions: Clear(x), On(x, TABLE), armEmpty
  - Effects:  $\neg$ armEmpty,  $\neg$ On(x, TABLE), Holding(x)
- Putdown(x)
  - Preconditions: Holding(x)
  - Effects: armEmpty, On(x, TABLE),  $\neg$ 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) TODO
  - (b) TODO
  - (c) TODO
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### 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),  $\neg$ Value(W, X)