Assigned: 04/02/19 Due: 04/07/19 at 11:55 PM (submit via Canvas, you may take a picture of handwritten solutions, but you must put them in a pdf) <u>Submit only pdf or txt files</u>

Written/drawn:

Problem 1. (15 points)
Find the mixed strategy Nash equilibrium of the following game (the reward pairs are in the order (row, column) player):

2, 6	7, 2	5, 1
4, 0	5, 9	6, 0
8, 2	2, 1	0, 3

Problem 2. (15 points)
Considering the same payoff-matrix as from problem 1, assume you will play this game multiple times using a tit-for-tat agent. What would be the "cooperative" way of both players playing? What is the "uncooperative" way for both players to play?

Assume you play in the order: cooperative, uncooperative, uncooperative, cooperative. What moves would the tit-for-tat agent do?

Problem 3. (25 points)
Consider the following CSP of jobs under the following constraints:
J1 takes 3 time units to complete
J2 takes 2 time units to complete
J3 takes 1 time unit to complete
J1 must happen before J3
J2 cannot happen at time 1 or 2
All tasks must finish before time 7 (i.e. it is valid if J3 starts at time 6, but not if J2 starts at time 6 as it would end before time 8 yet after time 7.)

The domain (i.e. valid values) for all jobs is {1, 2, 3, 4, 5, 6, 7, 8, 9, 10} (these are the time units).

(1) Convert the last constraint ("All tasks must finish before time 7") into a mathematical expression(s).
(2) Apply all unary constraints and show the resulting domains for all variables.
(3) Apply all 2-consistency constraints (assuming you already applied part (2)) and the resulting domains for all variables (i.e. run AC-3 on this problem).
(4) Apply all 3-consistency constraints (assuming you already applied part (2) and (3)) and the resulting domains for all variables.

(5) Based on the modifications to search, what variable and with what value should be expanded first using the information from part (3).

Problem 4. (20 points)
Consider the following sentence:

$$A \wedge (B \vee C) \wedge (C \Rightarrow B)$$

(1) What is the set models that satisfy this sentence?
(2) What models satisfy the sentence: B?
(3) Show whether or not "(1) entails (2)" (i.e. does the sentence at the top entail "B").
(4) What does "X entails Y" and "Y entails X" mean in terms of the satisfying models of X and Y?

Programming (python/lisp):

This time we will look at the constraint satisfaction code in:
/root/csp.py
/root/tests/test_csp.py

Problem 5. (10 points)
We will again test the N-queens problem (framed as a constraint satisfaction problem this time).

(1) Report the run-time for board sizes = {11, 20} when solving the N-Queens CSP problem with backtracking search.

(2) Report the run-time for board sizes = {11, 20, 40} when solving the N-Queens CSP problem with min-conflicts.

(3) Find what board size takes approximately 10 seconds to solve with min-conflicts (make sure it is not ending early).

Problem 6. (15 points)
The "Zebra" problem is a classic constraint satisfaction problem defined as a set of 5: houses, people (of nationality), pets, cigars, drinks and colors. House 1 is on the far left with house 5 on the far right (house 3 is in the middle). Each house (numbered) has a single person (nationality), pet, cigar, drink and color associated with the house. No two houses share the same of any property (for example, each house has its own unique pet). The rules are:

- There are five houses.
- The Englishman lives in the red house.
- The Spaniard owns the dog.
- Coffee is drunk in the green house.
- The Ukrainian drinks tea.
- The green house is immediately to the right of the ivory house.
- The Old Gold smoker owns snails.
- Kools are smoked in the yellow house.
- Milk is drunk in the middle house.
- The Norwegian lives in the first house.
- The man who smokes Chesterfields lives in the house next to the man with the fox.

- Kools are smoked in the house next to the house where the horse is kept.
- The Lucky Strike smoker drinks orange juice.
- The Japanese smokes Parliaments.
- The Norwegian lives next to the blue house.

The question is then: Who owns the Zebra? And who drinks water?

(1) This classic problem is what is already put in as the Zebra problem. Run the backtracking_search() on this problem and report the answer to the two questions above. (It is fine to use the default parameters for backtracking_search().)

(2) Modify the problem to match the Zebra problem below (with names, sports, transportation and lawns) and report: Who has flowers in their yard? Who likes to watch Starcraft2?

- There are five houses.
- Albert likes baseball.
- Dietfried has a lawn with cleanly cut grass.
- Virgilijus enjoys watching rugby.
- Gallchobhar gets to work by walking.
- Bricius lives next to Virgilijus.
- The owner of the house with an Astroturf lawn likes baseball.
- The house with flowers in the lawn is between the house with trees and the house with rocks in the lawns.
- The person who likes baseball goes to work on a motorcycle.
- The 2nd house owners like to watch debates.
- The owner of the 4th house goes to work on a bicycle.
- The person who likes soccer takes a bus to work.
- The house with trees on the lawn to the right of the house with an owner who drives a car to work.
- Gallchobhar lives to the right of the person who likes Rugby.