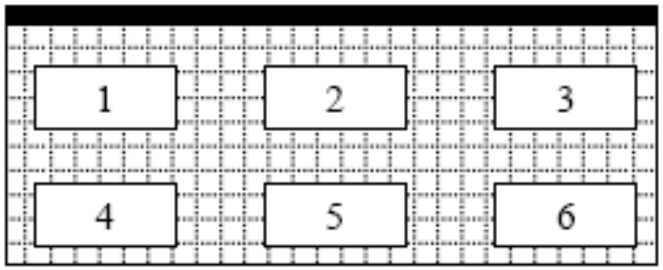
–Tutorial -5

During an examination, an invigilator has to arrange six students in a way to make sure that the examination is properly conducted and no one cheats. 3 students have makeup in Mathematics, 2 students have makeup in Computer science and 1 student in physics. As shown in figure below, there exist 6 desks arranged into two rows and three
.columns



The problem for the invigilator is to arrange students so that students having the same makeup exam should not be neighbors (in the same column or in the same row for example neighbors of 5 are 2, 4 and 6). Furthermore, the student who has Physics exam is suspected of cheating, and hence should be in the first row (desk 1 or 2 or 3).

Question #1 cont,

a) Propose a formulation of the problem in term of CSP by
. specifying variables, domains and constraints

Problem Formulation

Variables X1, X2, X3, X4, X5, X6

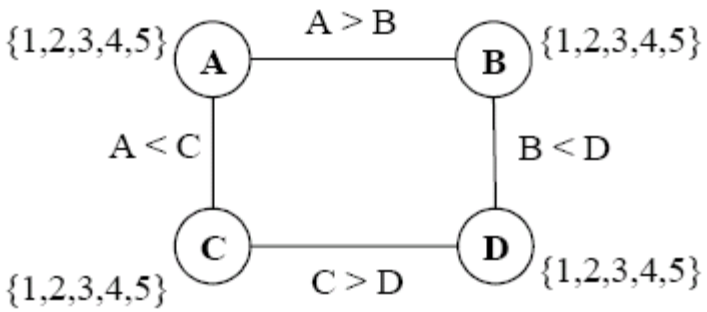
Domain D1 = {P, M, M, M, CS, CS} D2 = {P, M, M, M, CS, CS}
D3 = {P, M, M, M, CS, CS} D4 = {M, M, M, CS, CS}
D5 = {M, M, M, CS, CS} D6 = {M, M, M, CS, CS}

Constraints X1 ≠ X2 X1 ≠ X4
X2 ≠ X5 X2 ≠ X3 X3 ≠ X6
X5 ≠ X6 X5 ≠ X4

.Propose a solution to help the invigilator) 2

Solution M P M
Cs M Cs

Q2: Given the constraint graph below, answer the :following questions



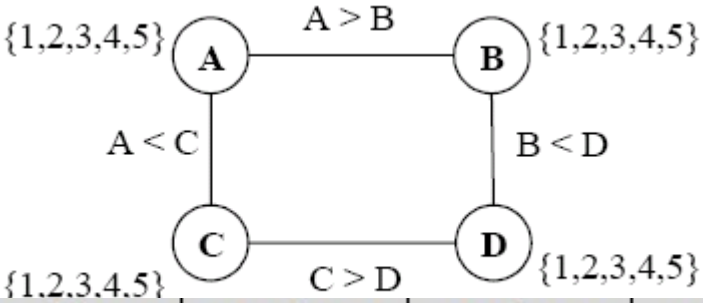
a) Trace Arc Consistency (AC3) algorithm on this graph. Initially, the queue contains the following arcs: AB, BA, AC, CA, CD, DC, BD, DB

b) According to the obtained results, what can you conclude about the completeness of AC3

c) Using forward checking, find a solution to this problem. Hints:

- use MRV (Minimum Remaining Value) heuristic to select variables. In case of similarity, variables are selected according to the alphabetical order.
- Values are selected in ascending order.

Q2- answer (a)



ieue	{1,2,3,4,5}	{1,2,3,4,5}	{1,2,3,4,5}	{1,2,3,4,5}	Added
	{2,3,4,5}	{1,2,3,4,5}	{1,2,3,4,5}	{1,2,3,4,5}	CA
	{2,3,4,5}	{1,2,3,4}	{1,2,3,4,5}	{1,2,3,4,5}	DB
	{2,3,4}	{1,2,3,4}	{1,2,3,4,5}	{1,2,3,4,5}	BA
	{2,3,4}	{1,2,3,4}	{3,4,5}	{1,2,3,4,5}	DC
	{2,3,4}	{1,2,3,4}	{3,4,5}	{1,2,3,4,5}	---
	{2,3,4}	{1,2,3,4}	{3,4,5}	{1,2,3,4}	BD
	{2,3,4}	{1,2,3}	{3,4,5}	{1,2,3,4}	AB
	{2,3,4}	{1,2,3}	{3,4,5}	{2,3,4}	CD
	{2,3,4}	{1,2,3}	{3,4,5}	{2,3,4}	---
	{2,3,4}	{1,2,3}	{3,4,5}	{2,3,4}	---
	{2,3,4}	{1,2,3}	{3,4,5}	{2,3,4}	---
	{2,3,4}	{1,2,3}	{3,4,5}	{2,3,4}	---
	{2,3,4}	{1,2,3}	{3,4,5}	{2,3,4}	---
	{2,3,4}	{1,2,3}	{3,4,5}	{2,3,4}	---
	{2,3,4}	{1,2,3}	{3,4,5}	{2,3,4}	---

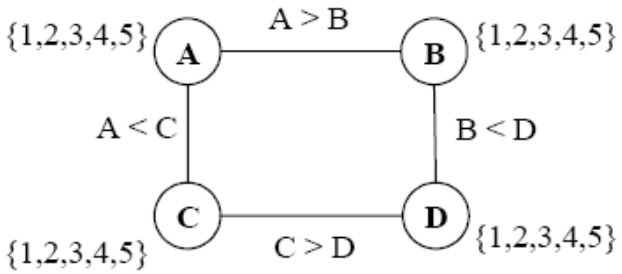
Q2- answer (b)

AC is not complete.

Q2- answer (c)

FC with MRV

After assigning a value to each variable (A for instance) check all unassigned variables that are connected to it (B and C in the case of node A) , and delete any inconsistent .value from their domains



=1	1	-----	2,3,4,5	1,2,3,4,5	Failure
=2	2	1	3,4,5	1,2,3,4,5	
=1	2	1	3,4,5	2,3,4,5	
=3	2	1	3	2	
=2	2	1	3	2	Goal

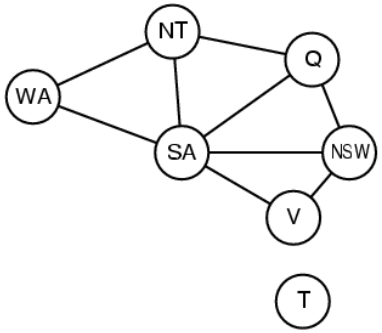
Question 3:

Define in your own words the following terms: Constraint satisfaction Problem, Constraint, .Backtracking search, and arc consistency

- **A constraint satisfaction problem:** is a problem in which the goal is to choose a value for each of a set of variables in such a way that the values all obey to a set of constraints.
  OR: A CSP is defined by a set of variables, domains and constraints.
- **A constraint:** is a restriction on the possible values of two or more variables. For example, a constraint might say that A = a is not allowed in conjunction with B = b.
- **Backtracking search:** is a form of depth-first search in which there is a single representation of the state that gets updated for each successor, and then must be restored when a dead end is reached. (i.e.: choosing values for one variable at a time and backtracks when a variable has no legal values left to assign.)
- **Arc consistency:** a directed arc from variable A to variable B (Arc AB) in a CSP is consistent if, for every value in the current domain of A, there is some consistent value of B.

Question 4:

How many solutions are there for Australia map coloring problem with three colors?



Number of Solutions for Map Coloring

- There are 18 solutions for coloring Australia with three colors.
  - Start with SA, which can have any of three colors.
  - Then moving clockwise, WA can have either of the other two colors, and everything else is strictly determined.
  - That makes 6 possibilities for the mainland, times 3 for Tasmania yields 18.

$$3 * 2 * 1 * 1 * 1 * 1 * 3 = 18$$

Q5: Consider the problem of constructing crossword puzzles: fitting words into a rectangular grid. The grid which is given as part of the problem specifies which squares are blank and which are shaded. Assume that a list of words (i.e. a dictionary) is provided and that the task is to fill in the blank squares using any subset of the list. Formulate this problem in two ways: as a general search and as a CSP.

)Q5- answer (a

- **Formulations of Crossword Puzzle**

A. **As a general Search Problem**

- State
  - An arrangement of n words on the puzzle.
- Initial Sate
  - No words on puzzle.
- Successor Function
  - Fill a word in the puzzle with one of the words in dictionary.
- Goal
  - Fill all the words in the puzzle.
- Path Cost
  - Each fill cost 1.
- Solution
  - Crossword puzzle construction can be solved many ways.
  - One simple choice is depth-first search.
    - Each successor fills in a word in the puzzle with one of the words in dictionary.
    - It is better to go one word at a time, to minimize the number of steps.

)Q5- answer (b

As a CSP Problem : As a CSP there are even more choices.

- You could have…
  - **Variables**: Each box in the crossword puzzle.
  - **Domains:** {a,.. z}.
  - **Constraints**: The letters must make words.

- Alternately, we could have…
  - **Variables**: Each string of consecutive horizontal or vertical boxes.
  - **Domains:** Words in the dictionary of the right length.
  - **Constraints**: Two intersecting words must have the same letter in intersecting box.
  - Solving a problem in this formulation requires fewer steps, but the domain are larger (assuming a big dictionary) but there are fewer constraints.