CMPE461 AI
Tutorial on CSPs

Q.1. Assume that we invited several historical lectures to our department and you are asked to create a lecture schedule for them. There are 4 time slots available: 1pm, 2pm, 3pm, 4pm. There are also some restrictions on how you can schedule the lectures.

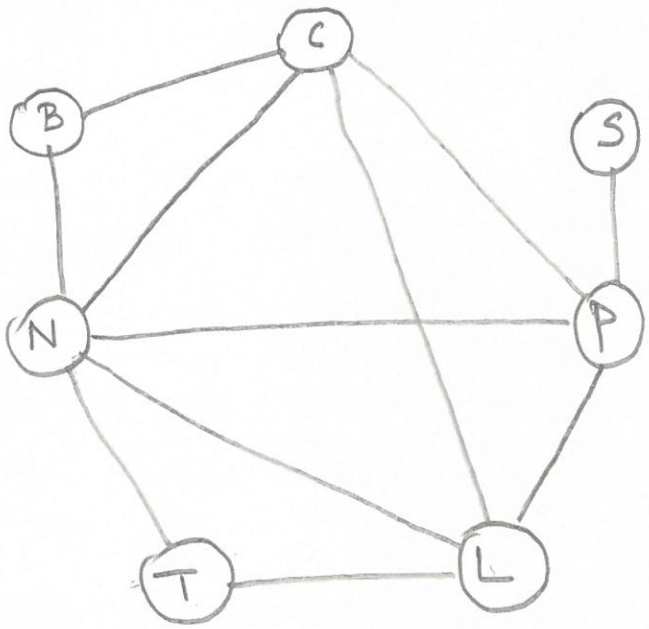
List of lecturers are:

T: Alan Turing
L: Ada Lovelace
B: Niels Bohr
C: Marie Curie
S: Socrates
P: Pythagoras
N: Isaac Newton

Constraints

1. T can only be assigned to the 1pm slot
2. Course X students want to see the physicists Bohr, Curi and Newton
3. Course Y students want to see mathematicians Lovelace, Pythagoras and Newton
4. Student club Z students wants to see Socrates and Pythagoras
5. Student club W want to see Lovelace and Curie
6. Student club D want to see Turing, Lovelace and Newton.
7. You want to see Curie and Pythagoras.

a) Draw The constraint graph

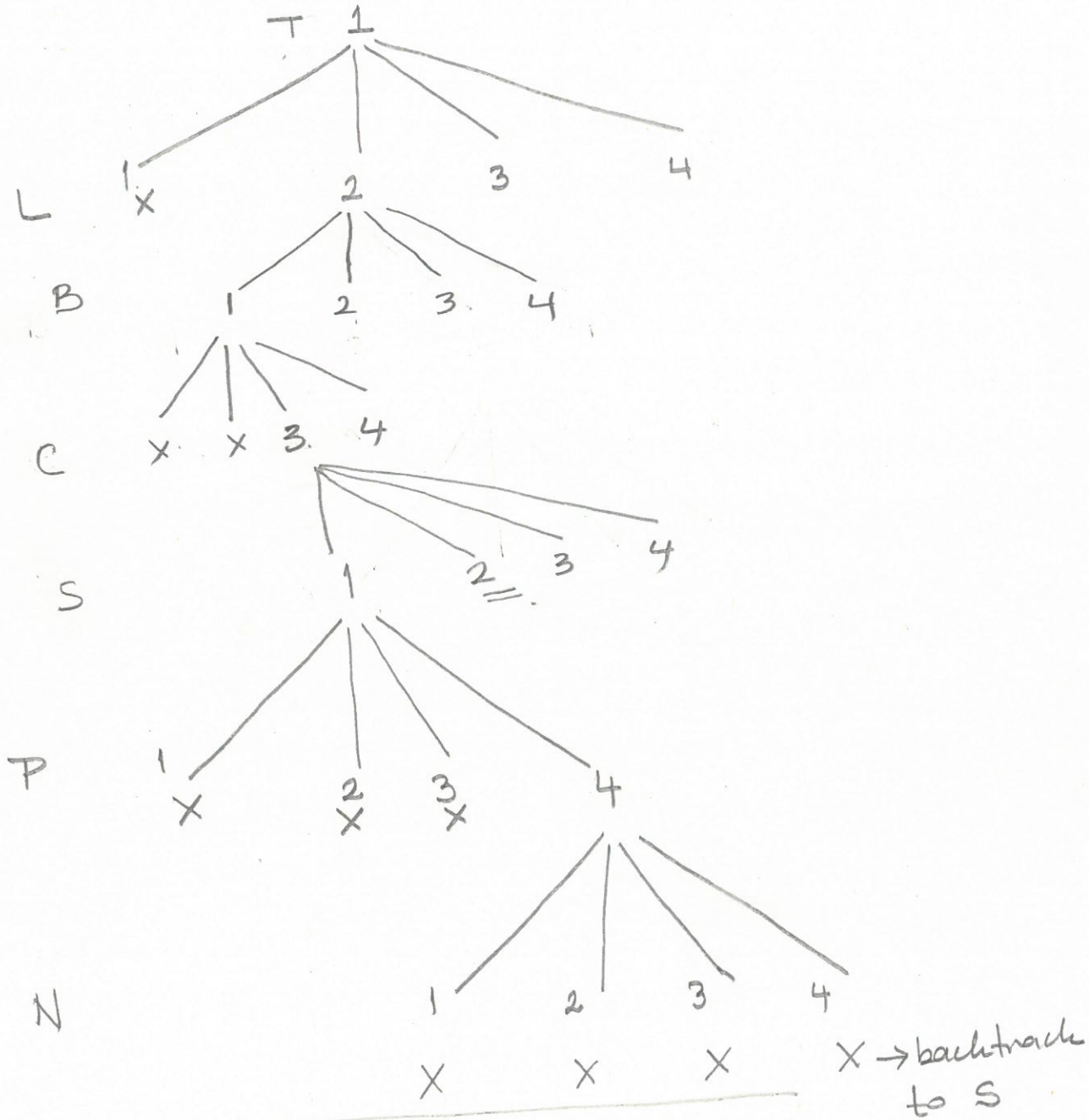


Simply draw a line between each pair of lectures who cannot share a time slot.

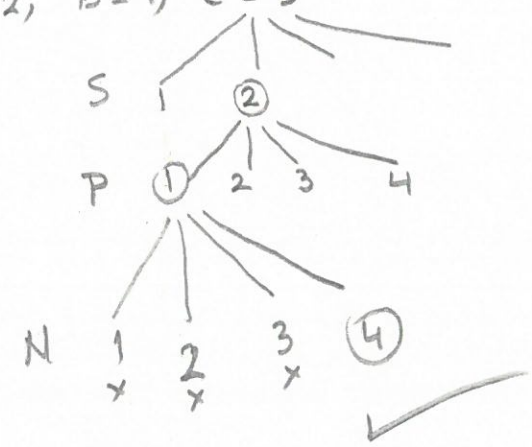
Domains

T ⟶ {1}
L ⟶ {1, 2, 3, 4}
B ⟶ "
C ⟶ "
S ⟶ "
P ⟶ "
N ⟶ "

b) Search for a solution using DFS only.
Assign each lecturer to the earliest timeslot available.



T=1, L=2, B=1, C=3



c) DFS with forward checking

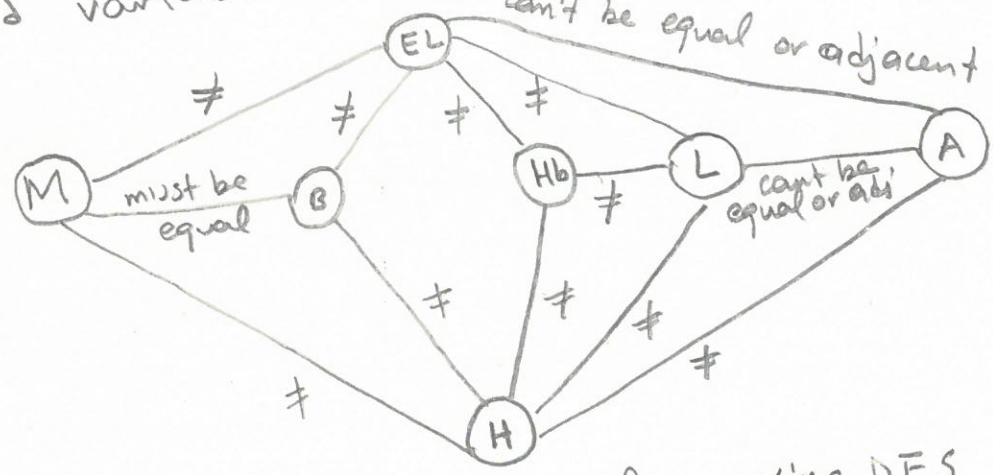
1. $T=1 \longrightarrow L \neq 1, \quad N \neq 1$
2. $L=2 \longrightarrow P \neq 2, \quad N \neq 2, \quad C \neq 2$
3. $B=1 \longrightarrow C \neq 1$
4. $C=3 \longrightarrow N \neq 3, \quad P \neq 3$
5. N is a singleton and should be assigned first

   $N=4 \longrightarrow P \neq 4$
6. P is a singleton and should be assigned first

   $P=1 \longrightarrow S \neq 1$
7. $S=2$ ✓

T: (1)
L: ~~1~~, (2) 3, 4
B: (1) 2, 3, 4
C: ~~1~~, ~~2~~, (3) 4
S: 1, 2, 3, 4
P: 1, ~~2~~, ~~3~~, ~~4~~
N: ~~4~~, ~~2~~, ~~3~~, (1)

Q.2. Consider the following constraint graph and variable domains for some CSP.



solve using DFS with forward checking and propagation.

✓ L → {1}
✓ Hb → {2, 3, 4}
✓ A → {3 4}
✓ EL → {2, 3, 4}
✓ H → {2, 3, 4}
✓ M → {1, 2, 3, 4}
✓ B → {1, 2, 3, 4}

1. L = 1 → None
2. H = 2 → M ≠ 2, B ≠ 2, Hb ≠ 2
3. A = 3 → EL = { }, backtrack
   A = 4 → EL ≠ 3, EL ≠ 4
4. EL = 2 → B ≠ 2, M ≠ 2
5. Hb → 4, None
6. M → 1, B ≠ 1
7. B = 4, None

Q. 3. Consider The following CSP involving 4 variables where constraints among These variables are

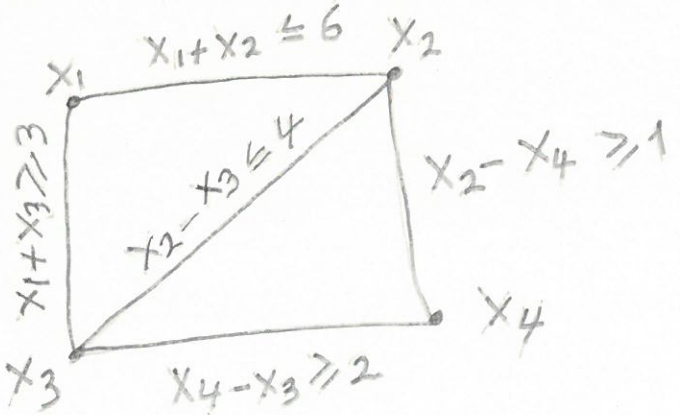
$x1 + x2 \leq 6$
$x1 + x3 \geq 3$
$x2 - x3 \leq 4$
$x2 - x4 \geq 1$
$x4 - x3 \geq 2$

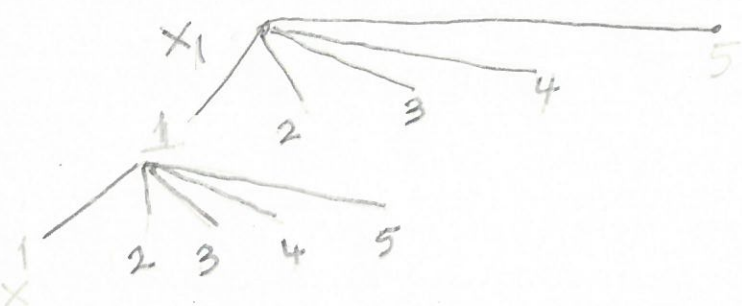
$D = \{1, 2, 3, 4, 5\}$ for all variables.

solution with forward checking

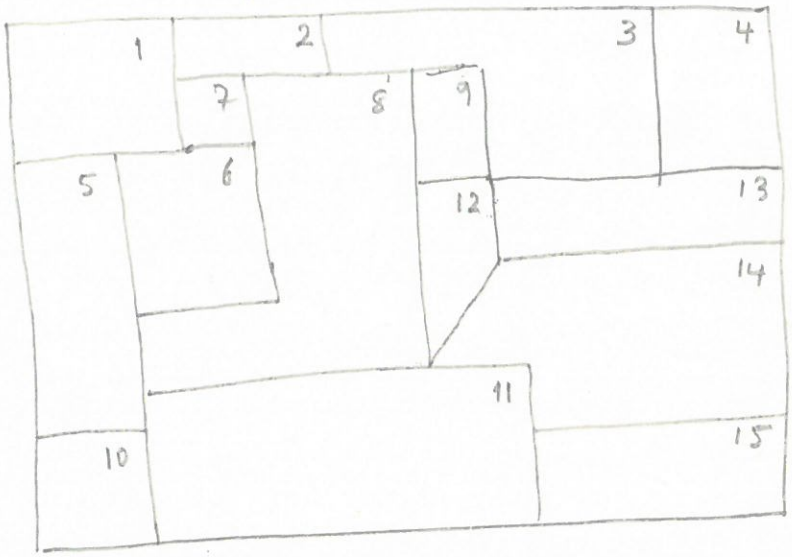
$x1$: 1, 2, 3, 4, 5
$x2$: 1 2, 3, 4, 5
$x3$: ~~1~~, 2, 3, 4, ~~5~~
$x4$: 1, 2, 3, 4, ~~5~~

Apply arc consistency

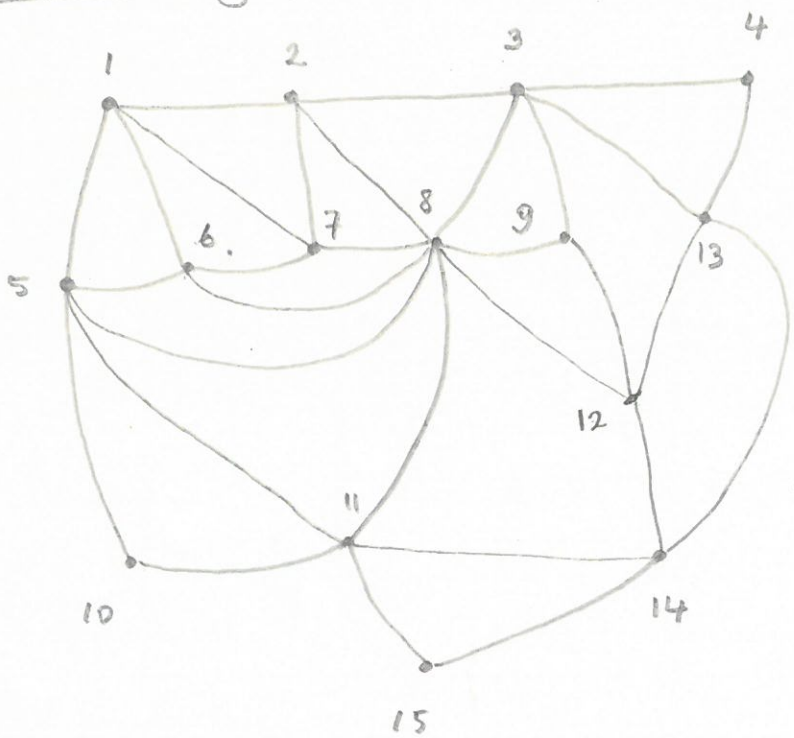




Q.4.



Constraint graph:



Region	Red	Green	Blue
1	(7) Red	X_5	X_6
2	X_8	X_7	(8) Blue
3	X_8	(9) Green	X_2
4	(14) Red	X_3	X_{13}
5	X_8	(2) Green	
6	X_8	X_5	(3) Blue
7	X_8	(5) Green	X_6
8	(1) Red		
9	X_8	X_3	(10) Blue
10	(6) Red	X_5	X_{11}
11	X_8	X_5	(4) Blue
12	X_8	(11) Green	X_9
13	X_{12}	X_3	(13) Blue
14	(12) Red	X_{12}	X_{11}
15	X_{12}	(15) Green	X_{11}

1. $d(8) = 8$, max. degree
2. Assign 5, $d(5) = 4$, $|R| = 2$
   look at update const. graph
3. Assign 6 and 11, $|R| = 1$
4. Assign 7 and 10, $|R| = 1$
5. Assign 1, $|R| = 1$
6. Assign 2, $|R| = 1$
7. " 3, $|R| = 1$
8. " 9, $|R| = 1$
9. " 12, $|R| = 1$
10. " 14, $|R| = 1$
11. Assign 13, $|R| = 1$
12. " 4, $|R| = 1$
13. " 15, $|R| = 1$