National University

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AI 2002: Artificial Intelligence

Assignment No. 4

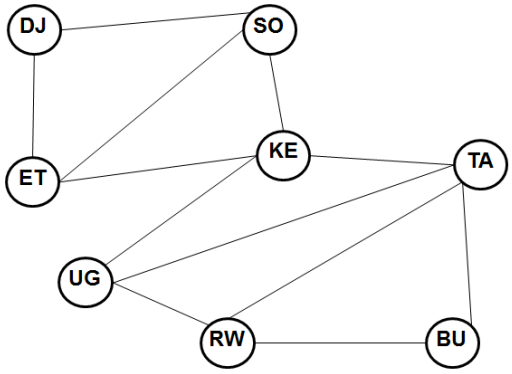
Due Date: Wednesday, 03 April 2024 **(02:00 pm)**

Instructions:

1. Submit your assignment with a **report** in soft form within the due date and time. Late submission will result in a deduction of marks.
2. Mention your names and roll numbers clearly on your document.
3. Name your zip or other folder/file that you want to submit, according to the following format, **AI_A4_RollNo_FirstName**
4. Try to solve each task of the assignment on your own.
5. No excuse or resubmission is permissible.

Question No. 1: [CSP … map coloring problem]

Consider the constraint satisfaction problem of the following map coloring problem where the state space is represented as,



Variables: DJ, SO, ET, KE, UG , TA, RW, BU

Domains: Di = red; green; blue

Constraints: adjacent regions must have different colours, e.g.,

- $DJ \neq SO$
- $(DJ; SO) \in [(red;\ green);\ (red;\ blue);\ (green;\ red);(green;\ blue)\ \ldots\ ]$

How many solutions are there for the above-mentioned map-coloring problem? How many solutions if four colors are allowed? Two colors?

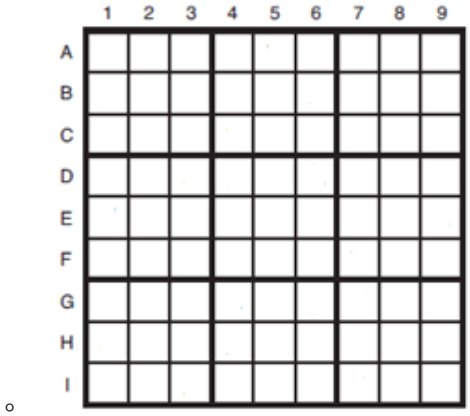
Question No. 2: [CSP … N-queens problem]

Consider the problem of placing k queen on an $n \times n$ chessboard such that no two queens are attacking each other, where k is given and $k \leq n^2$.

1. Choose a CSP formulation. In your formulation, what are the variables?
2. What are the possible values of each variable?
3. What sets of variables are constrained, and how?

Question No. 3: [CSP … Sudoku]

Implement constraint satisfaction problem of the following Sudoku puzzle with 9×9 grid. The state space is represented as,



Variables: empty cells

Domains: numbers range from 1 to 9

Constraints: rows, column, boxes contain all different numbers.

Moreover, the user have choice to enter any number on any cell considering the constraint as mentioned above.

Hint: An example of Sudoku puzzle has been shown where the task is represented on left side while the solution is on right side.

	1	2	3	4	5	6	7	8	9
A			3		2		6		
B	9			3		5			1
C			1	8		6	4		
D			8	1		2	9		
E	7								8
F			6	7		8	2		
G			2	6		9	5		
H	8			2		3			9
I			5		1		3		

	1	2	3	4	5	6	7	8	9
A	4	8	3	9	2	1	6	5	7
B	9	6	7	3	4	5	8	2	1
C	2	5	1	8	7	6	4	9	3
D	5	4	8	1	3	2	9	7	6
E	7	2	9	5	6	4	1	3	8
F	1	3	6	7	9	8	2	4	5
G	3	7	2	6	8	9	5	1	4
H	8	1	4	2	5	3	7	6	9
I	6	9	5	4	1	7	3	8	2

Question No. 4: [Sentence Validity]

(a) Decide whether each of the following sentences is valid, unsatisfiable, or neither with some proof:

i. (Smoke $\Rightarrow$ Fire) $\Rightarrow$ ($\neg$Smoke $\Rightarrow$ $\neg$Fire)
ii. Smoke $\vee$ Fire $\vee$ $\neg$Fire
iii. ((Smoke $\wedge$ Heat) $\Rightarrow$ Fire) $\Leftrightarrow$ ((Smoke $\Rightarrow$ Fire) $\vee$ (Heat $\Rightarrow$ Fire))
iv. (Smoke $\Rightarrow$ Fire) $\Rightarrow$ ((Smoke $\wedge$ Heat) $\Rightarrow$ Fire)
v. Big $\vee$ Dumb $\vee$ (Big $\Rightarrow$ Dumb)

(b) Consider the following sentence:

[(Food $\Rightarrow$ Party) $\vee$ (Drinks $\Rightarrow$ Party)] $\Rightarrow$ [(Food $\wedge$ Drinks) $\Rightarrow$ Party]

i. Determine, using enumeration, whether this sentence is valid, satisfiable (but not valid), or unsatisfiable.
ii. Convert the left-hand and right-hand sides of the main implication into CNF, showing each step, and explain how the results confirm your answer to (a).
iii. Prove your answer to (a) using resolution.

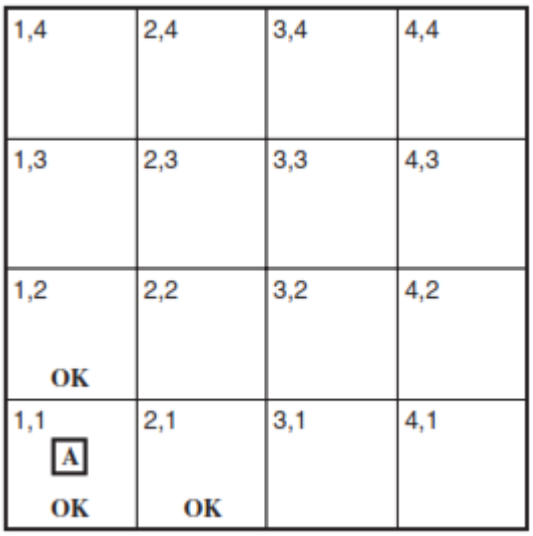
Question No. 5: [Propositional Logic]

Consider a vocabulary with only four propositions, A, B, C, and D. How many models are there for the following sentences?

(a) B $\vee$ C.
(b) $\neg$A$\vee\neg$B $\vee\neg$C $\vee$ $\neg$D.
(c) (A $\Rightarrow$ B) $\wedge$ A$\wedge$ $\neg$B $\wedge$ C $\wedge$ D.

Question No. 6: [Inference in Propositional Logic]

[Wumpus world]: Consider the following example where the knowledge base is:



R_1: $\neg P_{1,1}$.

R_2: $B_{1,1} \Leftrightarrow (P_{1,2} \vee P_{2,1})$.

R_3: $B_{2,1} \Leftrightarrow (P_{1,1} \vee P_{2,2} \vee P_{3,1})$.

R_4: $\neg B_{1,1}$.

R_5: $B_{2,1}$.

$P_{1,1}$= pit in [1,1] and $B_{1,1}$= Breeze in [1,1]

- Apply the inference rules and derive the proof step by step that ¬P1,2.
- Apply the resolution theorem and derive the proof step by step that ¬P1,2.