Indian Institute of Engineering Science & Technology, Shibpur
B. Tech - M. Tech Dual Degree Part IV Examination
8th Semester Final Examination, April – May, 2019
Artificial Intelligence (CS- 801)

Time-3 Hours   Full Marks-70

Use one Answer script.
All questions are of equal marks.
Answer any FIVE questions.

1. a) Name four different methods of reasoning with Propositional Logic. Use modus ponens to illustrate the reasoning process in each of the four methods you named.

   b) Use natural deduction to prove the following.

   i)   Everything must either be or not be.
   ii) $p \to (q \to r)$, p, $\neg r \vdash \neg q$

   c) Prove the soundness of natural deduction system. [(2+4) +(2+2) +4]

2. a) Explain briefly following logical systems:
   epistemic logic, doxastic logic, deontic logic, temporal logic.

   b) Explain the difference between 'de dicto' and 'de re', giving appropriate examples, with respect to modal operators 'necessity' and 'possibility'.

   c) Obtain the formula that is true in each of the worlds 1, 2, 3 and 4 of the following model of the modal logic.   [8+2+4]
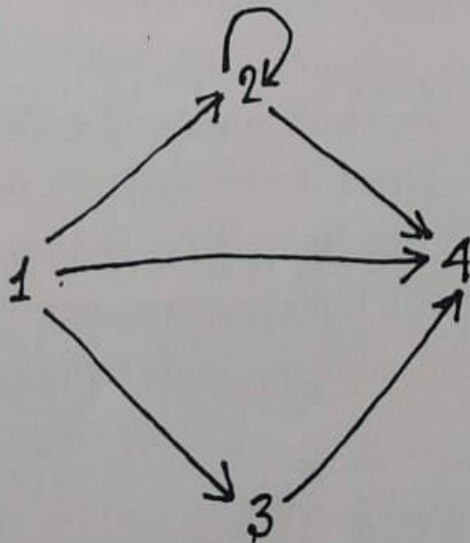
3. a) One of the successful applications of expert systems has been analyzing the problem of which chemical syntheses are possible. Consider the following example of such a problem.

We know we can perform the following chemical reactions:

$$MgO + H_2 \rightarrow Mg + H_2O$$
$$C + O_2 \rightarrow CO_2$$
$$CO_2 + H_2O \rightarrow H_2CO_3$$
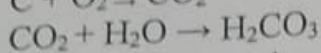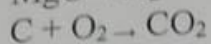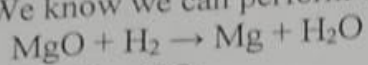
   i) Represent these rules and the assumptions that we have some MgO, H_2, O_2 and C by propositional logic formulae.

   ii) Describe the state of affairs in clausal form and as a PROLOG program.

   iii) Give a resolution proof in Propositional Logic that we can get some H_2CO_3

   b) What are the different applications of an Expert Systems? Discuss Explanation System in Rule Based Expert System. [(2+3+3)+(3+3)]

4. a) Premises: The custom officials searched everyone who entered this country who was not a VIP. Some of the drug pushers entered this country and they were only searched by drug pushers. No drug pusher was a VIP.

   Conclusion: Some of the officials were drug pushers.

   Prove the conclusion using Resolution in First Order Predicate Logic.

   b) Art is the father of John. Bob is the father of Kim. Mary is the mother of John. Fathers are parents. Mothers are parents. Use answer extraction in FOPL to find who are the parents of John? [8+6]

5. a) What is Production System model of problem solving?

   b) There are two water jugs: one 4-gallon and another 3-gallon. Neither has any measuring mark on them. There is a pump from which the jugs can be fully or partially filled. The water from the jugs can be fully or partially emptied too. Initially both jugs are empty. Write a Prolog program that enumerates the steps to obtain exactly 2 gallons of water in the 4-gallon jug.

c) There is a monkey at the door into a room. In the middle of the room a banana is hanging from the ceiling. The monkey is hungry and wants to get the banana, but he cannot stretch high enough from the floor. At the window of the room there is a box that the monkey can use. The monkey can perform the following actions: walk on the floor, climb the box, push the box around (if he is already at it), and grasp the banana if he is standing on the box and directly underneath the banana. Write a Prolog program to get the answer to the question: Can the monkey grasp the banana? [2+7+5]

6. a) What is an accumulator in a Prolog Program? What is its advantage?

   b) Write Prolog programs for the following using accumulators.

   i)   To find the length of a list.
   ii) To reverse a list.
   iii) To remove duplicate elements from a list.
   iv) Quick Sort.   [(2+1) + (2+3+3+3)]

7. a) Write a general state space search algorithm assuming state space to be a tree and modify it to Breadth First and Depth First state space tree searches. What are the further modifications needed for each of Breadth First and Depth First state space searches if the search space is a graph in each case?

   b) Explain alpha-beta pruning with a suitable example and hence write MiniMax procedure with alpha-beta pruning for perfect two-player deterministic games.   [(6+2) + 6]

8. a) Discuss, with a suitable example(s), superiority of A* heuristic search algorithm over Best First heuristic search algorithm. Write A* heuristic search algorithm assuming state space to be a graph. Why do we expect better performance using Manhattan distance heuristic compared to number of tiles mismatching heuristic for 8-puzzle problem in A* algorithm?

b) How would A*algorithm behave (give reasons), if:

i) h (x) = 0?
ii) h(x) = h'(x)?   [(4+4+3) + (1x3)]
iii) g(x) = 0?

9. a) Write IDA* algorithm for state space search in a tree.
   Consider the following graph, with heuristic value at each node shown beside it. Show in what sequence will IDA* algorithm search the nodes?
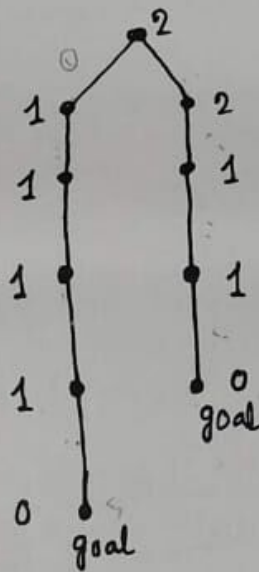
b) Write the steps of AND-OR graph search algorithm and illustrate it
   with an example. Explain how is a longer path may be desirable as
   solution for AO* algorithm?   [(4+2) +(6+2)]