ARTIFICIAL INTELLIGENCE
(CSEN 3281)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

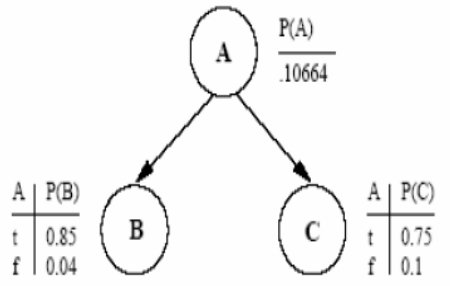
Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) If the maximum depth of the game tree is m, and there are b legal moves at each point, then which of the following represents the space complexity of MINIMAX algorithm
(a) $O(b^m)$ (b) O(bm) (c) O(blog m) (d) None of these.

(ii) A wff P∧¬P is a -
(a) satisfiable sentence (b) valid sentence
(c) contradiction (d) All of these.

(iii) Consider the following Bayesian network:



prob. (¬B, C|A)=?
(a) 0.12272 (b) 0.23487 (c) 0.1125 (d) None of these.

(iv) A Perceptron is a ----------
(a) Feed-forward neural network
(b) Back-propagation algorithm
(c) Back-tracking algorithm
(d) Feed Forward-backward algorithm.

(v) In a semantic network, A is a meronym of B if
(a) A is part of B (b) B has A as a part of itself
(c) A is a kind of B (d) A is super-ordinate of B.

(vi) Genetic Algorithm is a part of
(a) Evolutionary Computing
(b) inspired by Darwin's theory about evolution - "survival of the fittest"
(c) are adaptive heuristic search algorithm based on the evolutionary ideas of natural selection and genetics
(d) All of the above.

(vii) In genetic algorithm, mutating a string is:
(a) Changing all the genes in the string
(b) Removing one gene in the string
(c) Randomly changing one gene in the string
(d) Removing the string from the population.

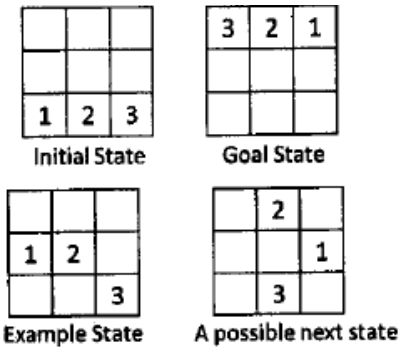
(viii) What helps Simulated Annealing get out of local minima?
(a) The acceptance threshold is established probabilistically.
(b) The exponential form of the Metropolis condition, i.e., that p is less than exp (-ΔE/kT) where DE is the change in energy, T the temperature, and k is a constant
(c) Annealing follows a declining temperature schedule
(d) Positive energy changes are not discarded automatically.

(ix) Semantic network is used to represent the following kind of knowledge
(a) Procedural knowledge (b) Inheritable knowledge
(c) Inferential knowledge (d) All of these.

(x) Which function is used to calculate the feasibility of whole game tree?
(a) Evaluation function (b) Transposition
(c) Alpha-beta pruning (d) All of these.

Group – B

2. (a) Consider a N x N chess board. N pawns, numbered 1, 2, ..., N are initially placed in the bottom row such that pawn i is at position (i, 1). The goal is to move the pawns to the top row but in reverse order, so that pawn i ends up in position (N-i+1, N). On each time step, each of the N pawns can move one square left, right, up, down, or remained at the same position. But if a pawn stays at the same place, an adjacent pawn may hop over it. Two pawns cannot occupy the same square. An example with N = 3 is shown below:



(i) Formulate the above problem as a state-space-search problem. Mention explicitly the state description, allowed moves, pre-condition of applying the moves.

(ii) What is approximately the branching factor of the state-space for the above problem?
(iii) Give at-least one solution of the problem.

(b) If a state-space has branching factor b, the best goal is at depth d and the total depth of the space is N, then what are the time and space complexities of DFS and Iterative Deepening DFS on this state-space?

(4 + 1 + 3) + 4 = 12

3. (a) What do you mean by Horn clauses? Give examples.
Convert the following propositional sentence into CNF clauses:
¬[((P∨¬Q)→R)→(P∨R)]

(b) Justify the following statements for propositions:
(i) "Chaining is a special case of resolution".
(ii) "Modus ponens is also a special case of resolution".

(2 + 6) + (2 + 2) = 12

Group – C

4. (a) Suppose you are in charge of scheduling of 5 classes that meet on Mondays, Wednesdays and Thursdays. Three professors will be taking those classes. You are constrained by the fact that each professor can only take one class at a time.
Class timings are as follows:
1. OS – 8:30 am to 9:30 am
2. AI – 9:30 am to 10:30 am
3. NLP – 10:30 am to 11:30 am
4. IR – 10:30 am to 11:30 am
5. ML – 11:30 am to 12:30 pm

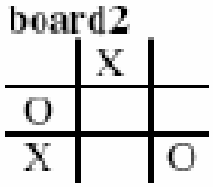
Details of the 3 professors are as follows:
1. Professor A is available to take the classes of NLP and IR
2. Professor B will take the classes of AI, NLP, ML and IR
3. Professor C is available to take the classes of OS, AI, NLP, ML and IR

Now, answer the following questions:
(i) Formulate the above problem as a CSP problem by mentioning variables, domain of each variable and the constraints. You are also supposed to provide the constraint graph.
(iii) Apply backtracking method along with 'the most constraining variable' as the heuristic to give one solution of the problem

(b) Consider the game of tic-tac-toe. Assume that X is the MAX player and O is the MIN player. Given the game board **board2** below where it is X's turn to play next, show the game tree with a cut-off depth of two ply (i.e., stop after each player makes one move). Use the following evaluation function on all leaf nodes: $Eval(s) = 10X_3(s) + 3X_2(s) + X_1(s) - (10O_3(s) + 3O_2(s) + O_1(s))$, where we define $X_n(s)$ as the number of rows, columns, or diagonals in state s with exactly n X's and no O's, and similarly define $O_n(s)$ as the number of rows, columns, or diagonals in state s with exactly n O's and no X's.

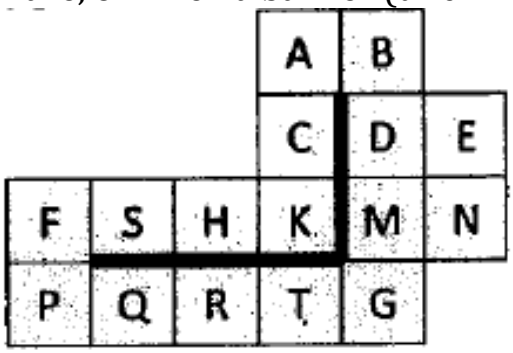
(i) Use the MINIMAX algorithm to determine X's best move.

(ii) What nodes would not need to be examined using α – β cutoff algorithm along with the type of cutoff – assuming that nodes are examined in left-to-right order?



(3 + 3) + (3 + 3) = 12

5. (a) Consider the following maze where the successors of a cell include any adjacent cell in the directions North, South, East, and West of the current cell, except at the boundary of the maze, or when a barrier (thick line) exists.



For example, successors (M) = {D, N, G}.
Find the order of the nodes expanded if A* search algorithm is applied on the above maze to find a solution path from S to G. Use the function h(S) as the heuristic function which is defined as the Manhattan distance from state S to G assuming there are no barriers. For example, h (K) = 2, h (S) = 4. Assume that each move has cost 1.

(b) Do you think the heuristic used in part (a) is admissible? Give reasons in support of your answer.

9 + 3 = 12

Group – D

6. (a) As per the rule of HIT-K, any security person who allows any outsider to enter the campus without any valid ID-proof will be suspended. Some outsiders without any valid ID-proofs are found inside the campus. All these outsiders were allowed to enter the campus by a security person named Mr. X.
Now, answer the following questions:

(i) Formulate the given English sentences in CNF

(ii) By using Resolution method, prove that "Mr. X must be suspended".

(iii) Write a PROLOG program to determine whether "Mr. X must be suspended" by defining necessary facts and rules.

(b) Explain the significance of conditional independence using suitable example and how it is different from conditional probability.

(3 + 4 + 3) + 2 = 12

7. (a) Consider 4 Boolean random variables, named as A, B, C and D. Given that: A and B are (absolutely) independent. C is independent of B given A. D is independent of C given A and B.

(i) Draw the Bayesian network corresponding to the situation mentioned above

(ii) Suppose the following conditional probabilities are annotated with the Bayesian network that you have drawn:

prob(A=T) = 0.3, prob(B=T) = 0.6, prob(C=T|A=T) = 0.8, prob(C=T|A=F) = 0.4,
prob(D=T|A=T,B=T) = 0.7, prob(D=T|A=T,B=F) = 0.8,
prob(D=T|A=F,B=T) = 0.1, prob(D=T|A=F,B=F) = 0.2
Now, compute the following:
(1) prob(D=T)
(2) prob(D=F,C=T)

(b) Define a fuzzy relation.

(c) Consider two universal sets X = {a, b, c, d} & Y = {1, 2, 3, 4}. Three fuzzy sets A, B and C are defined as follows:
A = {(a, 0), (b, 0.8), (c, 0.6), (d, 1)}, B = {(1, 0.2), (2, 1), (3, 0.8), (4, 0)},
Determine the implication relation – 'If x is A THEN y is B', $\forall x \in X, \forall y \in Y$

(2 + 5) + 2 + 3 = 12

Group – E

8. (a) Consider the following start state and goal state description of blocks world problem:
Start: ON(A, B) ∧ON(C,D) ∧ ONTABLE(B) ∧ONTABLE(D) ∧ARMEMPTY
Goal: ON(C,B) ∧ON(D,A) ∧ONTABLE(B) ∧ONTABLE(A)

(i) Write a set of STRIPS style operators that might be used here

(ii) Show how the technique of planning using a goal stack could be used to solve this problem by using the operators that you have defined in (i)

(b) Differentiate between supervised and unsupervised learning methods. Explain with suitable example

(3 + 5) + 4 = 12

9. (a) Define Information gain as an attribute selection measure of a decision tree.

(b) Consider the following table where the attribute 'class' is the class label.

	sex	mask	cape	tie	ears	smokes	class
batman	male	yes	yes	no	yes	no	Good
robin	male	yes	yes	no	no	no	Good
alfred	male	no	no	yes	no	no	Good
penguin	male	no	no	yes	no	yes	Bad
catwoman	female	yes	no	no	yes	no	Bad
joker	male	no	no	no	no	no	Bad

Calculate the information gain corresponding to the attributes sex, mask, cape, tie, ears & smokes in selecting an attribute to construct (induct) a decision tree from the data provided in the above table. Also mention the attribute you will select based on the calculated information gain in each step. (Note: No need to draw the whole decision tree).

2 + 10 = 12

Department & Section	Submission Link
CSE	https://classroom.google.com/c/MzY5MTE4NTM0MjIx/a/MzY5MTE4NTM0Mjk4/details