INTRODUCTION TO ARTIFICIAL INTELLIGENCE
(AML2201)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

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

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) If the parameter m (maximum depth of the state space) is infinite, which search method should not be used at all?
(a) BFS (b) DFS
(c) Uniform-cost Search (d) Depth Limited Search

(ii) For a branching factor b = 10 and deep goals in a state space search graph, which of the following is true
(a) Iterative-Deepening search expands only about 11% more nodes than a BFS expands
(b) BFS expands only about 11% more nodes than iterative-deepening search expands
(c) The number of nodes both the methods expand are same
(d) None of these

(iii) Which of these is a valid constraint for a 4-queen problem on a 4x4 chess board, where Q_i stands for the column number of the queen positioned in the i^{th}row?
(a) $|Q_3 - Q_4| \neq 2$ (b) $Q_1 - Q_4 \neq -1$
(c) $|Q_1 - Q_3| \neq 3$ (d) $Q_2 - Q_4 \neq -2$

(iv) Which of the following methods are used to optimize a backtracking DFS that is being done to solve a Constraint Satisfaction Problem?
(a) Forward Checking (b) Constraint Propagation
(c) Variable Ordering (d) All of the above

(v) Consider an English sentence given as: "All Romans were either loyal to Caesar or hated him". Which of the following is the correct FOPL form of the given sentence?
(a) ∀x: loyalto (x, Caesar) ∨ hated (x, Caesar) → Roman (x)
(b) ∀x: Roman (x) → loyalto (x, Caesar) ∨ hated (x, Caesar)
(c) ∃x: Roman (x) → loyalto (x, Caesar) ∨ hated (x, Caesar)
(d) None of these

(vi) Consider the following PROLOG clauses:
p(2,4).
p(ann, mary).
p(X,Y):-r(X),s(Y),t(X,Y).
r(X):-member(X,[4,6,9,15]).
s(X):-member(X,[3,5,4,2]).
t(X,Y):-X mod Y = 0.
member (X,[X|_]).
member (X,[_|T]):-member(X,T).
Which of the following is correct, if the goal: ?- p(X, Y) is placed
(a) X = 2, Y = 4 (b) X= ann, Y= mary
(c) both (a) and (b) (d) None of these

(vii) A Bayesian network is
(a) an undirected graph (b) a tree
(c) a DAG (d) all of these

(viii) 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

(ix) In Baye's theorem, what is the meant by $p(H_i|E)$?
(a) The probability that hypotheses H_i is true given evidence E
(b) The probability that hypotheses H_i is false given evidence E
(c) The probability that hypotheses H_i is true given false evidence E
(d) The probability that hypotheses H_i is false given false evidence E

(x) Consider the following confusion matrix:

		Predicted Class	
		Class = Yes	Class = No
Actual Class	Class = Yes	90	210
	Class = No	140	9560

Which of the following represents the sensitivity of the classifier correctly?
(a) 9560/9700 (b) 90/300 (c) 90/230 (d) 90/9560

Fill in the blanks with the correct word

(xi) A* finds an optimal solution path in a tree if the heuristic estimates are _____.

(xii) _____ estimates the cost to reach the goal from a given state by providing additional formation to guide the search process.

(xiii) Alpha-Beta pruning significantly reduces the number of nodes evaluated compared to _____ algorithm by pruning branches that cannot affect the final decision.

(xiv) If h=0 for all nodes then A* reduces to _____.

(xv) If b is the branching factor, d is the depth of solution and m is the maximum depth of the search tree, then the worst case time complexity of DFS algorithm is_____.

Group - B

2. (a) Define a state-space representation of a problem of Tic –Tac –Toe problem. *[(AML2201.1)(Remember/LOCQ)]*

(b) Consider the following problem:
There is a village consisting of 3 pair-bonded couples that straddle a river to reach their home. Restrictions
Rule 1:- The boat can only carry two people at a time. If the third person is trying to get into the boat, the boat will sink.
Rule 2:- The husbands are so jealous that they cannot let their wife with another man, without their presence.
Rule 3:- The boat cannot run on itself. At least one person should be on the boat to go from one side to another.
For the above problem, let's assume that the set of states is defined as:
S (P_b, [$H1_L$ $W1_L$, $H2_L$ $W2_L$, $H3_L$ $W3_L$], [$H1_R$ $W1_R$, $H2_R$ $W2_R$, $H3_R$ $W3_R$]), where P_b represents the position of the boat, i.e., $P_b \in \{L, R\}$, each of Hk_L , $Wk_L \in \{0, 1\}$, $k \in \{1,2,3\}$ representing the fact that husbands and wives are present/ absent in the left bank at any instant, similarly each of Hk_R, $Wk_R \in \{0, 1\}$, $k \in \{1,2,3\}$ representing the fact that husbands and wives are present/ absent in the right bank at any instant.
Now, following the above state representation, answer the following questions:
(i) Mention the initial & final states
(ii) Specify the operators that can be applied to the states and also mention the precondition of those operators.
(iii) How many river crossings are required for n-couple transfers? *[(AML2201.4)(Apply/IOCQ)]*

(4 + 1) + (2 + 4 + 1) = 12

3. (a) Justify each of the following statements:
(i) BFS is a special case of Uniform-Cost search.
(ii) DFS can be viewed as a special case of Depth-limited search. *[(AML2201.4)(Analyze/IOCQ)]*

(b) Convert the following propositional sentence into CNF clauses:
$\neg[((P \vee \neg Q) \rightarrow R) \rightarrow (P \vee R)]$. *[(AML2201.3)(Apply/IOCQ)]*

(4 + 4) + 4 = 12

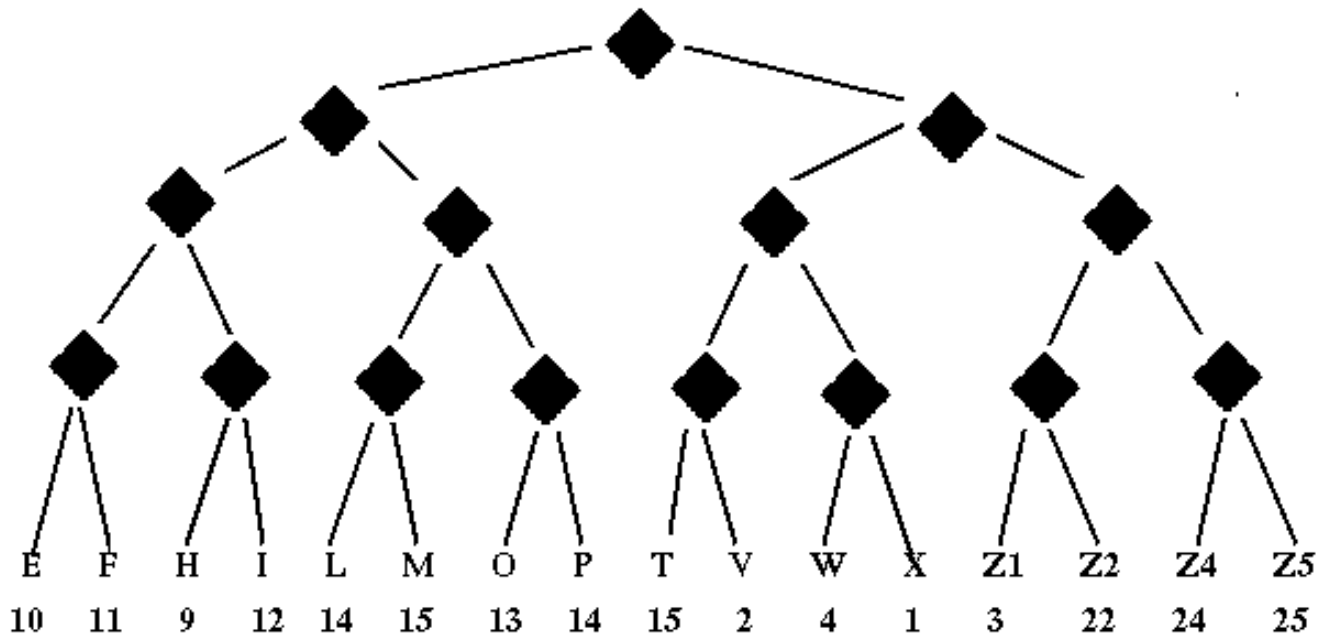
Group - C

4. (a) (i) When do you call a heuristic to be consistent?
(ii) If a heuristic h is consistent, then prove that $h(n) \leq c(n, n') + h(n')$ is applicable for any descendant n' of n.
[(AML2201 .4)(Understand/HOCQ)(Apply/IOCQ)]

(b) For 8-puzzle problem, there are two commonly used admissible heuristics h1 and h2, where h1 is defined as the number of misplaced tiles, whereas h2 is defined as sum of the Manhattan distances of each tile from its misplaced position to its final position. But the heuristic h2 is more popularly used than h1 to solve 8-puzzle problem. Why? Give your explanation properly. *[(AML2201.6)(Evaluate/HOCQ)]*

(3 + 3) + 6 = 12

5. (a) Consider the following game tree where the evaluation scores at the leaf nodes are from the first player's perspective. Assume that the first player is a MAX player.



Now, answer the following questions:

(i) What is the minimax value for the root node? Indicate which action the first player would choose assuming a fully rational opponent.

(ii) Show which branches (if any) would be pruned by alpha – beta cutoff assuming that the nodes are evaluated in left-to-right order. Also mention the type of cutoff in each case.

(iii) Suppose that in any game tree, the search tree is cutoff at depth D, and in the second game tree at depth D + 1. Why do you expect that you will have a better strategy in the second case? *[(AML 2201.4)(Apply,Analyze/IOCQ)]*

(b) What problems can you face when you apply Hill Climbing method on any optimization problem? *[(AML2201.4)(Analyze/IOCQ)]*

(2 + 4 + 4) + 2 = 12

Group - D

6. (a) Consider the following English sentences:

A. Tom owns a kindle.
B. Every kindle owner loves books.
C. No book lover preserve books.
D. Either Tom or Austin preserve the book called “MITTI KE LOG”.
E. Every kindle is a book.

Now, answer the following questions:

(i) Encode each sentence in First Order Predicate Logic (FOPL) form using the following predicates:
owns(x, y): x owns y
bookLover(x): x is a book lover
burns(x, y): x preserves y
book(x): x is a book
kindle(x): x is a kindle

(ii) Apply resolution method on these CNF sentences to answer the query “Did Austin preserve the book named “MITTI KE LOG”?” *[(AML 3104.3)(Apply/IOCQ)]*

(b) Determine whether each of the following sentence is satisfiable, contradictory or valid, where P, Q & R are propositions:
(i) $(P \& Q) \vee \neg (P \& Q)$ (ii) $(P \vee Q) \rightarrow (P \& Q)$ *[(AML 2201.2)(Apply/IOCQ)]*

(3 + 3) + (3 × 2) = 12

7. (a) State Modus Ponens inference rule.
“Modus ponens is a special case of resolution” – justify the statement. *[(AML 2201.3)(Apply/IOCQ)]*

(b) Consider two fuzzy sets A & B defined as follows:
A = {1/a, 0.3/b, 0.2/c, 0.8/d, 0/e}
B = {0.6/a, 0.9/b, 0.1/c, 0.3/d, 0.2/e}
Now, compute the following:
(i) A U B (ii) A ∩ B (iii) support (A) *[(AML 2201.3)(Apply/IOCQ)]*

(3 + 3) + (3 × 2) = 12

Group - E

8. (a) (i) What do you mean by N-Grams language model?
(ii) Calculate the probability of the sentence **“i want Chinese food”** by using bigram model. You may use the probabilities Prob. (i|<s>) = 0.19, Prob.(want| i) = 0.33, Prob. (Chinese| want) = 0.0065, Prob. (food| Chinese) = 0.52 and Prob. (</s>|food) = 0.40. *[(AIML 2201.5)(Remember and Apply /LOCQ)]*

(b) What do you infer by the working knowledge of Prolog? Can the NLP be applied to the Sentence in English? If so draw the parse tree of Sentence: “The cat chased the rat in the garden. *[(AIML 2201.5)(Understand/IOCQ)]*

(3 + 3) + 6 = 12

8. (a) Consider the following training dataset:

Day	Outlook	Temperature	Humidity	Wind	Play Tennis
Day1	Sunny	Hot	High	Weak	*No*
Day2	Sunny	Hot	High	Strong	*No*
Day3	Overcast	Hot	High	Weak	Yes
Day4	Rain	Mild	High	Weak	Yes
Day5	Rain	Cool	Normal	Weak	Yes
Day6	Rain	Cool	Normal	Strong	*No*
Day7	Overcast	Cool	Normal	Strong	Yes
Day8	Sunny	Mild	High	Weak	*No*
Day9	Sunny	Cool	Normal	Weak	Yes
Day10	Rain	Mild	Normal	Weak	Yes
Day11	Sunny	Mild	Normal	Strong	Yes
Day12	Overcast	Mild	High	Strong	Yes
Day13	Overcast	Hot	Normal	Weak	Yes
Day14	Rain	Mild	High	Strong	*No*

Based on the above training data, classify the following test data x using Naïve Bayes classifier:
x = (Outlook=Sunny, Temp=Cool, Humidity=High, Wind=strong). Your answer will tell whether it is more likely to play Tennis or not on the given day mentioned as test data. *[(AML 2201.4)(Apply/IOCQ)]*

(b) With the help of flowchart discuss Genetic Algorithm. What does the fitness function signify? Does GA provide global optimal solution? *[(AML2201.6)(Analyze/IOCQ)]*

6 + (4 + 1 + 1) = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	11.46	79.17	9.37