ARTIFICIAL INTELLIGENCE
(CSEN 3141)

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) 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

(ii) What is the truth value of the proposition sentence (¬P ∧ (Q → S)), when proposition P is true, Q is true and S is false?
(a) True (b) False (c) both True and False (d) Neither True nor False

(iii) If h(n) is the estimate of the cost of a minimum cost path from n to a goal node and h*(n) is the actual cost of a minimal cost path from n to a goal node, then the heuristic h(n) is said to be admissible if for each node n belonging to the graph the following condition holds –
(a) $0 \le h(n) \le h^*(n)$ (b) $0 \le h^*(n) \le h(n)$
(c) $h(n) = h^*(n)$ (d) None of these

(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) In AO* algorithm, if n is an OR node with successors r_1, r_2, r_3, ...,r_p, and c (n, r_i) represents the cost of the edge between n and r_i, for 1<=i<=p, then f(n) will be calculated as -
(a) $f(n) = \min \{f(r_1)+c(n, r_1), f(r_2)+c(n, r_2),...., f(r_p)+c(n, r_p)\}$
(b) $f(n) = \max \{f(r_1)+c(n, r_1), f(r_2)+c(n, r_2),...., f(r_p)+c(n, r_p)\}$
(c) $f(n) = f(r_1)+c(n, r_1)$
(d) None of these

(vi) 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

(vii) Inheritable knowledge is best represented by
(a) Semantic net (b) Database (c) FOPL (d) None of these

(viii) A Bayesian network is
(a) an undirected graph (b) atree (c) aDAG (d) all of these

(ix) Suppose a computer program for recognizing dogs in photographs identifies 9 dogs in a picture containing 13 dogs and some cats. Of the 9 dogs identified, 6 actually are dogs, while the rest are cats. Which of the following is the precision for the given situation?
(a) 6/9 (b) 6/13 (c) 9/13 (d) None of these

(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 perceptron is a _____ neural network .

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

(xiii) In First Order Predicate Logic (FOPL) formula, only _____ are quantified by the universal and existential quantifiers.

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

(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) You know that for a branching factor of b, depth of goal node d, the number of nodes expanded by iterative-deepening search is given by –

$$(d + 1)b^0 + (d)b^1 + (d - 1)b^2 + \ldots\ldots\ldots + (1)b^d$$

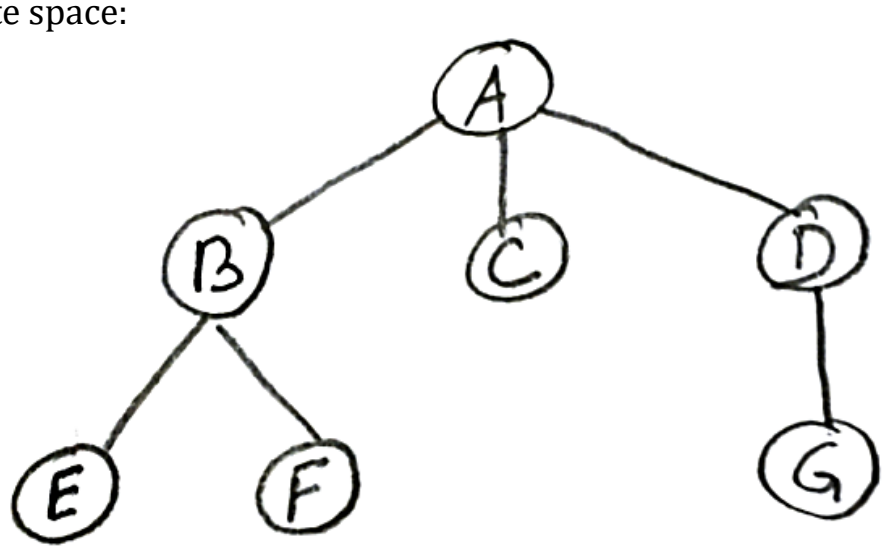
Note that it is an arithmetico-geometric series. Hence find the closed form for this expression. *[(CSEN 3141.4) (Apply/IOCQ)]*

(b) Prove that for a branching factor of b, depth of goal node d, the ratio of the number of nodes expanded by iterative-deepening search w.r.t. breadth first search is given by $b/(b - 1)$. *[(CSEN 3141.4) (Analyze/IOCQ)]*

(c) Hence show that for b = 10 & deep goals, iterative-deepening search expands only about 11% more nodes than a breadth-first search expands. *[(CSEN 3141.4)(Analyze/IOCQ)]*

5 + 4 + 3 = 12

3. (a) Consider the following state space:



Apply BFS algorithm on the above search space to find the path from A to G. *[(CSEN 3141.4) (Apply/IOCQ)]*

(b) Compare between goal based agents and utility based agents. *[(CSEN 3141.1) (Understand/LOCQ)]*

(c) Consider the following propositional sentence:

$$(P \wedge Q) \rightarrow R$$

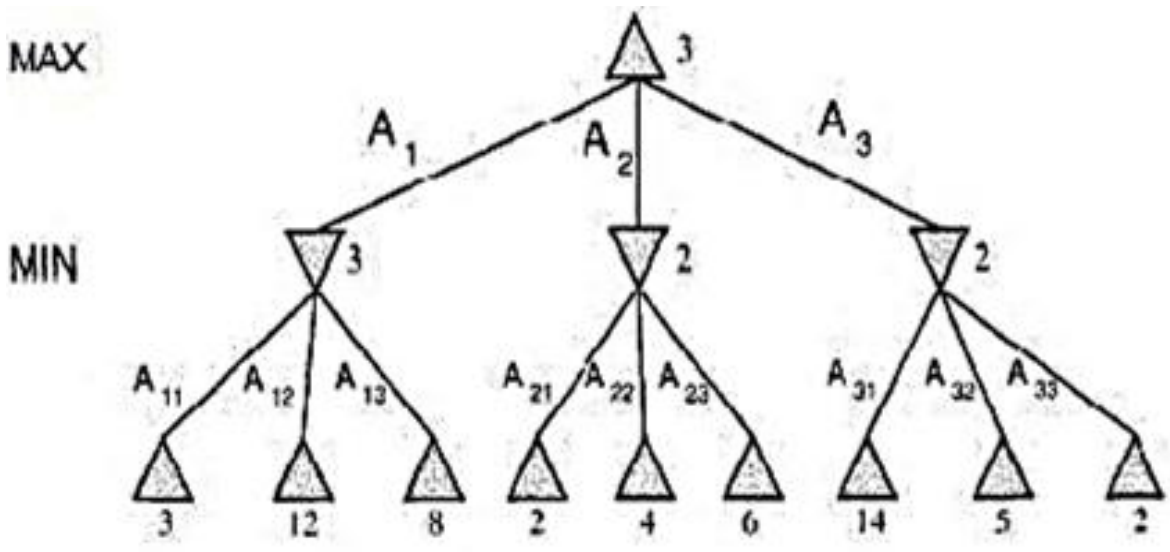
Convert the above sentence into its equivalent CNF clauses. *[(CSEN 3141.3) (Apply/IOCQ)]*

6 + 4 + 2 = 12

Group - C

4. (a) In MINIMAX algorithm, evaluation function is always applied only on the leaf nodes of the game tree. Why? *[(CSEN 3141.4)(Analyze/IOCQ)]*

(b) A two-ply game tree generated by MINIMAX algorithm is shown below, where the terminal nodes contain the evaluation score returned by some evaluation function.

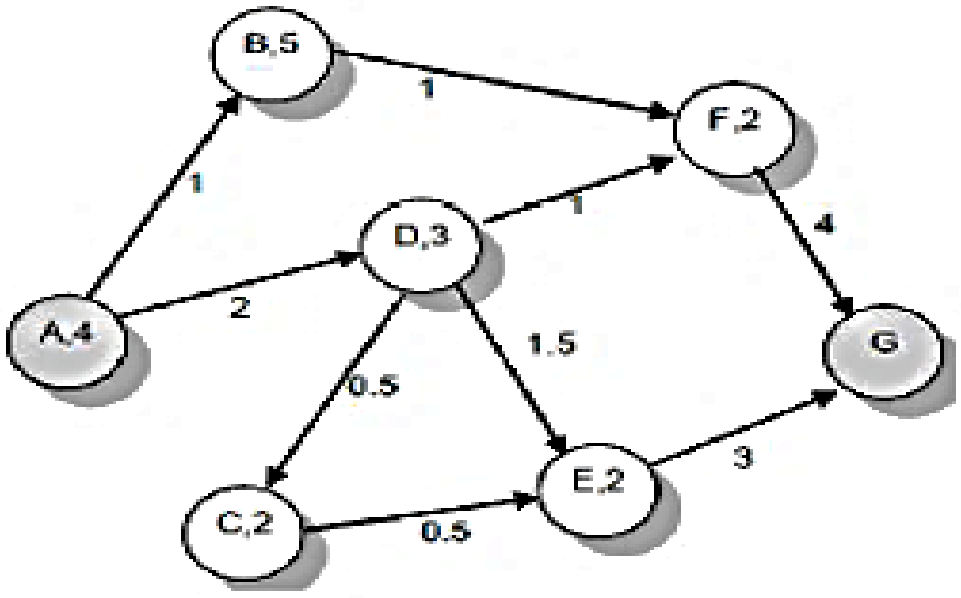


Apply alpha-beta pruning algorithm on the above game tree to find which of the nodes in the game tree can be pruned and which of the nodes can't be pruned. In each case you should mention the type of pruning where pruning is allowed. *[(CSEN 3141.4) (Apply/IOCQ)]*

(c) "In deterministic game, to get the minimax value at the end, only the relative ordering of the evaluation values matters, not the absolute values" – Justify the above statement with an example.
Is the above statement also valid for non-deterministic games? Give explanations. *[(CSEN 3141.4) (Analyze/IOCQ)]*

3 + 4 + (3 + 2) = 12

5. (a) Consider the following state-space, where each state shows its state id and the value of its heuristic estimate (h(s)) of how far it is from a goal state. Edges are labelled with the cost of the operation. The start state is A, and G is the goal state.



Now, answer the following questions:

(i) Are the heuristics in this problem admissible? Justify your answer

(ii) Use A* algorithm to find the optimal path from the start state to the goal state. Show the usage of the Data structures, OPEN & CLOSED, where OPEN holds the nodes generated in the explicit graph, but not yet expanded, whereas CLOSED holds list of expanded nodes in the graph. Tie-breaking of equal f-values on the Open list (frontier) is done alphabetically (lower values first). A search node consists of the state id, g-value, h-value, and the parent state id, e.g. [A, 0, 4, -]. The table below shows the open and closed lists when tracing an execution of the algorithm. Continue the trace until you have identified a path to a goal state. Show the contents of both the open and closed list after each (expansion) step. *[(CSEN 3141.4)(Apply/IOCQ)]*

(b) Define Constraint Satisfaction Problem (CSP). *[(CSEN 3141.1)(Remember/LOCQ)]*

(2 + 8) + 2 = 12

Group - D

6. (a) State Baye's Theorem. Explain the significance of conditional independence using suitable example and how it is different from conditional probability. *[(CSEN 3141.1) (Understand/LOCQ)]*

(b) Define a Fuzzy set.
Consider two fuzzy subsets of the universal set X = {a, b, c, d, e}, referred to as A and B, where 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 find the result of the following operations done on two fuzzy sets A & B:
(i) AUB, (ii) A∩B, (iii) A ⊆ B, (iv)support (A), (v) core (A), (vi) height (A). *[(CSEN 3141.3) (Apply/IOCQ)]*

(c) The relation balanced (L) takes a list of characters as argument. Each character in L is either an open parenthesis '(' or a closed parenthesis ')'. Write a PROLOG program to determine whether L when viewed as a sequence of parenthesis is well-formed in the normal algebraic sense. *[(CSEN 3141.5) (Apply/IOCQ)]*

(2 + 2) + [2 + (6 × 0.5)] + 3 = 12

7. (a) Consider the following English sentences:

A. Tom owns a kindle.
B. Every kindle owner loves books.
C. No book lover burns books.
D. Either Tom or Austin burned the book called Origin.
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 burns y
book(x): x is a book
kindle(x): x is a kindle

(ii) Convert all the FOPL sentences to Conjunctive Normal Form (CNF).

(iii) Apply resolution method on these CNF sentences to answer the query "Did Austin burn the Origin?" *[(CSEN 3141.3) (Apply/IOCQ)]*

(b) What do you mean by conditional independence? *[(CSEN 3141.1) (Remember/LOCQ)]*

(2.5 + 2.5 + 5) + 2 = 12

Group - E

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*

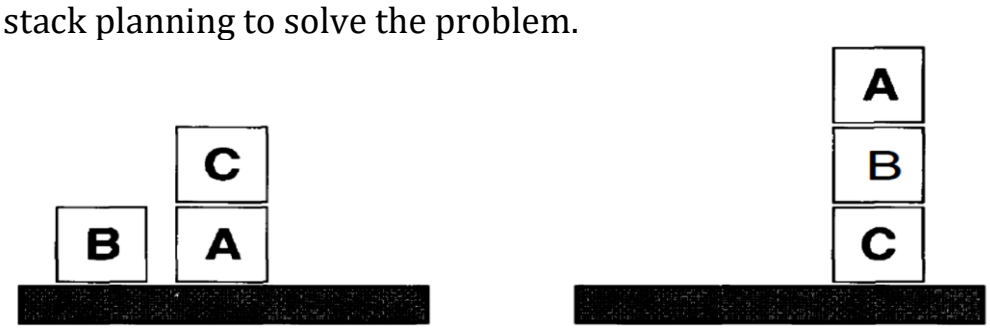
Based on the above training data, classify the following test data x using Naïve Bayes classifier:
x = (Outlook=Sunny, Temp=Cool, Humidity=High, Wind=strong). Your answer will tell whether it is more likely to play Tennis or not on the given day mentioned as test data. *[(CSEN 3141.4) (Apply/IOCQ)]*

(b) In which case do you think roulette wheel selection method of genetic algorithm will not work? Explain your answer. *[(CSEN 3141.4) (Analyze/IOCQ)]*

8 + (1 + 3) = 12

9. (a) Explain how Roulette Wheel Selection process can be used in the selection process of the Genetic Algorithm to create new offspring representing the best chromosomes. *[(CSEN 3141.4) (Understand/LOCQ)]*

(b) Following figure shows a blocks-world planning problem known as the Sussman anomaly. The problem was considered anomalous because the non-interleaved planners of the early 1970s could not solve it. Encode the problem using STRIPS operators, and use goal stack planning to solve the problem.



Start State Goal State

[(CSEN 3141.4) (Apply/IOCQ)]

5 + 7 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	17.71	82.29	0