ARTIFICIAL INTELLIGENCE
(CSEN 3111)

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) Which of the following best describes the propositional sentence **P** ∨ **¬P**?
(a) contradiction (b) valid
(c) equivalence (d) logical consequence.

(ii) 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.

(iii) If out of the 13124 occurrences of the POS tag MD in a corpus, it is associated with 'will' 4046 times, then which of the following is the correct estimation of the expression prob. (will | MD)?
(a) 0.31 (b) 0.80 (c) 0.004 (d) None of these.

(iv) For alpha-beta pruning, the best case occurs when
(a) each player's best move is the rightmost alternative
(b) each player's best move is the leftmost alternative
(c) there is no pruning
(d) None of these.

(v) 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) $Q_2 - Q_4 \neq -2$.

(vi) 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.

(vii) Which is a correct statement w.r.t. AO* search?
(a) All goals following an OR node must be realized
(b) Only one goal following an AND node must be realized
(c) Both the above options are TRUE
(d) None of the above.

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

(ix) 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) $0 \leq h(n) \leq h^*(n)$ (b) $0 \leq h^*(n) \leq h(n)$
(c) $h(n) = h^*(n)$ (d) None of these.

(x) 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.

Group – B

2. (a) Define a state-space representation of a problem.

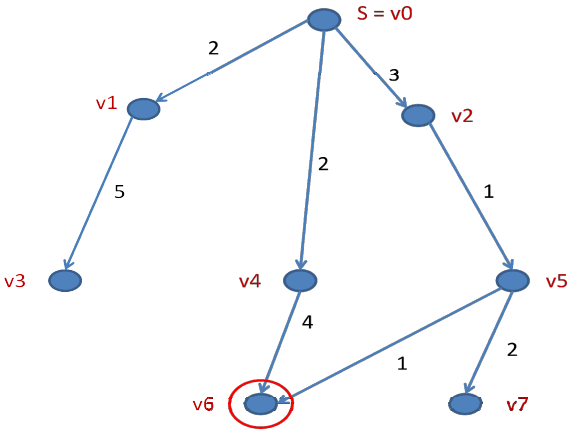
(b) Consider the following problem:
A farmer is on the left bank of a river with a boat, a cabbage, a goat, and a wolf. The task is to get everything to the right bank of the river.
Restrictions:
(a) Only the farmer can handle the boat
(b) When he is in the boat, there is only space for one more item
(c) The farmer can't leave the goat alone with the wolf, nor with the cabbage (or something will be eaten)

For the above problem, let's assume that the set of states is defined as:
S (P_b, [w_L, g_L, c_L], [w_R, g_R, c_R]), where P_b represents the position of the boat, i.e., $P_b \in \{L, R\}$, each of w_L, g_L, $c_L \in \{0, 1\}$, representing the fact that wolf, goat or cabbage is present/ absent in the left bank at any instant, similarly each of w_R, g_R, $c_R \in \{0, 1\}$, representing the fact that wolf, goat or cabbage is 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 on the states and also mention the precondition of those operators.

(c) State Modus Ponens inference rule.
"Modus ponens is a special case of resolution" – justify the statement.

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

3. (a) Consider the above graph. The source node is s and the only goal node v6 is marked with a double circle. Perform a uniform cost search on this graph to find the optimal path to the goal node. Do not write much text. Just show the steps by mentioning the g( ) values of the vertices and show the status of the lists that you maintain (eg. OPEN and CLOSED) at each step.



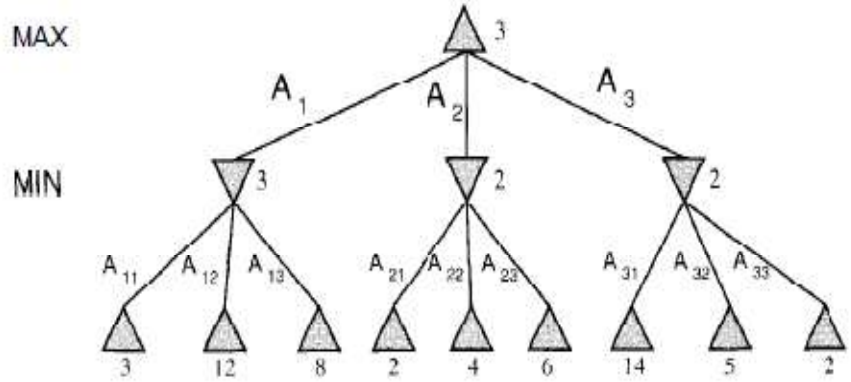
(b) Describe a state-space in which the iterative-deepening search will perform much worse asymptotically (like $O(n^2)$ vs. $O(n)$) than the depth first search. You may draw a tree or a graph, if that helps you to describe the situation than writing down the whole thing formally.

6 + 6 = 12

Group – C

4. (a) In MINIMAX algorithm, evaluation function is always applied only on the leaf nodes of the game tree. Why?

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

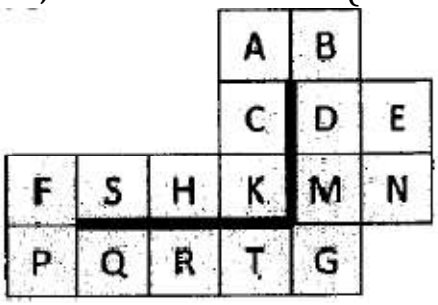


Apply alpha-beta pruning algorithm on the given game tree to find which of the nodes in the game tree can be pruned and which of the nodes can't be pruned. In each case you should mention the type of pruning where pruning is allowed.

(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 statement with an example.
Is the above statement also valid for non-deterministic games? Give explanations.

3 + 4 + (3 + 2) = 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**} and successors(**B**) = {**A**, **D**}.
Suppose the source node is **H** and there are two goal nodes – **D** and **T**.

Find the order of the nodes expanded if A* search algorithm is applied on the above maze to find any of the solution paths. Use the function h(**X**) as the heuristic function, which is defined as the smallest Manhattan distance from node **X** to any of the goal nodes assuming there are no barriers. For example, h (**K**) = 1, h (**S**) = 3. Assume that each move has cost 1.

(b) (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.

8 + (1 + 3) = 12

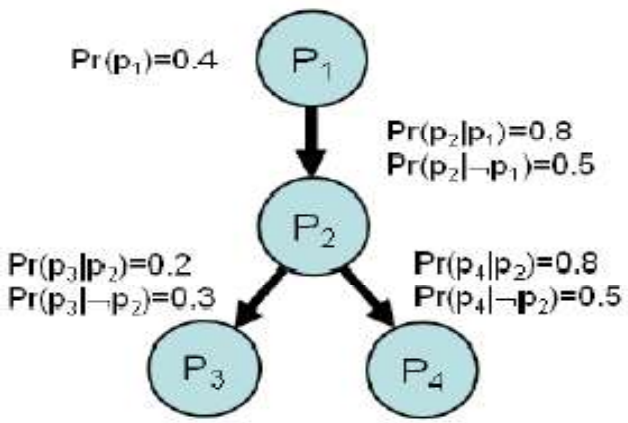
Group – D

6. (a) Consider the following English sentences:
Jack owns a dog.
Every dog owner is an animal lover.
No animal lover kills an animal.
Either Jack or Curiosity killed the cat, who is named Tuna.
Now, answer the following questions:
(i) Translate the given sentences to its equivalent FOPL form
(ii) Apply Resolution method to answer the question "Did Curiosity kill the cat?"

(b) Write a Prolog program to delete an element K from a given list L.

(3 + 6) + 3 = 12

7. (a) Consider the following Bayesian network along with conditional probability values attached:



Now, calculate the marginal and conditional probabilities:
(i) Prob. (¬p3) (ii) Prob. (p2|¬p3)

(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) (iv) support (B)

(4 + 4) + 4 = 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.

(b) In which case do you think roulette wheel selection method of genetic algorithm will not work? Explain your answer.

8 + (1 + 3) = 12

9. (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

(b) Why XOR function can't be implemented using a single layer perceptron?

(c) Consider the following initial and goal state description of blocks world problem:
Initial State: ON (C, A), ON (A, Table), ON (B, Table), Clear (C), Clear (B)
Goal State: ON (A, B), ON (B, C), ON (C, Table), Clear (A)
Apply Goal Stack planning strategy to find the total sequence of actions that could be applied to reach to the goal state from the given initial state. You should define the actions before starting the process.

(2 + 2) + 2 + 6 = 12

Department & Section	Submission link:
CSE A	https://classroom.google.com/c/MTIyMzk2NjkwNjE2/a/Mjc0NDMxMzU1ODk0/details
CSE B	https://classroom.google.com/c/MTIyMzk2NjkwNjgz/a/Mjc0NDM1NDQzNDM1/details
CSE C	https://classroom.google.com/c/MTIyMzk2NjkwNzE0/a/Mjc0NDM1NDQzNDcw/details