Course Code : CAT 206 **QVRU/RS – 22 / 1172**

Fourth Semester B. Tech. (Computer Science and Engineering / Artifical Intelligence and Machine Learning) Examination

ARTIFICIAL INTELLIGENCE : PRINCIPLES AND TECHNIQUES

Time : 3 Hours] [Max. Marks : 60

Instructions to Candidates :—

(1) All questions are compulsory.
(2) All questions carry marks as indicated.
(3) Explain your answer with neat sketches, wherever applicable.

1. (a) Formulate 8-puzzle problem as search : i.e. give a state space representation, start state, goal state and operators. Also draw the search tree upto depth 2. 5 (CO 1)

   (b) Give the initial state, goal test, successor function (operators) and cost function (path cost) for each of the following :—

      (i) You have to color a planar map using only four colors, in such a way that no two adjacent regions have the same color.

      (ii) A 3-foot-tall monkey is in a room where some bananas are suspended from the 8-foot ceiling. He would like to get the bananas. The room contains two stackable, movable, climbable 3-foot-high crates. 5 (CO 1)

2. (a) Give the algorithm for breadth first search. Use BFS to solve 3-water jug problem. 5 (CO 1)

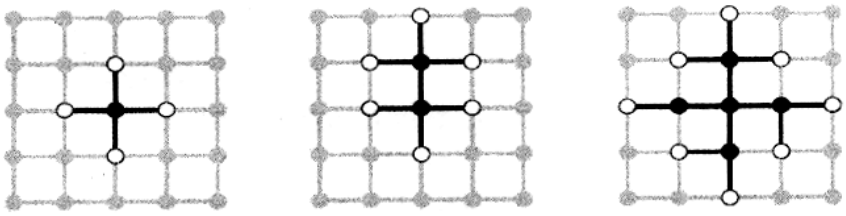
   (b) What is the maximum number of nodes generated in the following searching algorithms with branching factor of b and depth d ?

      (a) Depth limited DFS with depth d.

      (b) Iterative Deepening Search (IDS).

   What are the total numbers of nodes generated for $b = 6$ and $d = 8$? 5 (CO 1)

3. (a) Consider the unbounded version of the regular 2D grid shown in the below Figure. The start state is at the origin, (0, 0), and the goal state is at (x, y).



(a) (b) (c)

The separation property of GRAPH-SEARCH, illustrated on a rectangular-grid problem. The frontier (white nodes) always separates the explored region of the state space (black nodes) from the unexplored region (gray nodes). In (a), just the root has been expanded. In (b), one leaf node has been expanded. In (c), the remaining successors of the root have been expanded in clockwise order.

(i) What is the branching factor b in this state space ?

(ii) How many distinct states are there at depth k (for $k > 0$) ?

(iii) Is $h = |u - x| + |v - y|$ an admissible heuristic for a state at (u, v) ? Explain. 3 (CO 1)

(b) Determine two heuristic functions for the problem such that it works on the following example where the numbers are pushed into a 3×3 grid from left to right starting at top :—

Start here : 1, 2, 3, 5, 8, 6, 4, 7

Goal state : 1, 2, 3, 4, 5, 6, 7, 8. 4 (CO 1)

(c) Explain the drawbacks of the Hill Climbing algorithms. Also propose possible remedies over them. 3 (CO 1)

4. (a) Consider a Latin sequence problem where no two letters will have same value and value for each letter ranges between 0 to 9. If the equation is CROSS + ROAD = DANGER.

What is a value of D + A + N + G + E + R ? 5 (CO 2)

(b) Explain with an example the significance of using alpha - beta pruning w.r.t. min - max strategy in two player game. 5 (CO 2)

5. (a) Consider a first-order logical knowledge base that describes worlds containing people, songs, albums (e.g., "Meet the Beatles") and disks (i.e., particular physical instances of CDs). The vocabulary contains the following symbols :—

CopyOf (d, a) : Predicate. Disk d is a copy of album a.

Owns (p, d) : Predicate. Person p owns disk d.

Sings (p, s, a) : Albuma includes a recording of song s sung by person p.

Wrote (p, s) : Person p wrote song s.

McCartney, Gershwin, BHoliday, Joe, EleanorRigby, TheManILove,

Revolver : Constants with the obvious meanings.

Express the following statements in first-order logic :—

(i) Every song that McCartney sings on Revolver was written by McCartney.

(ii) Gershwin did not write any of the songs on Revolver.

(iii) Every song that Gershwin wrote has been recorded on some album. (Possibly different songs are recorded on different albums.)

(iv) There is a single album that contains every song that Joe has written.

(v) Joe owns a copy of an album that has Billie Holiday singing "The Man I Love." 5 (CO 3)

(b) This exercise uses the function MapColor and predicates In(x, y), Borders(x, y), and Country(x), whose arguments are geographical regions, along with constant symbols for various regions. In each of the following we give an English sentence and a number of candidate logical expressions. For each of the logical expressions, state whether it (1) correctly expresses the English sentence ; (2) is syntactically invalid and therefore meaningless; or (3) is syntactically valid but does not express the meaning of the English sentence.

(1) Paris and Marseilles are both in France.

(i) In(Paris $\wedge$ Marseilles, France).

(ii) In(Paris, France) $\wedge$ In(Marseilles, France).

(iii) In(Paris, France) $\vee$ In(Marseilles, France).

(2) There is a country that borders both Iraq and Pakistan.

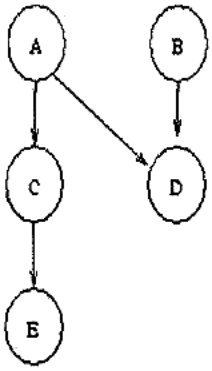
(i) $\exists c$ Country(c) $\wedge$ Border (c, Iraq) $\wedge$ Border (c, Pakistan).

(ii) $\exists c$ Country(c) $\Rightarrow$ [Border (c, Iraq) $\wedge$ Border (c, Pakistan)].

(iii) [$\exists c$ Country(c)] $\Rightarrow$ [Border (c, Iraq) $\wedge$ Border (c, Pakistan)].

(iv) $\exists c$ Border (Country(c), Iraq $\wedge$ Pakistan). 5 (CO 3)

6. (a) Consider the following Bayesian network. Suppose that the net further records the following probabilities :



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
Prob(E=T | C=T) = 0.7
Prob(E=T | C=F) = 0.2

Compute P(D), P(A | C), and P(~D | C)

5 (CO 4)

(b) How basic operations union, intersection and set difference are defined in terms of membership functions on fuzzy sets. Explain with proper example. 5 (CO 4)