INTRODUCTION TO ARTIFICIAL INTELLIGENCE
(CSEN 3104)

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**

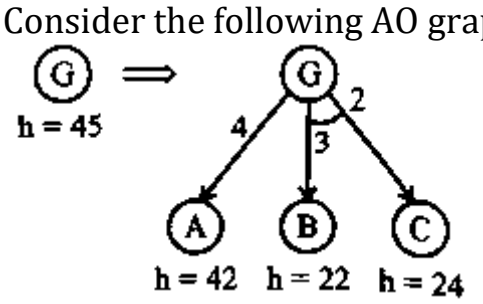
Choose the correct alternative for the following

(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) Which of the following best describes the propositional sentence P ∨ ¬P?
(a) Contradiction (b) Valid
(c) Equivalence (d) Logical consequence.

(iii) A heuristic h1 is said to dominate heuristic h2, if at any node n
(a) h1 (n) > h2 (n) (b) h1 (n) < h2 (n)
(c) h1 (n) ≥ h2 (n) (d) h1 (n) ≤ h2 (n)

(iv) Consider the following AO graph. Which is the best node to expand next by AO* algorithm?



(a) B (b) C (c) A (d) B and C

(v) If an admissible heuristic is adapted in an algorithm (for example in A* search algorithm), then this algorithm
(a) will eventually find an optimal solution to the goal
(b) might not find an optimal solution to the goal
(c) will run slowly
(d) will get stuck to wrong solution

(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) Consider the following PROLOG clauses:

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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).
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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

(viii) human(x)→mortal(x) is equivalent to
(a) ¬human(x)∨ ¬mortal(x) (b) ¬human(x)∨mortal(x)
(c) human(x)∨ ¬mortal(x) (d) All the above

(ix) The metric that measures the fraction of relevant instances among the retrieved instances, is called
(a) Recall (b) Accuracy (c) Precision (d) F-measure

(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) In _____ planning, actions are partially ordered, meaning only the necessary precedence constraints are imposed.

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

(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

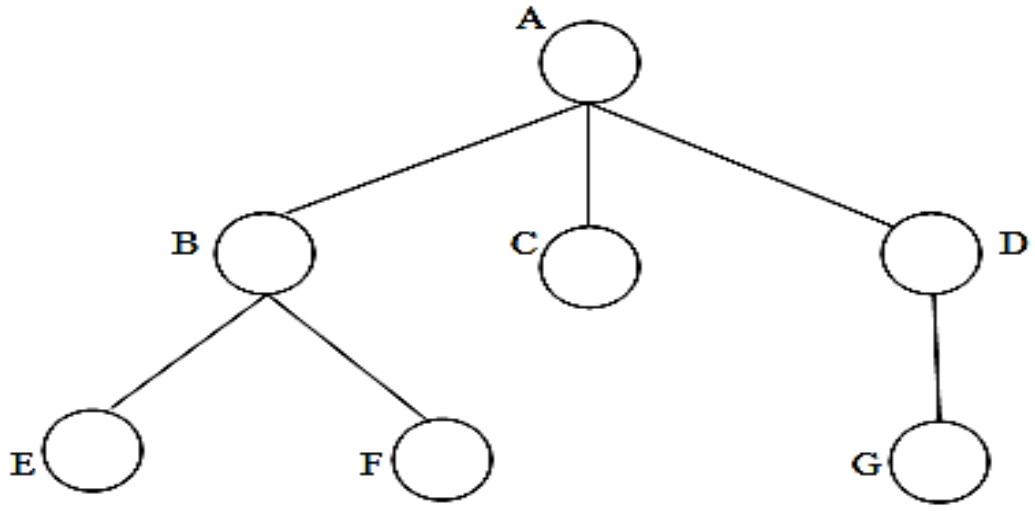
2. (a) Define a state-space representation of a problem. *[(CSEN 3104.1)(Remember/LOCQ)]*

(b) Consider the following problem:
There is a village consisting of 3 pair-bonded couples that straddles 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 is 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 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 to the states and also mention the precondition of those operators.
(iii) How many river crossings are required for n-couple transfers? *[(CSEN 3104.1)(Apply/IOCQ)]*

(c) State Modus Ponens inference rule.
"Modus ponens is a special case of resolution" – justify the statement. *[(CSEN 3104.2)(Remember/LOCQ)(Analyze/ IOCQ)]*

2 + (2 + 3 + 2) + (1 + 2) = 12

3. (a) Consider the following state space:



Apply DFS algorithm on the above search space to find the path from A to G. *[(CSEN 3104.4)(Apply/IOCQ)]*

(b) Compare between simple reflex agents and goal based agents. *[(CSEN 3104.1)(Understand/LOCQ)]*

(c) Consider the following propositional sentence:
$(P \wedge Q) \rightarrow R$
Convert the above sentence into its equivalent CNF clauses. *[(CSEN 3104.3)(Apply/IOCQ)]*

6 + 4 + 2 = 12

Group - C

4. (a) (i) When do you call a heuristic to be consistent?

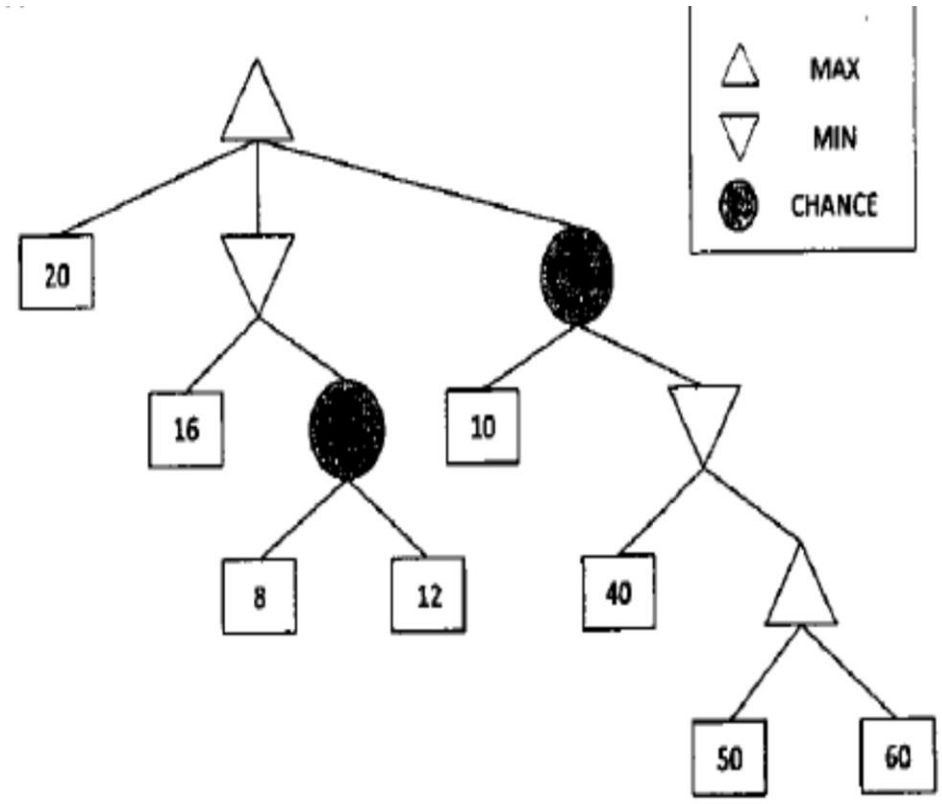
(ii) If a heuristic h is consistent, then prove that $h(n) \leq c(n, n') + h(n')$ is applicable for any descendant n' of n.

[(CSEN 3104.4)(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.

[(CSEN 3104.6)(Evaluate/HOCQ)]

(c) Consider the following game tree which contains MAX nodes, MIN nodes and chance nodes:

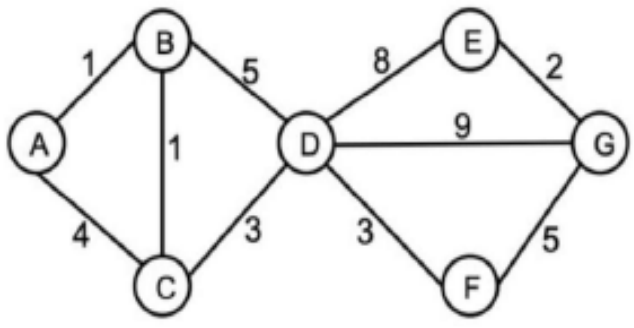


Apply MINIMAX algorithm on the above game tree to find the propagated value at the root node if each outcome of the chance nodes is equally likely.

[(CSEN 3104.4)(Apply/IOCQ)]

(1 + 4) + 3 + 4 = 12

5. (a) Consider the state space graph shown below. A is the start state and G is the goal state. The costs for each edge are shown on the graph. Each edge can be traversed in both directions. Note that the heuristic h_1 is monotonic but the heuristic h_2 is not monotonic.



Node	h_1	h_2
A	9.5	10
B	9	12
C	8	10
D	7	8
E	1.5	1
F	4	4.5
G	0	0

For each of the following graph search strategies, examine which, if any, of the listed paths it could return. Write Yes / No in the table accordingly. Note that for some search strategies the specific path returned might depend on tie-breaking behaviour. In any such cases, make sure to write Yes in all the boxes corresponding to paths that could be returned under some tie-breaking scheme. Show the detailed steps in each case.

Search Algorithm	A-B-D-G	A-B-C-D-F-G
A* search with heuristic h_1		
A* search with heuristic h_2		

[(CSEN 3104.4)(Apply, Analyze/IOCQ)]

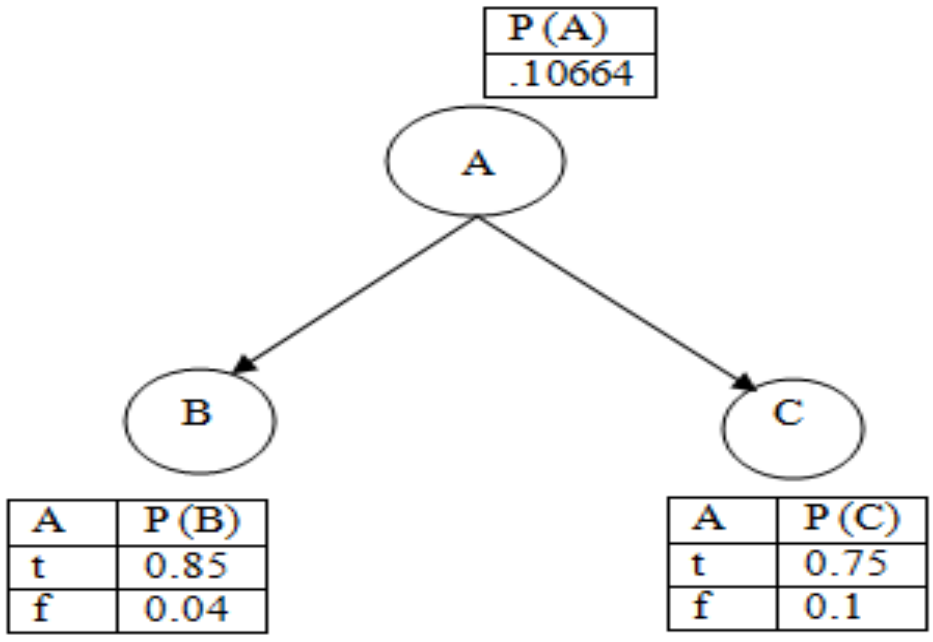
(b) Define Constraint Satisfaction Problem (CSP). *[(CSEN 3104.1)(Remember/LOCQ)]*

10 + 2 = 12

Group - D

6. (a) Given the following facts & rules as a knowledge base:
A1. If X is on top of Y, Y supports X
A2. If X is above Y and they are touching each other, X is on top of Y.
A3. A cup is on a book
A4. A cup is touching a book
(i) Translate these sentences into CNF form
(ii) Show by using resolution that the predicate 'supports (book, cup)' is true
(iii) Write a PROLOG program to show that SUPPORTS (book, cup) is true using A1 to A4. *[(CSEN 3104.3)(CSEN3104.5)(Apply/IOCQ)]*

(b) Consider the following Bayesian Network containing 3 Boolean random variables:



Compute the following quantities:
(i) p (~B, C | A) (ii) p (A | ~B, C)

[(CSEN 3104.3)(Apply/IOCQ)]
(3 + 4 + 2) + 3 = 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=T) = 0.2
Now, compute the following:
1) prob(D=T)
2) prob(D=F,C=T)

[(CSEN 3104.3)(Apply/IOCQ)]

(b) Define a fuzzy relation. *[(CSEN 3104.3)(Remember/LOCQ)]*

(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', ∀x ∈ X, ∀y ∈ Y *[(CSEN 3104.3)(Apply/IOCQ)]*

(2 + 5) + 2 + 3 = 12

Group - E

8. (a) Discuss the significance of crossover operation in the implementation of genetic algorithm and its convergence.
[(CSEN 3104.4)(Understand/LOCQ)]

(b) "Artificial Neural Network can be used as a classifier" – Give proper explanation against this statement.
[(CSEN 3104.4)(Analyze/IOCQ)]

6 + 6 = 12

9. (a) Create a decision tree by using the following given dataset that identifies the gender of a person. A person is characterized by the factors like, Height, Eye and Hair length. Use entropy as the impurity measure while creating the Decision Tree.

Sl. No	Height Over 170CM	Eye	Hair length	Gender
1	No	Blue	Short	Male
2	Yes	Brown	Long	Female
3	No	Blue	Long	Female
4	No	Blue	Long	Female
5	Yes	Brown	Short	Male
6	No	Blue	Long	Female
7	Yes	Brown	Short	Female
8	Yes	Blue	Long	Male

[(CSEN 3104.4)(Apply/IOCQ)]

(b) Differentiate between supervised and un-supervised learning techniques. *[(CSEN 3104.1)(Remember/LOCQ)]*

10 + 2 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	19.78	77.08	3.12