# ARTIFICIAL INTELLIGENCE
## (CSE3141)

**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) An 'agent' is anything that
(a) perceives its environment through sensors and acting upon that environment through actuators
(b) takes input from the surroundings and uses its intelligence and performs the desired operation
(c) an embedded program controlling line following robot
(d) All of the above

(ii) In a complex decision-making environment, propositional logic fails to capture all knowledge. What is the primary limitation?
(a) Syntax too complex
(b) Cannot represent uncertainty and relations
(c) Too slow for inference
(d) Requires neural networks

(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 is true regarding the heuristic measure used in IDA* algorithm -
(a) It is used to determine the order of the selection of the nodes for expansion
(b) It is used to check the depth cut-off
(c) It is of no use
(d) None of these

(v) A delivery robot uses A* search to plan the shortest path in a warehouse. The heuristic function h(n) sometimes overestimates the distance to the goal. What is the most likely outcome?
(a) The search will still find the optimal solution but more slowly
(b) The search may fail to find any solution
(c) The search may find a suboptimal solution
(d) The search will run faster but use more memory

(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) 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

(viii) 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

(ix) 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

(x) How the decision tree reaches its decision?

(a) Single test (b) Two test

(c) Sequence of tests (d) No test

*Fill in the blanks with the correct word*

(xi) In a decision tree, a homogeneous split should have _____ degree of purity.

(xii) A formula is said to be valid if _____ _____.

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

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

(xv) The _____ test is a behavioural criterion used to assess if a machine can exhibit intelligent behaviour indistinguishable from a human.

## Group - B

2. (a) Consider the water-jug puzzle, where we are given a 3-litre jug, named THREE, and a 4-litre jug, named FOUR. Initially, both THREE & FOUR are empty. Either jug can be filled with water from a tap,T, and we can discard water from either jug down a drain, D. Water may be poured from one jug into the other. There is no additional measuring device. We want to find a set of operations that will leave precisely two litres of water in FOUR.

(i) Give the state-space representation of the problem by mentioning the initial state, goal state, possible operators and the pre-condition of the operators.

(ii) Provide at-least one solution of the given problem following the same state-space representation given at part (i).

[(CO1) (Apply/IOCQ)]

(b) Consider the following set of propositional sentences:

1. $p \vee q$, 2. $p \rightarrow r$ 3.$q \rightarrow r$

Apply resolution theorem to prove the goal 'r'.

[(CO3) (Apply/IOCQ)]

**(6 + 2) + 4 = 12**

3. (a) State one limitation of uniform cost search when applied to real-world navigation problems. [(CO4) (Understand/IOCQ)]

(b) A detective AI must infer the culprit based on logical clues:

- "If the butler was in the kitchen, then the maid was in the garden."
- "The maid was not in the garden."

Use resolution in propositional logic to infer the butler's location. [(CO2) (Analyze/LOCQ)]

(c) An AI-based online shopping recommender is criticized for bias. It recommends expensive products more often, ignoring customer budget constraints. Discuss how utility-based agents and knowledge representation improvements can make the system fairer.

[(CO2) (Evaluate/IOCQ)]

**4 + 4 + 4 = 12**

## Group - C

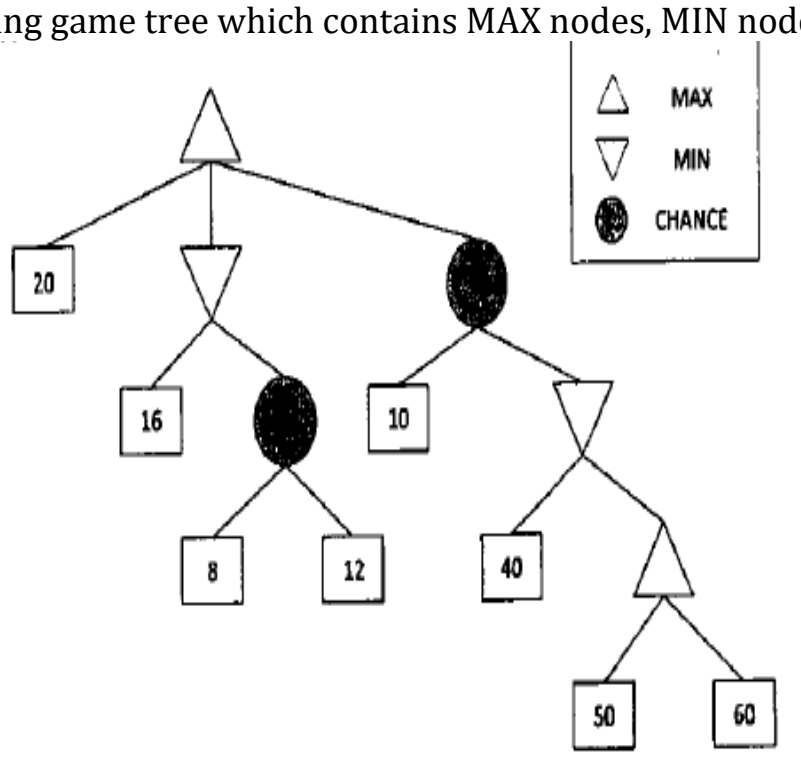
4. (a) (i) When do you call a heuristic to be consistent?

(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.

[(CO4) (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. [(CO6) (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.

[(CO4) (Apply/IOCQ)]

**(1 + 4) + 3 + 4 = 12**

5. (a) Suppose you are in charge of scheduling of 5 classes that meet on Mondays, Wednesdays and Thursdays.Three professors will be taking those classes. You are constrained by the fact that each professor can only take one class at a time.
Class timings are as follows:
1. OS – 8:30 am to 9:30 am
2. AI – 9:30 am to 10:30 am
3. NLP – 10:30 am to 11:30 am
4. IR – 10:30 am to 11:30 am
5. ML – 11:30 am to 12:30 pm
Details of the 3 professors are as follows:
1. Professor A is available to take the classes of NLP and IR
2. Professor B will take the classes of AI, NLP, ML and IR
3. Professor C is available to take the classes of OS, AI, NLP, ML and IR
Now, answer the following questions:
(i) Formulate the above problem as a CSP problem by mentioning variables, domain of each variable and the constraints. You are also supposed to provide the constraint graph.
(ii) Apply backtracking method along with 'the most constraining variable' as the heuristic to give one solution of the problem. [(CO4) (Apply/IOCQ)]

(b) Prove that the heuristic 'sum of manhattan distances' for the 8-puzzle problem used by A* algorithm is an admissible heuristic. [(CO6) (Analyze/IOCQ)]

**(3 + 4) + 5 = 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?" [(CO3) (Apply/IOCQ)]

(b) Write a PROLOG program to delete an element K from a given list L. [(CO5) (Apply/IOCQ)]

**(3 + 6) + 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=F) = 0.2
Now, compute the following:
1) prob(D=T)
2) prob(D=F,C=T) [(CO3) (Apply/IOCQ)]

(b) Define a fuzzy relation. [(CO3) (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. [(CO3) (Apply/IOCQ)]

**(2 + 5) + 2 + 3 = 12**

## Group - E

8. (a) Calculate the information gain corresponding to the attributes Weather, Parents and Financial Condition in selecting an attribute to construct (induct) a decision tree in from the data provided in the following table. Also mention the attribute you will select based on the calculated information gain in each and every step. Consider the attribute 'Decision' as the class label.

| *Weekend* | *Weather* | *Parents* | *Financial Condition* | *Decision* |
|---|---|---|---|---|
| W1 | Sunny | Yes | Rich | Cinema |
| W2 | Sunny | No | Rich | Play Tennis |
| W3 | Windy | Yes | Rich | Cinema |
| W4 | Rainy | Yes | Poor | Cinema |
| W5 | Rainy | No | Poor | Stay in |
| W6 | Rainy | Yes | Poor | Cinema |
| W7 | Windy | No | Poor | Cinema |
| W8 | Windy | No | Rich | Shopping |
| W9 | Windy | Yes | Rich | Cinema |
| W10 | Sunny | No | Rich | Play Tennis |

[(CSEN3141.4)(Apply/IOCQ)]

(b) Explain in brief the working principle of Goal Stack Planning. [(CO1) (Remember/IOCQ)]

**9 + 3 = 12**

9. (a) A hospital is deploying an expert system for cancer diagnosis. Doctors express concerns about bias and explainability.
(i) Identify two sources of bias in expert system development.
(ii) Suggest strategies to ensure fairness and explainability.
(iii) Discuss how knowledge representation choice (e.g., rules vs. semantic networks) influences transparency.
[(CO2) (Evaluate/IOCQ)]

(b) A robot must make a cup of tea in a kitchen: boil water, put a teabag in a cup, pour water, and add sugar. The order of "add sugar" and "pour water" does not matter.
(i) Explain how partial-order planning solves this problem more efficiently than total-order planning.
(ii) Why is this important for real-world autonomous systems? [(CO1) (Analyze/IOCQ)]

**(3 + 3 + 2) + (2 + 2) = 12**

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| Cognition Level | LOCQ | IOCQ | HOCQ |
|---|---|---|---|
| Percentage distribution | 6.25 | 90.62 | 3.13 |