CBCS SCHEME

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Fifth Semester B.E./B.Tech. Degree Examination, Dec.2024/Jan.2025
Artificial Intelligence

Time: 3 hrs. Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. M : Marks , L: Bloom's level , C: Course outcomes.

		Module – 1	M	L	C
Q.1	a.	Define the following : i) Intelligence ii) Artificial Intelligence iii) Agent iv) Rationality v) Logical reasoning.	5	L2	CO1
	b.	Examine the AI literature to discover whether the following tasks can currently be solved by computers. i) Playing a decent game of table tennis (ping-pong) ii) Discovering and proving new mathematical theorems iii) Giving competent legal advice in a specialized area of law iv) Performing a complex a surgical operation.	8	L2	CO1
	c.	Implement a simple reflex agent for the vacuum environment. Run the environment with this agent for all possible initial dirt configurations and agent locations. Record the performance score for each configuration and the overall score.	7	L3	CO1
		OR			
Q.2	a.	Is AI a science, or is it engineering or neither or both? Explain.	5	L2	CO1
	b.	Write pseudocode agent programs for the goal based and utility based agents.	8	L1	CO1
	c.	For each the following activities give a PEAS description. i) Playing a tennis match ii) Performing a high jump iii) Bidding on an item in an auction.	7	L1	CO1
		Module – 2			
Q.3	a.	Explain why problem formulation must follow goal transformation.	5	L1	CO1
	b.	Give complete problem formulation for each of the following choose a formulation that is precise enough to be implemented. i) Using only four colors, you have to color a planar graph 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, moveable, climbable 3-foot high crates.	8	L2	CO2
	c.	Prove each of the following statements or given counter example : i) Breadth – first search is a special case of uniform – cost search. ii) Uniform – cost search is a special case of A^* search.	7	L2	CO2

		OR			
Q.4	a.	Define the following terms with example. i) State space ii) Search node iii) Transition model iv) Branching factor.	8	L2	CO2
	b.	Show that the 8-puzzle states are divided in to two disjoint sets, such that any state is reachable from any other state in the same set, while no state is reachable from any state in the other set. Devise a procedure to decide which set a given state is in and explain why this is useful for generating random state.	7	L2	CO2
	c.	Describe a state space in which iterative deepening search performs much worse than depth first search for example, $O(n^2)$Vs $O(n)$).	5	L2	CO2
		Module – 3			
Q.5	a.	Devise a state space in which A^* using GRAPH-SEARCH returns a suboptimal solution with h(n) function that is admissible but inconsistent.	7	L2	CO3
	b.	Which of the following are correct? i) $(A \vee B) \wedge (\neg C \vee \neg D \vee E) F (A \vee B)$ ii) $(A \vee B) \wedge (\neg C \vee \neg D \vee E) F (A \vee B) \wedge (\neg D \vee E)$ iii) $(A \vee B) \wedge \neg(A \Rightarrow B)$ is satistiable iv) $(A \Leftrightarrow B) \Leftrightarrow C$ has the same number of models as $(A \Leftrightarrow B)$	8	L1	CO3
	c.	Consider a vocabulary with only four propositions, A, B, C and D. How many models are there for the following sentences? i) $B \vee C$ ii) $\neg A \vee \neg B \vee \neg C \vee \neg D$ iii) $(A \Rightarrow B) \wedge A \wedge \neg B \wedge C \wedge D$.	5	L1	CO3
		OR			
Q.6	a.	Prove that if a heuristic is consistent, it must be admissible. Construct an admissible heuristic that is not consistent.	8	L1	CO3
	b.	Prove each of the following assertions : i) $\alpha \equiv \beta$ if and only if the sentence $(\alpha \Leftrightarrow \beta)$ is valid ii) $\alpha \neq \beta$ if and only if the sentence $\alpha \wedge \neg\beta)$ is unsatisfiable.	7	L1	CO3
	c.	Prove, or find a counter example to each of the following assertions. i) If $\alpha \neq (\beta \wedge \gamma)$ then $\alpha \neq \beta$ and $\alpha \neq \gamma$ ii) If $\alpha \neq (\beta \vee \gamma)$ then $\alpha \neq \beta$ and $\alpha \neq \gamma$ (or) both	5	L1	CO3
		Module – 4			
Q.7	a.	Which of the following are valid necessary true sentences? i) $(\exists x\, x = x) \Rightarrow (\forall y \exists z\, y = z)$ ii) $\forall x\, P(x) \vee \neg p(x)$ iii) $\forall x$ smart(x) $\vee (x = x)$	7	L1	CO4
	b.	Prove that universal Instantiation is sound that existential instanticition produces an inferentially equivalent knowledge base.	5	L1	CO4

	c.	Write down logical representations for the following sentences, suitable for use with generalized modulus ponens : i) Horses, cows and pigs are mammals ii) Bluebeard is Charlie's parent iii) Offspring and parent are inverse relations	8	L1	CO4
		OR			
Q.8	a.	Consider a knowledge base containing just two sentence ; P(a) and P(b) does this knowledge base entail $\forall x\, P(x)$? Explain your answer interms of models.	5	L2	CO4
	b.	Suppose a knowledge base contains just one sentence, $\exists x AsHighAs(x, Everest)$ which of the following are legitimate results of applying existential instantiation? i) AsHighAs(Kilimanjaro, Everest) ii) AsHighAs(Kilimanjaro, Everest) $\wedge$ AsHighAs (Benvevis, Everest)	8	L2	CO4
	c.	Explain how to write any 3-SAT problem of arbitrary size using a single first order definite clause and no more than 30 ground facts.	7	L2	CO4
		Module – 5			
Q.9	a.	i) Give a backward chaining proof of the sentence $7 \leq 3 + 9$. Show only the steps that leads to success ii) Give a forward chaining proof of the sentence $7 \leq 3 + 9$. Show only the steps that leads to success.	8	L1	CO5
	b.	Describe the differences and similarities between problem solving and planning.	5	L2	CO5
	c.	Prove that backward search with PDDL problems is complete.	7	L1	CO5
		OR			
Q.10	a.	The following prolog code defines a predicate P P(x, [x|y]), P(x, [y|z]) :- P(x, z) i) Show proof trees and solutions for the queries P(A, [2, 1, 3]) and P(z,[1, A, 3]) ii) What standard list operation does P represent?	8	L1	CO5
	b.	Explain why dropping negative effects from every action schema in a planning problem results in a relaxed problems.	5	L2	CO5
	c.	Prove the following assertions about planning graphs : i) A literal that does not appear in the final level of the graph connot be achieved. ii) The level cost of a literal in a serial graph is no greater than the actual cost of an optimal plan for achieving it.	7	L1	CO5

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ARTIFICIAL INTELLIGENCE – BCS515B

FIFTH SEMESTER B.E. EXAMINATION, DEC 2024/JAN2025

VTU EXAM SOLUTION

Module-1

Q1a. Define the following:
i) Intelligence
ii) Artificial Intelligence
iii) Agent
iv) Rationality
v) Logical reasoning

- **Intelligence**: The ability to perceive, understand, and apply knowledge to solve problems and adapt to new situations.
- **Artificial Intelligence (AI)**: The field of study focused on building systems that exhibit intelligence similar to human reasoning and learning.
- **Agent**: An entity that perceives its environment through sensors and acts upon it using actuators.
- **Rationality**: The quality of making decisions that maximize expected utility given available information.
- **Logical reasoning**: The process of deriving conclusions from premises using formal logic.

Q1b. Examine the AI literature to determine whether the following tasks can currently be solved by computers.
i) Playing a decent game of table tennis (ping-pong)
ii) Discovering and proving new mathematical theorems
iii) Giving competent legal advice in a specialized area of law
iv) Performing a complex surgical operation

- **Playing a decent game of table tennis (ping-pong):**
  AI has demonstrated competence in playing table tennis through deep reinforcement learning and robotic systems. Systems like the Omron Forpheus robot utilize sensors and AI algorithms to track ball movement, predict trajectories, and respond effectively. However, AI lacks human-like adaptability and intuition in real-time play against skilled opponents.
- **Discovering and proving new mathematical theorems:**
  AI tools like DeepMind's AlphaTensor and The Lean Mathematical Library have contributed to theorem discovery and proof automation. AI can generate new mathematical insights, assist in proving conjectures, and verify complex proofs. However, AI still struggles with creative intuition and deep abstract reasoning required for groundbreaking discoveries.
- **Giving competent legal advice in a specialized area of law:**
  AI-driven legal assistants, such as ROSS Intelligence and IBM Watson, analyze legal documents and provide case law references. These systems can assist in legal research and contract analysis. However, AI lacks the nuanced understanding of ethics, precedent interpretation, and argumentation required for complex legal cases, making human expertise indispensable.

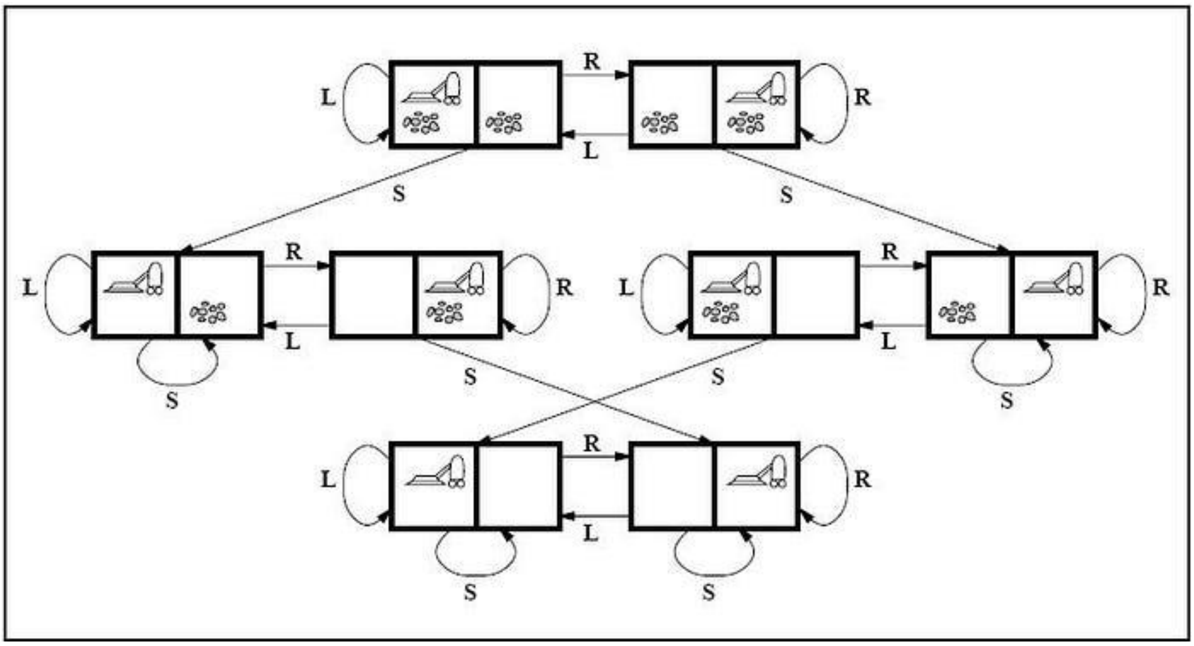
- **Performing a complex surgical operation:**
  AI-assisted robotic surgery, such as the Da Vinci Surgical System, enhances precision and minimizes human error in procedures like laparoscopy. Machine learning models analyze patient data to assist surgeons in decision-making. However, full autonomy in complex surgeries is not yet feasible due to the need for adaptive decision-making, ethical considerations, and real-time complication management.

Q1c. Implement a simple reflex agent for the vacuum environment.

Percept:
The vacuum cleaner's sensors detect the current state of the environment, which includes information about whether a particular location is dirty or clean.
Action:
If the current location is dirty, the vacuum cleaner performs the "suck" action to clean the area. If the current location is clean, the vacuum cleaner moves to the next location.
Rule:

- "If the current location is dirty, then suck." "If the current location is clean, then move to the next location." This simple reflex agent operates based on a direct mapping between percept and action.
- It doesn't have memory or the ability to learn from past experiences. Its decision-making is determined solely by the immediate state of the environment.
- While this basic model may work for scenarios with a limited and predictable environment (e.g., a small room with known dirt locations), more sophisticated AI techniques, such as model-based or learning-based approaches, might be necessary for complex environments where the state is dynamic and uncertain. Additional variables and parameters are required for larger and more complex scenarios.

Case:
Room A and Room B are Dirty, and initially, an agent is inside Room A. There are 2 rooms so we would have 4 cases of dirt and clean and 8 possible states for an agent.
A vacuum cleaner as a simple reflexive AI intelligent agent
Scenario and States:



Q2a. Is AI a science, engineering, neither, or both? Explain.

AI is both a science and engineering discipline as it studies intelligent behavior while building intelligent systems.

- **Science**: AI seeks to understand intelligence itself, developing theories and principles about cognition, learning, and reasoning. It involves mathematical models, algorithms, and formal logic to study problem-solving and decision-making.
- **Engineering**: AI applies scientific principles to build intelligent systems that solve real-world problems, such as self-driving cars, medical diagnosis tools, and chatbots. It involves programming, data structures, and computational efficiency.

Thus, AI combines theoretical exploration (science) with practical application (engineering) to create intelligent systems.

Q2b. Write pseudocode for agent programs for goal-based and utility-based agents.

Goal-based agent program

```
function GOAL-BASED-AGENT(percept) returns an action
  persistent: state, the agent's current conception of the world state
              goal, a description of what the agent would like to achieve
              rules, a set of condition-action rules
              action, the most recent action, initially none

    state ← UPDATE-STATE (state, action, percept, goal)

    rule  ← RULE-MATCH (state, rules, goal)

    action ← rule.ACTION

 return action
```

Utility based agent program

function UTILITY-BASED-AGENT(*percept*) **returns** an action
persistent: *state,* the agent's current conception of the world state
possible states, possible states that may maximize happiness
rules, a set of condition-action rules
action, the most recent action, initially none

state ← UPDATE-STATE (*state, action, percept, possible states*)

rule ← RULE-MATCH (*state, rules, possible states*)

action ← *rule*.ACTION

return *action*

Q2c. For each of the following activities, give a PEAS description:
i) Playing a tennis match
ii) Performing a high jump
iii) Bidding on an item in an auction

Playing a Tennis Match

- **Performance Measure**: Winning the match, accuracy of shots, endurance.
- **Environment**: Tennis court, opponent, ball, net, weather conditions (for outdoor matches).
- **Actuators**: Racket movement, footwork, body coordination.
- **Sensors**: Vision (to track the ball and opponent), motion tracking (for positioning and timing).

Performing a High Jump

- **Performance Measure**: Jump height, clearance over the bar, proper landing technique.
- **Environment**: Track & field stadium, jumping surface, bar height.
- **Actuators**: Leg muscles (for jumping), arms (for balance), body posture control.
- **Sensors**: Body position awareness, muscle feedback, vision (to judge the bar's height and position).

Bidding in an Auction

- **Performance Measure**: Profit maximization, winning the bid at the lowest price.
- **Environment**: Online auction platform or physical auction, competing bidders.
- **Actuators**: Bidding system (for placing bids), decision-making algorithms.
- **Sensors**: Market analysis tools, price trends, competitor activity monitoring.

- **Playing a tennis match**: (Performance: Winning, Environment: Tennis court, Actuators: Racket, Sensors: Vision, motion tracking)
- **Performing a high jump**: (Performance: Jump height, Environment: Track & field, Actuators: Legs, Sensors: Body position)
- **Bidding in an auction**: (Performance: Profit maximization, Environment: Online auction, Actuators: Bidding system, Sensors: Market analysis)

Module 2

Q3a. Explain why problem formulation must follow goal transformation.

In goal formulation, we decide which aspects we are interested in and which aspects can be ignored. In the goal formulation process, the goal is to be set and we should assess those states in which the goal is satisfied. In problem formulation, we decide how to manipulate the important aspects, and ignore the others.The agent's task is to find out how to act, now and in the future, so that it reaches a goal state. Before it can do this, it needs to decide (or we need to decide on its behalf) what sorts of actions and states it should consider" (Russell & Norvig, 65). So, without doing goal formulation, if we do the problem formulation, we would not know what to include in our problem and what to leave, and what should be achieved. So problem formulation must follow goal formulation. That means problem formulation must be done only after the goal formation is done.

Goal formulation and problem formulation:

- Goal formulation:
  - This is a technique for an agent to conclude which goals need to be achieved.
  - The most complicated task during goal formulation is to develop representations for agents to reason about and find out when the new goals need to be formulated due to plan failures or opportunities.
- Problem formulation:
  - In this technique, the problem is precisely defined and the definition should also comprise of precise specification of the initial situation as well the final situation with acceptable solutions to the problem.
  - The major step is to select the best problem-solving technique and apply it to the particular problem.
- When it comes to goal formulation, user gets to decide which aspects of the world we are interested in, and which can be ignored or abstracted away.
- In problem formulation, it is decided how to manipulate the important aspects.
- If the problem formulation is performed before goal formation then it is not possible to know what to include and what to exclude.
- There may be a cycle of iterations between goal formulation, problem formulation, and problem solving until one arrives at a sufficiently useful and efficient solution.

Q3b. Give complete problem formulations for each of the following choose a formulation that is precise enough to implemented.

i) Using only four colors, you have to color a planar graph 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. The monkey wants to get the bananas. The room contains two stackable, movable, climbable 3-foot-high crates.

a) Using only four colors, you have to color a planar map in such a way that no two adjacent regions have the same color.

States: Any color on any region is a state.
Initial State: No regions colored. Any region can be the initial state
Actions: Color a region one of the four colors
Transition model: Returns the region with its color and any two adjacent regions cannot be that color.
Goal test: All regions colored, no two adjacent regions have the same color
Path cost: N/A

b) 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.

States: Any combination of the 2 crates in the room, with or without the monkey on them.
Initial State: A 3-foot-tall monkey is in a room with an 8-foot ceiling, does not have the bananas. The location of the crates is unknown, as is the size, and the location of the bananas hanging from the ceiling.
Actions: Move a crate; climb on a crate; stack a crate; unstack a crate; climb down from a crate; grab bananas; monkey can move in any direction.
Transition model: The actions have their expected effects.
Goal test: Monkey has bananas
Path cost: N/A

i) The Four-Color Map Coloring Problem is a classic graph coloring problem. It asks you to color the regions of a planar map using only four colors such that no two adjacent regions share the same color. Below is a detailed problem formulation, precise enough to be implemented in a computational system.

Problem Description:

Given a planar map consisting of regions (countries, states, etc.), color each region using one of four available colors such that:

1. No two adjacent regions share the same color.
2. The goal is to minimize the number of colors used, although the four-color constraint must be adhered to.

Inputs:

- Regions (R): A set of regions, where each region represents an area on the map.
- (R = {R1, R2, R3, …, Rn}), where (n) is the number of regions.
- Adjacency Relations (A): A set of region pairs that represent adjacency between regions. If two regions (Ri) and (Rj) are adjacent, they cannot share the same color.
- (A = {(Ri, Rj) mid Ri) and (Rj) are adjacent}
- Colors ©: A set of four colors.
- (C = {c1, c2, c3, c4})

Output:

- Color Assignment (X): A function (X: R right arrow C) that assigns a color (ck in C) to each region (Ri in R), such that for any two adjacent regions (Ri) and (Rj), (X(Ri) neq X(Rj)).

Constraints:

1. For any pair ((Ri, Rj) in A), (X(Ri) neq X(Rj)). This ensures that adjacent regions do not share the same color.

2. Each region must be colored with one of the four available colors (C).
Objective:
- Assign a valid color to each region such that no two adjacent regions share the same color.
Graph-Based Representation
The problem can be modeled as a graph:
- Nodes: Each region (Ri) is represented as a node in the graph.
- Edges: Each adjacency pair ((Ri, Rj)) is represented as an edge between nodes (Ri) and (Rj).

Graph Coloring Problem:
This reduces the map-coloring problem to the Graph Coloring Problem, where the objective is to assign colors to the nodes of a graph such that no two adjacent nodes have the same color, using only four colors.

Example
Input:
- Regions (R): ({R1, R2, R3, R4})
- Adjacency Relations (A): ({(R1, R2), (R1, R3), (R2, R3), (R3, R4)})
- Colors ©: ({red, green, blue, yellow})

Output:
- Color Assignment (X):
- (X(R1) = red)
- (X(R2) = green)
- (X(R3) = blue)
- (X(R4) = red)

Adjacency Validation:
- (R1) is adjacent to (R2) (red ≠ green, valid).
- (R1) is adjacent to (R3) (red ≠ blue, valid).
- (R2) is adjacent to (R3) (green ≠ blue, valid).
- (R3) is adjacent to (R4) (blue ≠ red, valid).

Q3c. Prove or give a counter example for the following statements:
i) Breadth-first search is a special case of uniform-cost search.
ii) Uniform-cost search is a special case of A* search.

i) Breadth-first search can be viewed as a special case of uniform-cost search by setting step costs to a constant. Both breadth-first, depth-first, and uniform-cost search can be seen as special cases of best-first search when defining f(n) differently for each case. Lastly, uniform-cost search can be seen as a special case of A* search by setting h(n) to 0.

Explanation:
Breadth-first search is indeed a special case of uniform-cost search. This is because if we set the step cost in uniform-cost search to always be 1 (or any constant), it will behave like a breadth-first search. Breadth-first search always explores the fringe nodes based on the shortest path first. Therefore, if all step costs are equal, the selection will be based only upon the order in which nodes are added to the fringe, resulting in a breadth-first behavior.

ii) Uniform-cost search is a special case of A* search. In the A* search, a node n is selected based on the function f(n) = g(n) + h(n), where g(n) is the cost from the starting point to node n, and h(n) is the estimated cost from node n to the goal. When h(n) = 0 for all n (which means there is no knowledge about the distance to the goal), this turns into uniform-cost search, where nodes are selected based solely on g(n).

Q.4 a. Define the following terms with example

i) State space

ii) Search node

iii) Transition model

iv) Branching factor

State space – State space is the environment that the agent is working in. The state space for the vacuum cleaner agent, is the two squares, or the state space for the taxi driver is the roadways that it would travel.

Search node – A search node is part of the search tree, which represents the possible states that are available in the given state space. The diagram in the book on page 76 shows the individual nodes starting at the initial state that would make up a search tree.

Transition model – A transition model tells you the description of what each action would do. In each possible state there is an action that the agent could take, for example with the vacuum cleaner agent, it can move left, or right. So the transition model would show that it is possible for the agent to move left or right, but that it is impossible to move left when it is already in the leftmost square and vice versa.

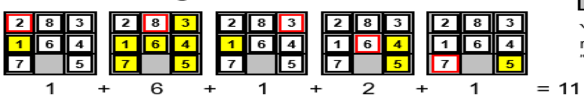
Branching factor – The branching factor is the "maximum number of successors of any node" (Russell & Norvig, 80). So the branching factor deals with the complexity of a tree, and allows you to calculate the number of nodes that would be created and the space and time complexity of the problem.

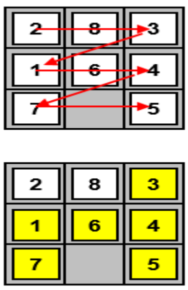
b. Show that the 8-puzzle states are divided into two disjoint sets, such that any state is reachable from any other state in the same set, while no state is reachable from any state in the other set. Devise a procedure to decide which set a given state is in and explain why this is useful for generating random states.

Definition: Define the order of counting from the upper left corner to the lower right corner (see figure).

Let N denote the number of lower numbers following a number (so-called "inversions") when counting in this fashion.

$N = 11$ in the figure.





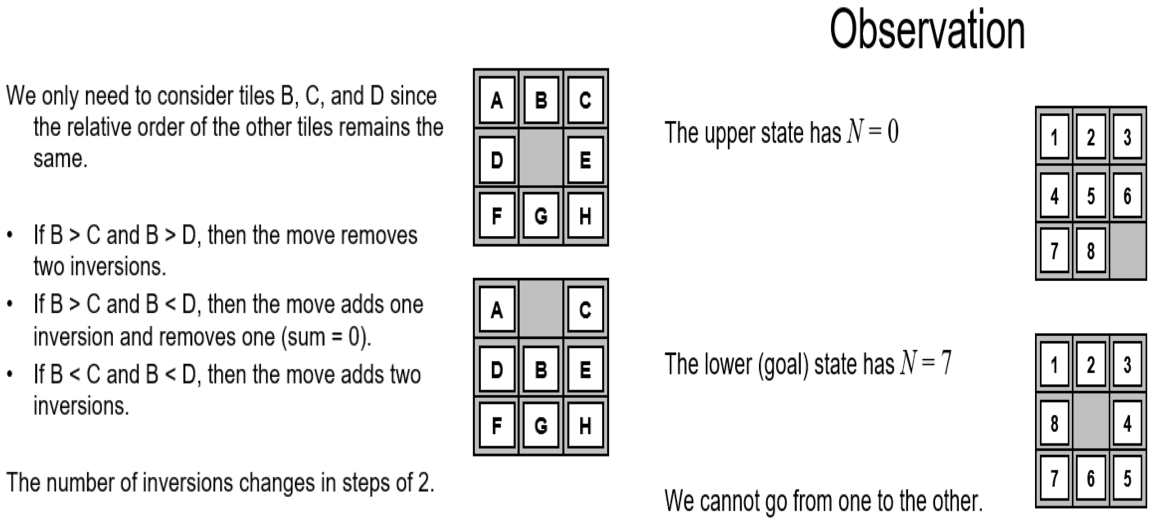
Yellow tiles are inverted relative to the tile with "8" in the top row.

Proposition: N is either always even or odd (i.e. $N \mod 2$ is conserved).

Proof:

(1) Sliding the blank along a row does not change the row number and not the internal order of the tiles, i.e. N (and thus also $N \mod 2$) is conserved.

(2) Sliding the blank between rows does not change $N \mod 2$ either, as shown on the following slide.

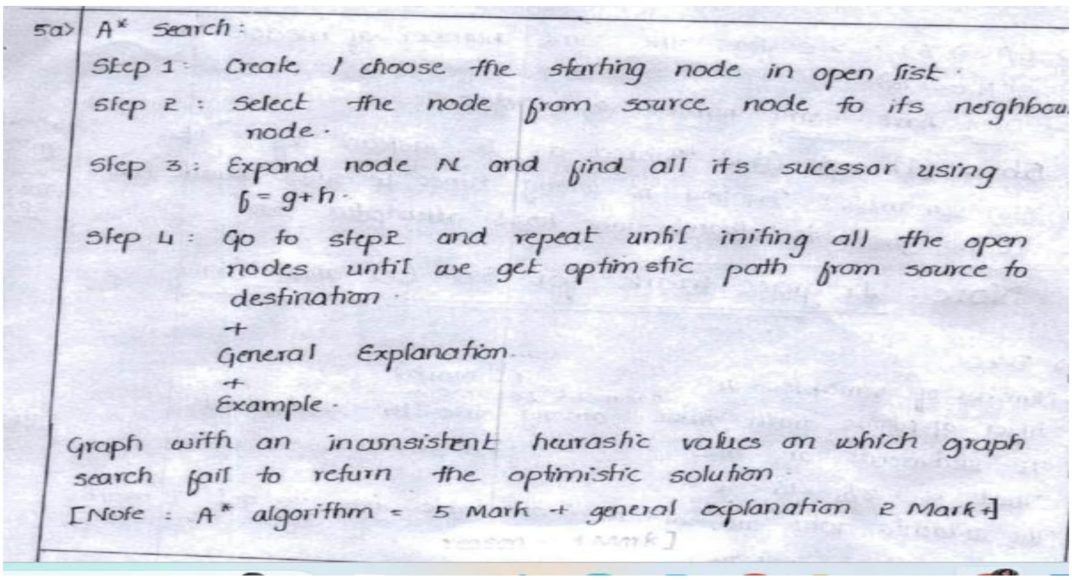


c. Describe a state space in which iterative deepening search performs much worse than depth-first search (for example, $O(n^2)$VsO(n))

If we consider a domain in which every state has one successor, and there is one goal at depth n.
Then depth-first search will find the goal in n steps, whereas iterative deepening search will take
1+2+3+4+5 ... + n = O(n2) steps.

Module - 3

Q.5 a.



5a> A* Search:

Step 1: Create / choose the starting node in open list.

Step 2: Select the node from source node to its neighbou[r] node.

Step 3: Expand node N and find all its sucessor using f = g+h.

Step 4: Go to step2 and repeat until inifing all the open nodes until we get optimistic path from source to destination.

+
General Explanation
+
Example.

Graph with an inconsistent heurastic values on which graph search fail to return the optimistic solution.

[Note: A* algorithm = 5 Mark + general explanation 2 Mark +]

b)

5b) i) $(A \vee B) \wedge (\neg C \vee \neg D \vee E)$ F $(A \vee B)$

- True

ii) $(A \vee B) \wedge (\neg C \vee \neg D \vee E)$ F $(A \vee B) \wedge (\neg D \vee E)$

- False

iii) $(A \vee B) \wedge \neg(A \Rightarrow B)$ is satisfiable

- Satisfied / True both are correct

iv) $(A \Leftrightarrow B) \Leftrightarrow C$ has the same number of models as $(A \Leftrightarrow B)$

- Does have same number of models

5b = (i) and (ii) Printed as F instead as $\models$ (is semantic). Printing is wrong hence 4 grace mark has to be given to student who have attempted 5b

Note: 4 grace mark for 5b (i) and (ii)

C. Consider a vocabulary with only four propositions, A, B, C, and D. How many models are there for the following sentences?

5c) i> B V C

Number of variables = 4   statement possible = $2^4 = 16$ (1 Mark)

After applying truth table among the 16 statement 12 statements are true.

That is $3/4 \times 16 = 12$.

The students who are written truth table has to get 2 marks.

Final result   1 (Mark)

ii> $\neg A \vee \neg B \vee \neg C \vee \neg D$

Number of var

Above statemements is True only when A, B, C, D are ... False

Only the case where it is false when A = B = C = D = True.

This happen in one mode $\therefore$ $16 - 1 = 15$

iii> $(A \Rightarrow B) \wedge A \wedge \neg B \wedge C \wedge D$

$A \Rightarrow B$. B must be true

$A \wedge \neg B \wedge C \wedge D$. for this case leads to False [0]

$\therefore 1 \wedge 0$

$= 0$

Students who have written truth table are also admittable

6a)

Detailed description on heurastic function

$$f(n) = g(n) + h(n)$$

Any general explanation on heurastic function is admissible

+

heurastic function is consistent if the estimated cost from the intial node N to goal state should not be greater than total step cost.

If heurastic function is inconsistent step cost will be overestimated compared to the cost of goal cost

+

Any statement which are related to the above topic is admittable.

6b) It was resolved to give full grace marks since the question was not from the syllabus.

Total Grace Marks = 7.

6c) It was resolved to give full grace marks since the question was not from the syllabus

Total Grace Marks = 5

Moudule-4

7a)

On i> $(\exists x = x) \Rightarrow (\forall y \exists z\, y = z)$

$\Rightarrow$ This expression is always true

[Note: There exist something equal to itself]

$(\forall y \exists z\, y = z)$

$\Rightarrow$ This means every y exist in some of z. Means $y = z$

Both the statement ensure true. Hence Answer is VALID/TRUE

[Students who are written the statement valid has to get 3 Mark]

ii> $\forall x\ P(x) \vee \neg P(x)$

$\Rightarrow$ For every x either p(x) in true or false by law of excluded middle the expression is always TRUE/VALID. 2 Marks

iii> $\forall x$ smart $(x) \vee (x = x)$

$\Rightarrow$ For all x smart(x) is true or false. Since here 'V' operator is used statement is always TRUE/VALID

[Students who are written statement valid has to get 2 Marks]

Universal Instantiation

b)

Universal Instantiation

=> Let SUBST (θ, a) denote the result of applying the substitution θ to the

$$\frac{\forall v a}{SUBST(v/g.\ a)}$$ is written ..

Rule : If something is true for all elements in a domain you can apply it to any specific element.

From : From " $\forall x\, P(x)$ " $P(x)$ is true for all (x)

You can infer " $P(a)$ " for any specific 'a'.

Existential Instantiation (EI) :

In the rule for EI, the variable is replaced by a single new constant symbol.

The formal statement is as follows :

$$\frac{\exists v\ a}{SUBST(\{v/k\} \cdot a)}$$

\+

Any general Explanation can be admitable.

c)

i) Horse (x) → Mammal (x)

Cows (x) → Mammal (x)

Pigs (x) → Mammal (x)

OR $\forall x, y, z$ Horse $(x) \wedge$ Cows$(y) \wedge$ Pigs$(z) \Rightarrow$ Mamals .

ii) Parent (Bluebeard . charlie)

iii) offspring (x . y) → Parent (y . x)

parent (x . y) → offspring (y . x)

8a)

The KB does not entail $\forall x, p(x)$ because there exist models where p(a) and p(b) are true. But p(x) is not true for all x.

Entailment requires that $\forall x, p(x)$ be true in all possible models, which is not guaranteed here

Hence if the student who has written any content / information about knowledge base is admittable.

b)

Existential Instantiation which replace the variable 'x' with specific constants. which implies the existence of atleast one entity / variable. Not necessary of multiple entity / variable. According to that

i> AsHighAs (Kilmanjaro, Everest)

Here $\exists x$ AsHighAs (x, Everest), x is replaced by kilmanjaro.

Hence the statement is legitimate / valid.

[student have written valid / legitimate can get 3marks]

ii> AsHighAs (Kilmanijaro, Everest) $\wedge$ AsHighAs (Benvevi's, Everest)

Here x is replaced by kilmanijaro and Benvevi's which is not possible

Hence the statement is not legitimate / Invalid

[student have written valid / legitimate can get 3 marks].

c)

In order to represent 3-SAT problem of arbitary size can be done by making use of :

i> Single First order clause

ii> No more than 30 ground facts · [understanding 3-SAT problem]

Approach: Three SAT formula is a conjunction of classes where each class has exactly 3 literals ·

Example : (A ∨ ¬B ∨ C) ∧ (¬A ∨ D ∨ ¬E)

Explain the definate classes

Single class with ground fact

4> Encoding the ground facts ·

5> Definate class for satisfaction

6> Thirty facts limitation

Explanation related to above points are admittable ·

[preamble /Introduction = 1 Marks

Remaining 6 points carry 1 Mark]

Module-5

9a)

Incomplete Questions or the axioms are required to solve backward chaining as well as foward chaining .

Note: who are attended this question · 8 marks should be given to student · (Grace Mark - 8)

b)

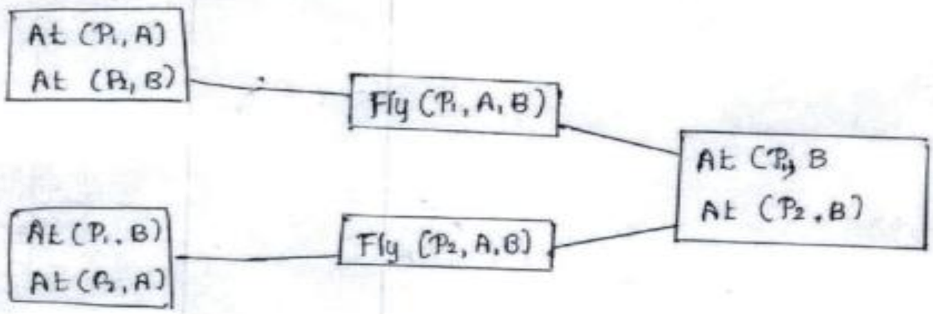
Problem solving	Planning
- Finding the solution - Explorning the state - Explaing the solution	- Determining the sequence of action to reach the desired state.
Goal: To reach desired state.	- Goal: Finding the sequence of action from intial to goal state.
Problem solving approach: It involves searching algorithm BFS, DFS Example: Chess Tic-Tac-Toe.	- Approach: Planning usually required to creat a models. - Example: Robot Moving around the room Any examples can be written.

Related to problem solving and planning any generalized example and explanation are admittable.

c)

PDDL Mainly consists of intial state, goal state and set of operators which can perform an action that leads to transition from one state to another state

Backward Search: In Backward search it start from goal state and work ourway towards intial state, and it finds sequence of action that leads to solution.



Backword Search Diagram

+

Any related general Explanation can be admittable related to figure and topic.

10a)

Solution : P(A , [2 , 1, 3])
|
P(A , [1, 3])
|
P(A, [3])
|
P(A, [A, 1 []])

Solution A = 3

1. Goal : P(2, [1, A, 3])
2. Match Rule 2 : P(x, [Y|z]) : P(x, z)
   - x = 2
   - Y = 1
   - Z = [A, 3]
3. New Goal : P(2, [A, 3])
4. Match Rule 2 : P(x , [Y|z] : - P(x, z)
   - x = 2
   - Y = A
   - Z = [3]
5. New Goal : P (2 , [3])

   No rule matches : The goal P(2, [3]) cannot be satisfied .

Proof Tree :

P(2, [1, A, 3])
|
P(2, [A , 3])
|
P(2, [3])

Solution : No solution .

b)

Dropping Negative Effect :

1) No states are removed : Removing the negative Effect
2) Easier goal Achivement : Simple way to reach the goal
3) Onderestimation : Solution to the Relaxed problem

Suitable Explanation related to above mentioned point can be admittable .

c)

i) : The literal that does not appear in the final graph cannot be achieved.

[suitable Explanation related to above point is admittable]

ii) The level of cost in serial graph is admissible and it never over estimates the true cost.

• [level cost and serial graph estimation has to be written.

[Suitable explanation related to above point is admittable]

NOTE:

Module 3	5 (b)	4 Marks
	6 (b)	7 Marks
	6 (c)	5 Marks
Module 5	9 (a)	8 Marks

The above questions are out of syllabus and grace marks are given to students.