—Best of Luck—

Total No. of Pages :04

Roll No. 2K20/C

SIXTH SEMESTER

B.Tech. [CSE]

MID SEMESTER EXAMINATION *March-2023*

CO304 ARTIFICIAL INTELLIGENCE

Time: 1:30 Hours *Max. Marks: 25*

Note:	Answer *ALL* questions. Assume suitable missing data, if any. CO# is course outcome(s) related to the question. L# is the cognitive level required to solve the question.

Total No. of Pages: 2 *Roll No.....*

VI[TH] SEMESTER B.Tech.(Computer Engineering)

MID SEMESTER EXAMINATION (March, 2020)

CO304 ARTIFICIAL INTELLIGENCE

Paper Code

Time: 1:30 Hours Max. Marks: 25

Note:	Answer all questions. Assume suitable missing data, if any.

Total No. of Pages: 2 *Roll No.....*

VI[TH] SEMESTER B.Tech.(Software Engineering)

MID SEMESTER EXAMINATION (March, 2019)

CO_304 ARTIFICIAL INTELLIGENC

Paper Code

Time: 1:30 Hours Max. Marks: 25

Note:	Answer all questions. Assume suitable missing data, if any.

Total No. of Pages: 2 *Roll No.....*

VI[TH] SEMESTER **B.Tech.(Computer Engineering)**

MID SEMESTER EXAMINATION **(March, 2019)**

CO304 **ARTIFICIAL INTELLIGENCE**

Paper Code

Time: 1:30 Hours **Max. Marks: 25**

Note:	Answer all questions. Assume suitable missing data, if any.

Total Number of Pages 2

Roll No. .....

SEVENTH SEMESTER

B.E.(COE)

MID SEMESTER EXAMINATION ***SEPTEMBER-2010***

COE- 405 ARTIFICIAL INTELLIGENCE

Time : 1 Hour 30 Minutes *Max. Marks : 20*

Note :	Answer *ALL* questions. Assume suitable missing data, if any.

Total No. of Pages:1

Roll No..... 12

SIXTH SEMESTER

B. Tech.

END SEMESTER EXAMINATION

July-2023

CO304 ARTIFICIAL INTELLIGENCE

...0 Hours *Max. Marks: 50*

Attempt any five questions. Assume suitable missing data, if any.

Roll No. .....

B.Tech.[CSE]

May-2023

Total No. of Pages 04

SIXTH SEMESTER

END SEMESTER EXAMINATION

CO304 ARTIFICIAL INTELLIGENCE

Max. Marks: 40

Time: 3:00 Hours

Note:	Answer *ALL* questions. Assume suitable missing data, if any. CO# is course outcome(s) related to the question.

Signature

Page No.
Date

(c) What are the applications of Artificial Intelligence? / 2023SE [2]

The applications of AI are:

MUNDANE TASKS

- Perception
  - → Computer vision
  - → Speech recognition
- Natural Language (NLP)
  - → Understanding
  - → Generation
  - → Translation
- Common Sense Reasoning
- Robot control

FORMAL TASKS

- Games
  - → Chess
  - → Backgammon
  - → Checkers - etc
- Mathematics
  - → Geometry
  - → Logic
  - → Integral calculus
  - → Proving properties of programs
- Search and control strategies

EXPERT TASKS

- Engineering
  - → Design
  - → Fault finding
  - → Manufacturing planning
- Scientific / Medical / Financial analysis

(b) Define components of AI program. 2023SE

1.) LEARNING: Learning involves the capability of the system to acquire knowledge and improve its performance over time, akin to human learning processes.

2.) REASONING: Reasoning grants the system the ability to analyze info., draw conclusions and make decisions based on logical thinking.

3.) PROBLEM-SOLVING: AI program with this excel at defining problems, exploring various solutions, and implementing effective strategies to achive desired outcome

4.) PERCEPTION: This component refers to the systems ability to interpret sensory input such as vision, sounds, smell, touch enabling it to understand and interact with environment.

5.) LANGUAGE-UNDERSTANDING: The computer uses software to interpret text, translate to computer language and produce an output in language that humans can understand.

Page No.
Date

Page No.
Date

Q1 (a) Mention the categorization of intelligent systems. 2023SE [2]

Based on the functionality of AI based systems, they can be categorised into the following:

1. REACTIVE MACHINES AI: Operates based on present data, performing pre-defined tasks without forming future inferences.

2. LIMITED MEMORY AI: Utilizes past data stored in a temporary memory to make informed decisions
Eg.) Self driving car.

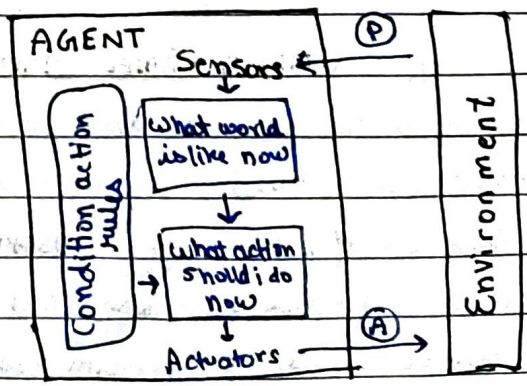
3. THEORY OF MIND AI: Advanced AI focussing on emotional intelligence, currently under rigorous research for better understanding human beliefs and thoughts.

4. SELF-AWARE AI: Speculative and futuristic type of AI with its own consciousness, which is now a distant possibility.

Q2 (a) Explain in detail, the structure of different intelligent agents. 2023SE [8]

An intelligent agent is an autonomous entity which act upon an environment using sensors and actuators for achieving goals. These are:

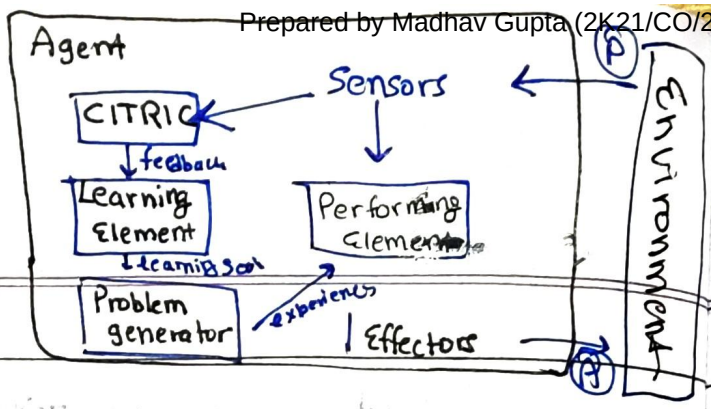
1. SIMPLE REFLEX AGENTS:
works only on current situation / perception and ignores the history of prev. state.
↳ Condition - Action Rule.



Limitations
i) very limited knowledge
ii) no knowledge about non perceptual parts of state
iii) can be in ∞ loop.

5. LEARNING AGENTS :

Can learn from its past knowledge Starts to ACT with basic knowledge and then able to act by adapting learning.



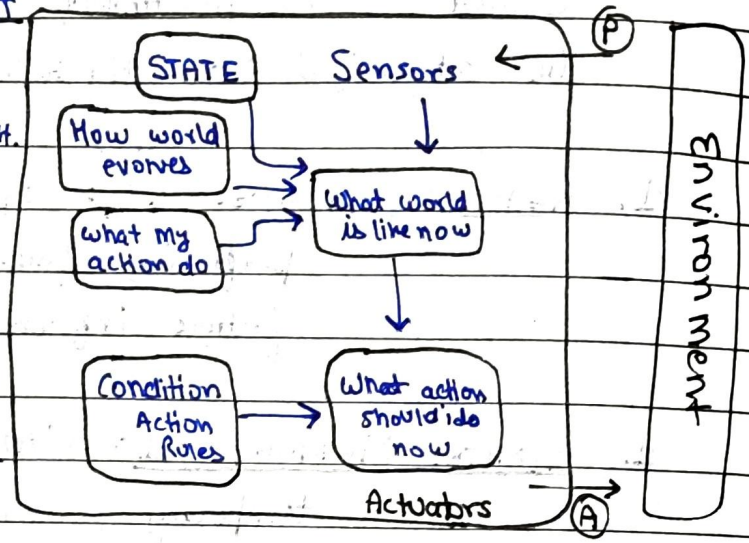
2. MODEL-BASED REFLEX AGENT :

→ It works by finding the rule whose condition matches current sit.

→ Can work in partially observable env. and track situation.

→ Agent keeps track of internal state which is adjusted by each percept and that depends on percept history. It uses info :

① How world is evolving? | ② How agent's action affect the world?



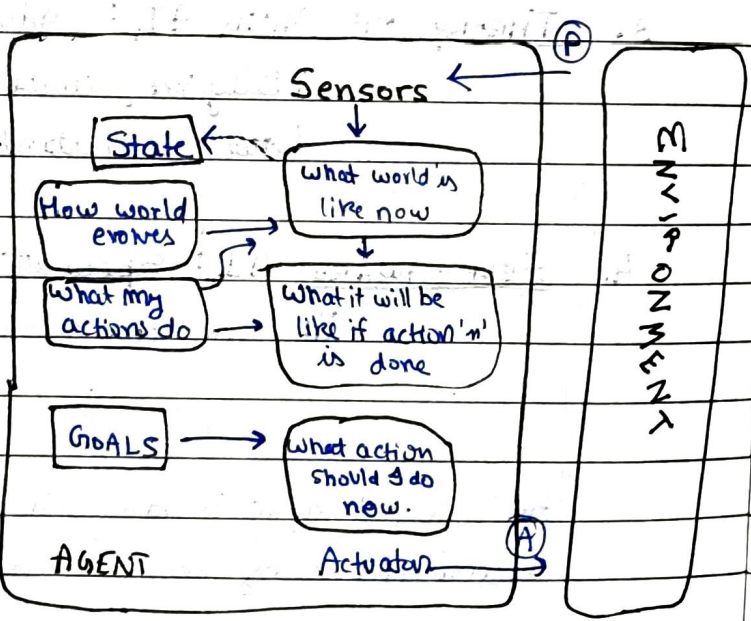
3. GOAL-BASED AGENTS :

↳ Focuses only on reaching the goal set

↳ Agent takes decision based on how far it is currently from the goal state

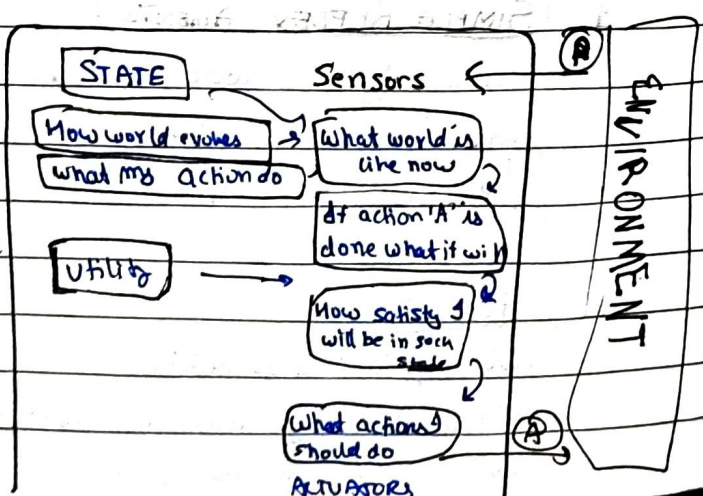
↳ Every decision is taken to minimize dist to goal state.

↳ More Flexible Agent.



4. UTILITY-BASED AGENTS :

Agents are more concerned about the utility for each node. Act based not only on goals but also the best way of achieving goal. Useful when there are multiple possible alternatives and agent has to choose in order to perform best action.



Page No. Date

[b] Differentiate between forward reasoning and backward reasoning. 2

2019M

The difference between the problem solving methods are :-

	FORWARD REASONING	BACKWARD REASONING
1.	It is a data driven task	It is a goal driven task.
2.	It begins with new data	It begins with uncertain conclusions
3.	The objective is to find a conclusion that would follow.	The objective is to find the facts that support the conclusions.
4.	It is an opportunistic type approach	It is a conservative type approach.
5.	It tests all rules and can produce an infinite no. of conclusions	It tests some rules and produce a finite no. of conclusions.
Eg)	Suitable for answering problems such as planning, control monitoring etc.	Suitable for problems like diagnosis.

1. Answer *any TWO* of the following

2023E

[a] Assume that you are hired by a company to evaluate the potential for using artificial intelligence (AI) techniques (not robots) to improve efficiency and reduce costs. You are given a list of tasks and are asked to identify which of the tasks can be replaced by an AI agent. The major tasks involved in the manufacturing process are: Assembly line tasks, Quality control inspections, Inventory management, Predictive maintenance, and Logistics

(i) Identify which of the tasks can be automated using AI techniques.
(ii) Evaluate the benefits and limitations of using AI to perform the identified tasks. [Maximum two sentences for each task]

[2+2] [CO1]

i)

Page No.
Date

(ii) Explain the concepts of state space, production rules and control strategy. 2018E

(b) Define state space and give the state space for water jug problem. Define the production rules and work out the production rule for this problem. 2018E

(5,5)

A state space is a set of all possible states that a system can exhibit. It provides a structural representation of the different configurations or situations that can occur within a given problem domain.

Water Jug Problem :

You are given two jugs, a 4-gallon one and a 3-gallon one. Neither has any measuring markers on it. There is a pump that can be used to fill the jugs with water. How can you get exactly 2 gallons of water into the 4-gallon jug.

STATE SPACE: It can be described as a tuple (x,y) where x represents the amount of water in 4-gallon jug and y represents the amount of water in 3-gallon jug. such that $0 \le x \le 4$ and $0 \le y \le 3$.

Q1. Answer to the point for any five from following:

(i) Define the production system using water jug problem. 2018S

Production system helps in structuring AI program in a way that facilitates describing and performing the search process. It consists of production rules which are (condition, action) pairs which mean, "If condition then action".

Sr	Current State	Next State	Descriptions.
1.	(x,y) if $x<4$	$(4,y)$	Fill the 4 gallon jug
2.	(x,y) if $y<3$	$(x,3)$	Fill the 3 gallon jug
3.	(x,y) if $x>0$	$(x-d,y)$	Pour some water out of 4 gallon jug.
4.	(x,y) if $y>0$	$(x,y-d)$	Pour some water out of 3 gallon jug.

5.	(x,y) if $y>0$	$(0,y)$	Empty the 4 gallon jug
6.	(x,y) if $x>0$	$(x,0)$	Empty the 3 gallon jug
7.	(x,y) if $x+y>=4$ and $y>0$	$(4, y-(4-x))$	Pour water from the 3 gallon jug into the 4 gallon jug until 4 gallon jug is full.
8.	(x,y) if $x+y>=3$ and $x>0$	$(x-(3-y), 3)$	Pour water from the 4 gallon jug into the 3 gallon jug until 3 gallon jug is full.
9	(x,y) if $x+y<=4$ and $x>0$	$(x+y, 0)$	Pour all the water from the 3 gallon jug into the 4 gallon jug
10.	(x,y) if $x+y<=3$ and $y>0$	$(0, x+y)$	Pour all the water from the 4 gallon jug into the 3 gallon jug.
11.	$(0,2)$	$(2,0)$	Pour the 2 gallons from 3 gallon jug into the 4 gallon jug.
12.	$(2,y)$	$(0,y)$	Empty the 2 gallons in the 4 gallon jug

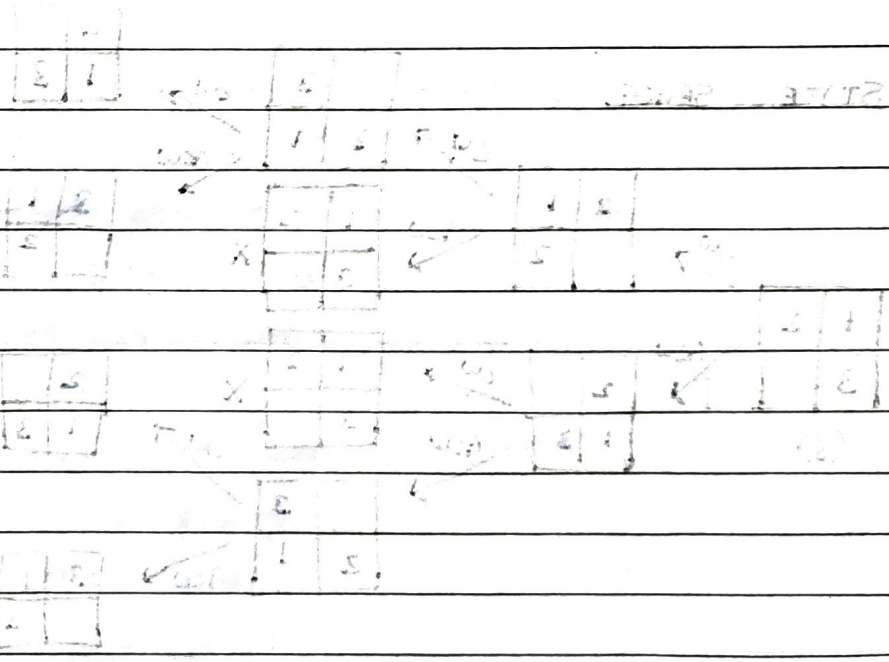
1[a] Define production system. What are the requirements of a good control strategy? 2010 M 3

A good control strategy:

1. Causes motion. i.e. in water jug problem, blindly following rules without progress won't lead to a soln. essentially.

2. Should be systematic: i.e taking random actions, although causes motion, might be ineffient, revisiting states and using unnessary steps in the process.

Page No.
Date



1[a] Consider 3-puzzle problem, it consists of a 2×2 board with three numbered tiles and a blank space. A tile adjacent to the blank space can slide into the space. The object is to reach a specified goal state(s). The initial state S goal states G_1 and G_2 are shown in Fig. 1. Give the problem formulation for the above problem. Illustrate the state space with the help of a diagram, along with applicable actions. Also, give a possible sequence of actions to achieve goals G_1 and G_2, if there are any.

[1+2+2] [CO1, CO2] [L3]

2023 M

Fig.1: (a) S, (b) G_1, (c) G_2

Page No. Date

PROBLEM FORMULATION

Initial State (S): A 2×2 board with three numbered tiles and a blank space arranged in a certain order

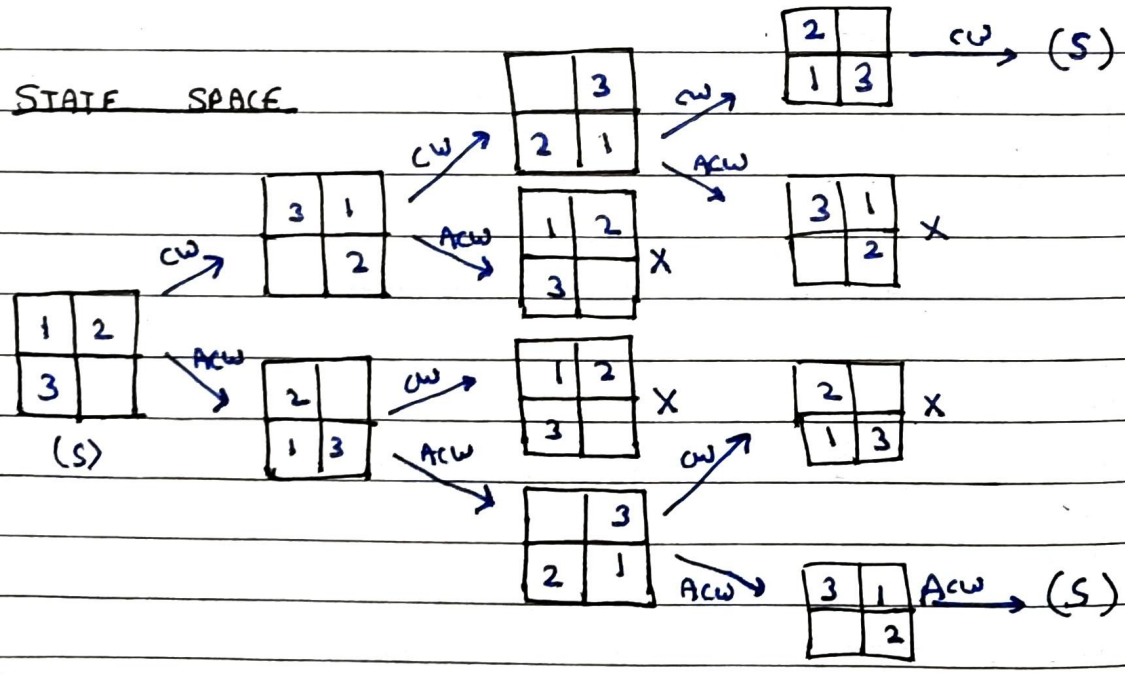
Actions (A): Slide a tile adjacent to the blank space into the space. Clockwise / Anticlockwise

Transition model: defines the result of an action, i.e. the new state after performing a valid action.

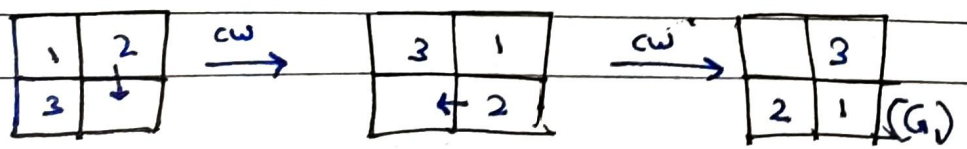
Goal Test: Check if the current State matches either of the specified goal states G_1 or G_2

Cost Function: Let it be uniform cost.

STATE SPACE



Reaching G_1



Reaching G_2 can't be reached, not in SS.

[b] Consider a vacuum-clear World shown in Fig. 2. This World has just three locations: rooms A, B and C. The vacuum agent perceives which room it is in and whether there is dirt. It can move left, move right, suck up the dirt, or do nothing. One straightforward agent function is the following: if the current room is dirty, then suck; otherwise, move to the other room. Find the number of states in the state space and write a pseudo code for the reflex agent program.

[1+2] [CO2] [L3]

2023M

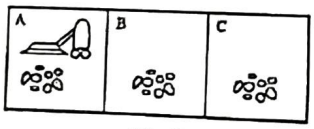


Fig. 2

Page No.	
Date	

There are 3 rooms and each room can be dirty or clean

∴ # States = 2^3 = 8 possible states.

PSEUDO CODE

```
function REFLEX-VACUUM-AGENT ([location, status]) ⟶ action
        if status == Dirty :
                return "Suck"
        if location == A :
                return "Right"
        elif location == B :
                return "Right"
        elif location == C :
                return "Left"
        else
                return "nothing"
```

Q2. Analyze the project characteristics of 8 puzzle problem. 2020M [2]

The 8-puzzle is a square tray in which are placed, eight square tiles. The remaining ninth tile is uncovered. Each tile has a number on it. A tile that is adjacent to the blank space can be slid into that place. A game consists of a starting position and a specified goal position. The goal is to transform the starting position into goal position by moving the tiles around

Start

2	8	3
1	6	4
7		5

goal

1	2	3
8		4
7	6	5

R.T.O.

Page No.
Date

1.) Is the problem decomposable ?
No, one game have single solution.

2.) Can the steps be ignored or undone ?
Yes, we can undo the present move.

3.) Is the universe predictable ?
Yes, since it requires only one agent and we can predict the position of blocks in next move.

4.) Is a good solution absolute or relative ?
It is absolute as we dont have to bother about other sol^n

5.) Is the solution a state or a path ?
The solution is a path to reach the goal state.

6.) What is the role of knowledge ?
Lots of knowledge helps to constrain the search for a solution.

7.) Does the task require human-interaction ?
No, additional human interaction/assistance is not needed.

b. Give any five project characteristics to analyze a problem domain 2019S

(iii) List five project characteristics to analyze a problem domain 2018E (4,5,5)

1.) Is the problem decomposible into a set of (nearly) independent smaller or easier subproblems.

2.) Can solution steps be ignored or atleast undone if they prove unwise ?

3.) Is the problem's universe predictable?

(d) Mention characteristics of a problem. 2023 SE

6.) Is a large amount of knowledge absolutely necessary to solve the problem, or is knowledge important only to constrain the search?

7.) Can a computer that is simply given the program return the solution, or will the soln of the problem require interaction with the person?

4.) Is a good solution to the problem obvious without comparison to all other possible solutions.

5.) Is the desired solution a state of the world or a path to the state

(ii) Analyze the problem characteristics of Travelling sales man problem. 2018M

A salesman has a list of cities, each of which he must visit exactly once. There are direct roads between each pair of cities on the list. Find the route the salesman should follow for the shortest possible round trip that both starts and finishes at any one of the cities.

Is the problem decomposable?
No

Can solution steps be ignored or undone?
Yes, we can explore other path if one isn't optimal.

Is the good solution absolute or relative?
Relative, as we need to find the best path.

Is the soln a path or state?
Its the path to travel in all cities optimally in a round trip.

What is the role of knowledge?
Specialized algorithms and heuristics play a vital role in and a large amount of general knowledge isn't req.

Does the task require human interaction?
NO.

Page No.
Date

Q1(a) Explain different project characteristics and analyze the problem characteristics for robot moving a desk from one room to another? 2019E [5]

The characteristics are mentioned beforehand.

1. Decomposable: Its partially decomposable as it can be broken into subtasks like lifting, navigating, placing down.

2. Reversibility: Some steps like path planning can be reversed.

3. Predictability: The robot's movements and basic physics are predictable while external and human obstacles introduce unpredictability

4. Good Solution: No, its relative since various factors are to be considered.

5. Path to final state

6. Knowledge requirement: Knowledge is helpful regarding the environment, capabilities to avoid collision. But it can be done with limited knowledge too.

7. Human Interaction: Likely needed incase of unforeseen events, safety.

Page No.
Date

Page No.
Date

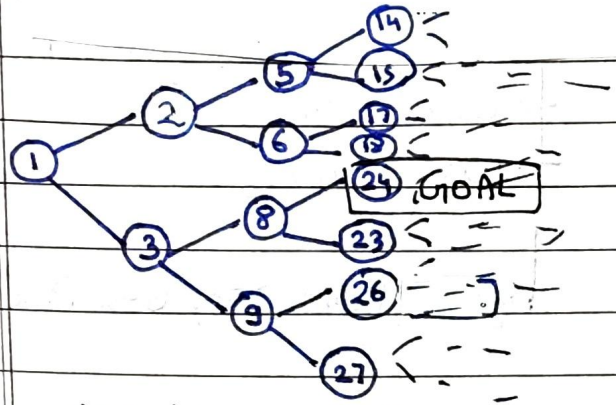
(e) Write about the analysis of search methods 2023ES [2] [CO1]

Page No. Date

Q2. Consider a state space where start space is number 1 and successor for state numbered n is 3n and 3n-1. Draw the search tree. List the order in which nodes will be visited using following search techniques if goal node is numbered as 24 2018M

(i) Depth first search, (ii) Iterative deepening search. [2]

Search Tree



Using lexicographical order

i.) DFS : 1 → 2 → 5 → 14 → 41 → 122 → - - - - - -

ii.) Iterative deepening search

d = 0 : 1

d = 1 : 1 → 2 → 3

d = 2 : 1 → 2 → 5 → 6 → 3 → 8 → 9

d = 3 : 1 → 2 → 5 → 14 → 15 → 6 → 17 → 18 → 3 → 8 → 23 → 24 Goal

(iii) Define the term admissibility of a search procedure. Which search procedure is admissible? 2019M

A search procedure is admissible if it always find an optimal solution if one exists. In this the heuristic function never underestimates the cost of reaching the goal i.e.

"h(n) is always less than or equal to actual cost of lowest path from node 'n' to goal"

Thus, it underestimates :

It ensures that it never overlooks the optimal sol'n and does not return solutions with cost higher than optimal

Eg:- A* search algorithm.

Page No.
Date

Q1. (a) What are the advantages and disadvantages of intelligent search over non intelligent search? Give an example of intelligent and non intelligent program for Tic Tac Toe problem. 2018S

Uninformed Search	Informed Search
→ Search without information.	→ Search with information
→ No knowledge	→ Use knowledge to find steps to soln
→ Time consuming	→ Quick Soln
→ More Complexity (Time/Space)	→ Less Complexity (T/S)
Eg) DFS, BFS, etc.	Eg) A*, Heuristic DFS, Best First Search

Q1. Answer following to the point.

Tic Tac Toe

a. Give an example of intelligent and Non intelligent program for Tic Tac Toe Problem. 2019S

2 What do you mean by a heuristic function? Explain with an example. 2 2010M

Heuristic functions are mechanisms used to estimate the cost from a given state to the goal. Informed search algorithms utilize these functions to prioritize paths that are likely to lead to optimal answer efficiently.

Eg)

2	3	1
7	8	
6	4	5

Start

	3	2
8	1	6
7	4	5

Goal

In 8-puzzle problem,
h(n) = no of misplaced tiles
h(n) = 7

Page No.
Date

2.5(a) Create a partial game tree for the game of tic-tac-toe 2023 SE [5]

Page No.
Date

Q1. Answer following with suitable reasoning:
(i) Is Breadth first search is intelligent search procedure? 2020M

No, BFS is not considered an intelligent search procedure because

→ It lacks knowledge and operates blindly, exploring all paths equally without any preference or guidance.

→ BFS remains static throughout the search, unable to learn from explored paths or adapt its strategy based on new information

Q1. Answer to the point following:
(i) Describe the characteristics of the control strategy. Is breadth first search a control strategy? justify . 2019M

refer 2010 M

BFS is considered a control strategy because it systematically explores the search space, ensuring progress by considering all possible paths level by level.

2[a] Consider the state space shown in Fig. 3. Numbers on the edges show the step path cost between the nodes. Use the breadth-first search algorithm to find the path from start state S to a goal state G. What should be the step path cost(instead of given values) if the optimal path is desired using the breath-first search? Show each step clearly. Answer with limited words; you may use diagrams for an explanation. Do not use large text paragraphs. 2023M

[2+1] [CO1, CO2] [L3]

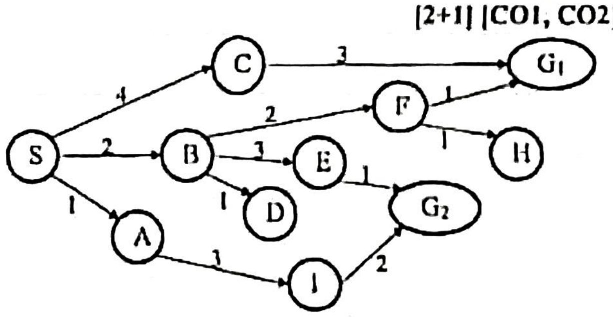
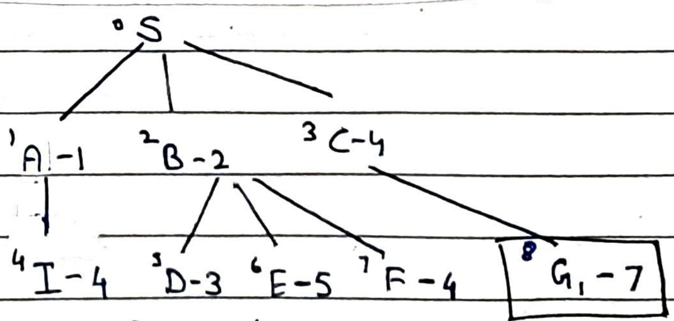


Fig. 3

Traversal



∴ path [illegible]S : S →3 C →4 G1

Page No.
Date

Modified Step path Costs

[b] Consider the state space shown in Fig. 3. Find the optimal cost path from the start state to a goal state using the uniform cost search algorithm.

c Compare the path cost obtain in part 2[a]. Also, explain why the difference in two path costs is given by breath-first and uniform cost search algorithms (use a maximum of three lines for explanation). [Note: if equal cost nodes are generated at any stage, the expansion order will be first-in-first-out (FIFO)]. 2023M [2+1] [CO2] [L4]

Page No.
Date

Q2.(a) Consider the graph in *Figure 1*, the node A is the start node and nodes J, G and R are goal nodes. The tree is being searched by DFS, BFS and DFID algorithm (searching left to right) Write the sequence of nodes inspected bythem till termination. Mention and show each and every step involved. 2018E

[5,5]

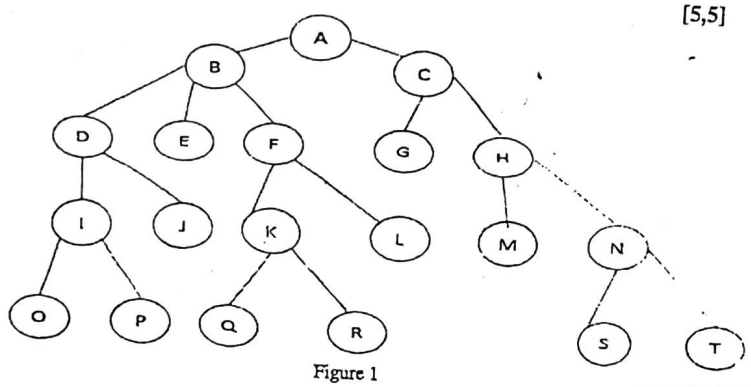


Figure 1

(b) As you get close to graduating MIT, you decide to do some career planning. *Figure 2* at end shows a graph of your options where the start node is M = MIT and your goal node is R = Retire, with a bunch of options in between. Your graph includes edge distances that represent, roughly, the "cost of transition" between these careers (don't think too hard about what this means). You also have heuristic node-to-goal distances which represent your preconceptions about how many more years you have to work until you retire. For example, you think it will take 25 years to go from MIT (M) to retirement (R), 30 years from Grad School (B), but only 2 years from Entrepreneur (E). Mention A* algorithm and Apply A* to find a respective career path after MIT till retirement. 2018E

A = Wall Street | B = Grad School | C = Professor | D = Government | E = Entrepreneur

[6,4]

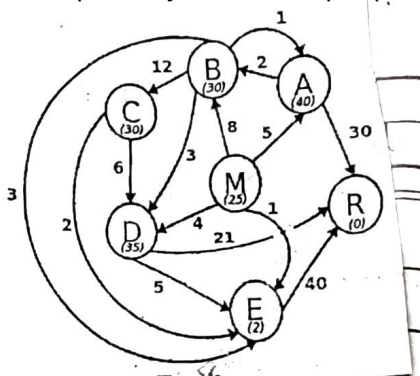


Figure 2.

[b] Consider the tree shown in Fig. 1. Perform a depth-first search (DFS) of the tree. Let the start node and goal node are S and G, respectively. Also, perform a breadth-first search (BFS) of the tree. Which nodes are visited first in DFS and BFS? 2023E [2+2] [CO2]

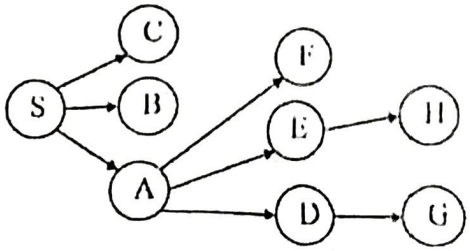
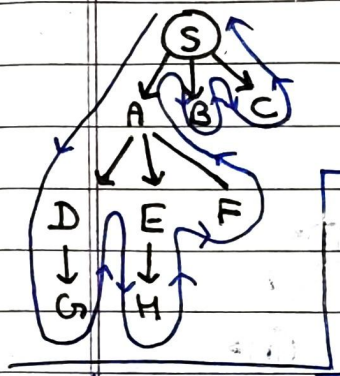


Fig. 1

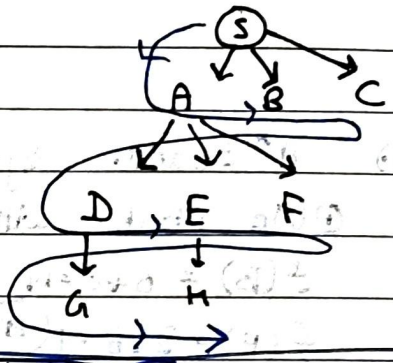


DFS

order : S → A → D → G

BFS

order : S → A → B → C → D → E → F → G

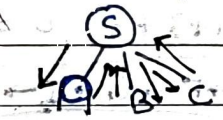


Nodes	S	A	B	C	D	E	F	G	H	
Visited First	–	–	BFS	BFS	DFS	DFS	–	DFS	DFS	– = same

[c] Suppose that the search algorithm is modified to use iterative deepening depth-first search (IDDFS). Assume that the maximum depth of the tree is 3. In what order are the nodes visited? Compare the number of nodes visited by DFS, BFS, and IDDFS. Which algorithm visits the fewest nodes in this case? 2023E [2+1+1] [CO2]

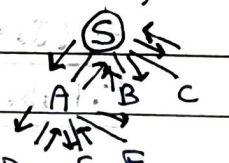
IDDFS with depth = 3

iteration 1, d=1



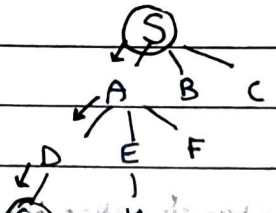
path : SABC

iteration 2, d=2



path : SADEFBC

iteration 3, d=3



path : SADG

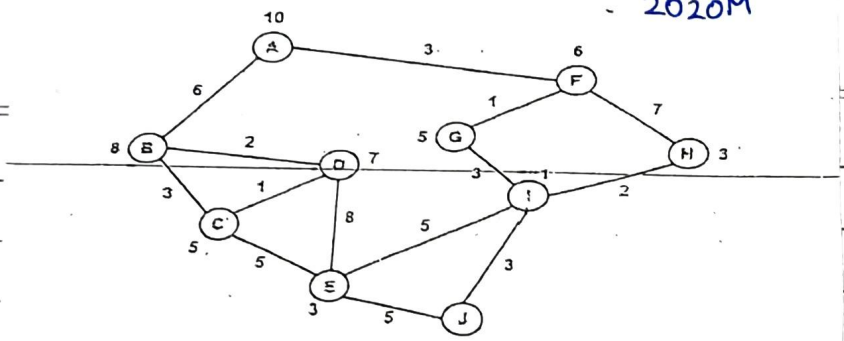
∴ Nodes visited in DFS : S A D G

" " BFS : S A B C D E G

" " IDDFS : S A B C D E F G

∴ DFS visits fewest nodes

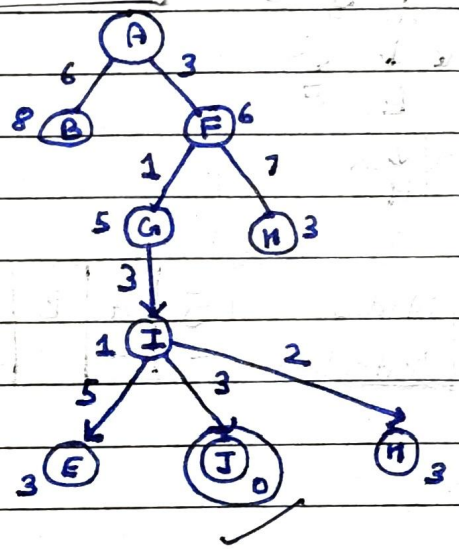
Q3. Consider the OR graph snown below, where number written on edges represent the distance between the nodes. The number written on nodes represent the heuristic values. - 2020M



Find the most cost-effective path to reach from start A to final state J using: (i) A* (ii)Best first search algorithm. Explain steps used. [4]

Page No.
Date

i.) **A* Search Algorithm**



① We start with node A

$f(B) = 6+8 = 14$

$f(F) = 3+6 = 9$ (A)

∴ path: A → F

② we are on F

$f(G) = (3+1)+5 = 9$

$f(H) = (3+7)+3 = 13$

∴ path: A → F → G

③ we are on G

$f(I) = (3+1+3)+1 = 8$

∴ path: A → F → G → I

④ we are on I

$f(E) = (3+1+3+5)+3 = 15$

$f(H) = (3+1+3+2)+3 = 12$

$f(J) = (3+1+3+3)+0 = 10$

∴ path: A → F → G → I → J

ii.) **Best First Search Algorithm**

OPEN		CLOSED	
Node	H(n)	Node	Parent
~~A~~	~~10~~	A	–
B	8	F	A
~~F~~	~~6~~	H	F
G	5	I	H
~~H~~	~~3~~	(J)	I
~~I~~	~~1~~		
E	3		
~~J~~	~~0~~		

path: J ← I ← H ← F ← A
(by backtracking)

[b] Consider the state-space shown in Fig. 4. The values of the heuristic function at each node are given in Table I. Find the path from start node S to the gaol node G using A* search algorithm (i) tree search version, (ii) Graph search version. Will it give the optimal path and the same path in both cases? If not, which one is an optimal path? Why does any one (or both) search versions give a sub-optimal path? 2023M

[2+2+2] [CO3] [L3, L4]

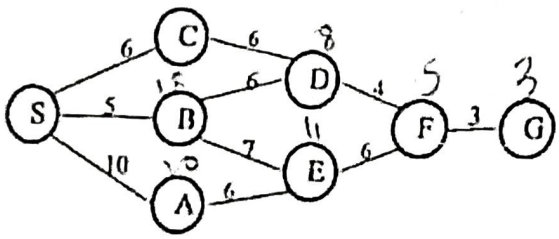
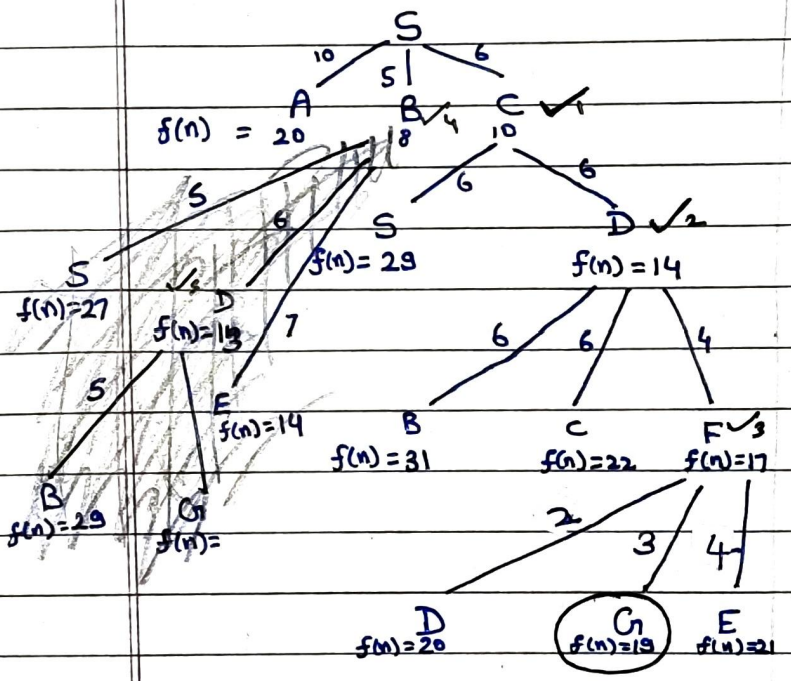


Fig. 4

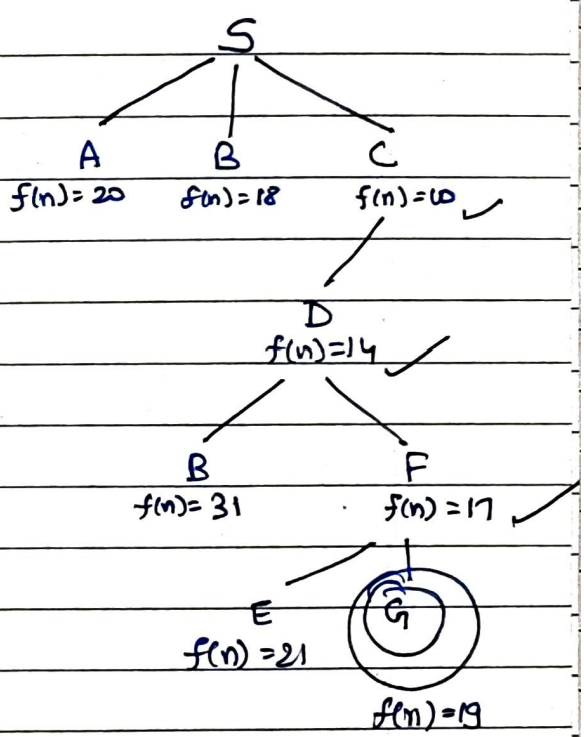
Table I

Node (n)	S	A	B	C	D	E	F	G
Heuristic $h(n)$	17	10	13	4	2	4	1	0

i) TREE VERSION (can revisit)



ii) GRAPH VERSION (can't revisit)



It gives sub-optimal path and same path in both cases.
Same path as no loop is formed.

Both versions give a sub optimal path due to overestimated h(n).

(iv) Does A* always find optimal solution? 2020M [4x2]

No, A* needs an admissible heuristic function which never overestimates cost to guarantee optimality.
Otherwise it may find a good solution but not necessarily the best solution.

(ii) Work out few steps of A* algorithm for slide back puzzle having following moves. 2019M

I. A tile may move to adjacent cell with unit cost
II. A tile may hope another tile with a cost of 4

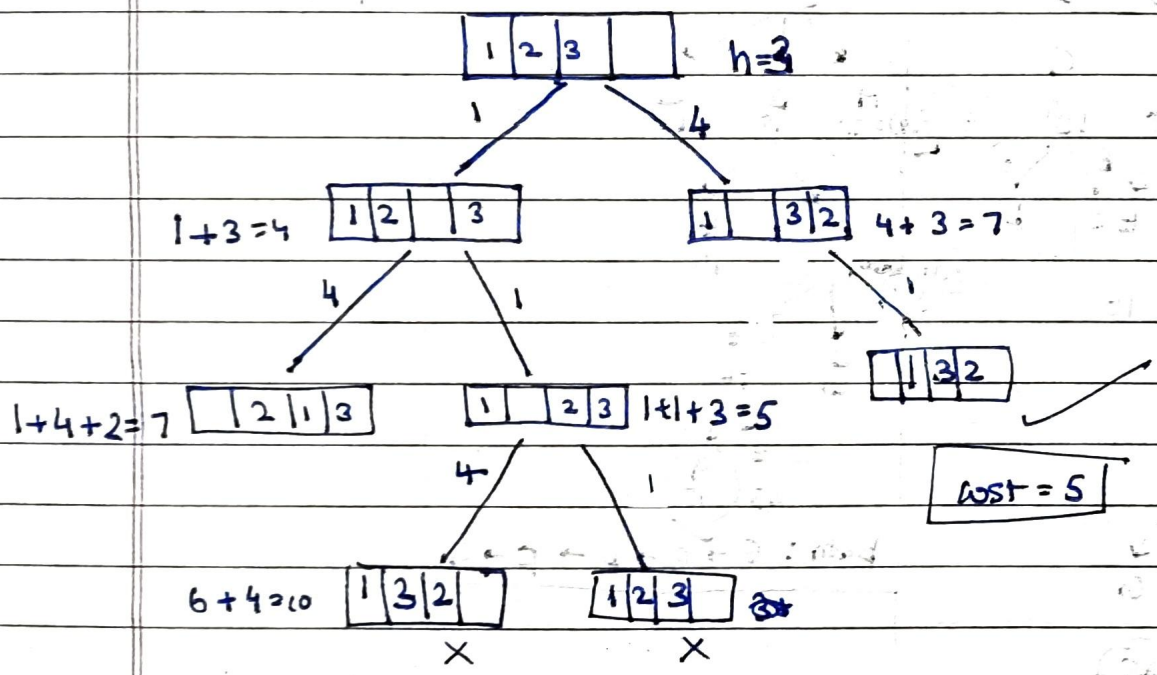
Initial and goal nodes are described as:

	1	3	2

1	2	3	

h = misplaced tyles.

lets start from goal for simplicity



Q4. Work out first two steps of A* algorithm to solve Eight puzzle problem where initial state and goal state are described below:

5	3	6
7		2
4	1	8

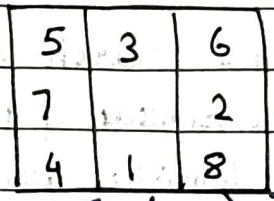
3	7	6
5	1	2
4		8

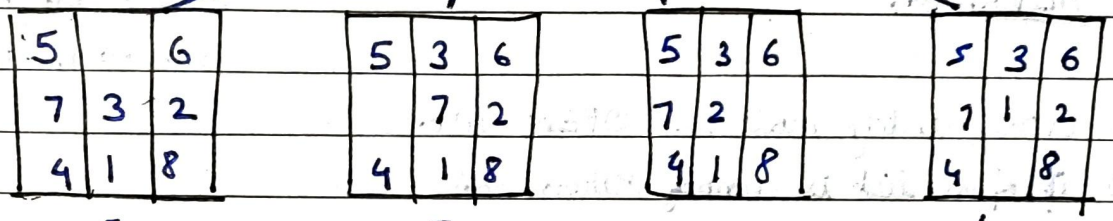
[3]

h(n) = no. of misplaced tiles
g(n) = depth of node

Page No.
Date

Step 1.)



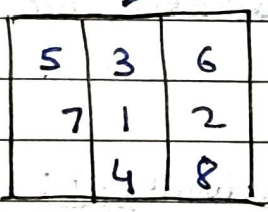


g(n) = 1

h(n) = 5 5 6 4

f(n) = 6 ✗ ✗ 6 ✗ 7 ✗ 5 ✓

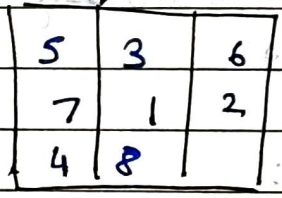
Step 2



h(n) = 5

f(n) = 2+5 = 7

✗



h(n) = 5

f(n) = 2+5 = 7

✗

→ least cost so expand with 6-f(n)

(iii). Why is A* search superior to best first search? 2018M

It is superior due to the following advantages:

1. Optimality: A* finds the shortest path guaranteed, while best first search only finds potentially shortest paths.

2. Efficiency: A* focusses on promising paths based on heuristic function (h) and g, avoiding wasteful exploration like pure BFS.

Page No.
Date

Q2.(a) Explain A* procedure to reach goal node from starting initial position. 2019S

(iii) A* Search 2018E

A* search is an informed search and graph traversal algorithm that finds the shortest path b/w start and goal node using a heuristic function.

$f(n) = g(n) + h(n)$ where $f(n)$ → estimated cost
$g(n)$ → cost to reach node
$h(n)$ → heuristic value.

ALGORITHM.

i.) Enter starting node in OPEN list.
ii.) if open list is empty return fail
iii.) Select node from OPEN list which has smallest value (g+h)
↳ if node == Goal, return Success.
iv.) Expand node 'n' and generate all successors
↳ compute (g+h) for each successor node.
v.) if node 'n' is already OPEN/CLOSED, attach to back ptr.
vi.) Go to iii.)

Advantages:	Disadvantages:
→ Best searching algorithms.	→ Doesn't always produces shortest
→ Optimal and complete	→ Complexity issues
→ Solving complex problems	→ Requires memory.

(ii) Best first Search 2018E

Best first search is a greedy graph search algorithm that explores a graph by expanding the most promising node chosen on the basis of a specified rule, typically a heuristic function that estimates cost to reach the goal. It uses a priority queue to store cost of nodes.

Page No.
Date

ALGORITHM

PRIORITY QUEUE 'PQ' containing initial states.

LOOP

if PQ = Empty

return fail.

else

Node ← Remove_first (PQ)

if Node == GOAL

Return Path from initial to Node

else

generate all successors of node and insert newly generated NODE into PQ according to COST value.

END LOOP.

Q2. (a) Explain with the help of suitable search tree the search procedure best first search and A* search. 2018 S

Best First Search	A* search
→ evaluation function is $f(n) = h(n)$	evaluation function is $f(n) = h(n) + g(n)$
so no past knowledge is involved	so past knowledge is involved
→ Its not complete and not optimal	Its complete and optimal (no overestimate)
→ TC: $O(b^m)$ | SC: polynomial	TC: $O(b^m)$ | SC: $O(b^m)$.

Eg.)

Page No.
Date

Consider two players playing a game. The game's setup is on a map and two pieces of knights (from chess): to indicate their positions on the map. Players can simultaneously move to a neighbouring city on the map at every turn. The time needed to move from city i to neighbour j is equal to the road distance $d(i, j)$ between the cities. The players take the next turn when both complete the previous turn. We want the two players to meet as quickly as possible. Let $D(i, j)$ be the straight-line distance between cities i and j. Which of the following heuristic functions is/are admissible? (i) $D(i, j)$: 2023 M
(ii) $2 \cdot D(i, j)$;
(iii) $D(i, j)/2$.
Give one or two lines of explanation for each. [2] [CO3] [L2]

i) D(i,j) may be admissible as it never overestimates the actual cost to reach the goal. It provides lower bound as actual distance on node.

ii) 2D(i,j) is not admissable as it overestimates the actual cost to reach the goal.

iii) D(i,j)|2 is admissible as it underestimates actual cost. and will find soln.

(b) Suppose two friends live in different cities on a map, such as the Romania map as shown in fig.1. On every turn, we can simultaneously move each friend to a neighboring city on the map.The amount of time needed to move from city i to neighbor j is equal to the road distance d(i, j) between the cities, but on each turn the friend that arrives first must wait untilthe other one arrives (and calls the first on his/her cell phone) before the next turn can begin.We want the two friends to meet as quickly as possible. Take the heuristic functions as 2 *D(i, j). Write the pseudo code for the problem using best first search and apply that on the problem to decide among the heuristic function. Assume one friend is at Oradea and other is at Neamt. [5] 2019 E

Page No.
Date

(b) Write the proof of optimality of A*. 20235E [5] [CO3]

(b) Write down search procedure for And/or graph 2019S

(c) AO* Search technique 2018E

AO* is a best first search informed seach algorithms. It is based on problem decomposition

It represents an AND-OR graph algorithm that is used to find more than one soln. It is an efficient method to explore a solution path.

AO* dynamically adjusts the heuristic function during the search process, allowing it to handle cases where h(n) is not admissible or where the search space is too large to search exhaustively.

ALGORITHM

DATA: Graph, Start Node

RESULT: The minimum cost path from Start Node to Goal Node

Current Node ← Start Node

while: There is a new path with lower cost from Start Node to the Goal Node

do calculate the cost of path from the current node to the goal node by

AND-ARCS then

sum up the costs of all paths in the AND ARC;

return the total cost;

end

calculate the cost of the single path in the OR side;

return the single cost;

end

find the minimum cost path

Current Node ← Successor Node of Min Cost Path

if Current Node has no successor node then

do backpropagation and correct the estimate cost;

Current Node ← Start Node, return current node, New esti cost

else return null

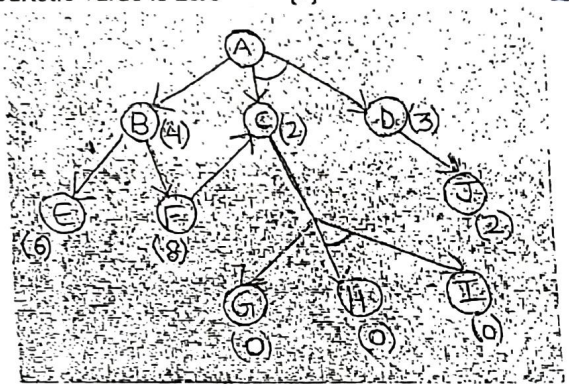
end

end return The min cost path

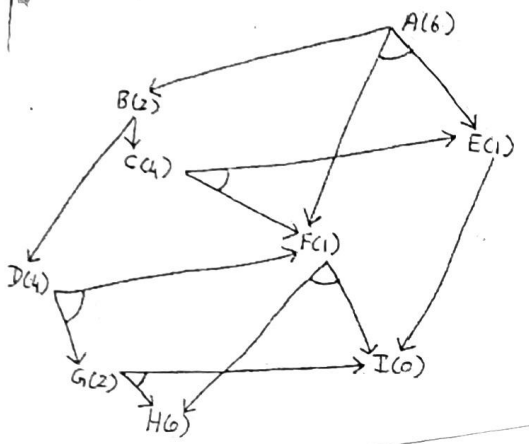
(b) Write the algorithm for AO* Search and differentiate it from A* Search 2018S (5,5)

A* Search	AO* search
A* algorithm is OR graph algo	AO* is AND-OR graph algo.
It only finds one solution	It will find more than one soln by ANDing two or more branches.
A* algo guarantees to give an optimal soln	AO* doesn't guarantee optimal soln.

Q4. Consider the AND OR graph shown below. Values in bracket represent heuristic values Work out the steps of AO* procedure on this graph and find out the path from Starting node A to goal state, where heuristic value is zero [3] 2020M



4 In the figure below, nodes H and I are goal stated nodes. Trace the AO* algorithm for this graph, and draw solution sub-graph. 2010M
Note that the heuristic 'h' is an underestimate and monotonic (function which preserves the given order). Check that the solution obtained by AO* is optimal by comparing with the other solutions. 5



Page No.
Date

Q3. Explain the traversing of graph in fig 1 using AO* procedure [2].
2018M

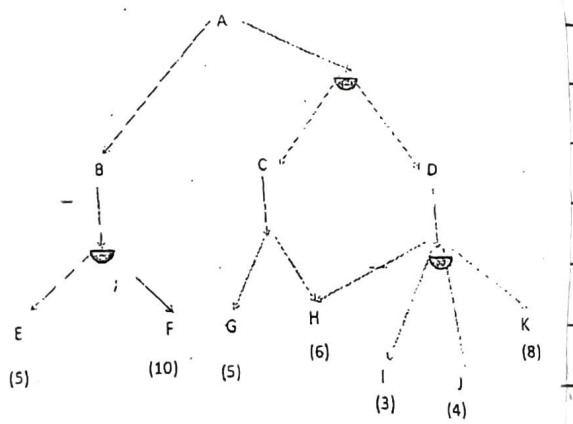


Fig.1

Page No.
Date

Q.6 (a) How to minimize total estimated cost using A* search with an example [5] 202336

Page No.
Date

2. [a] Consider a robot that needs to navigate through a grid world from its starting position to the goal position using A* algorithm. The grid world is represented by a 4x4 grid where each cell represents a state. The robot can move up, down, left, or right in the grid world and each move has a cost of 1. Assume that the robot is initially at (0,0) and wants to reach the goal at (3,3). There are four obstacles in the grid world: (1,1), (0,2), (2,1), and (3,2). The heuristic function $h(n)$ is the Manhattan distance between node n and the goal. Apply the A* algorithm to find the optimal path from the initial state to the goal state. Show the order in which the nodes are expanded, the cost g and h values of each expanded node, and the final optimal path. 2023 E [3+1] [CO1, CO2]

[b] Consider the robot navigation problem in 2[a]. Apply the uniform-cost search to find the optimal path from the initial state to the goal state. Show the order in which the nodes are expanded. Compare the performance of A* search to uniform-cost search on this problem. Which algorithm is more efficient and why? 2023E [3+1] [CO1, CO2]

Page No.
Date

Page No.
Date

(iii) Design the procedure to revise cost upward of AO*algorithm and illustrate the steps using suitable search tree 2019 M

(iv) Which problem solving approach used in Means End Analysis search procedure? 2018 M [4x2]

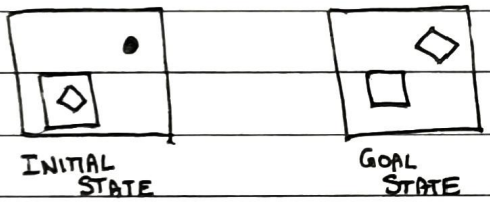
It is a mixture of forward and backward search technique. The main steps which describes the working of means end analysis technique for solving a problem are as follows:

a. Evaluate the difference b/w initial ~~good~~ state and goal state.

b. Select the various operators that can be applied for each difference.

c. Apply the operator at each element which reduces the difference b/w current state and goal state.

Eg.)



	Diff 1	Diff 2	Diff 3
a.)	no dark circle	position of diamond	Size of diamond
b.)	Delete	Move	Expand
c.)	APPLY		

Q2. Explain with example following search techniques
(i) Hill Climbing, 2018 E

Hill climbing is a greedy local search algorithm which continuously moves in the direction of increasing value to find the best solution. It terminates when no neighbour gives a higher value. It is a variant of generate and test method. It does not backtrack as it doesn't remember the search space.

It suffers from local optima.

3. Answer *any TWO* of the followings

[a] Consider the state of tic-tac-toe game as shown in Fig. 2. The objective of the game is to get three of your own symbols (either 'X' or '0') in a row, column, or diagonal. The symbol X represents AI player. The heuristic function for AI player is defined as below: 2023E

The heuristic function assigns to each move a score of: +10 for immediate win, +5 for blocking opponent's immediate win (in next move); +3 for creating potential winning position e.g. two X with one empty cell in a row, column, diagonal, +2 for blocking the opponent winning position; +1 for occupying the center cell.

Find the next two moves of AI player by applying Steepest-Ascent hill climbing algorithm with above heuristic function. Show each step clearly. Represent each by row and column number. Assume that opponent is a perfect player. [4] [CO1, CO2]

X		0
		X
0		

Fig. 2

4 Consider the blocks World problem shown in Fig. 5. It consists of cubes with alphabets. Some of the blocks are placed on a table. There is a robot arm to pick up or put down the blocks. The robot arm can move only one block at a time from the top of the stack or table. The aim is to achieve the goal state from the start state. Illustrate where the simple hill-climbing algorithm can be used to achieve the goal state. If not, why? Show the steps of the simple hill-climbing. Use heuristic function h. 2023M

h: for each block at the desired height (with respect to goal state), it adds the number of blocks underneath it (for example: in goal state, for block C it adds 2, and for block E, it adds 0; thus, h at goal state = 4+3+2+1+0 = 10). For each block at wrong height (with respect to goal state), it adds minus times the number of block positions displaced above or below (for example: in start stat, for block C it adds -1, and for A, it adds -1)

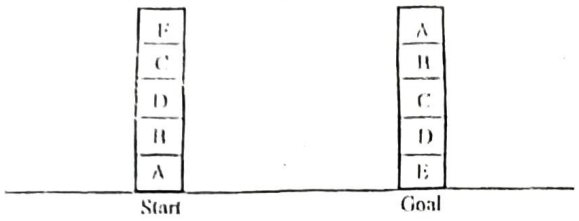


Fig. 5

Investigate whether the steepest ascent version of hill climbing will achieve the goal. [2+1] [CO3] [L3, L4]

Page No.
Date

(ii) Compare and contrast Depth first search and Hill Climbing. 2019H

(iii) Is Best First Search better than Hill Climbing? 2020M / 2019M

Q2. (i) Why best search is better than hill climbing

Best first search (which combines BFS, DFS) is considered better than hill climbing because it explores search space more efficiently. It evaluates nodes based on heuristic function considering long term while hill climbing only considers based on immediate neighbours without considering long term side effects.

(b) State the reason when hill climbing often gets stuck? 2023ES [2] [CO2]

Thus, Hill climbing can get stuck on local optima while BFS can avoid it by backtracking to explore other options in future. In hill climbing progress stops if no better successor nodes.

Page No.
Date

(vi) Describe the control strategy of constraint satisfaction problem 2018 M

[5x3]

3 What are the various problems associated with Hill Climbing? Give their possible solution. 2010M 3

(d) Crypt arithmetic problems 2019E

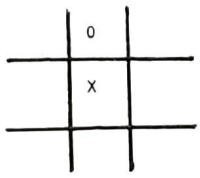
(ii) Explain steps to solve crypt arithmetic problems 2019S

Page No.
Date

Q3. (a) With suitable example illustrate how you solve crypt arithmetic problem. 2018S

Q5. Illustrate the steps of Minimax procedure to make a move for Maximizing player in response to following board position.

2018M [3]



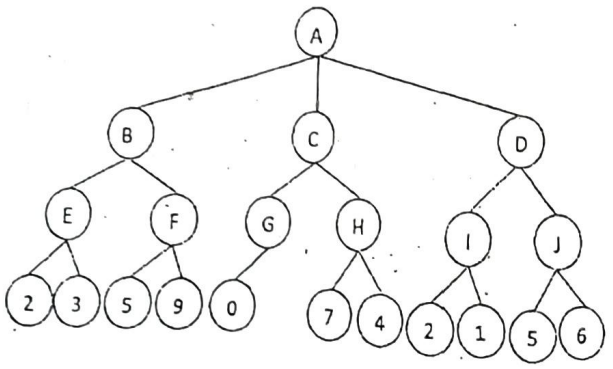
Page No.
Date

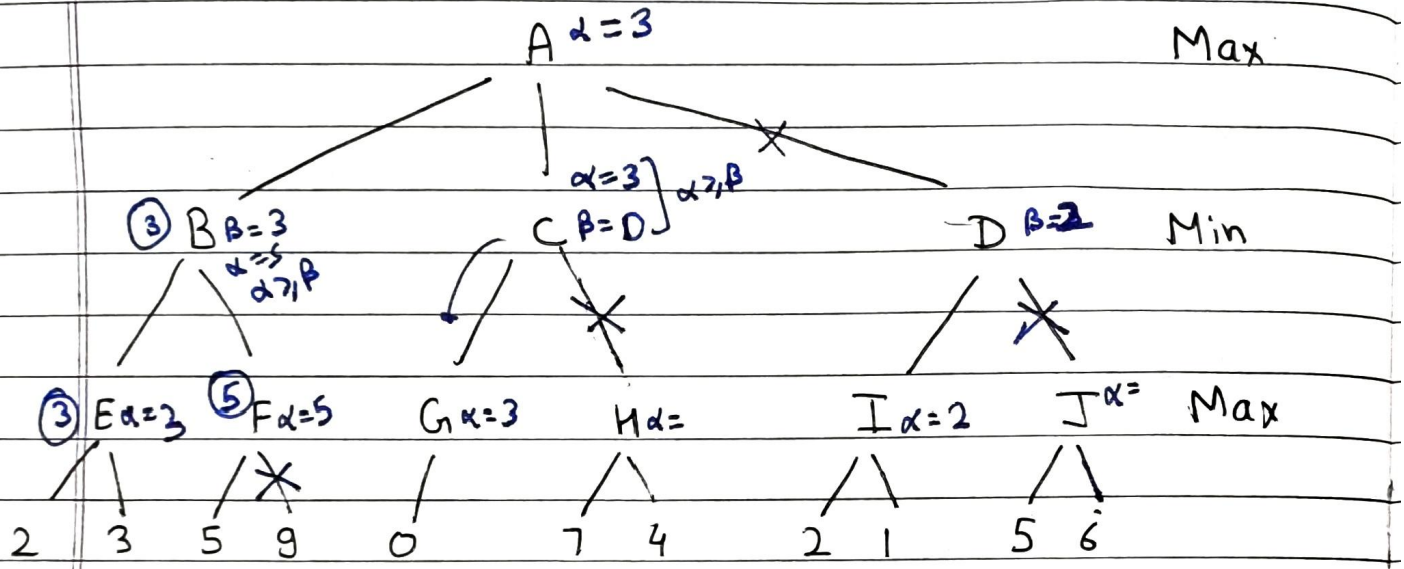
(b) Explain Minimax Procedure and show its step for Tic Tac Toe problem 2018S. (5,5)

(ii) With the help of Tic Tae Toe game, show how Min max procedure help in deciding a good move for maximizing player. 2018C [7,7]

Q5. For the graph below, apply min-max procedure to decide move for Player MAX. What is the max value at the root node by applying mini-max search? Also show alpha beta pruning [4]

2020M





∴ Max Val at Root = 3

(v) Define alpha-beta cut- off and their utility. 2018M

It is a modified technique of minimax algo which is an optimization for minimax algorithm for large sample spaces like chess. Here, we compute correct minimax decision without checking each node of game tree. We prune the nodes which cant affect node's final value based on parameters α and β.

Alpha - The best (highest value) choice we have found so far along the path of maximizer

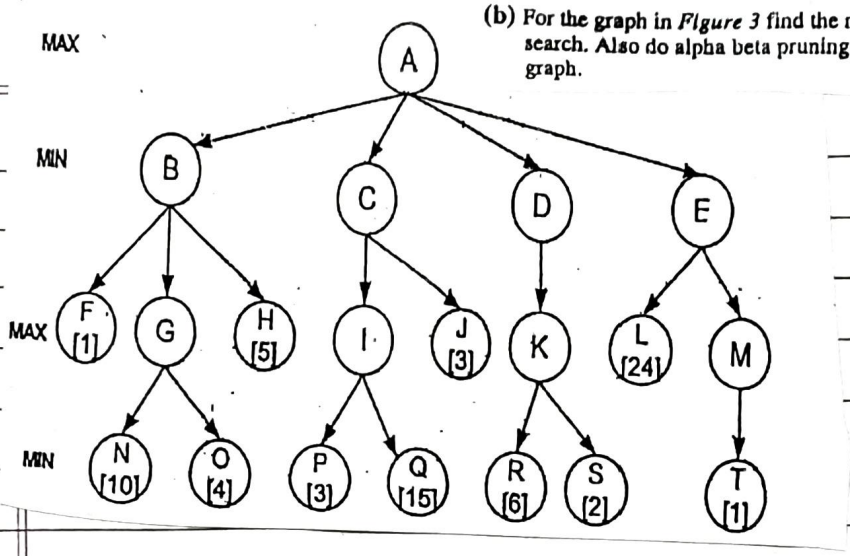
Beta :- The best (lowest ——— minimizes.

Q3. For the graph in Fig (1), find the max value at the root node by applying mini max search. Also show alpha beta pruning.

Page No.

(b) For the graph in *Figure 3* find the max value at the root node by applying mini max search. Also do alpha beta pruning. Choose and highlight the best strategy for the graph.

2018 E



Page No.
Date

(c) Explain the purpose of alpha and beta values in the alpha-beta pruning technique in minimax algorithm. Suppose you have a game tree with a depth of 4 levels. At level 3, a beta cutoff occurs during the alpha-beta pruning process. Explain the conditions that lead to a beta cutoff and how it affects the search. 2023E [2+2] [CO2]

(d) How would you demonstrate that alpha-beta pruning outperforms the minimax search algorithm? 2023SE [5] [CO2]

(c) Define alpha beta cut-offs? Show how the algorithm Alpha Beta explores the given game tree, searching from left to right. Refer Figure 3 [5]

2019E

Page No.
Date

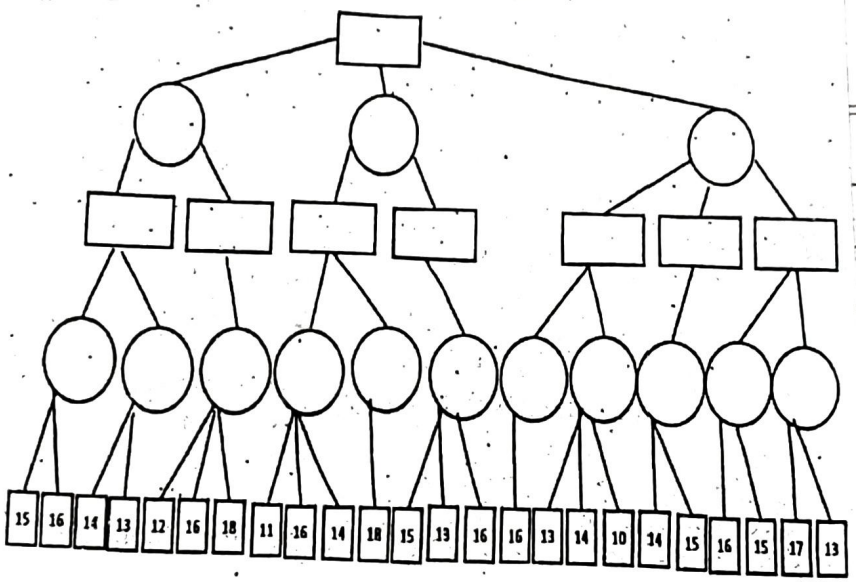


Figure 3

(i) Fill in the leaves that are inspected by AlphaBeta.Show the cutoffs and label them with their type.

(ii)Mark the move that AlphaBeta will choose for MAX at the root.

Page No.
Date

Page No.
Date

Q3. (i) Explain the concept of game tree with suitable example 2019

Q2(a) Consider the given graph (Refer fig. 2) that represents an AND-OR graph. The terminal nodes are labelled *SOLVED* indicated by doubled rectangle and have zero cost. The arcs (all of them labeled 1) represent the cost of transforming the problem. Values associated with nodes are heuristic estimates of solving that node. Simulate the exploration of graph by *AO** algorithm till it terminates. Show how the graph looks at the end of each cycle. Assume *FUTILITY* value of 45. Clearly mark the final solution (by double-lined arcs) in the final graph. for this question. 2019E [5]

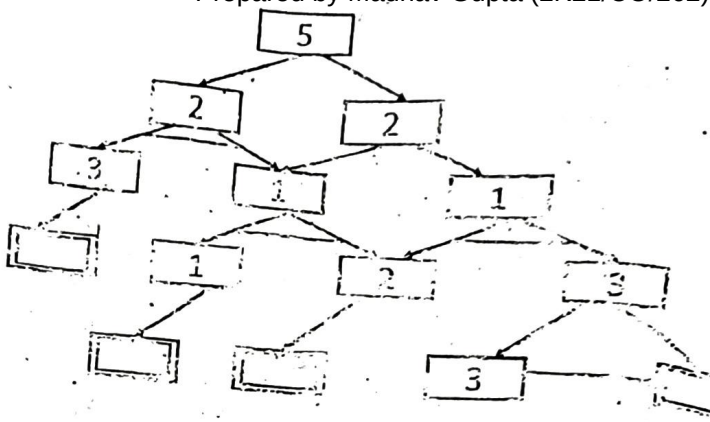


Figure2

(b) Consider a game tree of level 5 for two players MAX and MIN. Level 1 (MAX): A; Level 2 (MIN): B, C, D; Level 3 (MAX): E, F, G, H, I, J; Level 4 (MIN): K, L, M, N, O, P; Level 5: Q, R. Nodes B, C, & D are child nodes of A. Nodes (K, L), (M, N), (O, P), and (Q, R) are child nodes of F, G, J, and M, respectively. An evaluation function is used to assigns score to leaf nodes. The evaluation scores of leaf nodes are given in Table I. Here symbol ? represents inability of function to assign score. Is it possible to find minimax value and optimal strategy to play the game for MAX players? Also, calculate alpha and beta cut-offs if possible. [4] [CO3]

2023E

Table I

Node	K	L	O	R	N	H	I	O	P
Score	3	5	1	2	7	6	1	?	15

Q2(

Page No.
Date

c. Explain the concept of knowledge. What are the different ways to represent Knowledge? 2019S

Q1. (i) Define and explain the terms: heuristic Search, knowledge.

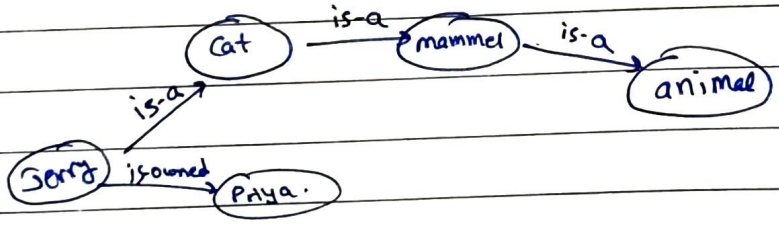
Knowledge is awareness or familiarity gained by experiences of facts, data and situations. It refers to the information about the world including facts, rules, beliefs and heuristics which enables AI systems to understand, reason, learn and make decisions to solve or accomplish tasks.

Q6. What are the different Knowledge representation methods available? What are the essential characteristics of any knowledge representation method ? 2020M [4]

Different knowledge representation methods are:-

→ LOGICAL REPRESENTATION: It is a language with some definite rules which deal with proposition and no ambiguity in representation.

→ SEMANTIC NETWORK REPRESENTATION: In semantic networks, we represent our knowledge in the form of graphical networks. This network consists of nodes representing objects and arcs which describe the relationship between these objects.



→ FRAME REPRESENTATION: A frame is a record like structure which consists of a collection of attributes and its values to describe an entity in the world. These are data structures which divide knowledge into substructures by representing stereotypes situations.

SLOTS	FILTERS
TITLE	Artificial Intelligence
GENRE	Comp. Sc
AUTHOR	Peter Norwig

EDITION	Third Ed.
YEAR	1996
PAGE	1152

→ **PRODUCTION RULES**: Production rule system consists of (condition, action) pairs which mean, "If condition then action". It has mainly three parts:

- → the set of production rules.
- → working memory
- → The recognize-act-cycle.

Eg.) IF (at bus stop AND bus arrives) THEN action (get into the bus).

CHARACTERISTICS

1. **Representational accuracy**: ability to rep. all kind of req. knowledge.
2. **Inferential Adequacy**: ability to manipulate KRS to produce new knowledge corresponding to existing structure.

(iv) What do you understand by inferential efficiency in Knowledge representation method. 2018M.

3. **Inferential Efficiency**: ability to direct inferential knowledge mechanism into the most productive dirn for storing attributes.
4. **Acquisitional efficiency**: ability to acquire new knowledge easily using automatic methods.

(ii) Are Database and knowledgebase same? 2020M

Q2(a

Page No.
Date

Q4. (i) Represent the sentence in clause form: Any student who is intelligent or hard working gets a good placement 2019 M

(ii) Given fact: A→ (B ^ C) and A, Use resolution procedure to prove that B is true. 2019 M

[2,2]