Section - (I)

Ans-(1) (i) Best First Search algorithm ⇒ It is combination of DFS & BFS.

It uses heuristic function $h(n) <= h^*(n)$

where $h(n)$ = heuristic cost

$h^*(n)$ = Estimated cost

→ It is implemented by priority Queue.

BFS :- (i) Place starting node into open List.

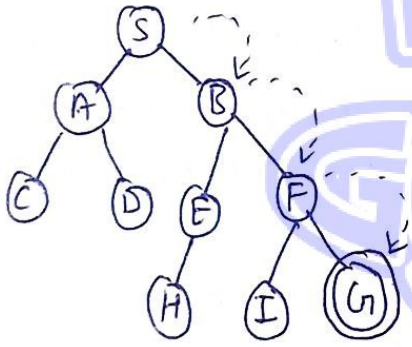
(ii) If openlist is empty, stop & return failure.

(iii) Remove node n from openlist which has lowest value of h(n) & places it in closed list.

(iv) Expand node n & generate successor of node n.

(v) Return to step (2)

Eg -



node	H(n)
A	12
B	4
C	7
D	3
E	8
F	2
H	4
I	9
S	13
G	0

Open{s}, close[ ]

Initialization :- open[A,B], close[s]

Iteration-1 :- Open[A], close[s,B]

Iteration-2 :- Open[E,F,A], close[s,B] ⇒ Open[E,A] close[s,B,F]

Iteration-3 :- Open[I,G,E,A] close[s,B,F]

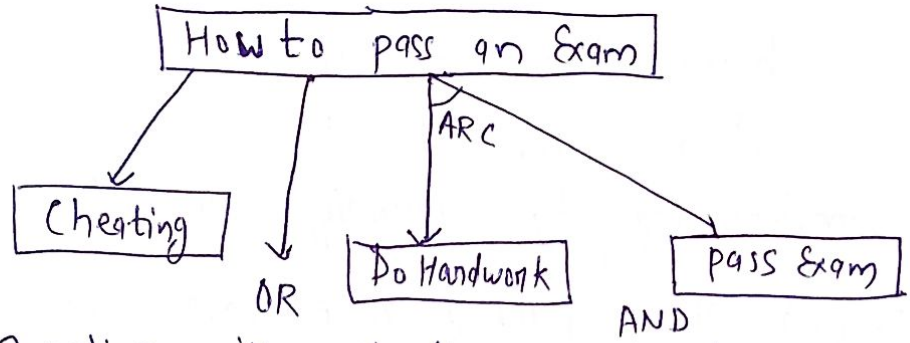
⇓

Open[I,E,G] close[s,B,F,G]

So path is S ⟶ B → F → G.

(b) AO* algorithm is basically based on problem decomposition when a problem can be divided into a set of sub problem, where each sub problem can be solved repeatedly and a combination of these will be a solution AND-OR graph & AND-OR trees are used for representing solution. (2)

Eg-



(i) We have 2 options either cheating or hardwork.
(ii) Pick one & we apply OR condition.
(iii) ARC denotes AND condition.
(iv) We have replicated arc b/w work hard & pass because doing both is more than cheating.

(d)

Propositional Logic	Predicate logic
(i) It is the logic that deals with a collection of declarative statements which have a truth value, true or false.	Predicate logic is an expression consisting of variables with specified domain
(ii) It is most widely used logic. Also known as Boolean logic.	It is an extension of propositional logic covering predicates & Quantification.
(iii) A proposition has a specific truth value, either true or false.	A predicate's truth value depends on the variable's value.
(iv) Scope analysis is not done in proposition logic	Predicate logic helps analyze the scope of subject using $\forall$, $\exists$, $\exists!$.
(v) It has $\sim, \wedge, \vee, \oplus, \Rightarrow, \Leftrightarrow$ operators	It adds by introducing quantifiers to the existing proposition.

(e) First order logic ⇒ It is another way of knowledge Representation in AI. It is an extension to propositional logic. (3)

→ FOL is sufficiently expressive to represent natural language statements.

→ FOL is also known as predicate logic on FOL.

→ FOL assumes facts, objects, relations & function.

Syntax of FOL:-

Constant → 1, 2, A, I- - -
Variables → x, y, a, b - - -
Predicates → Brother, father - - -
Function → sqrt - - -
Connectives → ∧, ∨, ~, ⇒, ⇔
Equality → ==
Quantifier → ∀, ∃

Quantifiers in FOL:-

(A) Universal → For all, everyone, everything (∀)

(B) Existential → For some, at least one (∃)

∀x man(x) ⟶ drink(x, coffee)
∃x : boys(x) ⟶ ∧ intelligent(x)

Properties of Quantifiers:-

∀x ∀y = ∀y ∀x ✓
∃x ∃y = ∃y ∃x ✓
∃x ∀y ≠ ∀y ∃x ✓

(C) Tiles Problem in AI ⇒ Given a 3x3 board with 8 tiles and one empty space. The objective is to place no. on tiles to match final configuration using empty space. We can slide 4 adjacent tiles into the empty space in direction up, down, Left & right.

We can do through uniformed search using directions OR

We can do through heuristic search.

In heuristic search, we use cost function $f = g + h$.

Section – ②

Ay-⑤ **Water-Jug problem** ⇒ In this, we are provided with 2 jugs, one having the capacity to hold 3 gallons of water & the other has capacity to hold 4 gallons of water.

There is no other measuring equipment available and the jugs also don't have any kind of marking on them.

So the task here is to fill the 4 gallon jug with 2 gallon of water by using these 2 jugs. Initially both our jugs are empty.

Production Rule:- $x = 4$, $y = 3$

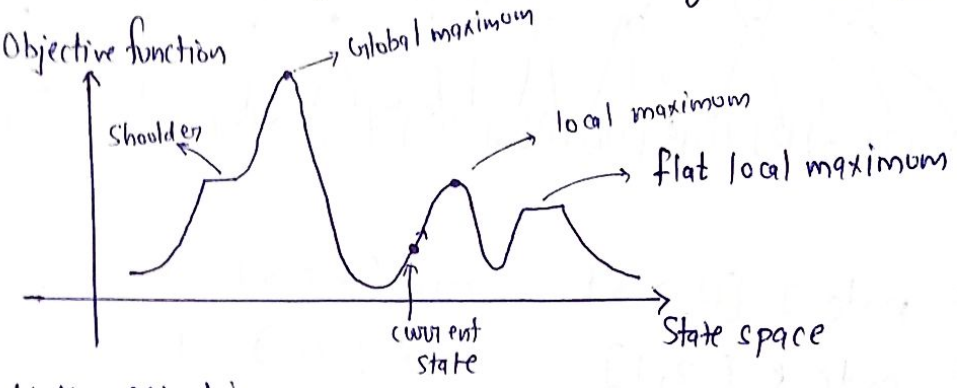
1. $(x, y) = (4, y)$
2. $(x, y) = (x, 3)$
3. $(x, y) = (x - d, y)$, $x > 0$
4. $(x, y) = (x, y - d)$, $y > 0$
5. $(x, y) = (0, y)$
6. $(x, y) = (x, 0)$
7. $(x, y) = (4, y - (4 - x))$, $y > 0$ $x + y >= 4$
8. $(x, y) = (x - (3 - y), 3)$ $x > 0$ $x + y >= 3$
9. $(x, y) = (x + y, 0)$, $x + y <= 4$
10. $(x, y) = (0, x + y)$, $x + y <= 3$

x	y	Rule
0	0	—
0	3	2
3	0	9
3	3	2
4	2	7
0	2	5
2	0	9

Ans (2) Hill Climbing concept ⇒ It is a local search algo which continuously moves in the direction of increasing elevation/value to find the peak of mountain or best solution to the problem. (5)

→ It terminates when it reaches a peak value where no neighbor has a higher value.

→ Hill Climbing is mostly used when a good heuristic is available.



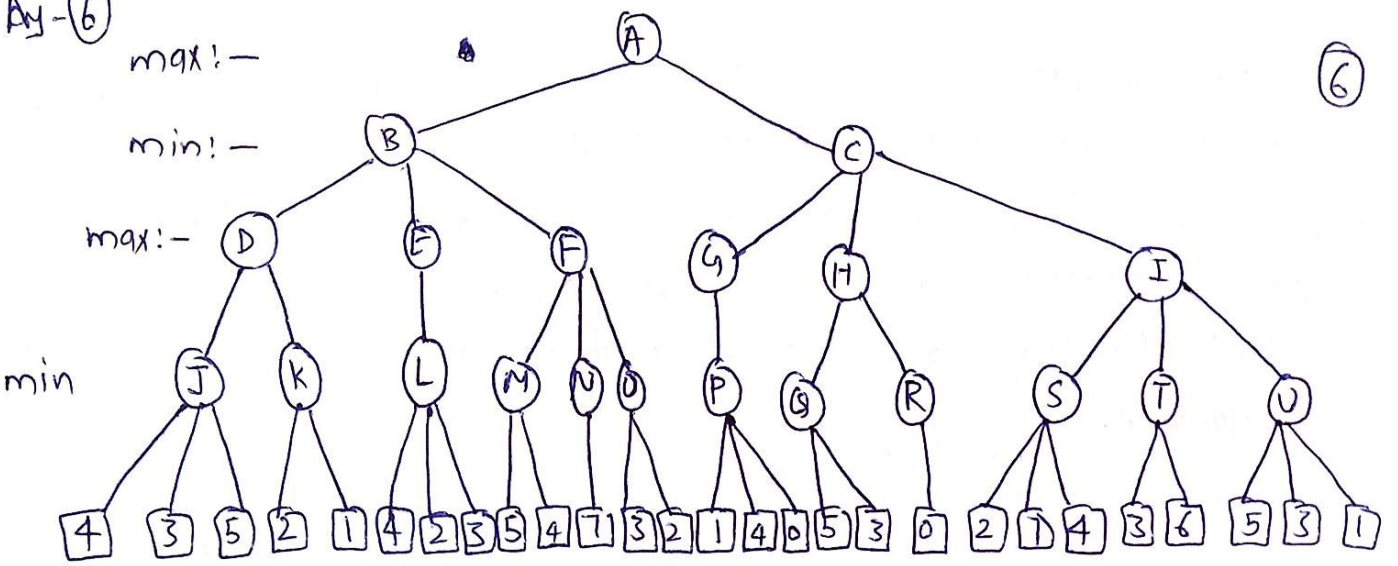
Types of Hill Climbing:-

(i) Simple Hill Climbing:- It only evaluates the neighbor node state at a time & selects the first one which optimizes current cost & set it as a current state.

(ii) Steepest-Ascent Hill Climbing:- This algorithm examines all the neighboring nodes of the current state & selects one neighbor node which is closest to the goal state. This algorithm consumes more time as it searches for multiple neighbors.

(iii) Stochastic hill climbing:- It does not examine for all its neighbor before moving. Rather, this search algo selects one neighbor node at random & decides whether to choose it as a current state or examine another state.

Ay-(6)



(6)

At node J {4,3,5} min (4,3,5) = 3

At node K {2,1} min {2,1} = 1

At node L {4,2,3} min (4,2,3) = 2

At node M {5,4} min (5,4) = 4

At node N (7) min (7,∞) = 7

At node O {3,2} min (3,2) = 2

At node P {1,4,0} min (1,4,0) = 0

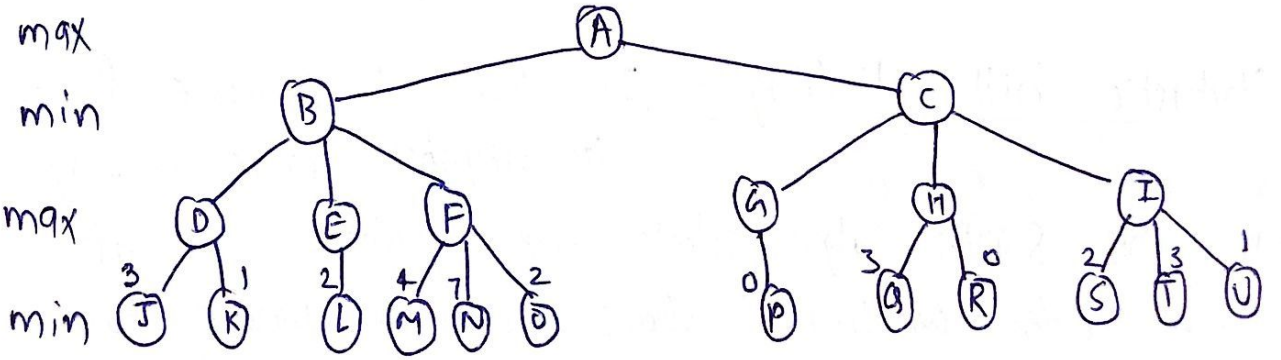
At node Q {5,3} min (5,3) = 3

At node R {0} min (0,∞) = 0

At node S {2,7,4} min (2,7,4) = 2

At node T {3,6} min (3,6) = 3

At node U {5,3,1} min (5,3,1) = 1



Now at node D {3,1} max(3,1) = 3

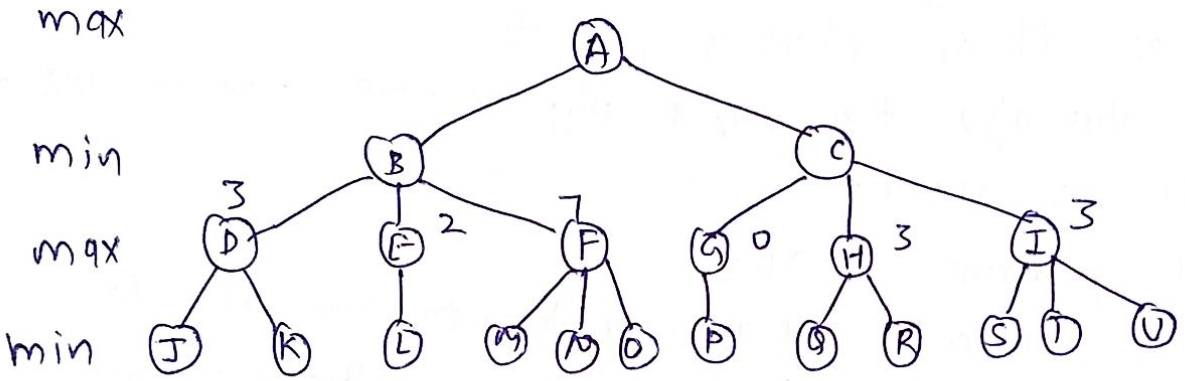
At node E {2} max(2,-∞) = 2

At node F {4,7,2} max(4,7,2) = 7

At node G {0} max(0,-∞) = 0

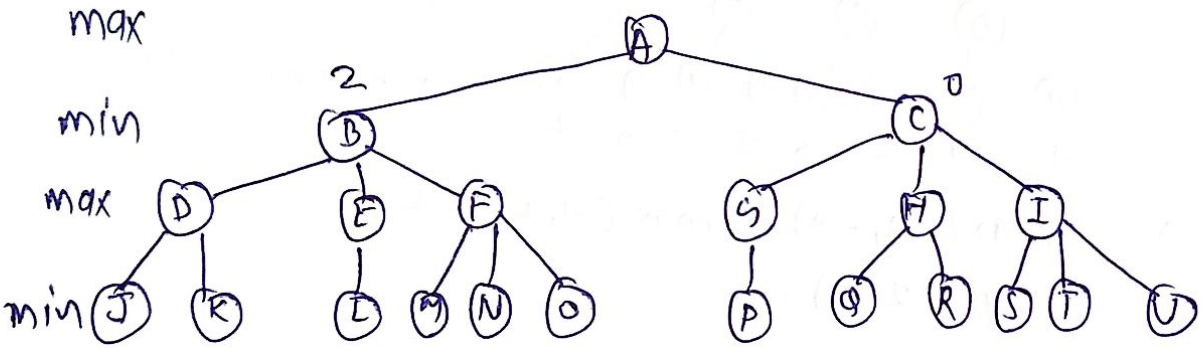
At node H {3,0} max(3,0) = 3

At node I {2,3,1} max(2,3,1) = 3



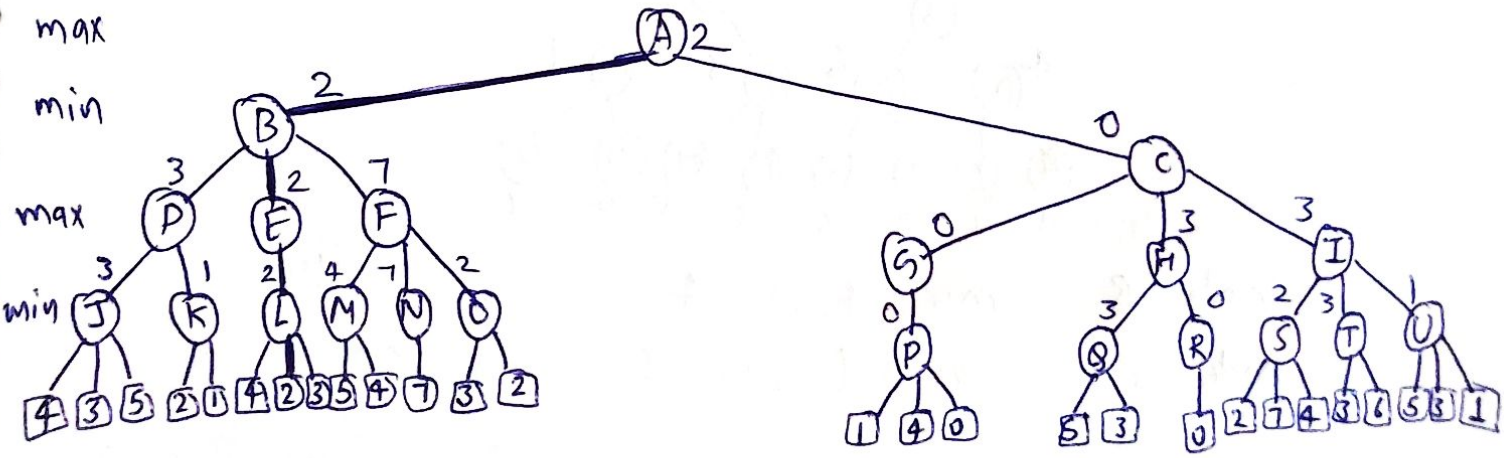
Now at node B {3,2,7} min(3,2,7) = 2

At node C {0,3,3} min(0,3,3) = 0



Now at node A {2,0} max(2,0) = 2

maximizer At A max(2,0) = 2



So A → B → E → L → 2

③ Minimax Algorithm ⇒

It is a recursive or backtracking algorithm which is used in decision making & game theory. It provides an optimal move for the player assuming the opponent is also playing optimally.

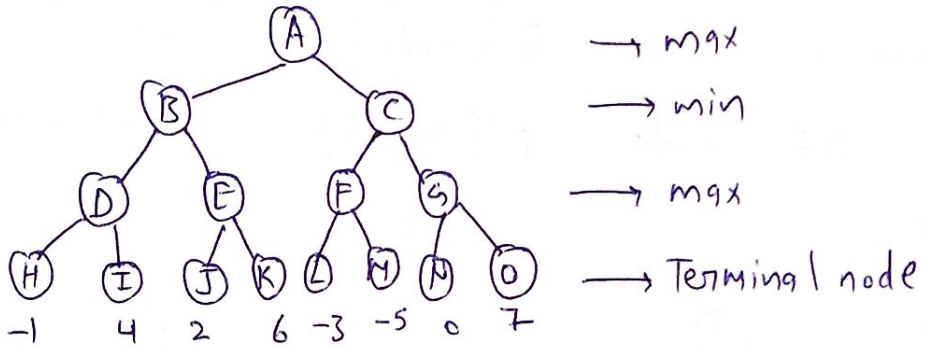
→ It uses recursion to search through the game-tree.

→ Mini-max algo. is mostly used for game playing in AI such as Chess, checkers, go etc.

→ In this algo two players play the game, one is MAX and other is MIN.

→ It performs a DFS.

→ It proceeds all the way down to terminal node of the tree, then backtrack the tree as the recursion.

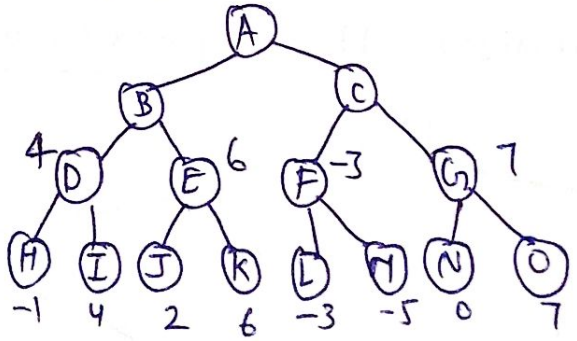


For node D $\max(-1, -\infty) \Rightarrow \max(-1, 4) = 4$

For node E $\max(2, 6) = 6$

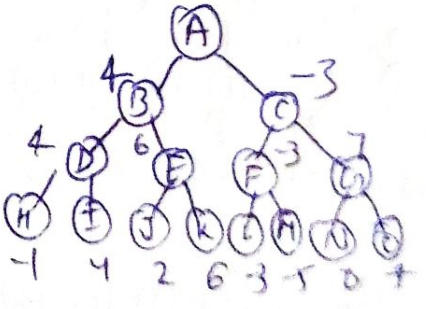
For node F $\max(-3, -5) = -3$

For node G $\max(0, 7) = 7$

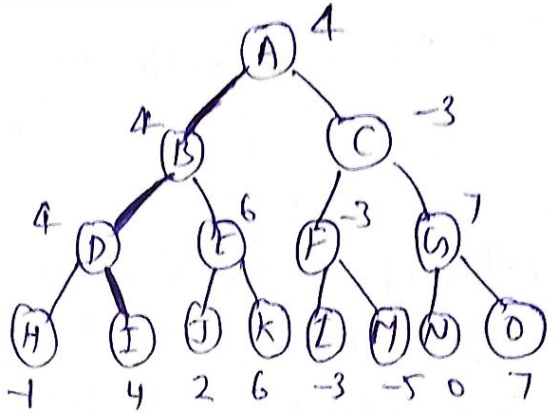


For node B $\min(4, 6) = 4$

For node C $\min(-3, 7) = -3$



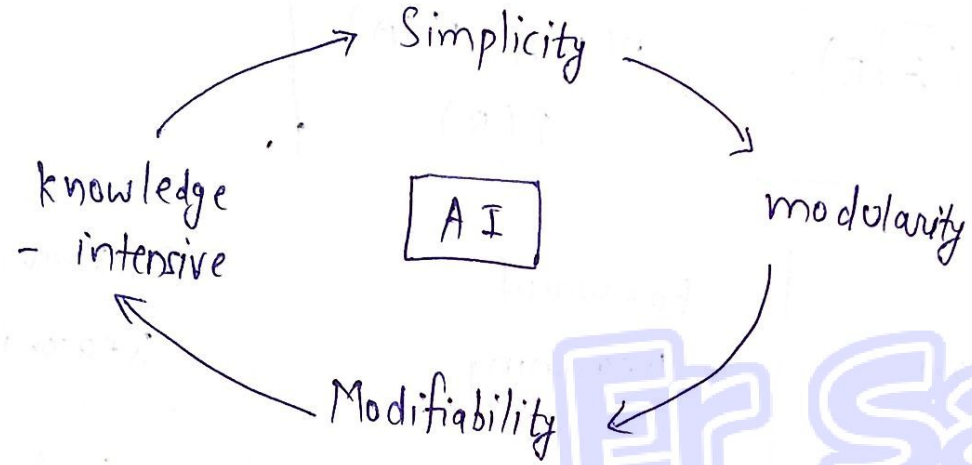
For node A:-
max(4, -3) = 4



Ans - (4) It is used for planning by asking for a situation in which a goal is true.
Answer extraction is used to find a situation in which the goal is true.
This situation can be interpreted as sequence of actions for agent to perform.

(a) Production System is based on set of rules about behavior. These rules are a basic representation found helpful in expert systems, automated planning & action selection.

Characteristic of Production System:-



Production System Rules ⇒

- Deductive Inference Rules
- Abductive Inference Rules

(b) Control Strategies ⇒

→ The first requirement for a good control strategy is that it should cause motion.

→ The second requirement for a good control strategy is that it should be systematic.

→ Finally, it must be efficient in order to find a good answer.

(c) Bayes Theorem :- It determines the probability of an event with uncertain knowledge.

→ It is a way to calculate the value of $P(B|A)$ with knowledge of $P(A|B)$ (2)

→ It allows updating probability prediction of an event by observing new information of real world.

$$P(A \wedge B) = P(A|B)\,P(B) \quad \text{OR} \quad P(B|A)\,P(B)$$

$$\star \quad P(A|B) = \frac{P(B|A)\,P(A)}{P(B)}$$

(d)

Comparison	Forward Reasoning	Backward Reasoning
1. Basic	Data-driven	Goal driven
2. Begins with	New data	Uncertain conclusion
3. Objective is to find	Conclusion that must follow	facts to support the conclusions
4. Flow	incipient to consequence	Consequence to incipient
5. Approach	Opportunistic	Conservative

(e) Learning is a process that improves the knowledge of an AI program by making

observations about its environment.

→ Learning is one of the fundamental building blocks of AI.

Knowledge Based Classification:- (3)

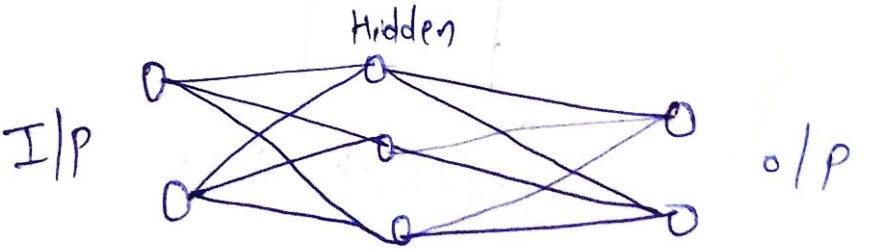
Factoring its representation of knowledge, AI learning models can be classified in 2 main types: inductive & Deductive.

Inductive :- It is based on inferring a general rule from datasets of input-output pairs.

Section - (2)

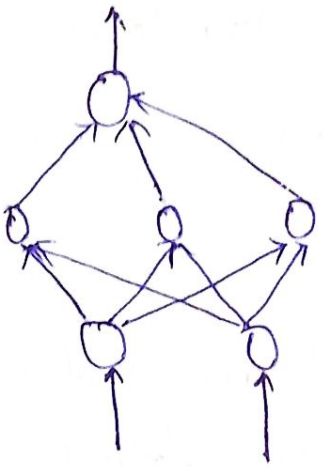
(a) Neural Networks :- These are computing systems inspired by the biological neural networks that constitute animal brains.

The idea of ANNs is based on belief that working of human brain, by making right connections, can be imitated using silicon & wires as living neurons & dendrites.



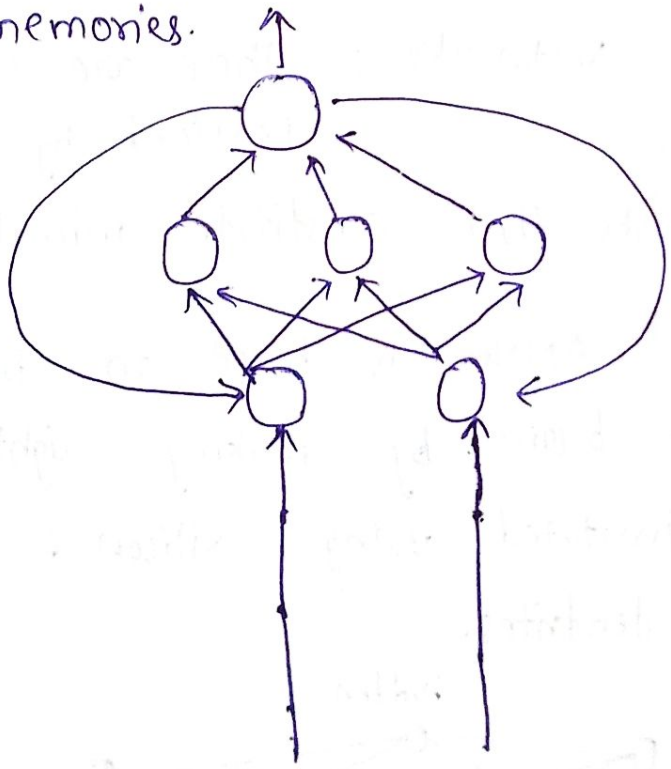
Types of ANN:-

(i) **Feed Forward ANN:⇒** The information flow is undirectional A unit sends information to other unit from which it does not receive any information. There are no feedback loops.



feedforward ANN

(ii) **Feed Back ANN:⇒** Feeback loops are allowed. They are used in content addressable memories.



feedBack ANN

(c) Expert System ⇒ It is a computer program that is designed to solve complex problems and to provide decision making ability like a human expert. It performs this by extracting knowledge from its knowledge base during the reasoning & inference rules according to user queries. (9)

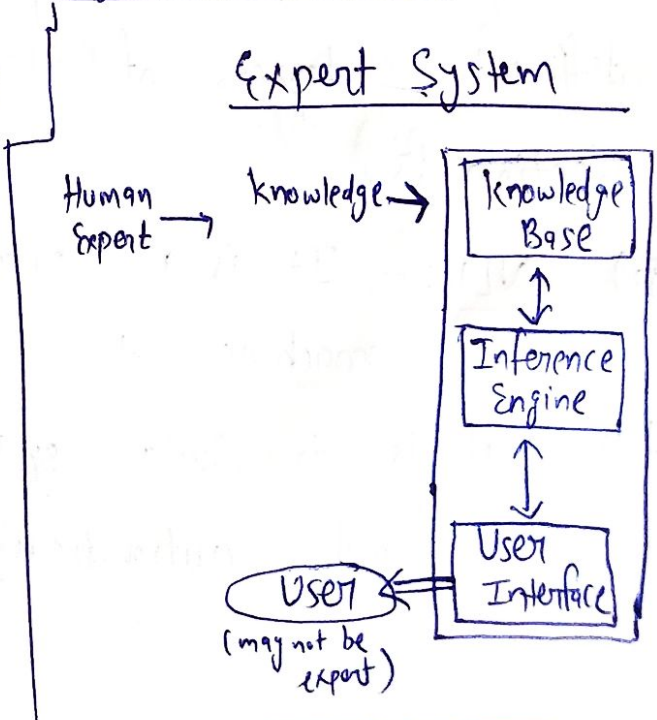
→ These systems are designed for a specific domain such as medicine, science, etc.

MYCIN ⇒ It was one of the earliest backward chaining expert systems that was designed to find the bacteria causing infections like bacteraemia & meningitis.

It was also used for the recommendation of antibiotics and the diagnosis of blood clotting diseases.

Characteristics of Expert System

→ High Performance
→ Understandable
→ Reliable
→ Highly Responsive



(d) Fuzzy set ⇒

Fuzzy logic systems (FLS) produce acceptable but definite output in response to incomplete, ambiguous, distorted, or inaccurate input. (10)

→ Fuzzy logic is a method of reasoning that resembles human reasoning. The approach of FL imitates the way of decision making in humans that involves all intermediate possibilities b/w digital values Yes and No.

→ FL is useful for commercial & practical purposes.

- It can control machines & consumer products.
- FL helps to deal with uncertainty in engineering.

⇒ In a binary system, a sample either belongs to a class or not, whereas in the fuzzy system, a sample can belong to different classes with different degrees of membership.

Section - (3)

(b) NLP :- It is a branch of AI that enables machines to understand the human languages Its goal is to build systems that can make sense of text and automatically perform tasks like

translation, spell check or topic classification.

→ NLP examples like Sini & Alexa.

→ NLP understands written & spoken text like "Hey sini" and transforms it into numbers, making it easy for machines to understand.

Another Application of NLP is <u>chatbots.</u> (11)

→ NLP applies 2 techniques :

→ Syntactic Analysis

→ Semantic Analysic

- Syntactic Analysis analyzes text using basic grammer rules to identify sentence structure.
- Semantic Analysis focuses on capturing the meaning of text.

Ans - (iii) <u>Learning from Example ⇒</u>

Induction Learning is carried out on the basis of supervised learning.

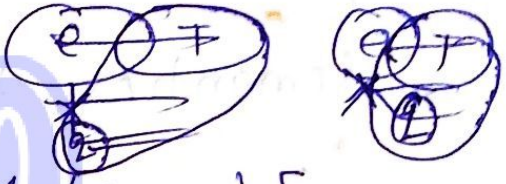
In this learning process, a general rule is induced by the system from a set of observed instance.

However, class definitions can be constructed with the help of classification method.

Eg- 'f' is target function & example is a pair $(x f(x))$ where 'x' is i/p & f(x) is o/p function.

Learning in Problem Solving:-

- Humans have a tendency to learn by solving various real world problems.
- As the outcomes have to be evaluated, this type of learning also involves the definition of a utility function.



$$Q(s_t, a_t) \leftarrow Q(s_t, a_t) + \alpha_t(s_t, a_t)\left[r_t + \gamma \max_a Q(s_{t+1}, a) - Q(s_t, a_t)\right]$$

$$0 \leq a_t(s,a) \leq 1$$

$$0 \leq \gamma < 1$$