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Course Title: Artificial Intelligence and Knowledge Management

Name: sahil Course code: MCSE-003

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Ques 1: state and justify the validity of following inference rules

i) implication

ii) Contra positive

i) Implication: Implication, in logic, a relationship b/w two proposition in which the second is a logical consequence of the first. In most systems of formal logic, a broader relationship called material implication is employed, which is read "If A, then B," and is denoted by $A \supset B$ or $A \rightarrow B$. The truth or falsity of the compound proposition $A \supset B$ depends not on any relationship b/w the meanings of the propositions but only on the truth values of A and B; $A \supset B$ is false when A is true and B is false, and it is true in all other cases. Equivalently, $A \supset B$ is often defined as $\sim(A \cdot \sim B)$ or as $\sim A \vee B$ (in which $\sim$ means "not," $\cdot$ means "and", and $\vee$ means "or"). This way of interpreting $\supset$ leads to the so-called paradoxes of material implication: "grass is red $\supset$ ice is cold" is a true proposition according to this definition of $\supset$.

In an attempt to construct a formal relationship more closely akin to the intuitive notion of implication, Clarence Irving Lewis,

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known for his conceptual pragmatism, introduced in 1932 the notion of strict implication. strict implication was defined as $\sim(A\cdot\sim B)$, in which means "is possible" or "is not self contradictory". Thus A strictly implies B if it is impossible for both A and $\sim B$ to be true. This conception of implication is based upon the meanings of the propositions, not merely upon their truth or falsity.

ii) Contra positive: In logic, the contra positive of a conditional statement is formed by negating both terms and reversing the direction of inference. More specifically, the contra positive of the statement "if A, then B" is "if not B, then not A." A statement and its contrapositive are logically equivalent, in the sense that if the statement is true, then its contrapositive is true and vice versa.

In mathematics, proof by contrapositive, or proof by contraposition, is a rule of inference used in proofs, where one infers a conditional statement from its contrapositive. In other words, the conclusion "if A, then B" is inferred by constructing a proof of the claim "if not B, then not A" instead. More often than not, this approach is preferred if the contrapositive is easier to prove than the original conditional statement itself.

For example let x be an integer.

To prove: if x^2 is even, then x is even.

Although a direct proof can be given, we choose to prove this statement by contraposition

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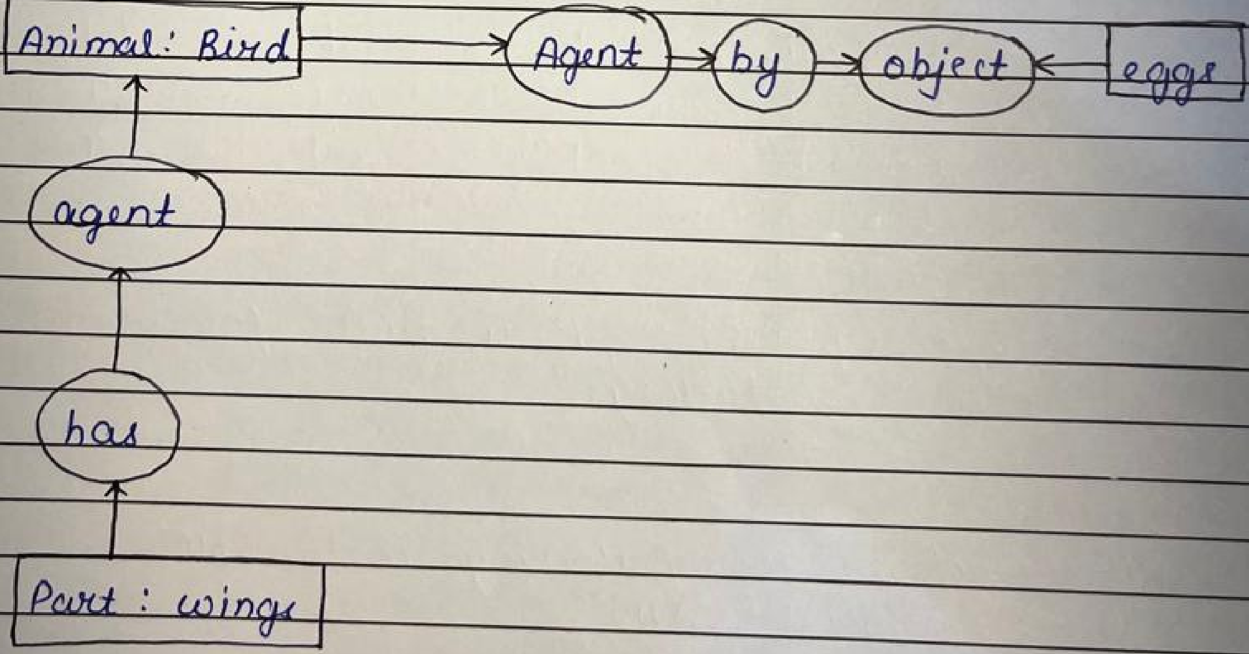
The contrapositive of the above statement is :
If x is not even, then x^2 is not even.
This latter statement can be proven as follows:
suppose that x is not even, then x is odd.
The product of two odd numbers is odd,
hence $x^2 = x \cdot x$ is odd. Thus x^2 is not even.
Having proved the contrapositive, we can
then infer that original statement is true.

Ques2: Transform the FOPL statement given below into equivalent English sentence and conceptual graph.
$\forall x\,(\text{Has wings}(x) \land \text{Layseggs}(x) \rightarrow \text{is\_Bird}(x))$

[X : ∀] ← (AGENT) ← [LAYS] → (OBJECT)
→ [EGGS] → (ATTRIBUTE) → [WINGS] → [BIRD : X]

Conceptual graph:



Ques 3: Determine whether each of the following WFF are satisfactory, contradictory or valid

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i) $(P \wedge Q) \vee \sim(P \wedge Q)$
ii) $(P \rightarrow Q) \rightarrow \sim P$

i) $(P \wedge Q) \vee \sim(P \wedge Q)$

P	Q	$P \wedge Q$	$\sim P \wedge Q$	$(P \wedge Q) \vee \sim(P \wedge Q)$
T	T	T	F	T
T	F	F	T	T
F	T	T	T	T
F	F	F	T	T

science, $(P \wedge Q) \vee \sim(P \wedge Q)$ is true for each combination, it is valid.

ii) $(P \rightarrow Q) \rightarrow \sim P$

P	Q	$P \rightarrow Q$	$\sim P$	$(P \rightarrow Q) \rightarrow \sim P$
T	T	T	F	F
T	F	F	F	T
F	T	T	T	T
F	F	T	T	T

since, $(p \rightarrow Q) \rightarrow \sim P$ is true for some cases, it is satisfactory.

Ques 4: Transform the following in to CNF
i) $\sim(C \rightarrow D) \vee (C \wedge D)$
ii) $\sim(X \rightarrow Y) \rightarrow Z$

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Using method 1: Truth Table

i) $\sim(C \rightarrow D) \vee (C \wedge D)$

C	D	$C \rightarrow D$	$\sim(C \rightarrow D)$	$C \wedge D$	$\sim(C \rightarrow D) \vee (C \wedge D)$
0	0	1	0	0	0
0	1	1	0	0	0
1	0	0	1	0	1
1	1	1	0	1	1

ii) $\sim(x \rightarrow y) \rightarrow z$

x	y	z	$x \rightarrow y$	$\sim x \rightarrow y$	$\sim x - y \rightarrow z$
0	0	0	1	0	1
0	0	1	1	0	0
0	1	0	1	0	1
0	1	1	1	0	0
1	0	0	0	0	1
1	0	1	0	1	0
1	1	0	1	1	1
1	1	1	1	8	0

Ques 5: With the help of a suitable example, describe the "member" function of PROLOG. How it is used for searching of a data in a list, recursively.

Member function of PROLOG:

member (? Term, ? List)

succeeds if Term unifies with a member of the list.

? Term

Prolog Term

? List

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List or variable

Description

Tries to unify Term with an element of the list list.

If Term is a variable and list is a list, all the members of the list are found on backtracking. If list is not instantiated, member/2 binds list to a new partial list containing the element Term. The definition of this Prolog library predicate is:

```
member (X, [X|_]).
member (X, [Y[T]):- member (X, T).
```

This predicate does not perform any type testing functions.

Modes and Determinism

- member (-, +) is nondet
- member (+, -) is nondet
- member (-, -) is multi

Fail conditions

Fails if term does not unify with a member of the list list

Resatisfiable

Yes.

Examples.

Success

```
member (q, [1, 2, 3, p, q, r])
member (q, [1, 2, F])          (gives F=q)
member (X, [1, X]).            (gives X=1; X=_g118)
member (X, [2, 1]).            (gives X=2 ; =_g114; X=_g94)
member (1, L)                  (gives L=[1]|_g64];
                       L= [_g62, 1|_g68] etc.
```

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Fail :

member (4, [1, 2, 3]).

List searching

We can use lists within facts and rules. One common way of using lists is to store inf. within a list and then subsequently search for this information when we run our programs. To order to search a list, Prolog inspects the first item in a list and then goes on to repeat the same process on the rest of the list. This is done by using recursion. We have already seen how we can go about doing this. In the previous section we showed how to take the head and a tail of a list:

[Head | Tail]

This method constitutes the basis of the searching method. We shall use it to pull apart a list, looking at the first item each time, recursively looking at the tail, until we reach the empty list [], when we will stop.

List searching : Example.

Consider the following problem. How can I see if a particular item is on a particular list? For example I want to test to see if item apples is on the list. One possible methods of doing this is by going through the list, an item at a time, to see if we can find the item we are looking for. The way we do this in Prolog is to say that we could definitely prove an item was on a list if we knew that the target item was the first one on the list. ie

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on (Item, [Item | Rest]). /* is the target item the head of the list */.
Otherwise we could prove something was on a list if we could prove that although it didn't match the existing head of the list, it nonetheless would match another head of the list if we disregarded the first item and just considered the rest of the list i.e
on(Item, [DisregardHead | Tail]).
        on (Item, Tail)
We now have a program consisting of a fact and a rule for testing if something is on a rule. If it is not, then we throw away the first item in the list and look at the rest.

Ques 6: Transform the following conceptual graph in to FOPL statement
[PERSON : Anita] ← (AGENT) ← [DRINK] → [OBJECT) → [FOOD : MILK] → ← (Instrument Glass)

(∃x) ((Persion (x : Anita and DRINK (x)) → Glass (x)

Ques 7: Write a recursive program is LISP to find factorial of a no. given by the user?
Factorial : The factorial of a non-negative integer n, denoted by n! is the product of all positive integers less than or equal to n.

$$n! = \begin{cases} 1 & \text{if } n=0 \\ (n-1)! \times n & \text{if } n>0 \end{cases}$$

Example: 4! = 4 * 3 * 2 * 1 = 24

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similarly 6! = 6 * 5 * 4 * 3 * 2 * 1 = 720
The value of 0! is 1, according to the convention for an empty ~~pockst~~ product.
SOURCE CODE (IF INCLUDED)

```
(defun factorial (n)
(if (= n 1)
1
(* n (factorial (- n 1)))))
(factorial 4)
24
(factorial 6)
720
```

Result:

Ques 8: How a language for artificial intelligence differs from normal programming languages? Give name of three languages frequently used as programming language for developing Expert system.

A typical program has three major segments: input, processing and output. So regular programming and Artificial Intelligence programming can be compared in terms of these three segments.

INPUT

In regular programming, input is a sequence of alphanumeric symbols presented and stored as per some given set of previously stipulated rules and that uses a limited set of communication media such as keyboard, mouse, disc etc. In artificial intelligence programming the input may be a sight, sound, touch,

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smell or taste. sight means one dimensional symbols such as typed text, two dimensional objects or three dimensional scenes.

PROCESSING

In regular programming, processing means manipulation of the stored symbols by a set of previously defined algorithms. In AI programming, processing includes knowledge representation and pattern matching, search, logic, problem solving and learning.

OUTPUT

In regular programming, output is a sequence of alphanumeric symbols, may be in a given set of colors, that represents the result of the processing and that is placed on such a medium as a CRT screen, paper, or magnetic disk. In AI programming, output can be in the form of printed language and synthesized speech, manipulation of physical objects or locomotion i.e, movement in space.

Three languages which is used in Expert system:

LISP (LIST Processing):

John McCarthy developed LISP in 1950, which stands of LISt processor. It supports symbolic manipulation and interactive trial and error style of programming. The most prolific advantage of LISP is that it has a set of primitive operator for carrying out deduction with sentences containing words representing predicates and their arguments and thus helps in implementing logical inferences.

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Prolog :
A PROLOG program consists of set of clauses. A clause is either a fact of a rule, which is used to indicate a relationship b/w elements. PROLOG tries to match the arguments of the query with the facts in the data base. This process is known as unification.
When a goal matches the head of a rule rather than a fact, the atoms within the body of the rule are treated as sub goals that must all be satisfied to prove that the head is satisfied.
Expert system tools :
The main task of expert system development tools is making development of an expert system much easier compared to programming language. Developers say that selecting the correct tool is a vital in design and development of an expert system. The reasons are manifold. Defining model, knowledge representation and inference design are built into the tools. Helps in maintaining the system and historical database.

Ques 9: What do you mean by term "Agents" in Artificial Intelligence? Classify the various types of agents.
Artificial intelligence is defined as a study of rational agents. A rational agent could be anything which make decisions, as a person, firm, machine or software. It

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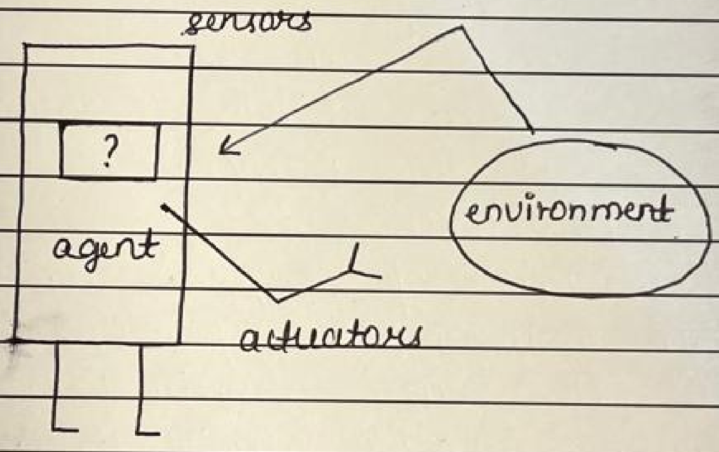
carries out an action with the best outcome after considering past and current percepts.
An AI system is composed of an agent and its environment. The agents act in their environment. The environment may contain other agents. An agent is anything that can be viewed as :

- perceiving its environment through sensors and
- acting upon that environment through actuators



Types of Agents :
Agents can be grouped into four classes based on their degree of perceived intelligence and capability :

- Simple Reflex Agents
- Model- Based Reflex Agents
- Goal- Based Agents
- Utility - Based Agents
- Learning Agent

Simple Reflex Agents
Simple Reflex Agents ignore the rest of the percept history and act only on the basis of the current percept. Percept history is the history of all that an agent has

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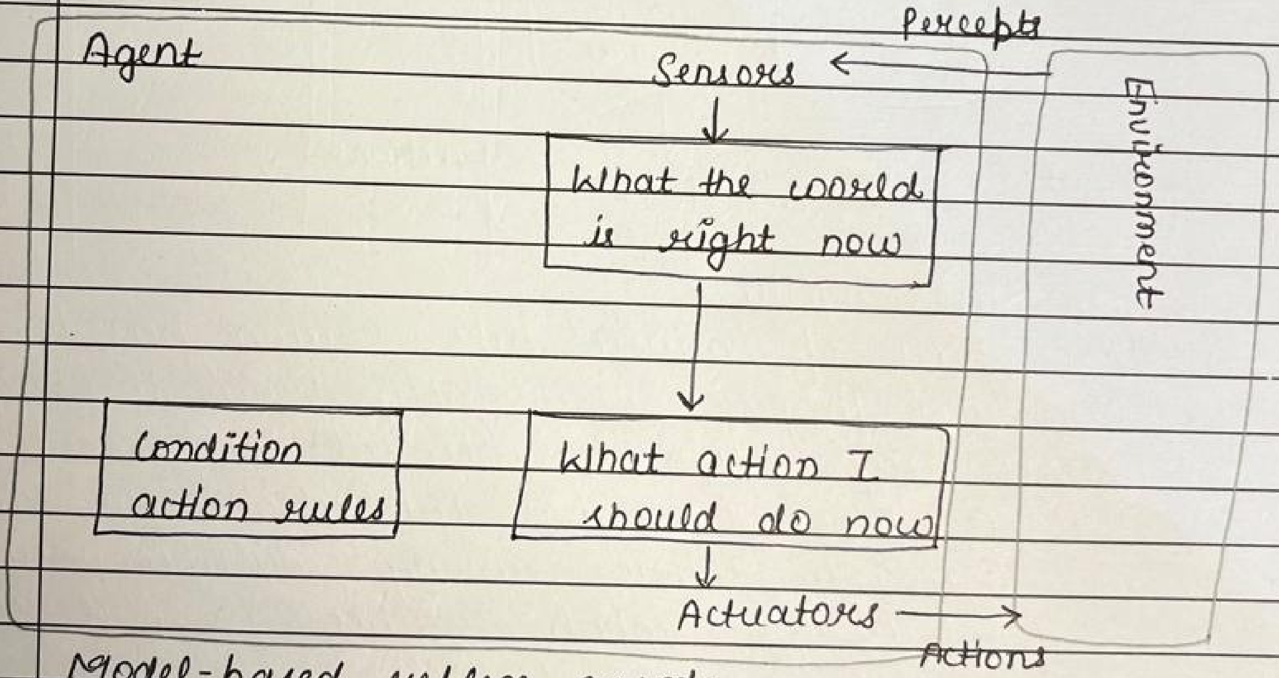
perceived till date. This agent function only succeeds when the environment is funny observable.

Problems with simple reflex agents are:

- Very limited intelligence
- No knowledge of non-perceptual parts of state.
- Usually too big to generate and store
- If there occurs any change in the environment, then the collection of rules need to be updated.



Model-based reflex agents

It works by finding a rule those condition matches the current situation. A model-based agent can handle partially observable environments by use of model about the world. The current state is stored inside the agent which maintains some kind of structure describing the part of the world which can not be seen.

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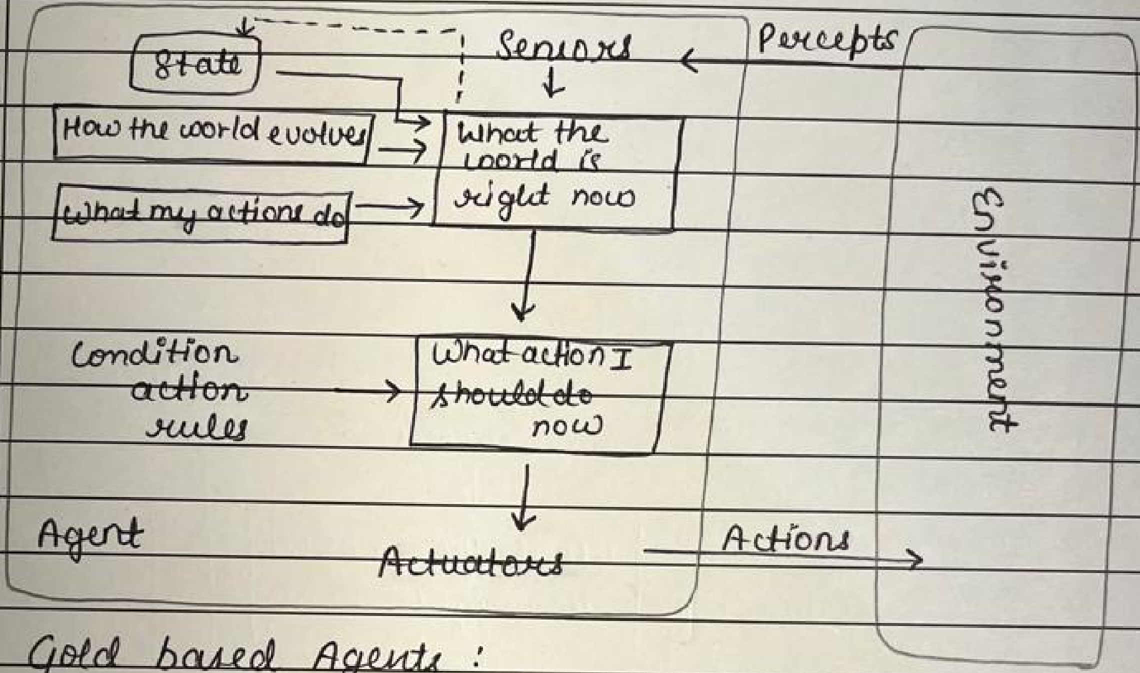
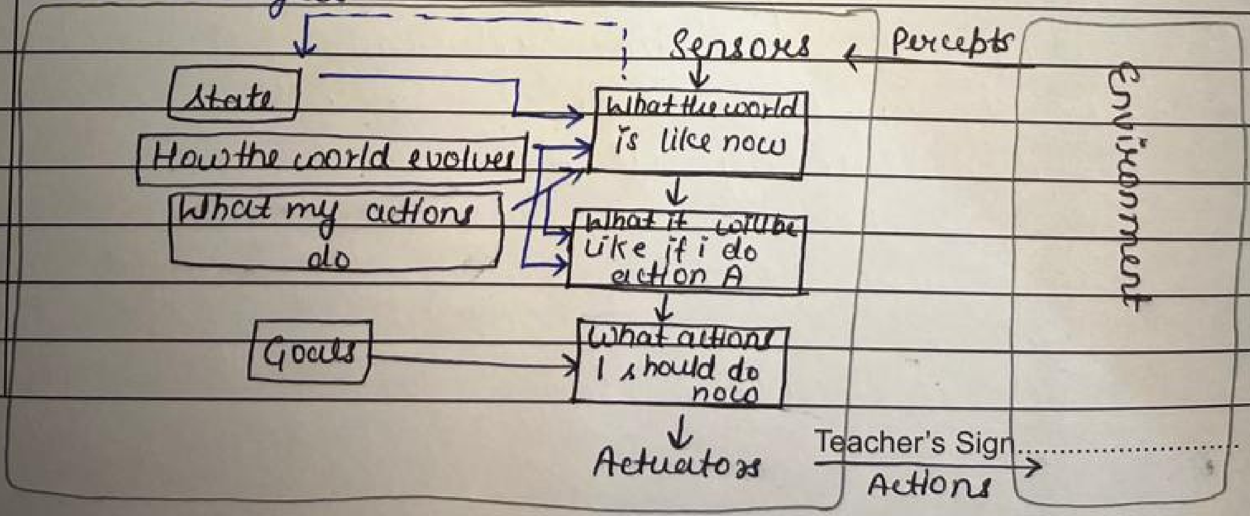
Updating the state requires information about:
- how the world evolves in-dependently from the agent and
- how the agent actions affect the world.



Gold based Agents:
These kind of agents take decision based on how far they are currently from their goal. Their every action is intended to reduce its distance from the goal. This allows the agent a way to choose among multiple possibilities, selecting the one which reaches a goal state. The goal-based agent's behaviour can easily be changed.


Sensors
Percepts
State
What the world is like now
How the world evolves
What my actions do
What it will be like if i do action A
Goals
What actions I should do now
Actuators
Actions
Environment

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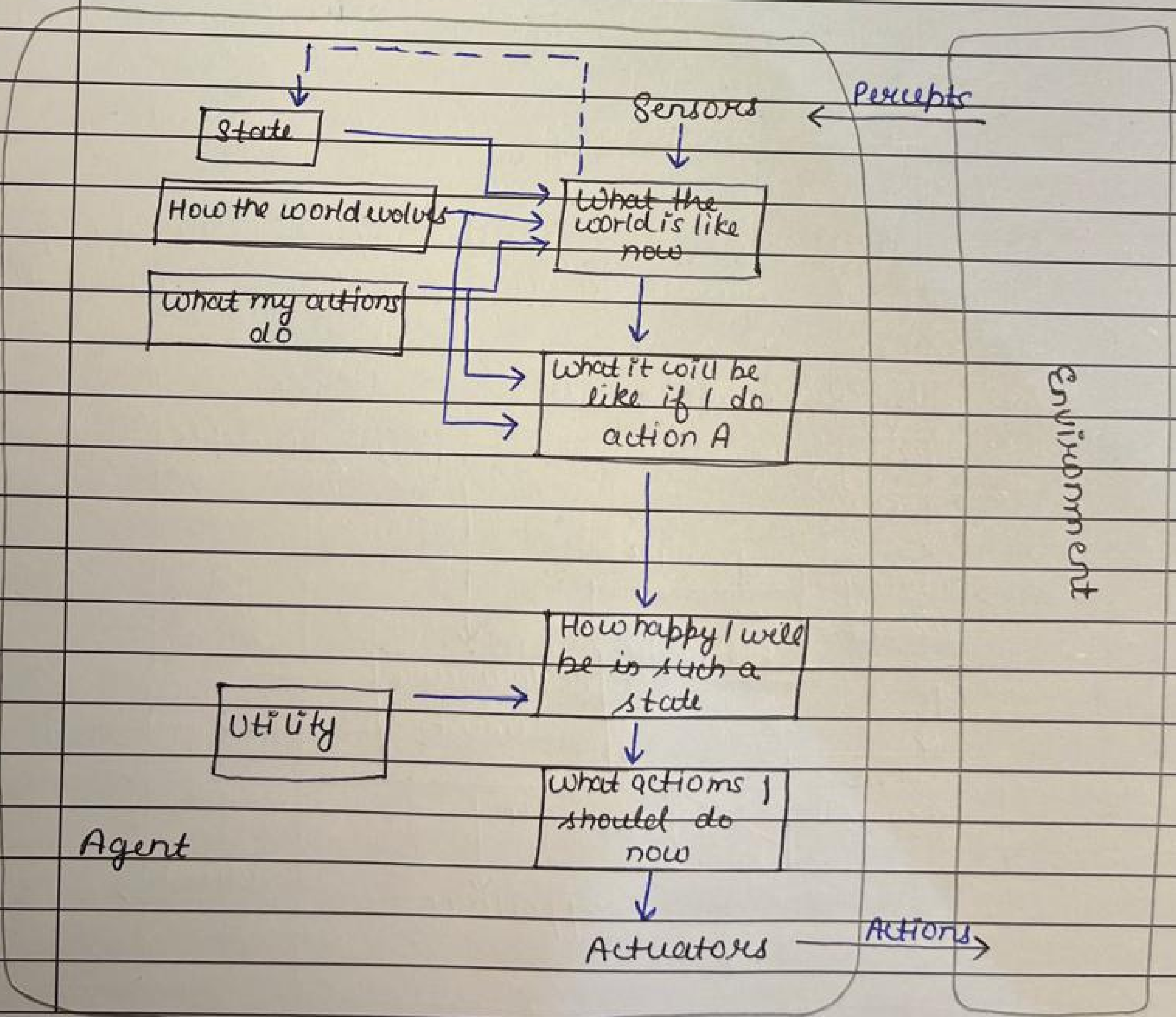
Utility Based Agents :

The agents which are developed having their end uses as building blocks are called utility based agents. When there are multiple possible alternatives, then to decide which one is best, utility based agents are used. They choose actions based on a preference for each state. Utility describes how " happy " the agent is. Because of the uncertainity in the world, a utility agent chooses the action that maximizes the expected utility.



State
How the world evolves
What my actions do
Sensors
Percepts
What the world is like now
What it will be like if I do action A
How happy I will be in such a state
Utility
What actions I should do now
Actuators
Actions
Agent
Environment

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Learning agent

A learning agent in AI is the type of agent which can learn from its past experiences or it has learning capabilities. It starts to act with basic knowledge and then able to act and adapt automatically through learning.

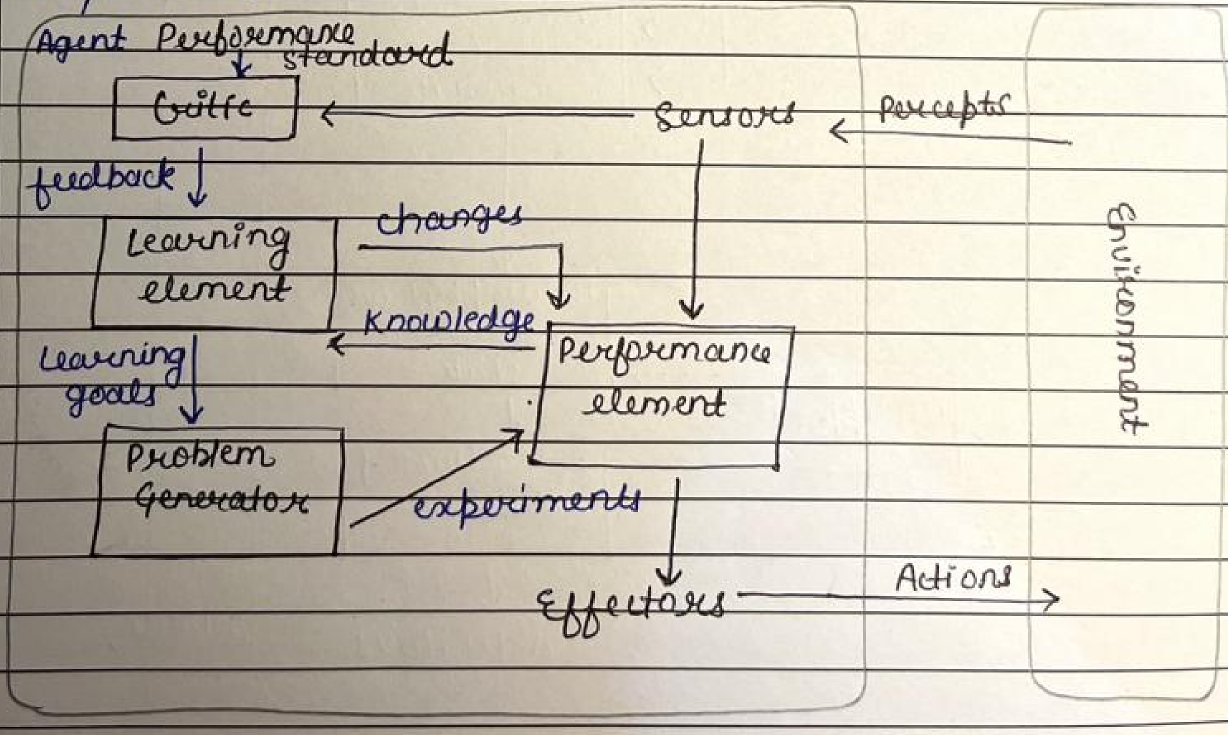
A learning agent has mainly four conceptual components, which are :

1, Learning element : improvements by learning from the environment.

2, Critic : Learning element takes feedback from critic which describes how well the agent is doing with respect to a fixed performance standard.

3, Performance element : Responsible for selecting external action

4, Problem Generator : responsible for suggesting actions that will lead to new and informative experiences.



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Ques10: Briefly describe the term "Truth Maintainance system - TMS".

Truth Maintenance system (TMS):

The logics are known as monotonic logics. The conclusions derived using such logics are valid deductions, and they remain so for all times. Adding new axioms increases the amount of knowledge contained in the knowledge base. Therefore, the set of facts and inferences in such systems can only grow larger, they can not be reduced, that is they increase monotonically. The form of reasoning referred to above, on the other hand, is non-monotonic. New facts become known which can contradict and can invalidate the old knowledge.

This can be illustrated by a real-life situation.

More typically, the initial knowledge will be incomplete, contain redundancies, inconsistencies, and other sources of uncertainity.

The main object of the TMS is the maintenan-ce of the knowledge base used by the problem solving system and not to perform any inference. As such, it frees the problem solver from any concerns of knowledge consistency check when new knowledge gets added or deleted and allows it to concentrate on the problem solution aspects. The TMS also gives the inference component the latitude to perform non-monotonic inferences. When new discoveries are made, this more recent information can displace the previous conclusions

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which are no longer valid.
In this way, the set of beliefs available to the problem solver will continue to be current and consistent. The Inference Engine (IE) from the expert system or decision support system solves domain specific problems based on its current belief set, maintained by the TMS. The updating process is incremental. After each inference, information is exchanged b/w the two components the IE and the TMS. The IE tells the TMS what deductions it has made. The TMS, in turn asks questions about current beliefs and reasons for failure of earlier statements. For example, suppose the knowledge base (KB) contained only the propositions P and $P \rightarrow Q$ and modus ponens. From this, the IE would rightfully conclude Q and add this conclusion to the KB. later, if it was learned that $\sim P$ become true it would be added to the KB resulting in P becoming false leading to a contradiction. consequently, it would be necessary to remove P to eliminate the inconsistency. But, with P now removed, Q is no longer a justified belief. It too should be removed. This type of belief revision is the job of the TMS. Actually, the TMS does not discard conclusions like Q as suggested. That could be wasteful, since P may again become valid, which would require that Q and facts justified by Q be re-derived. Instead, the TMS maintains dependency records for all such conclusions.

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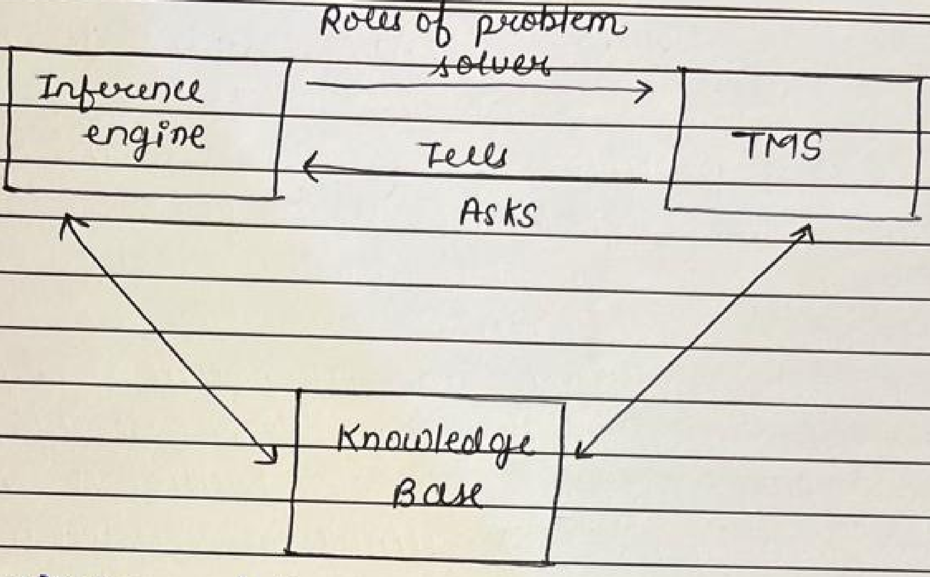

Architecture of the problem solver with a TMS.

Ques 11: Explain the following logic concepts, if required use suitable examples
a) satisfiable statement
b) Resolution principle in proposition logic.

a) Satisfiable statement: A formula is satisfiable if it is possible to find an interpretation (model) that makes the formula true. A formula is valid if all interpretations make the formula true. The opposite of these concepts are unsatisfiability and invalidity, that is, a formula is unsatisfiable if none of the interpretations make the formula true, and invalid if some such interpretation makes the formula false. These four concepts are related to each other in a manner exactly analogous to Aristotle's square of opposition. The four concepts can be raised to apply to whole theories: a theory is satisfiable if one of the interpretations make each of the axioms of the theory true, and a theory

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is unsatisfiable if all of the interpretations make each of the axioms of the theory false.
It is also possible to consider only interpretations that make all of the axioms of a second theory true. This generalization is commonly called satisfiability modulo theories.

b) Resolution principle in proposition logic:
Propositional Resolution is a rule of inference for Propositional Logic. Propositional Resolution works only on expressions in clausal form. A literal is either an atomic sentence or a negation of an atomic sentence. A clausal sentence is either a literal or a disjunction of literals. A clause is the set of literals in a clausal sentence. The empty set is also a clause, it is equivalent to an empty disjunction and therefore is unsatisfiable. Given a clause containing a literal x and another clause containing the litral $\sim x$, we can infer the clause consisting of all the literals of both clauses without the complementary pair. This rule of inference is called Propositional Resolution or the Resolution Principle. A resolution proof of a sentence ϕ from a set Δ of sentences is a resolution derivation of the empty clause from the clausal form of $\Delta \cup$. More generally, if a set Δ of Propositional Logic sentences is unsatisfiable, then there is guaranteed to be a resolution derivation of the empty clause from the clausal form of Δ. Propositional Resolution can be used in a proof procedure that always

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terminates without losing completeness.

Resolution Principle : The idea of Propositional Resolution is simple. suppose we have the clause (p, q). In other words, we know that p is true or q is true. suppose we also have the clause (-q, r). In other words, we know that q is false or r is true. One clause contains q, and the other contains -q. If q is false, then by the first clause p must be true. If q is true, then, by the second clause, r must be true. since q must be either true or false, then it must be the case that either p is true or r is true. so we should be able to derive the clause (p, r).

This intuition is the basis for the rule of inference shown below. Given a clause containing a literal x and another clause containing the literal -x, we can infer the clause consisting of all the literals of both clauses without the complementary pair. This rule of inference is called Propositional Resolution or the Resolution Principle.

$$\{\phi 1, \ldots x, \ldots, \phi m\}$$
$$\{\psi 1, \ldots, -x \ldots, \psi n\}$$
$$\{\phi 1, \ldots, \phi m, \psi 1, \ldots, \psi n\}$$

The case we just discussed is an example. If we have the clause {p, q} and we also have the clause {q, r}, then we derive the clause {p, r} in a single step.

$$\frac{\begin{array}{c}\{p, q\}\\ \{-q, r\}\end{array}}{\{p, r\}}$$

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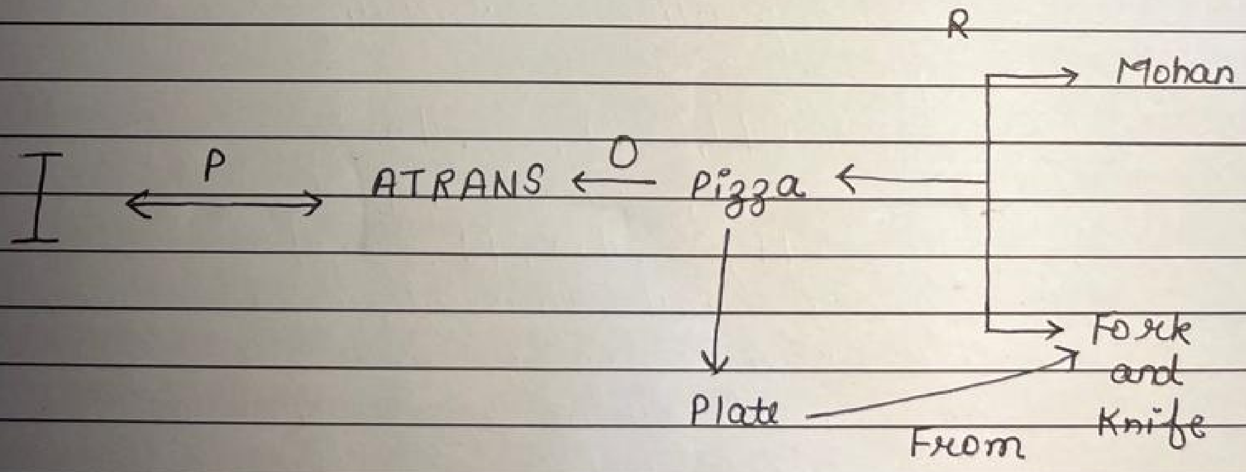
Note that, since clauses are sets, there cannot be two occurrences of any literal in a clause. Therefore, in drawing a conclusion from two clauses that share a literal, we merge the two occurrences into one, as in the following example.

$$\frac{\{-p, q\} \quad \{p, q\}}{\{q\}}$$

Ques12: Give conceptual dependency representation of the sentence given below:
" Mohan will eat pizza from the plate with fork and knife".
" Mohan will eat pizza from the plate with fork and knife".



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Ques 13: Compare and contrast the following:

i, Frames and scripts

A frame is a structure-like record that consists of a set of attributes and their values to represent an object in the universe. Frames are the AI data structure that divides information into substructures by representing circumstances linked to stereotypes. It contains a set of values for slots and slots. Those slots can be of any kind and size. Slots are called facets and have names and values. The slot filter representation of information in artificial intelligence is also known as a frame.

Frames are very similar to the class diagrams we draw to represent an object oriented algorithm and frames necessarily form a collection of slots. A single frame taken is rarely useful.

A script is a standardized representation of a stereotyped sequence of events in a given context. For natural language comprehensive systems, scripts are used to organize a knowled-ge base for terms of the conditions the program will understand. There are a few important components of scripts:

1, Entry conditions - What are the states of different objects at the beginning

2, Roles - What are the different slots involved in the events.

3, Props - What are the different slots involved in the events.

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4) Tracks - What is the sequence of events that is supposed to happen.
5) Scenes - The formal representation of events
6) Results - Conditions that will, in general be true after the events described in the scripts have occured.

ii) Informed search and uniformed search
Informed search: search with information.
example: A* algorithm. We chose our next state based on cost and 'heuristic information' with heuristic function. Case example: find the shortest path 1- Blind search, we just trying all location 2- Heuristic, say we have information about the distance b/w start point and each available location. We will use that to determine next location.
Uniformed search: searching without information.
example: BFS (one of blind search method).
We just generate all successor state (child node) for the current state (current node) and find is there a goal state among them. if not exist we will generate one of child's node's succesor and so on. Because we don't have information, so just generate all.

iii) Forward and Backward Chaining
Forward chaining: It is also known as a forward deduction or forward reasoning method when using an inference engine. Forward chaining is a form of reasoning which start with atomic sentences in the

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knowledge base and applies inference rules in the forward direction to extract more data until a goal is reached.
The forward-chaining algorithm starts from known facts, triggers all rules whose premises are satisfied, and add their conclusion to the known facts. This process repeats until the problem is solved.
Backward Chaining : Backward chaining is also known as a backward deduction or backward reasoning method when using an inference engine.
A backward chaining algorithm is a form of reasoning, which starts with the goal and works backward, chaining through rules to fink known facts that support the goal.

iv) Modus Ponens and Modus Tollens
Modus Ponens: is a form of valid inference.
An instance of MP inferences involves two premises: One is a conditional statement, i.e A in the conditional statement if A, then B. From these such pairs of premises, MP allows us to infer the consequent of the conditional statement, i.e B in if A then B.
Modus Tollens: is another form of valid inference
As in the case of MP, an instance of MT inferences involves two premises. One is again a conditional statement if A then B, while the other, unlike MP, is the negation of the consequent, i.e a statement of the form not B.
If A then B and not B are true. Then, by applying MP to A and if A then B, we can derive B. This is contradictory and thus A is

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false, i.e not A.

v) Syllogism and Disjunctive Syllogism:

Syllogism: While syllogism is a weird word, its quite simple to understand. Syllogism derives from the greek word syllogismos, meaning conclusion or inference. A simple syllogism definition is that it's a form of deductive reasoning where you arrive at a specific conclusion by examining premises or ideas.

For example

All roses are flowers

This is a rose

I'm holding a flower.

Disjunctive syllogism: The basic form of the disjunctive syllogism is: Either A is true or B is true. Thus, if A is true, B is false and if B is true, A is false. A and B cannot both be true.

Major premise: The major premise is given in the form of a choice b/w alternatives, with the assumption that one out of two or more alternative choices is right and the rest are wrong. This may appear in a single sentence: Either Jim, Fred or Billy did it.

Minor Premise: The minor premise either selects or rejects alternatives, thus leading to the conclusion.

Jim was in the bar. But fred had the motive.

Ques 14: Define following properties of propositional statement:

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i) satisfiable: A formula is satisfiable if it is possible to find an interpretation that makes the formula true. A formula is valid if all interpretations make the formula true. The opposites of these concepts are unsatisfiability and invalidity, that is a formula is unsatisfiable if none of the interpretations make the formula true and invalid if some such interpretation makes the formula false. It is also possible to consider only interpretations that make all of the axioms of a secondary theory rule. This generalization is commonly called satisfiability modulo theories.
In general, the question whether sentences in first-order logic are satisfiable is not decidable. In universal algebra and equational theory, the methods of term rewriting, congruence closure and unification are used to attempt to decide satisfiability.

ii) Contradiction: A contradiction consists of a logical incompatibility or incongruity b/w two or more propositions. It occurs when the propositions, taken together, yield two conclusions which form the logical, usually opposite inversions of each other. Illustrating a general tendency in applied logic, Aristotle's law of non-contradiction states that " It is impossible that the same thing can at the same time both belong and not belong to the same object and in the same respect."
In modern formal logic, the term is mainly used instead for a single proposition, often

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denoted by the falsum symbol $\perp$: a proposition is a contradiction if false can be derived from it, using the rules of the logic. It is a proposition that is unconditionally false. This can be generalized to a collection of propositions, which is then said to "contain a contradiction".

iii) Valid: A valid argument is not that it has true premises and a true conclusion, but the logical necessity of the conclusion, given the two premises. The argument would be just as valid were the premises and conclusion false. The following argument is of the same logical form but with false premises and a false conclusion, and is equally valid:

All cups are green
Socrates is a cup
Therefore, Socrates is green.

A standard view is that whether an argument is valid is a matter of the argument's logical form. Let the letters 'P', 'Q' and 'S' stand, respectively, for the set of men, the set of mortals, and Socrates. Using these symbols, the first argument may be abbreviated as:

All P are Q
S is a P
Therfore, S is a Q

An argument is termed formally valid if it has structural self-consistency i.e if when the operands b/w premises are all true, the derived conclusion is always also true.

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iv) Equivalent: Two logical expressions are said to be equivalent if they have the same truth value in all cases. sometimes this fact helps in proving a mathematical result by replacing one expression with another equivalent expression, without changing the truth value of the original compound proposition.
Two propositions are p and q said to be logically equivalent if $p \leftrightarrow q$ is a Tautology. The notation $p \equiv q$ is used to denote that p and q are logically equivalent.
One way of proving that two propositions are logically equivalent is to use a truth table. The truth table must be identical for all combinations for the given propositions to be equivalent.
In this case, there needs to be a better way to prove that the two given propositions are logically equivalent. That better way is to construct a mathematical proof which uses already established logical equivalences to construct additional more useful logical equivalences.

v) Logical consequence: Logical consequences are different from Natural Consequences in that they require the intervention of an adult - or other children in a family meeting or a class meeting. It is important to decide what kind of consequence would create a helpful learning experience that might encourage children to choose responsible cooperation.

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The three Rs and an H of Logical consequences
1. Related
2. Respectful
3. Reasonable
4. Helpful

Related means the consequence must be related to the behaviour.

Respectful means the consequence must not involve blame, shame or pain, and should be kindly and firmly enforced.

Reasonable: means the consequence is reasonable from the child's point of view as well as the adult's.

Helpful means just that - it helps rather than hurts. If any of the Three Rs and an H are missing, it can no longer be called a logical consequence. These could also be called the Three Rs and an H for focusing on solutions.

Ques 15: Write short notes on any two of the following:

i) expert systems: The expert systems are the computer applications developed to solve complex problems in a particular domain, at the level of extra-ordinary human intelligence and expertise.

Characteristics of Expert systems
- High performance
- Understandable
- Reliable
- Highly Responsive

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Capabilities of Expert systems

The expert systems are capable of -

- Advising
- Demonstrating
- Deriving a solution
- Diagnosing
- Explaining
- Interpreting input
- Predicting results
- Justifying the conclusion
- suggesting alternative options to a problem

They are incapable of -

- substituting human decision makers
- Possessing human capabilities
- Producing accurate output for inadequate knowledge base
- Refining their own knowledge.

The components of ES include -

- Knowledge Base
- Inference Engine
- User interface

Let us see them one by one briefly :

$$\begin{tikzcd}
\text{Human expert} \arrow[r] & \text{Knowledge Engineer} \arrow[r] & \text{Knowledge Base} \arrow[d, leftrightarrow] & \\
& & \text{Inference Engine} \arrow[d, leftrightarrow] & \\
& & \text{User Interface} \arrow[r] & \text{User (May not be an expert)}
\end{tikzcd}$$

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ii) Non deductive inference rule

All the inference rules of traditional logic are deduction rules, which are truth-preserving that is, the truth of the premises guarantee the truth of the conclusion. In a sense, in deduction the information in a conclusion is already in the premises, and the inference rules just reveal what is previously implicit.

The problem is, in human reasoning, there are other inference patterns, that are not truth-preserving in the traditional sense.

- Induction produces generalizations from special cases.
  Eg: from "Robins are birds" and "Robins have feather" to derive "Birds have feather".
- Abduction produces explanations for given cases.
  Eg: from "Birds have feather" and "Robins have feather" to derive "Robins are birds".

Ques 16: Express the following knowledge as a semantic network structure with interconnected nodes and labeled arcs. "Ram is Vice President of AB company. He is married to Raj and has a male child RamRaj. RamRaj goes to school. Ram plays golf and owns a silver color German made Car Mercedes Benz."

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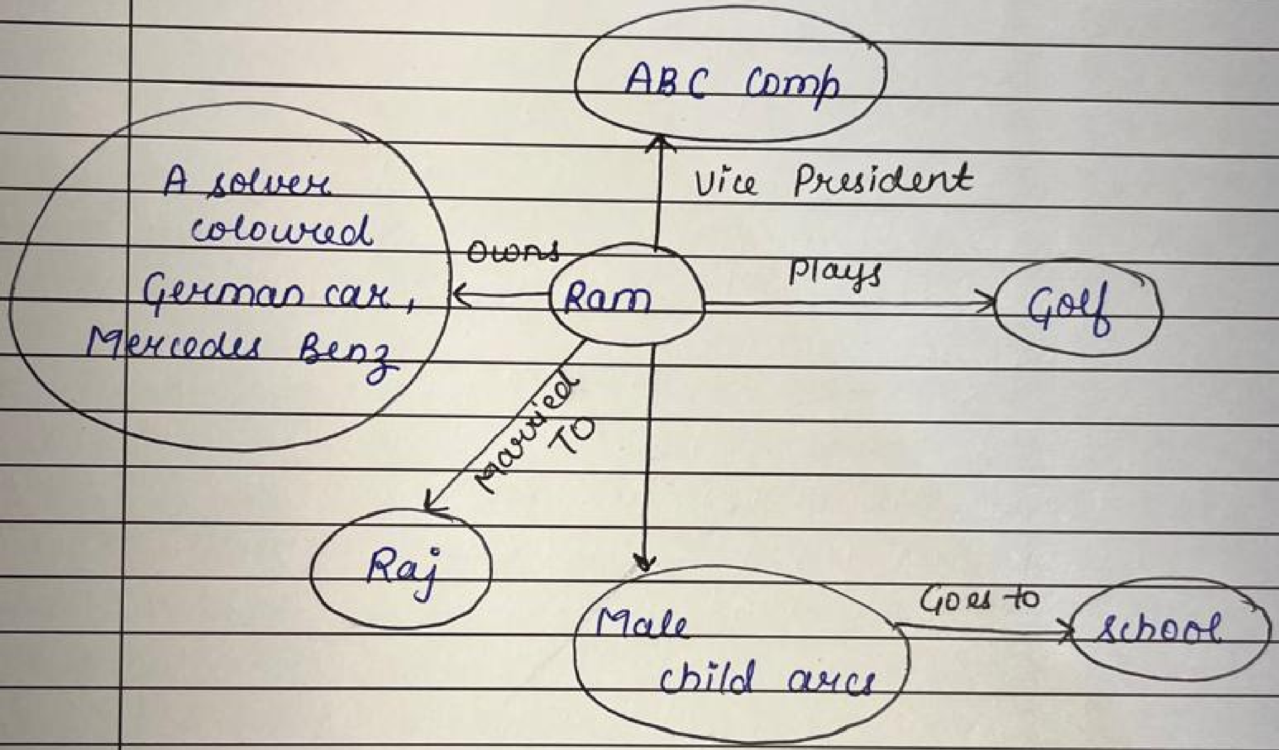
Ans :-



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