1(a) Search problem is ~~wa~~ a way in which we find a sequence of actions which transforms the agent from the initial state to a goal state G.

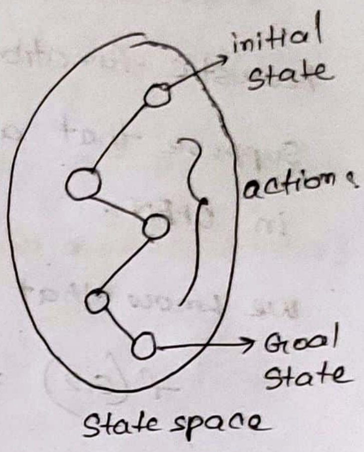
Here,

S: the full of state

S_0: Initial state.

A: S-S set of operators.

G: the set of final states.



Problem formulation must follow goal formulation because

→ we cannot know what to include in our problem and what to leave out without first doing goal formulation.

→ Goal formulation reveals the scope needed to define the problem set, therefore must be done before the problem formulation.

→ So, without doing goal formulation, if we do the problem formulation, we wouldn't know what to include in our problem and what to leave, and what should be achieved. So, problem formulation must follow goal formulation.

2017

1(b)

(1) (i) Initial state: no region colored.

(ii) goal state: All regions colored and no two adjacent regions have the same color.

(iii) Cost function: Number of assignments.

(iv) Operators:

Actions: Assign a color to an uncolored region,

transition model: The previously uncolored regions ~~have~~ has the assigned color.

(2) Initial state: As described in text.

Actions: Hop on create, Hop off crate, Push create from one spot to another, Stack one crate on another, walk from one spot to another, Grab bananas.

Goal test: Monkey has bananas

Cost function: Number of actions.

1(c)

(2)
(b)

(i)
(1) Man(marcus).

(2) Pompeian (marcus)

(3) Born (Marcus, 40 A.D.)

(4) $\forall_x$ (Man(x) $\rightarrow$ Mortal(x))

(5) $\forall_x$ (Pompeian (x) $\rightarrow$ die (x, 79 A.D)

(6) $\neg$ mortal(x) $\rightarrow$ liveslong(x, 150)

(7) Isnow(2014).

(8) Alive(x) $\rightarrow$ $\neg$ ~~dead (x)~~ die(x,y)

(ii) converting to clausal form:

1. Man (Marcus).

2. Pompeian(Marcus).

3. Born (Marcus, 40 A.D.)

4. $\forall_x$ $\neg$Man(x) $\vee$ Mortal(x)

5. $\forall_x$ ($\neg$Pompeian(x) $\vee$ die(x, 79, A.D)

6. mortal(x) $\vee$ livelong(x, 150)

7 - Isnow (2014)

8. ¬alive (x) v ¬die (x, y)

(iii) Proof by resolution :

goal :

"Marcus is not alive".

So, we have to prove via Alive (marcus) through contradiction.

Alive (Marcus)   ¬alive (marcus) v ¬die (~~marcus~~ x, y)

¬die (marcus, y)

¬pompeian (x) v die (x, 79.A.D)

¬Pompeian (marcus)

Pompeian (marcus)

null clause.

So, alive (marcus) is not true.

So, it will be ¬alive (marcus).

3

(a) The optimality of A^*:

Let OPEN be the set of nodes that are generated, heuristic function evaluated, but not yet explored. Suppose that a suboptimal goal node G_2 appears in OPEN.

We know that

$$f(G_2) = g(G_2) + h(G_2)$$

Since G_2 is goal node, $h(G_2) = 0$

Then,

$$f(G_2) = g(G_2) + 0 = g(G_2)$$

Let the cost of the optimal goal be c^*.

Then,

$$f(G_2) > c^* \quad \text{—— (1)}$$

Now, consider a node s that is in optimal solution path. If $h(s)$ does not overestimate the cost, then we know that

$$f(s) = g(s) + h(s) <= c^* \quad \text{—— (2)}$$

From (1) and (2)

$$f(s) \leq c^* < f(G_2) \quad \text{—— (3)}$$

Since both s and G_2 are the nodes in the OPEN, G_2 will never be explored. Thus, A^* will return optimal solution.

However, if $h(s)$ in equation (2) is overestimated,

$$f(s) = g(s) + h(s) > c^* \quad \text{——— (4)}$$

In this case, $f(s)$ will greater than c^* and node s will be explored to end up in a non-optimal solution.

3(b) No, hill-climbing doesn't gurantee to find the solution to the n-queen's problem. Usually, for n-queens problem, backtracking method is used.

→ Hill-climbing algorithm often fails to a goal because they might get stuck in local maxima.

3(c) Heuristics are criteria, methods or principles for deciding which among several alternative courses of action promise to achieve some goal. The name of two heuristics associated with eight puzzle problem are

— No. of tiles out of place

— Manhottom distance

2017

3(d)

The alpha-beta algorithm does the same calculation as Minmax but is more efficient because it prunes (allows us to ignore portions of the search tree that make no difference to the final choice) away branches of the search tree that it can prove are irrelevant to the final outcome.

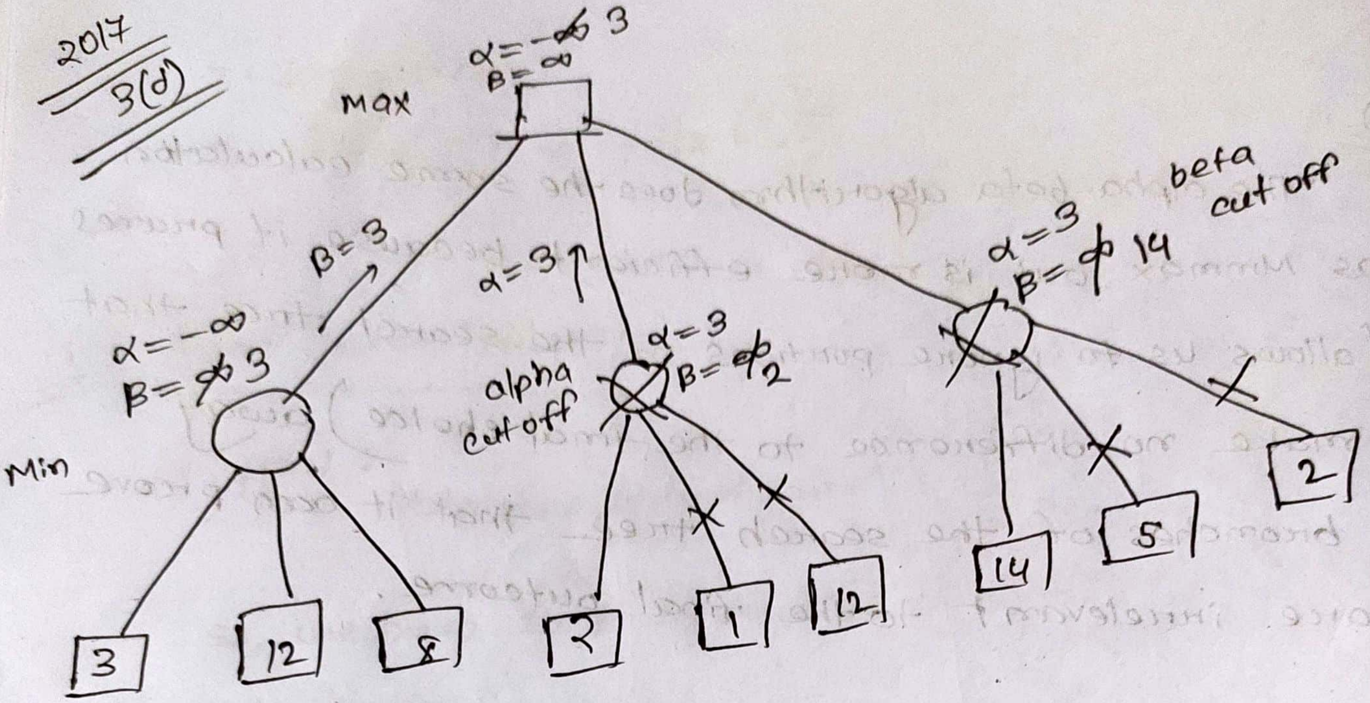
Pruning improv

$\alpha = -\cancel{\infty}\ 3$

$\beta = \infty$

2017

3(d)



As in the example, we don't have to traverse all the nodes to get the max. So, before pruning, (using minmax algorithm) the complexity will be $O(3^2) = 9$.

As in the given example, lots of pruning happens, so, we can assume the complexity for this will reduce to $O(b^{\frac{d}{2}})$

$$= O(3^{\frac{2}{2}}) = O(3^1) = O(3)$$

4(a)

Bayesian network is a representation of causal connection between different events with associated conditional probabilities.

Syntax:

A BN is

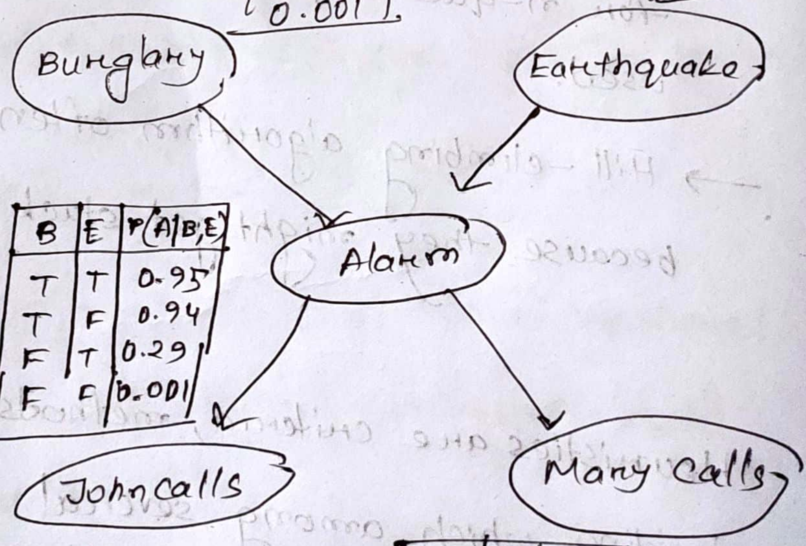
1. A directed acyclic graph whose nodes represent random variables

2. For each node X_i, a conditional probability distribution $P(X_i \mid parents(X_i))$

Example –

P(B)
0.001

P(E)
0.02



B	E	P(A|B,E)
T	T	0.95
T	F	0.94
F	T	0.29
F	F	0.001

A	P(J|A)
T	0.90
F	0.05

A	P(M|A)
T	0.70
F	0.01

Semantics:

A Bayesian Network represents a joint distribution

$$P(x_1, x_2, \ldots, x_n) = \prod P(x_i \mid Parents(x_i))$$

For example,

$$P(b, \neg e, a, \neg j, \neg m)$$

$$= P(b) \times P(\neg e) \times P(a \mid b, \neg e) \times P(\neg j \mid a) \times P(\neg m \mid a)$$

$$= 0.001 \times 0.98 \times 0.94 \times 0.05 \times 0.01$$

$$=$$

4(b) Inference in BN:

1. Diagonistic Inference (from effects to causes)

→ Given that John calls, what the probability of burglery ? i.e $P(B \mid J)$

2. Causal inference (from causes to effect)

→ Given Burglary, what is the probability that

- John calls $P(J \mid B)$
- Marry calls i.e $P(M \mid B)$

3. Intercausal inference (between causes of a common event)

— Given alarm, what is the probability of burglary ? ie $P(B|A)$

4. Mixed Inference (some causes and some effects are known)

— Given John calls and Earthquake, what is the probability of Alarm, i.e $P(A | J \wedge \neg E)$.

4(c)

Section - B

2017

5.

(a) According to the webster's Dictionary, intelligence is

"The faculty of acquiring and applying knowledge".

Scientific definition:

Intelligence is a measure of the success/performance of an entity in achieving its objectives/goals by interaction with its environment.

5(b) Yes, I agree with the statement that "AI is the study and construction of rational agent".

A rational agent could be anything that make decisions, as a person, firm, machine, or software. It 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

5(c) ~~The capabilities~~ Features required for a machine to pass the Turing test :

1. Natural Language Processing
2. ~~Kon~~ Knowledge Representation
3. Automated reasoning
4. Machine learning
5. Vision
6. Motor control.

5(d)

(i) Automated Taxi driving System :

Percepts	Actions	Goals	Environment
Video, sonar, speedometer, odometer engine sensors keyboard input microphone GPS	steer accelerate brake horn speak / display	Maintain safety reach destination maximize profits (fuel, tire wear) obey laws provide passenger comfort	urban streets freeways traffic pedestrians weather customers

(ii)

characteristic!

1. inaccessible
2. Non - deterministic
3. Non-episodic
4. ~~Stati~~ Dynamic
5. Continuous.

[Need to explain] ⟹ ?

(iii)

6(a)

Forward chaining: Forward chaining is known as data-driven approach because starting from the start state applying rules one by one to arrive the goal state.

Backward chaining is known as goal-driven technique because we start from the goal and reaches the initial state in order to extract the facts.

Selecting of forward or backward chaining depends on which direction offers less branching factor and justifies its chaining process to the user.

The following are the factors which determine the choice of direction for a particular problem:

1. Are there more possible start states or goal state? we would like to move from the smaller set of states to the larger set of states.

2. In which direction is the branching factor greater? we would like to proceed in the direction with the lower branching factor.

3. will the program be asked to justify its reasoning process to a user? If so, it is important to proceed in the direction that corresponds more closely with the way the user will think.

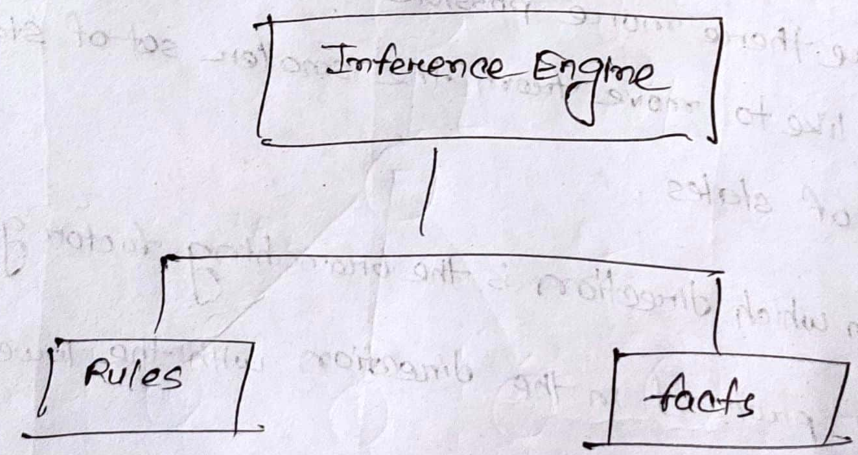
6(b) Conflict resolution strategies are used in production systems in AI, such as in rule-based expert systems, to help in choosing which production rule is to fire.

The two strategies are-

1. Refractoriness: Rules once fired will not be fired later.

2. Meta-rules: rules about rules embedded within the ~~later~~ inference machine that provide the information about ~~the~~ which of the rules apply under what conditions.

6(c) The architecture of a rule based system:



Rules:

R_1 : $A \wedge C \rightarrow E$

R_2 : $C \wedge D \rightarrow F$

R_3 : $B \wedge E \rightarrow F$

R_4 : $B \rightarrow C$

R_5 : $F \rightarrow G$

Facts
A
B

we have to prove the hypothesis G (goal).

Step-1: As A and B are true in facts. First we can trigger R_4. After triggering R_4, the C will also be added in the facts list.

Facts		
A	B	C

Step-2: As A and C are present in the facts, we can trigger R_1, so the E will be added in the facts list.

facts.			
A	B	C	E

Step-3: Now, B and E are both present in the facts, so we can trigger rule R_3. So, the F will be added to the facts list.

Facts

A B C E F

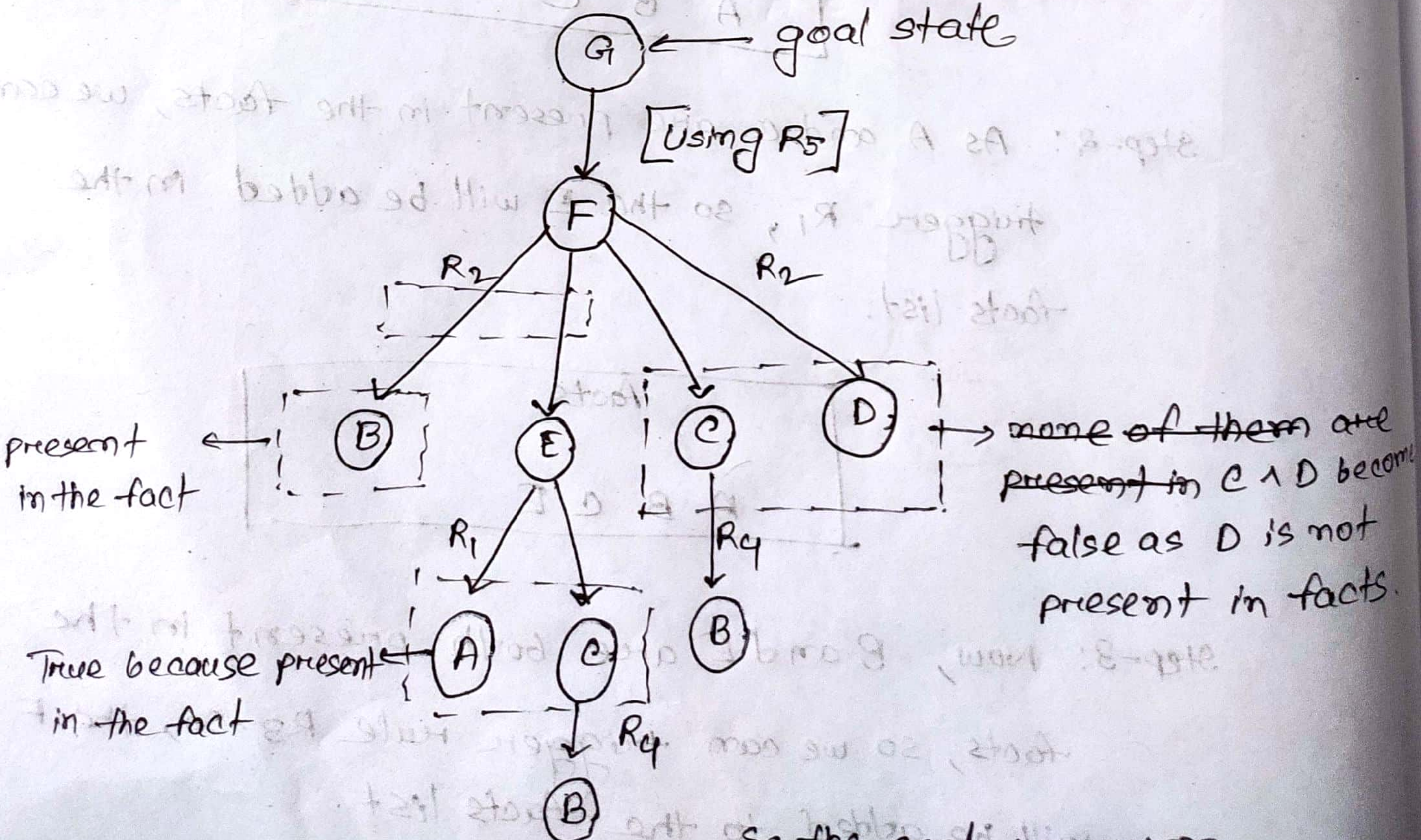
Step-4: As F is present in the facts list, we can now trigger R_5. So, we get G. which is ~~b~~ also the goal state.

Facts

A B C E F G

The above steps ~~are~~ followed the forward chaining procedure to reach the goal.

Using Backward chaining,



So, the goal is proven.

7 (a)

Goal Stack Planning is one of the simplest planning algorithm that is designed to handle problem having compound goals. In this method, the problem solver makes use of a single stack that contains both goals and operators that have been proposed to statisfy the goal. The problem solver also relies on the database that describes the current situation and a set of operators described as PRECONDITION, ADD and DELETE Lists.

(i) UNSTACK(A,B):

Precondition: ON(A,B) ∧ clear(A) ∧ ARMEMPTY

(ii) STACK(A,B)

Precondition: CLEAR(B) ∧ HOLDING(A)

(iii) PICKUP(A)

Precondition: CLEAR(A) ∧ ONTABLE(A) ∧ ARMEMPTY

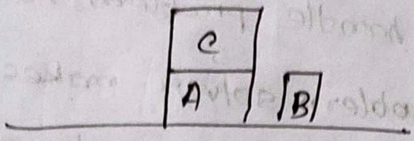
(iv) PUTDOWN(A)

Precondition: Holding(A)

(capital letter)

7(b)

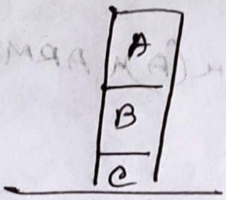
Initial state :



No precondition .

effects : $On(C,A) \wedge ONTABLE(A) \wedge ONTABLE(B) \wedge ARMEMPTY \wedge CLEAR(C) \wedge CLEAR(B)$

Goal state :



Precondition : $On(B,C) \wedge On(A \wedge B) \wedge ONTABLE(C)$

sequence of Actions:

$\boxed{A_0}$

ON(C,A) (on-table A) (on-table B) (clear C) (clear B)

(on CA) (clear C)

$\boxed{A_3 : \text{move C from A to Table}}$

¬(on CA) (on-table C) (clear A)

open condition

(clear B) (clear C) (on-table B)

$\boxed{A_1 : \text{move B from Table to C}}$

¬(on-table B) ¬(clear C) (on B C)

∧(on table C)

(clear A) (clear B) (on Table A)

$\boxed{A_2 : \text{move A from Table to B}}$

¬(onTable A) ¬(clear B) (on A B)

open condition

open condition

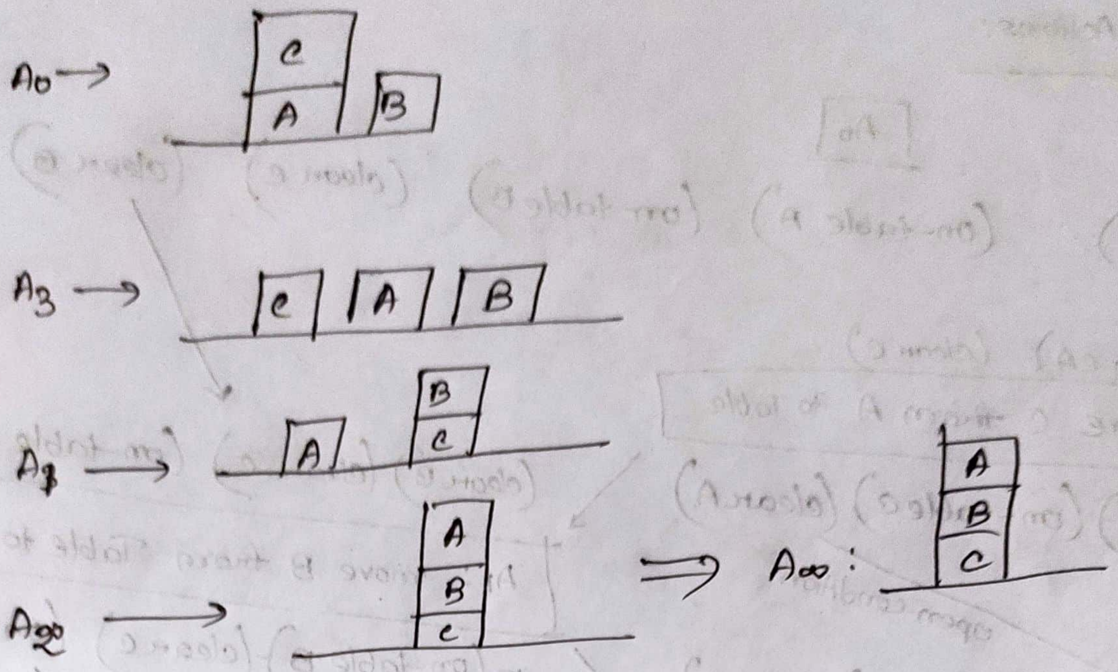
$\boxed{A \quad (\text{on A B}) \wedge (\text{on B C}) \wedge (\text{on-table C})}$

$\boxed{A_\infty}$

So, Path is $A_0 \rightarrow A_3 \rightarrow A_1 \rightarrow A_2 \rightarrow A_\infty$

A_2 is after A_1, because it is threatened by A_2 clear(B) →

doing promotion.



Final goal is $\rightarrow A_0 \rightarrow A_3 \rightarrow A_1 \rightarrow A_2 \rightarrow A_\infty$

8(a)

8(b)

Uncertainity : ~~Uncertainty is the factor in AI that the problem might not be in the fact that T/F values can change over~~

Uncertainity : Uncertainity is defined as the lack of exact information or knowledge that helps us to find correct conclusions :

Sources of uncertainity ! [Slide 11 এর sources gula]

~~1. Implications may be weak~~.

1. Uncertain data
   - ↳ missing data, unreliable, ambiguous

2. ~~Expert~~ uncertain knowledge
   - ↳ ~~Inconsistency between different experts~~
   - ↳ multiple causes leads to multiple effects
   - ↳ Incomplete knowledge of causality in domain,

3. Uncertain outputs.
   - ↳ Abduction, induction are uncertain
   - ↳ Default reasoning
   - ↳. Incomplete deduction, inference.

8(c)

Propositional logic is declarative, unambiguous, compositional and context independent. Adopting the foundation of propositional logic – with more expressive power, borrowing ideas from natural language while avoiding its drawbacks.

→ FOL is anothere way of knowledge representation in AI. It is an extension to propositional logic.

→ FOL is sufficiently expressive to represent the natural language statements in a concise way.

→ PL is sufficient to represent the complex sentences or natural language statements. The propositional logic has very limited expressive power

→ PL converts a complete sentence into a symbol and makes it logical whereas, in FOL, relation of particular sentence will be made that involves relations, constants, functions.

→ PL doesnot signify or express generalization, specialization or pattern for example 'Quantifiers' cannot be used in PL but in FOL, users can use quantifiers as it does express the generalization, specialization and pattern.

8(d)

8(e) Suppose,

~~P is True~~

P: It is the month of July

Q: It rains

R: $P \longrightarrow Q$

If it is the month of July, then it rains.

~~As of P~~

It is the month of July

Conclusion: It rains

As using modus ponens, we can easily reached to the conclusion, so we can say that it is very much a sound inference procedure.