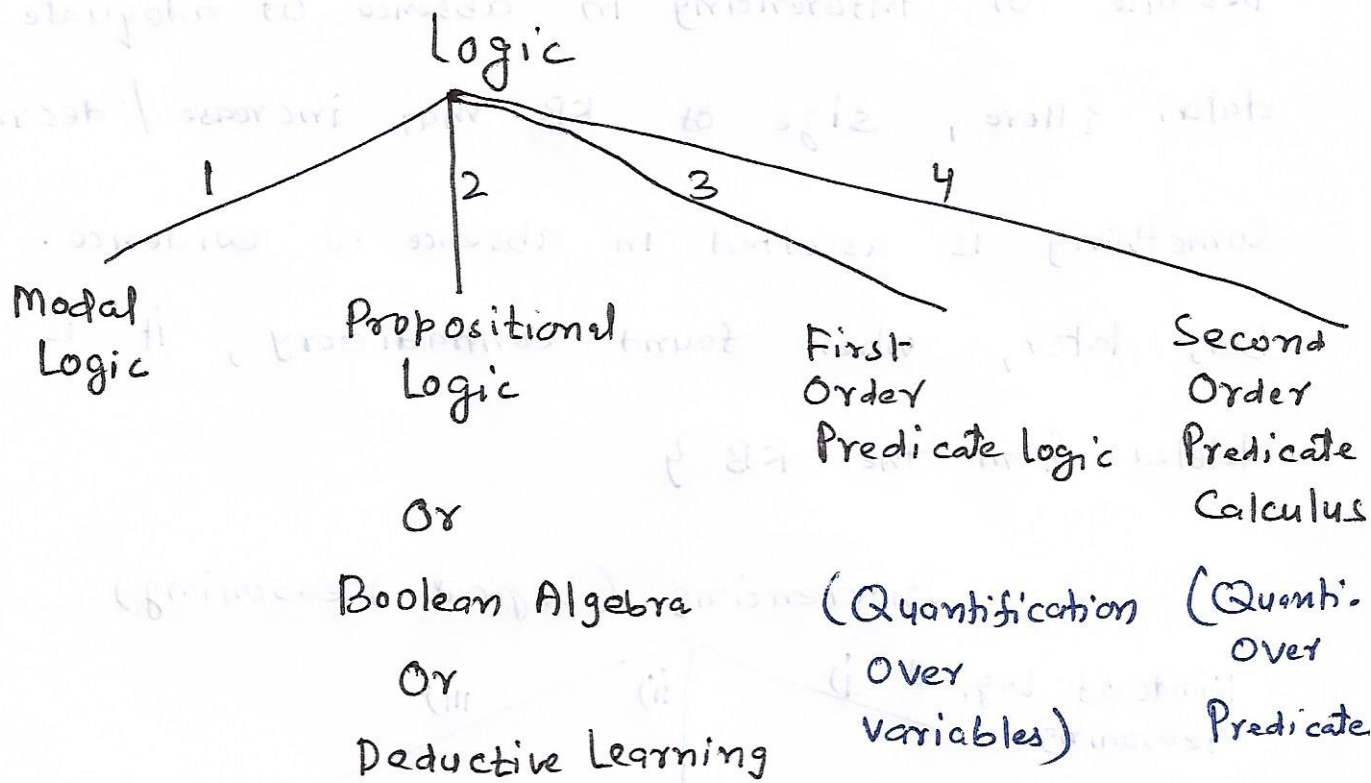


## Part II Knowledge Representation



Modal Logic includes :

i) Assertive sentences (facts)

ii) Modal sentences

Possibility - e.g. It I were president...

Belief Sentences - I suppose ...

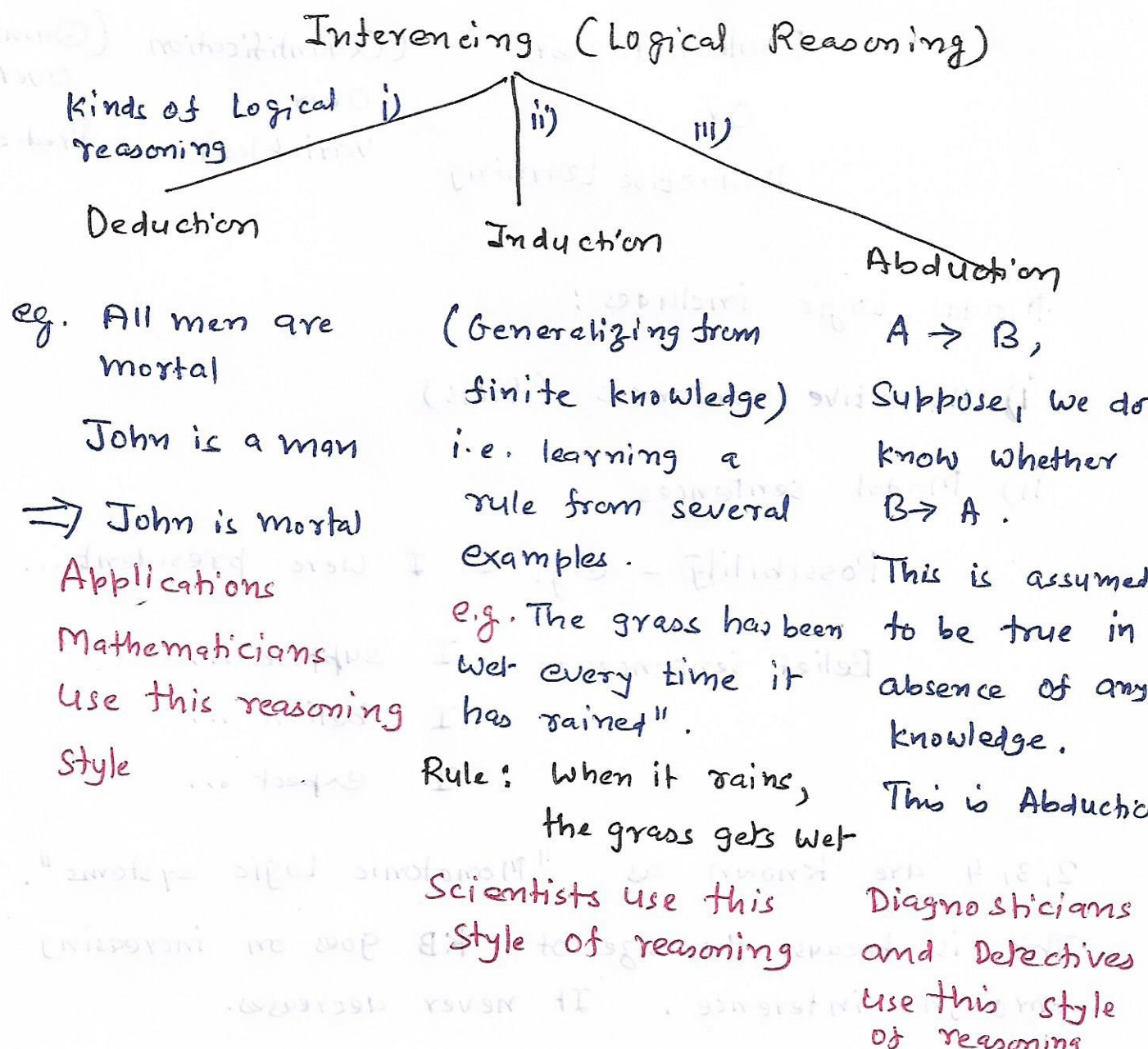
I believe ...

I expect ...

2, 3, 4 are known as "Monotonic Logic systems".

This is because the size of KB goes on increasing through inference. It never decreases.

1 is a Non-Monotonic Logic system. An asserted fact may be deleted later. This is because of inferencing in absence of adequate data. {Here, size of KB may increase / decrease. Something is asserted in absence of evidence. But, later, when found contradictory, it is deleted from the KB }



## Propositional Logic

Sentences	Proposition
It is raining	RAINING
It is sunny	SUNNY
It is windy	WINDY
It is raining, then it is not sunny	RAINING $\rightarrow$ $\neg$ SUNNY

## Predicate Calculus (First Order Logic)

### Motivation

i) To represent relationship between objects.

eg. Sky is blue : P

Screen is blue : Q

blue (sky).

blue (screen).

ii) Handling "For All" and "There exists"  
kind of sentences



## Operators in FO PL

 $\forall$  - For All [Universal Quantifier] $\exists$  - There exists [Existential Quantifier] $\rightarrow$  Implication $\neg$   $\wedge$   $\vee$  : NOT AND OR

Facts

Representation in Logic

1. Marcus was a man

man (Marcus)

2. Marcus was a Pompeian

pompeian (Marcus)

3. All Pompeians were Romans

 $\forall x: \text{pompeian}(x) \rightarrow \text{roman}(x)$ 

4. Caesar was a ruler

ruler (Caesar)

5. All Romans were either loyal to Caesar or hated him

 $\forall x: \text{Roman}(x) \rightarrow \text{loyalto}(x, \text{Caesar}) \vee \text{hate}(x, \text{Caesar})$ 

6. Everyone is loyal to someone

i)  $\forall x: \exists y: \text{loyalto}(x, y)$ ii)  $\exists y: \forall x: \text{loyalto}(x, y)$ iii)  $\forall x: \exists y: \text{loyalto}(y, x)$ Person to whom  $x$  is loyalPerson who is loyal to someone  
Everyone has a loyal person  
There is someone to whom

possibilities

$$i) \quad \forall x: \exists y: \text{loyalto}(x, y)$$

$$ii) \quad \exists y: \forall x: \text{loyalto}(x, y)$$

$$iii) \quad \forall x: \exists y: \text{loyalto}(y, x)$$

i) matches our interpretation

We should be careful about scope of the quantifiers and ambiguity

7. People only try to assassinate rulers they are not loyal to

Ambiguity

i) Only rulers people try to assassinate are those to whom they are not loyal

ii) Only thing people try to do is to assassinate rulers to whom they are not loyal

With interpretation i), the representation is:

$$\forall x: \forall y: \text{person}(x) \wedge \text{ruler}(y) \wedge \text{tryassassinate}(x, y) \rightarrow \neg \text{loyalto}(x, y)$$

8. Marcus tried to assassinate Caesar  
 $\text{tryassassinate}(\text{Marcus}, \text{Caesar})$

Question: Was Marcus loyal to Caesar?

$\neg \text{loyalto}(\text{Marcus}, \text{Caesar})$

$\uparrow$  7, substitution

person (Marcus)

ruler (Caesar)

$\text{tryassassinate}(\text{Marcus}, \text{Caesar})$

$\uparrow$  8

person (Marcus)

ruler (Caesar)

$\uparrow$  4

person (Marcus)

$\uparrow$

9, substitution

man (Marcus)

$\uparrow$  1  


How to know that  
 a person man is  
 a person. Needs to  
 be explicitly specified

9.  $\forall x: \text{man}(x) \rightarrow \text{person}(x)$



How should a program decide whether it should try to prove

$\text{loyalto}(\text{Marcus}, \text{Caesar})$  or

$\neg \text{loyalto}(\text{Marcus}, \text{Caesar})$

### Possibilities

1. Use forward chaining, i.e. using available knowledge, see what are the things that can be inferred.

Problem : branching factor increases with the amount of knowledge

2. Use Heuristic knowledge to decide which answer is more likely and then try to prove that.

If it can not be proved in some reasonable amount of time, then prove other thing.

3. Prove both things simultaneously and stop when one of the things is proved