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3- Propositional logic in AI

- It is the simplest form of logic where all the statements are made by propositions.
- A proposition is a declarative statement which is either true or false.
- Technique of KR in logical and mathematical form.

Eg: The sun rises from west. (False)
$3+3=6$ = (True)

- Also called Boolean logic as it works on 0 & 1
- Connectives can be said as logical operator which connects 2 sentences
- A Proposition formula which is always true is called tautology & it is also called a Valid sentence.
- A Proposition formula which is always false is called contradiction.
- Statements which are Questions, Commands, or Opinions are not propositions.

Proposition

Atomic

- simple proposition
- single propositional symbol.
- sentence which can be either true or false.

$2+2=4$ (true)
Sun is cold (false)

Compound

- combine simpler or atomic proposition using parenthesis & logical connectives

a) It is Raining today, and street is wet
b) Sonal is doctor and her clinic is in jaipur

Logical Connectives

- Used to connect 2 simpler propositions or representing a sentence logically.

1) Negation = $\neg P$ (Negation of P. A literal can can be either +ve or -ve

2) Conjunction = $P \wedge Q$. $\underbrace{\text{Sonal is intelligent}}_{P}$ & $\underbrace{\text{Hard working}}_{Q}$

P = Sonal is intelligent Q = Sonal is Hard working = ~~P~~

$P \wedge Q$

3) Disjunction : $P \vee Q$ eg: Sonal is doctor or Engineer
P - Sonal is doctor Q Sonal is Engineer

4) Implication : $P \rightarrow Q$ If it is raining then street is wet.

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5) Bidirectional $P \Longleftrightarrow Q$
If and only if I am Breathing then I am Alive

P = I am Breathing.
Q = I am Alive

$P \Longleftrightarrow Q$

Truth Table

→ For Bidirectional

P	Q	$P \Longleftrightarrow Q$
T	T	T
T	F	F
F	T	F
F	F	T

→ For Negation

P	$\neg P$
T	F
F	T

P	Q	$P \wedge Q$
T	T	T
T	F	F
F	T	F
F	F	F

P	Q	$P \vee Q$
T	T	T
T	F	T
F	T	T
F	F	F

Precedence of connectives

1) Parenthesis
2) Negation
3) Conjunction (and)
4) Disjunction (or)
5) Implication
6) Biconditional

Note: For better understanding use paranthesis to make sure of the correct interpretation such as $\neg R \vee Q$. It can be interpreted as $(\neg R) \vee Q$

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Properties of Operators

1) Commutativity

- $P \land Q = Q \land P$

Or

- $P \lor Q = Q \lor P$.

2) Associativity

- $(P \lor Q) \lor R = P \lor (Q \lor R)$

Or

- $(P \land Q) \land R = P \land (Q \land R)$

3) Identity Element

- $P \land \text{True} = P$
- $P \lor \text{True} = \text{True}$

4) Distributive

- $P \land (Q \lor R) = (P \land Q) \lor (P \land R)$
- $P \lor (Q \land R) = (P \lor Q) \land (P \lor R)$.

5) De Morgan's law

- $\neg(P \wedge Q) = (\neg P) \vee (\neg Q)$
- $\neg(P \vee Q) = (\neg P) \wedge (\neg Q)$

6) Double - Negation Elimination

$\neg(\neg P) = P.$

Limitation of propositional logic:

- We cannot represent relations like All, Some or None with propositional logic.

Eg:

- All the girls are Intelligent.
- Some Apples are Sweet.
- It has limited Expressive power.
- In propositional logic, we cannot describe Statements in terms of their properties or logical Relationships.

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Unit - 3 First Order Logic

- It is an another way of knowledge Representation in AI. It is an Extension to propositional logic.
- It is Sufficiently expressive to represent the Natural language statements in a concise way.
- Also known as Predicate logic or First Order predicate logic
- It is a Powerful language that develops information about the Objects in a more easy way & can also express the Relationships b/w those Objects.
- First Order logic has 2 main parts:

→ Syntax   &   → Syntax.

Basic Elements of First - Order logic

1) Constant : 1, 2, A, John, Mumbai, cat ..
2) Variables : x, y, z, a, b ....
3) Predicates : Brother, father, >, ...
4) Function : Sqrt, ...
5) Connectives : $\wedge$, $\vee$, $\neg$, $\Rightarrow$, $\Leftrightarrow$
6) Equality : ==
7) Quantifier : $\forall$; $\exists$.

Atomic Sentences

- Most Basic Sentences of FOL. These sentences are formed from predicate symbol followed by a parenthesis with a sequence of terms.

- We can Represent Atomic sentences as Predicate (term1, term2, ... ,termn).

Eg: Sonal and Rani are Sisters

Sisters(Sonal, Rani)

Pluto is a dog.

dog (Pluto).

Complex Sentences

These are made by combining atomic sentences using connectives.

→ FOL can be divided into 2 parts
- Subject : main part of the statement.
- Predicate : It can be defined as relation, which binds 2 atoms together in a statement.

Consider the statement : " x is an Integer ",
it consists of 2 parts.

$$\underbrace{x}_{\text{Subject}} \quad \underbrace{\text{is an integer}}_{\text{Predicate}}$$

Quantitifiers in First Order logic

- It is a language ~~statement~~ element which generates Quantification, and Quantification specifies the Quantity of specimen in the universe of discourse.
- These are the symbols that permit to determine or identify the Range and scope of the Variable in the logical expression

There are 2 types of Quantifier:

1) Universal Quantifier:

It is a symbol of logical Representation, which specifies that the statement within its Range is true for everything or every instance of Particular thing.

- Represented by symbol $\forall$, which resembles inverted A.

→ For all, → For each → For every

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Example: All man drink coffee.

x_1, x_2, ..., x_n] - drinks coffee

X_1, X_2, X_3, X_4, ... X_n

Man

Universe of Discourse

Shorthand Notation:

$$\forall x \; man(x) \rightarrow drink(x, coffee)$$

It will be read as

There are all x where x is a man who drinks coffee.

2) Existential Quantifier:

- These are type of Quantifier, which expresses that the statement within its scope is true for atleast one instance of something.

- It is denoted by logical Operator $\exists$, which resembles as inverted E.
- When it is used with Predicate Variable then it is called as an Existential Quantifier.

Note: In Existential Quantifier, we always use AND or Conjunction Symbol ($\wedge$).

If x is a Variable, then Existential Quantifier will be $\exists x$ or $\exists(x)$.
and it will be read as:
→ there exists a 'x', → For some 'x',
→ For atleast one 'x'.

Example
Some boys are intelligent
Short - Hand Notation:
$\exists x$: boys(x) $\wedge$ intelligent (x)