
Intelligence
Intelligence
the ability to understand, learn and think
Intelligence of humans is achieved—not by purely reflex mechanisms but by processes of reasoning that operate on internal representations of knowledge
Artificial Intelligence (AI) is about building machines and systems that can reason, learn, and solve problems, similar to how humans do. In many AI applications, logical reasoning plays a crucial role, allowing systems to make decisions based on given conditions and facts
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Why formal languages
Natural languages exhibit ambiguity
The boy saw a girl with a telescope
Our shoes are guaranteed to give you a fit
Ambiguity makes reasoning difficult / incomplete
Formal languages
promote rigour and thereby reduce possibility of human error
help reduce implicit / unstated assumptions by removing familiarity with subject matter
help achieve generality due to possibility of finding alternative interpretations for sentences and arguments.


Formal logic
• Formal logic: Uses syllogisms to make inferences, and examines how conclusions follow from premises based on the structure of arguments
• Symbolic logic: Uses symbols to accurately map out valid and invalid arguments.
• Mathematical logic: Uses mathematical symbols to prove theoretical arguments
• Propositional Logic


Why is it important?
• Core of AI
• Possibility of automating reasoning
Reasoning: draw inferences from knowledge
• answer queries
• discover facts that follow from the knowledge base decide what to do etc.
• In AI, propositional logic is essential for knowledge representation, reasoning, and decision-making processes
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Logical Arguments
(A) All humans have 2 eyes.
(B) Sujit is a human.
Therefore (P) Sujit has 2 eyes.
(C) All humans have 4 eyes.
(B) Sujit is a human.
Therefore (Q) Sujit has 4 eyes.
Which of P and Q are true / false ?
Is deducing P from A and B correct? Q from B and C?


All humans have 2 eyes.
Kishore has 2 eyes.
Therefore (P) Kishore is a human.
No human has 4 eyes.
Kishore has 2 eyes.
Therefore (Q) Kishore is not human.
Which of P and Q are true / false ?
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• All humans have 2 eyes.
• Kishore has 2 eyes.
• Therefore (P) Kishore is a human.
• No human has 4 eyes.
• Kishore has 2 eyes.
• Therefore (Q) Kishore is not human.
• Which of P and Q are true / false ?
• Is deducing P correct? Q?
• ...fallacy conclusion may be correct. The reasoning is incorrect
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Propositional Logic
Deals with propositions which are true or false
Also known as propositional calculus
Zero-order logic
Foundations for first order and higher order logics
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Order of 'Logic'
• The order of a logic refers to the degree of quantification that can be performed over sets:
• First-order logic: Quantifies only over individuals. It is also known as predicate logic, predicate calculus, or quantificational logic.
• Second-order logic: Quantifies over sets.
• Third-order logic: Quantifies over sets of sets.
• Higher-order logic: The union of first-, second-, third-, and higher-order logic. It allows quantification over sets that are nested arbitrarily deeply.
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Propositional Logic
Propositions are Declarative Statements
Atomic Propositions:
Simple, indivisible statements, cannot be broken down further
Each atomic proposition represents a basic fact or condition
Example: "The door is closed."
Compound Propositions:
Multiple atomic propositions can be combined using logical connectives (like AND, OR, NOT) to create compound propositions.
Example: "The door is closed AND the heater is on."


Excercise
Which of the following are propositions
(P) Today is Wednesday
(Q) It is raining today
(R) It will be raining tomorrow
(S) Close the door
(S) 2 + 7 = 9
(T) 3+9 = 10
(U) X+2 = 1


Logical connections
AND (∧) conjunction
S: P AND Q
S: P ^ Q
S is true if both P and Q are true
OR (V) disjunction
S: P OR Q
S: P V Q
S is true if any of P , Q is true
NOT (¬): Negation.
S: ¬P
S is true only if P is false
IMPLIES (→)
S: P → Q
S: ¬P V Q
S is true if P implies Q
IFF (↔)
S: P ↔ Q
S: ¬P XOR Q
S is true if P and Q are true or false together


P→Q
The only time P→Q evaluates to False is when
• P is True and Q is False
If P→Q is True, then:
• P is a sufficient condition for Q
• Q is a necessary condition for P

P ↔ Q
P → Q
Q → P
If P ↔ Q is true
• P and Q are equivalent
• P is necessary and Sufficient for Q
• Q is necessary and Sufficient for P


Truth Table
• A truth table is a breakdown of all the possible truth values returned by a logical expression
• Write down truth tables for, P, Q, ¬P, , P v Q, P →Q , P↔Q , ¬P V Q, ¬P XOR Q
• One row for each possible assignment of True/False to propositional variables
• Important: Above P and Q can be any sentence, including complex sentences
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~~Abo~~ Above P & Q can be any sentence, including complex sentences

P	Q	$P \vee Q$	$P \wedge Q$	$P \rightarrow Q$	$P \leftrightarrow Q$
0	0	0	0	1	1
0	1	1	0	1	0
1	0	1	0	0	0
1	1	1	1	1	1

Exercise
Given: A and B are true; X and Y are false, determine truth values of:
¬(A ∨ X)
A ∨ (X ∧ Y)
A ∧ (X ∨ (B ∧ Y))
[(A ∧ X) ∨ ¬B] ∧ ¬[(A ∨ X) ∨ ¬B]
(P∧Q) ∧ (¬A ∨ X)
[(X∧Y) → A] → [X → (Y→A)]