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"Logic is all about reasons. Every day we consider possibilities, we think about what follows from different assumptions, what would be the case in different alternatives, and we weigh up competing positions or options. In all of this, we reason. Logic is the study of good reasoning, and in particular, what makes good reasoning good."

– Greg Restall

"Logic is one of the most ancient intellectual disciplines, and one of the most modern."

– Graham Priest

Arguments & Representations

Definition

An **argument** is a set of **claims** or **propositions** where one or more **premises** are offered as **justification** or **reasons** for another **proposition**—the **conclusion**.

Arguments =

Premise(s)

+

Conclusion(s)

Propositions

A **proposition** is a **declarative sentence** that expresses an **assertion**, which can be **either true** or **false**.

Examples:

- "Snow is white."
- "Water is H_2O."
- "AI systems must have rights if they possess phenomenal consciousness."

Non-Propositional Statements

Not all **sentences** express **propositions** or **assertions**. Questions, commands, and exclamations are examples of sentences that **do not express propositions** because they **do not have truth values** (they **cannot** be **true** or **false**).

Examples:

- **Question:** "What time is it?"
- **Command:** "Please close the door."
- **Exclamation:** "How beautiful this painting is!"

Premises & Conclusions

- A premise is a **proposition** that intends to **support**, **justification**, or **reasons** for accepting the conclusion of an argument.
- A conclusion is a **proposition** that the **premises** of an **argument** are intended to **support** or **prove**.

Note: **All arguments** must have at least one **premise and** one **conclusion**.

Example

1. **Either** cats are green (P) **or** cats are blue (Q).
2. Cats are not blue. (¬Q)

Therefore, ∴

3. Cats are green. (P)

Note: This argument is presented in **standard form** with all the premises and conclusions numbered.

Logical Connectives

Logical connectives are **symbols** used in **propositional logic** to **connect propositions** and **form compound statements**.

Common Logical Connectives:

- **Conjunction** (∧): "and"
- **Disjunction** (∨): "or"
- **Negation** (¬): "not"
- **Conditional** (→): "if . . . then"
- **Biconditional** (↔): "if and only if"

Example Revisited

1. **Either** cats are green (P) **or** cats are blue (Q).
2. Cats are not blue. (¬Q)

Therefore, ∴

3. Cats are green. (P)

Logical Form: **Disjunctive Syllogism**

1. $P \vee Q$
2. $\neg Q$
3. $\therefore P$

Negation

¬ Cats are blue

Proposition

Negation

Indicator Words for Negation

- not
- no
- false
- it is false that
- it is not the case that

Validity & Logical Connectives

Definition

An **argument** is **valid** if and only if it is **logically impossible** for all the premises to be **true** and the conclusion to be **false** at the same time.

Key Concept: **If** *the premises are true,* **then** *the conclusion must be true*: the **logical connectives** (∧, ∨, →, ↔, ¬) **logically guarantee** the **truth** of the **conclusion if** the **premises** are **true**.

Invalidity or Bad Logic

Even if **all** the **propositions** are **true**, this **doesn't mean** the **argument** is **good**. The reason is because the **argument's logic** is **invalid** – the logic is bad.

Example:

1. $2 + 2 = 4$ (**True**) (P)
2. Tokyo is the capital of Japan (**True**) (Q)

Therefore, ∴

3. The moon is a satellite of Earth (**True**) (R)

Invalid!!

Invalidity or Bad Logic (Cont.)

The **conclusion**, the "*moon is a satellite of Earth*" (**R**), doesn't **logically follow** from the **premises** (**P** and **Q**); the **argument** is **invalid** the **logic** is **bad**.

Invalid Logical Form:

1. P
2. Q

∴ 3. R

Invalid!!

Any set of **propositions**, regardless of their truth, that uses this **invalid logical form** will **always** lead to a **logically unrelated conclusion**.

Disjunctions

Cats are green (P) ∨ Cats are blue (Q)

Disjunct 1 · Disjunct 2

Disjunction

Indicator Words for Disjunctions

- or
- either . . . or . . .
- unless
- alternatively
- otherwise
- in the alternative

Conjunctions

Cats are mammals (P) ∧ Cats are animals (Q)

Conjunct 1 · Conjunct 2

Conjunction

Indicator Words for Conjunctions

- and
- both . . . and . . .
- as well as
- also
- in addition
- moreover

Conditional

Cats are mammals (P) → Cats are animals (Q)

Antecedent · Consequent

Conditional

Indicator Words for Conditionals

- if
- if . . . then
- only if
- provided that
- on condition that
- in the event that

Biconditional

Cats are mammals (P) ↔ Cats are animals (Q)

Proposition 1 · Proposition 2

Biconditional

Indicator Words for Biconditionals

- if and only if
- just in case
- exactly when
- just when

Valid Logical Forms

Definition

A **logical form** is the **abstract pattern** or **structure** of an argument obtained when we replace the specific content of the propositions with placeholders (like $P, Q, R, \ldots$) and focus solely on the **logical connectives** and how they combine these placeholders.

Key Idea: The **logical form** shows how the conclusion is **supposed to follow** from the **premises** based purely on the **arrangement** of **logical connectives** (e.g., ∧, ∨, →, ↔, ¬) **rather** than on any **factual content**.

Definition

A **valid logical form** is a **logical pattern** such that any **argument** that **uses** or **instantiates** that **logical form** cannot have **all true premises** and **a false conclusion** at the same time.

Key Idea: A **valid logical form** ensures **truth preservation** from **premises** to **conclusion**. **No** substitution of any **propositions** into a **valid form** can produce a **counterexample scenario** (true premises, false conclusion). **Validity depends** entirely on the **argument's logical form, not** on the **subject matter**.

Valid Logical Form 1

1. The system can operate in normal mode (P)

or diagnostic mode. (Q)

2. The system isn't in normal mode. (¬P)

Therefore, ∴

3. The system is in diagnostic mode. (Q)

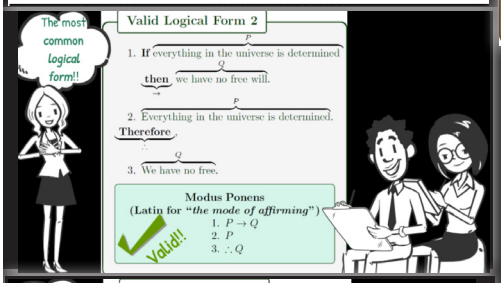
Valid!!

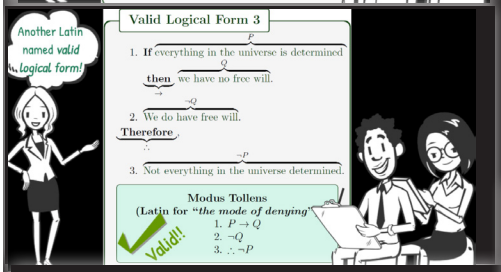
Disjunctive Syllogism

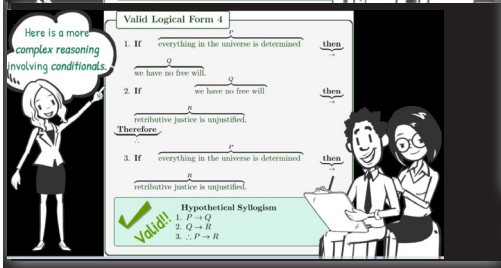
1. $P \vee Q$
2. $\neg P$
3. $\therefore Q$

Table 1: Logical Connectives and Indicator Words

Symbol	Indicator Words
Conjunction ($\wedge$)	*and, but, moreover, furthermore, while, although.*
Disjunction ($\vee$)	*or, either . . . or, unless, alternatively, otherwise, in the alternative.*
Conditional ($\rightarrow$)	*if . . . then, implies, only if, provided that, given that.*
Biconditional ($\leftrightarrow$)	*if and only if, just in case, exactly when.*
Negation ($\neg$)	*not, it is not the case that, it is false that, no, none, un-, non-.*







Implying vs. Inferring

Implying is about the **logical relationships** between propositions. When we say that certain premises **imply** a conclusion, we are talking about the logical relationship that exists between propositions as a result of logical connectives. The proposition Q is implied or follows from $P \rightarrow Q$, P $\therefore Q$ independent of any person's thoughts.

Inferring, on the other hand, is a **cognitive activity** performed by thinkers. Inferring is the interpretation the listener makes from the statements. Knowing it to be a leap year, a person may correctly infer that it is an even-numbered year. (Or she might incorrectly infer something mistaken, such as that it is an odd-numbered year.)

KEY DISTINCTIONS:

- **Propositions imply** other **propositions** when combined with **logical connectives**.
- **People infer propositions** from **other propositions** based on their **interpretations** and **beliefs** about the **propositions**
- **Propositions imply**, **people infer**.

What is Critical Thinking?

Critical thinking is a **methodical skill** that involves analyzing and evaluating the quality of reasoning in arguments. At its core, it's about using **logic** to refine how we think: by understanding **logical forms**, we can improve our ability to distinguish good arguments from poor ones.

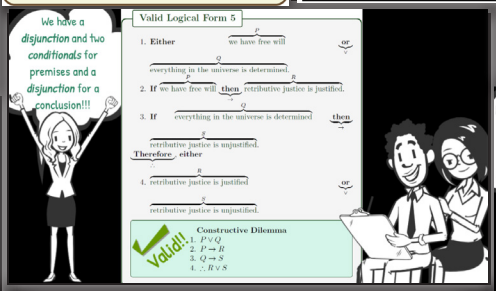
Yet critical thinking goes beyond form and structure. It also requires knowing what **evidence or data** is needed to confirm the **truth** of propositions, determining if that information is **accessible**, reliable, and sufficient. In this way, critical thinking merges abstract logical analysis with the practical challenge of verifying premises and conclusions, making it a skill that can be **taught**, **learned**, and **continuously refined** as we encounter new claims and contexts.

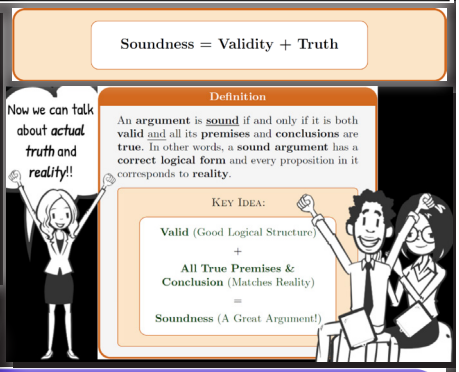
KEY INSIGHT:

Critical thinking
=
Logical reasoning
+
Informed judgment about evidence

Table 2: Concepts

Concepts	Description/Indicator Words
Propositional Variables (P, Q, R, . . .)	Represent propositions that can be true or false. EXAMPLE: Let P = "The sky is blue."
Premises	Propositions offered as reasons or evidence. INDICATOR WORDS: *since, because, as a result of, as shown by.*
Conclusion	The proposition the premises support. INDICATOR WORDS: *therefore, thus, hence, so, consequently.*
Conjuncts	Propositions joined by $\wedge$. In "Cats are mammals and cats are animals," each part is a *conjunct.*
Disjuncts	Propositions joined by $\vee$. In "Cats are green or cats are blue," each part is a *disjunct.*
Antecedent	In $P \rightarrow Q$, P is the *antecedent* (the "if" part).
Consequent	In $P \rightarrow Q$, Q is the *consequent* (the "then" part).





Truth & Soundness

Valid Logical Forms

Name of Inference Rule	Standard Logical Form
Modus Ponens	If $P \rightarrow Q$ and P, then $\therefore Q$.
Modus Tollens	If $P \rightarrow Q$ and $\neg Q$, then $\therefore \neg P$.
Hypothetical Syllogism	If $P \rightarrow Q$ and $Q \rightarrow R$, then $\therefore P \rightarrow R$.
Constructive Dilemma	If $(P \rightarrow R) \wedge (Q \rightarrow S)$ and $P \vee Q$, then $\therefore R \vee S$.
Disjunctive Syllogism	If $P \vee Q$ and $\neg P$, then $\therefore Q$.

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