Introduction to Logic: The Art of Reasoning

Fundamentals of Logical Thinking

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Welcome to Logic: The Art of Reasoning

- Logic is the systematic study of the principles of valid reasoning and argumentation.
- Logic provides tools to distinguish good reasoning from poor reasoning.
- Logical thinking helps us evaluate claims and make better decisions in everyday life.
- This course will develop your ability to recognize, analyze, and construct sound arguments.

What is Logic?

Logic is the study of the methods and principles used to distinguish correct from incorrect reasoning.

Why Study Logic? Applications in Daily Life and Academia

- Logic helps us critically analyze news, advertising, and social media claims.
- Logical reasoning is essential for success in many academic disciplines including philosophy, mathematics, computer science, and law.
- Clear thinking prevents us from being misled by emotional appeals and fallacious reasoning.
- Logic improves our communication by helping us articulate our own thoughts more precisely.

Example: Everyday Application

When evaluating a product advertisement claiming "9 out of 10 doctors recommend," logic helps us ask important questions: How many doctors were surveyed? What exactly were they asked? Is this a representative sample?

Historical Overview: From Aristotle to Modern Logic

- Logical study began with Aristotle's systematic analysis of syllogisms in ancient Greece.
- Traditional logic remained largely unchanged for nearly 2,000 years until the 19th century.
- Modern symbolic logic was developed by mathematicians like George Boole and Gottlob Frege.
- Contemporary logic includes modal, temporal, and computational logic systems.

Period	Key Figures	Contributions
Ancient	Aristotle	Syllogistic logic
Medieval	Aquinas, Ockham	Development of temporal logic
19th Century	Boole, Frege	Mathematical/symbolic logic
20th Century	Russell, Gödel	Modern formal systems

Table: Evolution of Logical Thought

Course Roadmap: What We'll Cover

- We'll begin by understanding the basic structure of arguments and how to identify them.
- We'll explore different types of arguments: deductive, inductive, and abductive reasoning.
- We'll learn to distinguish arguments from non-arguments and from explanations.
- We'll develop skills to analyze complex arguments and put them in standard form.

Course Goals

1. Recognize arguments in everyday language
2. Evaluate the strength of arguments
3. Construct your own valid arguments
4. Apply logical thinking to real-world situations

What Is an Argument? Basic Structure and Purpose

- An **argument** is a set of statements where some (the premises) are offered as support for another (the conclusion).
- Arguments attempt to provide reasons for accepting a particular claim as true or probable.
- Arguments can be expressed in conversation, writing, or even visually through diagrams.
- The purpose of an argument is to persuade others to accept a conclusion based on evidence.

Simple Argument Example

Premise 1: All mammals have lungs.
Premise 2: Whales are mammals.
Conclusion: Therefore, whales have lungs.

Premises: The Foundation of Arguments

- **Premises** are statements offered as evidence or reasons to support a conclusion.
- Premises can be facts, observations, opinions, or even hypothetical statements.
- The quality of premises significantly affects the strength of an entire argument.
- Premises may be stated explicitly or left implicit (unstated but assumed).

Important Note

For an argument to be sound, all premises must be true. Even a single false premise can undermine an otherwise logically valid argument.

Conclusions: What Arguments Aim to Establish

- A **conclusion** is the statement that the argument is trying to prove or support.
- The conclusion represents the main point the arguer wants the audience to accept.
- Conclusions should follow logically from the premises, though the strength of this connection varies.
- A single argument can have only one main conclusion, though it may have sub-conclusions.

Common Conclusion Indicators:

- Therefore
- Thus
- So
- Hence
- It follows that

Sometimes Conclusions:

- Appear at the beginning
- Are unstated (implied)
- Use no indicator words
- Require careful analysis

The Relationship Between Premises and Conclusions

- The premises of an argument should provide support or justification for the conclusion.
- The connection between premises and conclusion is called **inference**.
- The strength of this connection determines whether the argument is strong or weak.
- Premises may support a conclusion independently or work together as a unit.

Two Types of Premise Support

Independent Support Each premise provides separate evidence for the conclusion (like multiple witnesses)

Dependent Support Premises work together to support the conclusion (like links in a chain)

Indicators: Linguistic Clues for Premises and Conclusions

- **Indicator words** are terms that signal the presence of premises or conclusions.
- Premise indicators typically appear before statements that provide evidence or reasons.
- Conclusion indicators generally appear before statements that express what is being argued for.
- Recognizing these indicators helps identify argument structure in complex texts.

Premise Indicators	Conclusion Indicators
Because	Therefore
Since	Thus
Given that	Consequently
For the reason that	It follows that
As indicated by	So

Table: Common Indicator Words

Example: Identifying Premises and Conclusions

Spider-Man's Uncle Ben

"With great power comes great responsibility."
Analysis: This famous quote is actually an enthymeme (argument with unstated premises):

- **Implied premise 1:** Spider-Man has great power
- **Implied premise 2:** People who have great power have great responsibility
- **Conclusion:** Spider-Man has great responsibility

Batman's Reasoning

"The criminal is a coward and superstitious. Therefore, my costume must be terrifying to strike fear in their hearts."
Analysis:

- **Premise 1:** Criminals are cowardly and superstitious
- **Implied premise 2:** Terrifying symbols strike fear in the cowardly and superstitious
- **Conclusion:** Batman's costume must be terrifying (to be effective)

Distinguishing Arguments from Other Forms of Discourse

- Not all communication contains arguments—many texts simply inform, describe, or entertain.
- An **argument** specifically attempts to support a claim with reasons or evidence.
- Arguments involve both factual claims and logical connections between those claims.
- Identifying arguments requires recognizing when someone is trying to convince rather than merely inform.

Non-Argument vs. Argument

Non-Argument: "The capital of France is Paris. It has many famous landmarks."

Argument: "The capital of France must be Paris because all major guidebooks list it as such, and official government documents identify it as the capital."

Implicit vs. Explicit Arguments

- **Explicit arguments** clearly state both premises and conclusion.
- **Implicit arguments** leave some components unstated but implied.
- Many real-world arguments contain unstated premises (enthymemes) that are culturally assumed.
- Reconstructing implicit arguments requires careful consideration of context and charitable interpretation.

The Principle of Charity

When analyzing arguments, apply the **principle of charity** by interpreting them in their strongest possible form before evaluation—don't attack "straw man" versions.

Argument Indicators in Everyday Language

- Arguments in everyday conversation often lack formal indicator words.
- Questions can sometimes function as implicit conclusions ("Shouldn't we leave now?").
- Tone, emphasis, and context provide important clues about argumentative intent.
- Professional writing (academic, legal, scientific) tends to use more explicit argument structures.

Common Contexts for Arguments

- Persuasive essays and opinion pieces
- Political speeches and debates
- Academic papers and presentations
- Legal proceedings and documents
- Everyday disagreements and discussions

Finding Hidden Premises and Conclusions

- Many arguments leave crucial premises unstated because they're assumed to be obvious.
- **Hidden premises** are unstated assumptions necessary for an argument to work.
- **Implied conclusions** must sometimes be inferred from context and content.
- Identifying these unstated elements is essential for proper argument evaluation.

Argument with Hidden Premise

"Maria should take an umbrella because it's going to rain."
Hidden premise: People should take umbrellas when it rains.
Stated premise: It's going to rain.
Conclusion: Maria should take an umbrella.

Deductive Arguments: Aiming for Certainty

- **Deductive arguments** aim to provide conclusive support for their conclusions.
- In a properly formed deductive argument, if all premises are true, the conclusion must be true.
- Deductive arguments move from general principles to specific instances.
- Mathematics and formal logic primarily use deductive reasoning.

Key Concept: Validity

A deductive argument is **valid** if its conclusion must be true when all premises are true. This is about the logical structure, not factual accuracy.

Validity and Soundness in Deductive Reasoning

- A deductive argument can be valid even if its premises are false.
- A **sound** argument is both valid AND has all true premises.
- Soundness is the gold standard for deductive arguments—it guarantees a true conclusion.
- Evaluating deductive arguments requires checking both structure (validity) and content (truth).

Valid but Not Sound:
All fish can fly.
Sharks are fish.
Therefore, sharks can fly.

Both Valid and Sound:
All squares have four sides.
This shape is a square.
Therefore, this shape has four sides.

Common Deductive Argument Forms

- Certain argument patterns are recognized as valid deductive forms.
- **Modus ponens** (If P then Q; P; Therefore Q) is one of the most common valid forms.
- **Modus tollens** (If P then Q; Not Q; Therefore not P) is another reliable form.
- Understanding these patterns helps identify valid arguments regardless of content.

Modus Ponens Example

If it is raining, then the streets are wet. (If P then Q)
It is raining. (P)
Therefore, the streets are wet. (Q)

Inductive Arguments: Reasoning from Evidence to Probability

- **Inductive arguments** provide evidence that makes their conclusions probable rather than certain.
- Inductive reasoning moves from specific observations to general conclusions.
- Science relies heavily on inductive reasoning to formulate theories from data.
- The strength of inductive arguments depends on the quality and quantity of evidence.

Inductive vs. Deductive Reasoning

Inductive	Deductive
Specific to general	General to specific
Probabilistic conclusion	Certain conclusion (if valid)
Based on observation	Based on logical necessity
Can add new information	Conclusion contained in premises

Strength and Cogency in Inductive Arguments

- An inductive argument is **strong** if its premises make its conclusion probable.
- An inductive argument is **cogent** if it is strong AND all its premises are true.
- Strength comes in degrees—inductive arguments can be very strong, moderately strong, or weak.
- Adding relevant evidence can strengthen an inductive argument (unlike deductive arguments).

Important Distinction

Inductive arguments are evaluated as **strong** or **weak**, not valid or invalid. Using deductive standards for inductive arguments is a common mistake.

Common Inductive Reasoning Patterns

- **Generalization** draws conclusions about a whole group based on a sample.
- **Analogical reasoning** argues that similar cases should have similar outcomes.
- **Causal reasoning** infers cause-effect relationships from observed correlations.
- **Statistical syllogism** applies group probabilities to individual cases.

Inductive Generalization

Premise: 95% of the 1,000 randomly sampled voters support Candidate X.
Conclusion: Therefore, approximately 95% of all voters likely support Candidate X.
Note: The strength depends on sample size and representativeness.

Example: Deductive vs. Inductive Arguments

Superman's Deductive Reasoning

"All Kryptonians are weakened by Kryptonite. I am a Kryptonian. Therefore, I am weakened by Kryptonite."

Analysis: This is a valid deductive argument (syllogism):

- It has the form: All A are B; C is an A; Therefore, C is B
- If the premises are true, the conclusion must be true
- The conclusion follows with certainty

Sherlock Holmes' Inductive Reasoning

"The last three times Moriarty was in London, a major jewel theft occurred. Moriarty is now in London again. Therefore, another major jewel theft is likely to occur."

Analysis: This is an inductive argument:

- Based on observed pattern of past events
- Conclusion is probable but not certain
- New evidence could strengthen or weaken it

Abductive Arguments: Inference to the Best Explanation

- **Abductive reasoning** seeks the most plausible explanation for observed facts.
- It is sometimes called "inference to the best explanation."
- Abduction begins with observations and works backward to likely causes.
- This form of reasoning is common in medicine, detective work, and scientific discovery.

Abductive Reasoning Example

Observation: The patio is wet this morning.
Possible explanations: It rained, sprinklers ran, someone washed it.
Best explanation: It rained (most plausible given additional context like wet streets).

Example: Abductive Reasoning

Scooby-Doo Gang's Investigation

"The monster only appears when the lighthouse keeper is not around. There are footprints matching the lighthouse keeper's shoes. There's theatrical makeup in the keeper's drawer. The best explanation is that the lighthouse keeper is disguising himself as the monster."

Analysis: Classic abductive reasoning:

- Multiple observations collected (timing, footprints, makeup)
- Alternative explanations considered but rejected
- Conclusion is the most plausible explanation for all observed facts
- Classic "inference to the best explanation"

Comparing the Three Argument Types: When to Use Each

- **Deductive arguments** work best when applying established principles to specific cases.
- **Inductive arguments** are appropriate when projecting from observed patterns to new instances.
- **Abductive arguments** are valuable when seeking explanations for phenomena.
- Many real-world arguments combine elements of all three types of reasoning.

Type	Strength	Best Applications
Deductive	Certainty	Mathematics, formal logic, law
Inductive	Probability	Science, statistics, forecasting
Abductive	Plausibility	Diagnosis, investigation, research

Table: Comparison of Argument Types

Reports: Just the Facts

- **Reports** present information without attempting to establish a conclusion.
- Reports state what is observed or known without arguing for its truth.
- News articles (ideally) report facts without drawing conclusions from them.
- Reports may be used within arguments, but are not themselves arguments.

Characteristics of Reports

- Focus on observable data
- Lack inferential language
- Absence of conclusion indicators
- Often use neutral, descriptive language
- May contain measurements, statistics, or direct quotations

Expressions of Opinion: Beliefs Without Support

- **Expressions of opinion** state beliefs without providing supporting evidence.
- Unlike arguments, they don't attempt to convince through reasons.
- Opinions become premises in arguments only when supported by further evidence.
- Distinguishing between unsupported opinions and argued positions is crucial for critical thinking.

Mere Opinion:
"I believe that jazz is the best form of music."

Argument:
"Jazz is the best form of music because it combines technical complexity with emotional expression and allows for individual creativity through improvisation."

Illustrations and Examples: Not Yet Arguments

- **Illustrations and examples** provide instances that clarify or elaborate on a concept.
- They show rather than prove, though they may be incorporated into arguments.
- Concrete examples help understand abstract ideas but don't establish their truth.
- Examples become evidence only when used to support generalizations.

Illustration vs. Inductive Argument

Illustration: "Some birds cannot fly. For instance, penguins and ostriches cannot fly."

Inductive Argument: "Many flightless birds live in environments without predators. Penguins, ostriches, and kiwis all evolved in relatively predator-free environments. Therefore, lack of predators likely contributes to flightlessness in birds."

Expository Passages: Explaining Without Arguing

- **Expository passages** aim to explain concepts, processes, or relationships.
- They provide information to increase understanding, not to prove a conclusion.
- Textbooks, encyclopedias, and instructional materials often use expository writing.
- Exposition answers "what," "how," and "why" questions without advocating for claims.

Clarifying Questions for Distinguishing Exposition from Argument

1. Is the passage trying to prove something is true?
2. Or is it explaining how something works or what something means?
3. Does it assume the truth of what's being discussed?
4. Is it offering reasons for accepting a conclusion?

Conditional Statements: "If-Then" Without Asserting

- **Conditional statements** express relationships between conditions and consequences.
- They take the form "If P, then Q" but don't assert that P or Q is actually true.
- Conditionals state what would follow if a condition were met.
- They become parts of arguments only when the antecedent (the "if' part) is affirmed or the consequent denied.

Conditional vs. Argument

Conditional Statement: "If it rains, the game will be canceled."
Argument Using Conditional:
"If it rains, the game will be canceled.
It is raining.
Therefore, the game will be canceled."

Arguments vs. Explanations: Key Differences

- **Arguments** aim to establish the truth of a claim that is in doubt.
- **Explanations** assume the truth of a claim and clarify why or how it is the case.
- Arguments answer "Is it true?" while explanations answer "Why is it true?"
- The same set of statements can function as either an argument or explanation depending on context.

Essential Distinction

The key difference is in purpose and what is taken for granted:

- Arguments: The conclusion is in question; premises aim to establish it
- Explanations: The phenomenon is accepted as true; the goal is to account for it

When Explanations Look Like Arguments

- Explanations often use the same indicator words as arguments ("because," "since," etc.).
- Both explanations and arguments connect statements with inferential relationships.
- The difference lies in whether the statement being supported is in doubt or accepted.
- Context and the author's purpose are crucial for distinguishing between them.

Explanation:
"The bridge collapsed because the supporting cables snapped."
(Assumes bridge collapse is known and explains why)

Argument:
"The bridge must have collapsed because several cars were found in the river below."
(Uses evidence to establish that collapse occurred)

Causal Explanations vs. Justifying Reasons

- **Causal explanations** describe the mechanisms that brought about an event.
- **Justifying reasons** provide evidence for believing a claim is true.
- Causal explanations answer "Why did it happen?" in a factual sense.
- Justifying reasons answer "Why should I believe it happened?" in an epistemological sense.

Causal vs. Justifying

Causal Explanation:
"The water froze because the temperature dropped below 32°F." (physical cause)
Justifying Reason:
"I know the water froze because I observed ice in the container this morning." (evidence for belief)

Example: Argument vs. Explanation

Wonder Woman - Argument

"The prisoner must be telling the truth because she is bound by the Lasso of Truth, and the Lasso of Truth compels anyone bound by it to speak truthfully."
Analysis: This is an argument:

- It attempts to establish something in doubt (whether the prisoner is telling truth)
- It provides evidence/reasons to accept the conclusion
- The conclusion is what's being proven

Wonder Woman - Explanation

"The prisoner is telling the truth because she is bound by the Lasso of Truth. The Lasso works by magically connecting the bound person to the cosmic essence of truth."
Analysis: This is an explanation:

- It assumes the person is telling the truth (not in doubt)
- It explains the mechanism by which the truth-telling occurs
- It answers "how" rather than "is it the case"

Identifying the Purpose: Persuasion or Understanding?

- Context and rhetorical situation help determine if statements aim to persuade or explain.
- Arguments attempt to overcome doubt or disagreement about a claim.
- Explanations assume agreement about a claim and provide understanding of it.
- Ask: "Is the author trying to convince me this is true, or helping me understand why it's true?"

Contextual Clues

Look for these signals to distinguish arguments from explanations:

- Is the claim controversial or accepted?
- Is the audience likely to doubt the claim?
- Does the communication aim to resolve disagreement?
- Does the author treat the main claim as established or in need of support?

What Is Standard Form and Why Use It?

- **Standard form** presents arguments with premises clearly listed and the conclusion identified.
- It eliminates rhetorical flourishes and focuses on the logical structure.
- Standard form helps identify missing premises and evaluate logical connections.
- Converting arguments to standard form is a crucial skill for critical analysis.

Natural Language vs. Standard Form

Natural language:

"Since smoking damages the lungs and heart and increases cancer risk, anyone concerned about their health should avoid cigarettes."

Standard form:

P1: Smoking damages the lungs and heart.

P2: Smoking increases cancer risk.

P3: People should avoid behaviors that damage health.

C: Anyone concerned about their health should avoid cigarettes.

Step 1: Identifying All Premises and the Conclusion

- The first step is to carefully read the entire argument to understand its overall point.
- Identify the conclusion—the main claim the argument is trying to establish.
- Look for indicator words that signal premises and conclusions.
- Watch for premises that are stated in questions or commands rather than declarative sentences.

Common Challenge

Many everyday arguments have multiple conclusions, with some serving as intermediate steps (sub-conclusions). Identify the main conclusion first, then work backward to find supporting premises.

Step 2: Eliminating Irrelevant Material

- Arguments often contain material that doesn't directly support the conclusion.
- **Rhetorical flourishes** add persuasive force but not logical support.
- **Repetition** may emphasize points but doesn't add new support.
- **Tangential information** might be interesting but irrelevant to the logical structure.

Identifying Relevant Content

Original: "As any sensible person can clearly see, and as experts have repeatedly confirmed beyond any shadow of doubt, excessive sugar consumption leads to health problems. Sugar is in everything these days! Therefore, reducing sugar intake is essential for maintaining good health." Relevant content only: P1: Excessive sugar consumption leads to health problems. C: Reducing sugar intake is essential for maintaining good health.

Step 3: Arranging Premises Logically

- After identifying premises and conclusions, arrange them in logical order.
- Identify **suppressed premises** that are implied but not stated.
- Group related premises that work together to support a sub-conclusion.
- Number premises and clearly mark the conclusion.

Approaches to Arrangement

Two common ways to arrange premises:

1. **Linear arrangement:** Each premise builds on previous ones toward the conclusion
2. **Branching arrangement:** Multiple independent lines of support for the conclusion

Practice: Converting Real-World Arguments to Standard Form

- Converting real arguments requires practice and careful reading.
- Different readers may produce slightly different standard forms of the same argument.
- The goal is to capture the logical essence of the argument faithfully.
- Standard form should clarify, not distort, the original argument's intent.

Practice Example

Original text: "Free college education should be available to all qualified students. After all, an educated population benefits society through increased productivity and innovation. Furthermore, making higher education dependent on wealth perpetuates inequality."
Standard form:
P1: An educated population benefits society through increased productivity and innovation.
P2: Making higher education dependent on wealth perpetuates inequality.
P3: (Implied) Society should maximize benefits and reduce inequality.
C: Free college education should be available to all qualified students.

Example: Hidden Premises

Popeye's Reasoning

"I need to be strong. Therefore, I must eat spinach."
Analysis: This enthymeme has multiple hidden premises:

- **Stated premise:** I need to be strong
- **Hidden premise 1:** Spinach makes me strong
- **Hidden premise 2:** If I need to be strong and spinach makes me strong, then I should eat spinach
- **Conclusion:** I must eat spinach

Captain America's Appeal

"The Sokovia Accords restrict our freedom to act. Therefore, we should oppose them."
Analysis: Hidden value premise:

- **Stated premise:** The Sokovia Accords restrict freedom to act
- **Hidden premise:** Restrictions on freedom to act (for superheroes) are harmful/wrong
- **Hidden premise:** We should oppose harmful/wrong policies
- **Conclusion:** We should oppose the Sokovia Accords

Breaking Down Extended Arguments

- **Extended arguments** contain multiple inferences leading to a main conclusion.
- These arguments often have a hierarchical structure with sub-arguments.
- Break down complex arguments by identifying intermediate conclusions.
- Analyze each sub-argument individually before examining how they work together.

Extended Argument Structure

P1: Studies show that exercise increases endorphin production.

P2: Increased endorphin production improves mood.

SC1: Therefore, exercise improves mood.

P3: Improved mood reduces stress.

P4: Reduced stress strengthens immune function.

MC: Therefore, exercise strengthens immune function.

(where SC1 = sub-conclusion, MC = main conclusion)

Argument Maps: Visualizing Reasoning Structures

- **Argument maps** are visual diagrams showing logical relationships between statements.
- They use boxes for claims and lines/arrows to indicate support relationships.
- Mapping reveals the overall structure of an argument at a glance.
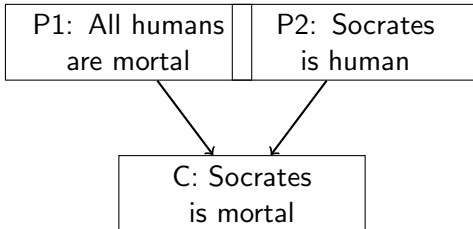- Maps help identify weak points and understand how parts of an argument relate.

Figure: Simple Argument Map

Sub-arguments and Chains of Reasoning

- **Sub-arguments** are smaller arguments that support premises in the main argument.
- A **chain of reasoning** occurs when conclusions become premises for further arguments.
- The strength of each link affects the overall strength of the argument chain.
- Complex arguments often blend multiple types of reasoning (deductive, inductive, abductive).

Critical Insight

In a chain of reasoning, the conclusion is only as strong as the weakest link. If any step in the chain is flawed, subsequent conclusions become questionable, even if their immediate inferences are valid.

Logic in Action: Applying What We've Learned

- Logic isn't just an academic exercise—it's a practical tool for everyday reasoning.
- Recognizing argument structures helps evaluate news, advertisements, and political discourse.
- Constructing good arguments improves your ability to communicate and persuade effectively.
- Critical thinking skills developed through logical analysis transfer to all areas of life.

Key Takeaways

- Arguments provide reasons to accept conclusions
- Different types of arguments serve different purposes
- Standard form clarifies logical structure
- Complex arguments can be broken down into components
- Logic improves both our thinking and communication