

Higher Secondary Course

Philosophy
Logic

XI



Government of Kerala
Department of General Education

Prepared by
State Council of Educational Research and Training (SCERT) Kerala
2026

THE NATIONAL ANTHEM

Jana-gana-mana adhinayaka, jaya he
Bharatha-bhagya-vidhata
Punjab-Sindh-Gujarat-Maratha
Dravida-Utkala-Banga
Vindhya-Himachala-Yamuna-Ganga
Uchchala-Jaladhi-taranga
Tava subha name jage,
Tava subha asisa mage,
Gahe tava jaya gatha.
Jana-gana-mangala-dayaka jaya he
Bharatha-bhagya-vidhata
Jaya he, jaya he, jaya he,
Jaya jaya jaya, jaya he!

PLEDGE

India is my country. All Indians are my brothers and sisters.

I love my country, and I am proud of its rich and varied heritage.
I shall always strive to be worthy of it.

I shall give my parents, teachers and all elders, respect and treat everyone with courtesy.

To my country and my people, I pledge my devotion. In their well-being and prosperity alone, lies my happiness.

PHILOSOPHY



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Dear learners,

It is a privilege for the State Council of Educational Research and Training (SCERT) to present this textbook on Philosophy for our first year higher secondary learners. Central to this volume is the study of Logic, the foundational framework for determining truth and validity across all spheres of human knowledge. Logic provides the essential architecture for human thought, enabling us to navigate complex analysis and rigorous argumentation. While its roots lie deep in philosophy, logical rigor is now the heartbeat of every intellectual pursuit—from scientific inquiry to legal reasoning. We have designed this textbook to be an active companion in your intellectual journey. Through curated activities, real-world case studies, and illustrative anecdotes, we aim to bridge the gap between abstract theory and practical application. Our goal is to help you internalize the principles of logic, transforming them into a lived practice for your everyday life. I extend my sincere gratitude to the dedicated subject experts and teachers who contributed their expertise to this work. We welcome your constructive feedback to further enhance our educational materials. May this book empower you to think clearly, argue fairly, and seek truth with unwavering clarity.

Dr. Jayaprakash R.K.

Director
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Learning activity



**For additional reading -
not for assessment**

THE CONSTITUTION OF INDIA

PREAMBLE

WE, THE PEOPLE OF INDIA, having solemnly resolved to constitute India into a ¹**[SOVEREIGN SOCIALIST SECULAR DEMOCRATIC REPUBLIC]** and to secure to all its citizens :

JUSTICE, social, economic and political;

LIBERTY of thought, expression, belief, faith and worship;

EQUALITY of status and of opportunity; and to promote among them all

FRATERNITY assuring the dignity of the individual and the ²[unity and integrity of the Nation];

IN OUR CONSTITUENT ASSEMBLY this twenty-sixth day of November, 1949 do **HEREBY ADOPT, ENACT AND GIVE TO OURSELVES THIS CONSTITUTION.**

1. Subs. by the Constitution (Forty-second Amendment) Act, 1976, Sec.2, for "Sovereign Democratic Republic" (w.e.f. 3.1.1977)
2. Subs. by the Constitution (Forty-second Amendment) Act, 1976, Sec.2, for "Unity of the Nation" (w.e.f. 3.1.1977)

Chapter

1 INTRODUCING PHILOSOPHY



Diogenes and the Lamp

The philosopher Diogenes was famously seen walking through the crowded marketplace of Athens in broad daylight, carrying a lighted oil lamp.

*When the puzzled onlookers asked him why he needed a light when the sun was shining, Diogenes would hold the lamp up to their faces and reply:
"I am looking for a man".*



Activity 1

In the story of Diogenes and the Lamp, what was the significance of the statement, 'I am looking for a man'?

Write your thoughts

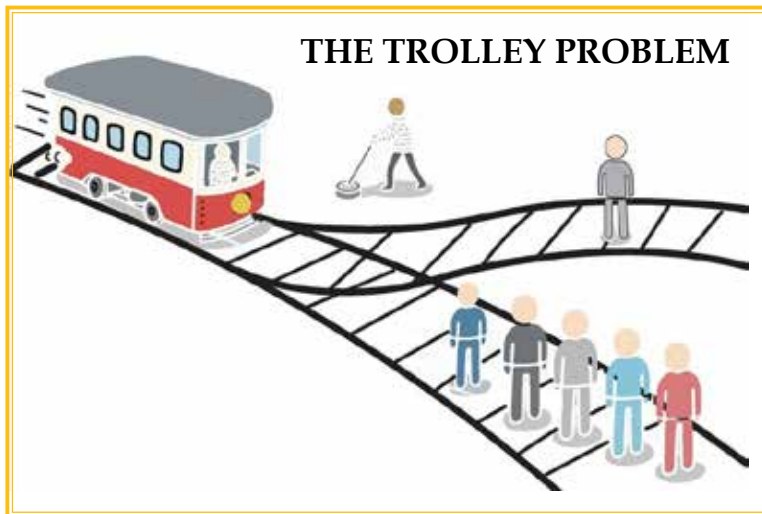
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Welcome to philosophy. Don't worry, this isn't about memorising ancient names or studying things that do not matter. Philosophy is simply the study of **big questions**—questions about reality, knowledge, and how we ought to live.

Here is a challenge to begin with. Let us imagine a scenario that forces you to confront your deepest beliefs about right and wrong. Take a rational decision.



Imagine you are standing next to a train track. Down the track, a runaway trolley is speeding toward five workers who are currently unable to move and will certainly be killed if the trolley continues its current path.

Next to you is a lever. If you pull the lever, the trolley will switch to a different track. However, there is one person working on that side track, and that one person will be killed instead.

You have only a moment to act.



Activity 2

Option	Outcome	Philosophical Question
Do nothing	Five workers die.	Are you responsible for the deaths you could have prevented?
Pull the lever	One worker dies.	Is it morally acceptable to intentionally sacrifice one person to save five?

Choose an option and prepare a note justifying your choice.

.....

.....

Most people immediately say they would pull the lever. Five lives saved for the cost of one seems logical, perhaps even a necessary, choice. This initial impulse often aligns with a philosophical school of thought which argues that the most ethical choice is the one that results in the greatest good for the greatest number of people.

Similarly, we face many big problems in our life. Have you ever looked at the sky and wondered? "Where does it end?"

Or

Have you ever thought, "Why am I here? What is the purpose of my life?"

There are situations in our life that make us think deeply. But we are not always aware of them. Most of us take things for granted. But some are very thoughtful and reflective. They wonder about the things around them. When we ask such deep questions about life, knowledge, truth, value and so on, we are actually doing philosophy. **Philosophy is nothing but a search for answers to such fundamental questions.** The people who spend their lives asking such deep questions and trying to find logical answers are called philosophers.

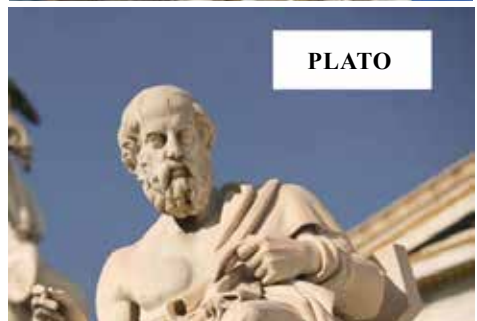
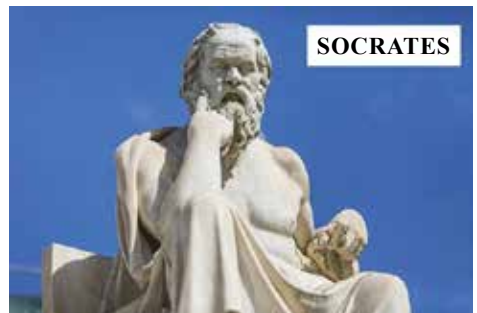
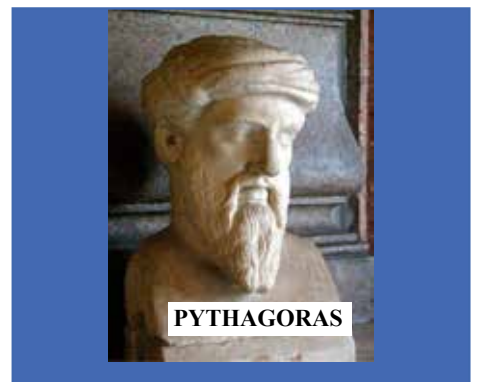
Meaning and Definition of Philosophy

The term **philosophy** comes from the two Greek words *philo*, meaning love, and *sophia*, meaning wisdom; therefore, philosophy literally means *love of wisdom*. The word philosophy was first used by the Greek thinker Pythagoras, and later, Plato popularized the term philosopher in his writings to honour Socrates as a true "lover of wisdom."

A **philosopher** is one who seeks to understand the world and human life not by merely accepting what is given, but by questioning, reasoning, and thinking critically. Plato remarked "Wonder is the feeling of the philosopher, and philosophy begins in wonder," while Socrates described the philosopher as a seeker after wisdom. Naturally, we ask the question: Who is a philosopher? Generally, **a philosopher is someone who asks the fundamental questions about life and tries to answer them in a systematic and convincing way.**

Philosophy is important because it teaches us to:

- think critically
- argue logically
- make sense of complex issues
- accept diversity in thought.



It deals with questions such as: what is real? what is knowledge? what are values? and the like. Although these questions may not have final answers, they encourage deep reflection and personal growth.

Philosophy can be defined as "rational, systematic and critical inquiry into the basic principles of any dimension of reality or the reality as a whole" (A Concise Dictionary of Philosophy).

Read the following quotes



John Dewey - "Philosophy is thinking which has become conscious of itself."

Herbert Spencer- "Philosophy is concerned with everything as a universal science."



Sarvepalli Radhakrishnan:
"Philosophy is a product of life" and its main purpose is to "advance and ennoble life."

Swami Vivekananda: Philosophy is a practical tool for realizing one's own divinity; "when the soul wants to depend upon nothing... that is the height of philosophy, the height of manhood."



Activity 3

Analyse the above quotes and define philosophy in your own words.

.....

.....



*In Indian philosophy, the term for philosophy is **Darsana**, which literally means "vision" or "instrument of vision". Unlike many Western traditions that treat philosophy as a purely intellectual quest, Indian philosophers define it as the direct, immediate, and intuitive perception of the Reality and the Truth.*

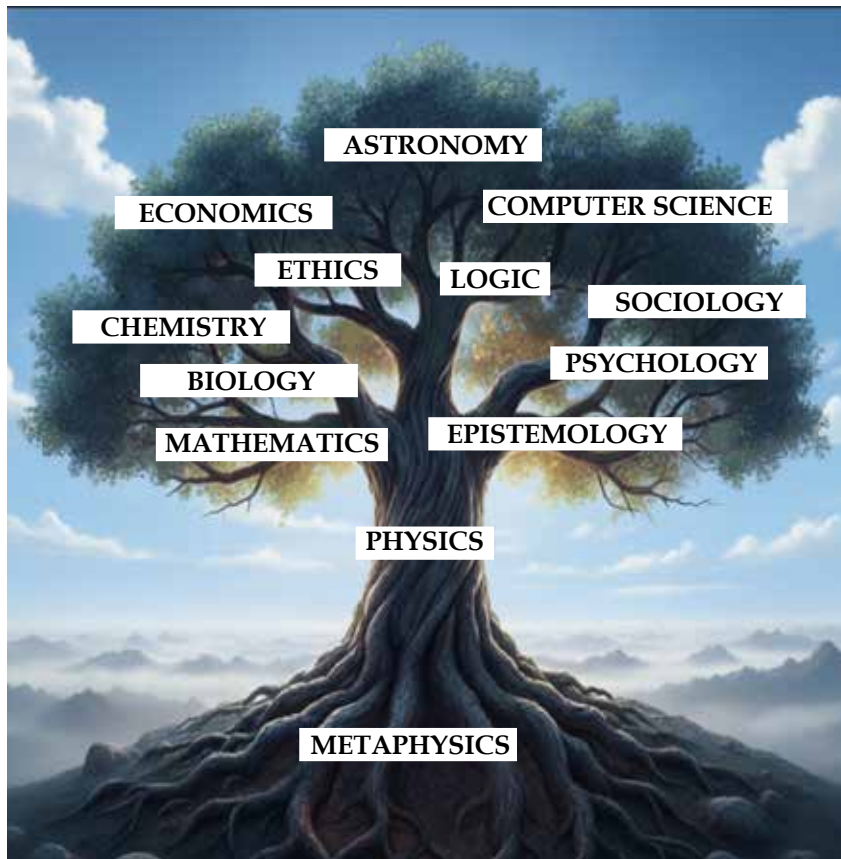
Philosophy and Science

According to Rene Descartes, “All Philosophy is like a tree, of which Metaphysics is the root, Physics is the trunk and all other sciences are the branches that grow out of its trunk...”

Principles of Philosophy



Rene Descartes



Philosophy is often called “*the mother of all sciences*”. In ancient Greek tradition, all forms of knowledge were studied under philosophy. Philosophy is regarded, the first science until first half of the 19th century. What we now call science was ‘Natural philosophy.’ There were no separate subjects like physics, biology, psychology, economics, etc. Later, as human knowledge expanded, different areas of study became too large and detailed to remain under philosophy. Therefore, these areas got separated and developed into independent sciences to study their subjects more deeply and systematically.



Long ago philosophy was like a 'huge library' that stored all branches of knowledge: Science, Mathematics, Arts, Medicine, Law and so on. If a person became a Master of Philosophy (M.Phil.), it meant that person had mastered reading and understanding one section of that big library. If someone became a Doctor of Philosophy (Ph.D.), it meant he went further- he wrote a new book and placed it in the library, adding new knowledge for everyone. "Even today, the M.Phil. and Ph.D. in any subject are called 'Master of Philosophy' and 'Doctor of Philosophy' because they reflect a deep pursuit of wisdom and a significant contribution to human knowledge."

However, in the modern world philosophy and science are distinct fields of study with different approaches. Science is the systematic study of anything that can be examined, tested and verified. It relies mainly on observation and experimentation, focusing on empirical evidence to build knowledge. The word **science** is derived from the Latin word *scientia* meaning *knowledge*. Philosophy is more speculative and seeks answers through introspection and rational synthesis rather than experimental methods. While science depends on verifiable evidence, philosophy explores questions that cannot be fully resolved by experiments.



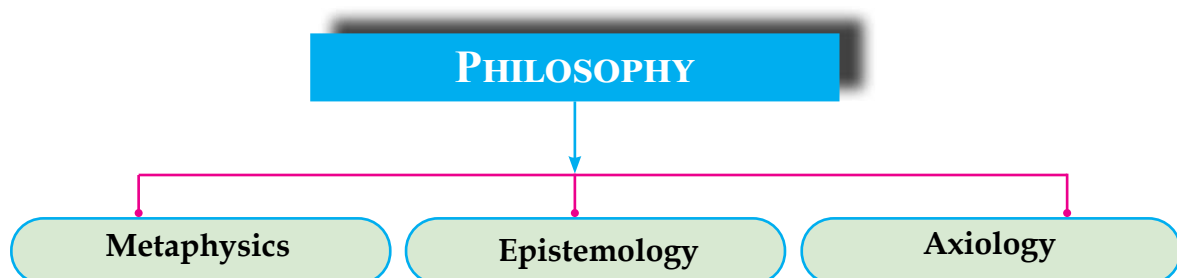
"Science is organized knowledge. Philosophy is organized life"

-Immanuel Kant-



Branches of Philosophy

Philosophy can be organised into three core branches. They are Metaphysics, Epistemology and Axiology.



Metaphysics

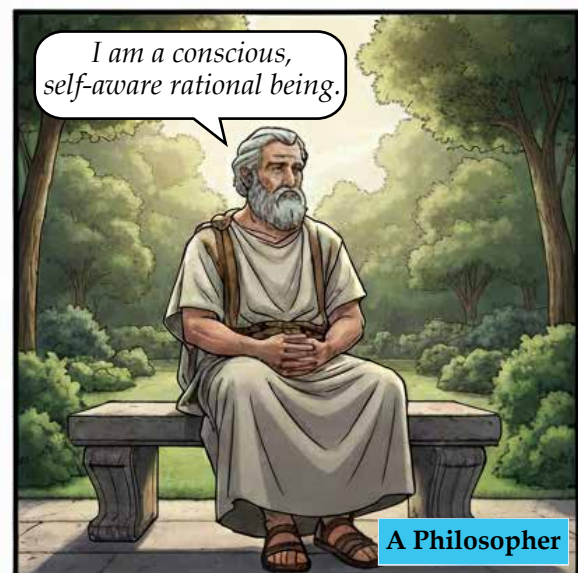
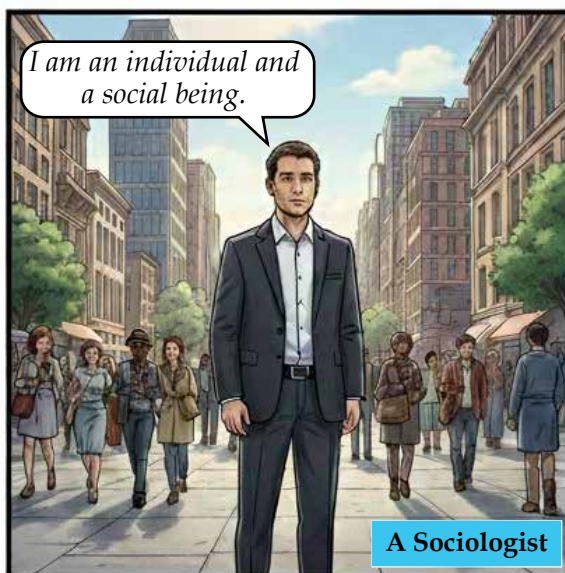
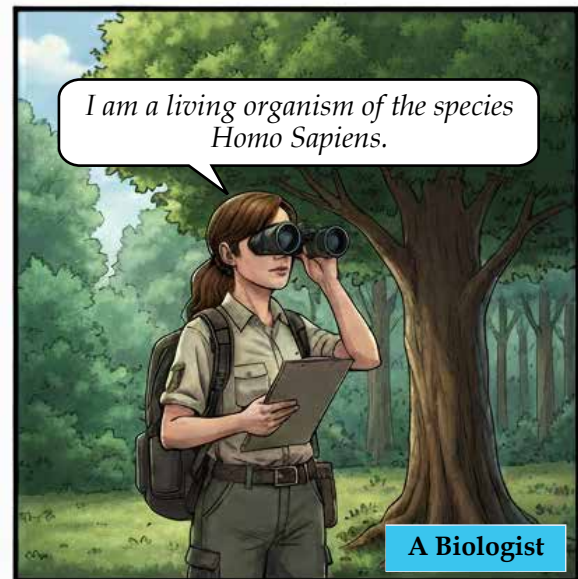
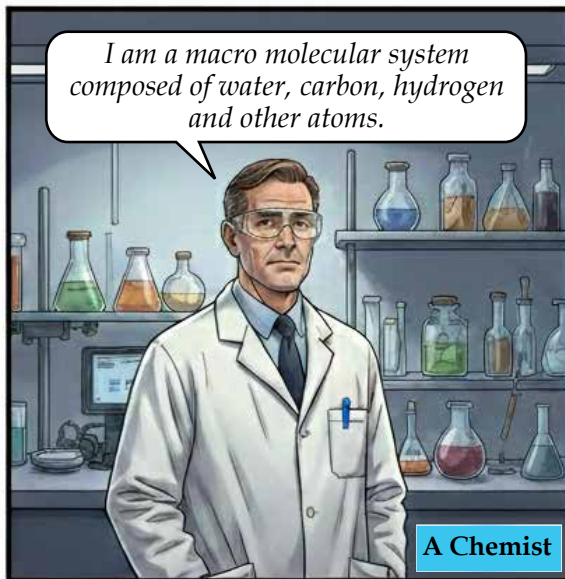


Activity 4

“Who am I?”

I am.....
.....

Let us see what different people say about it.



Each person answers the question “Who am I?” from their own perspective. However, it is the philosopher who attempts to go beyond the physical, biological or social explanation to discover the Ultimate Truth.

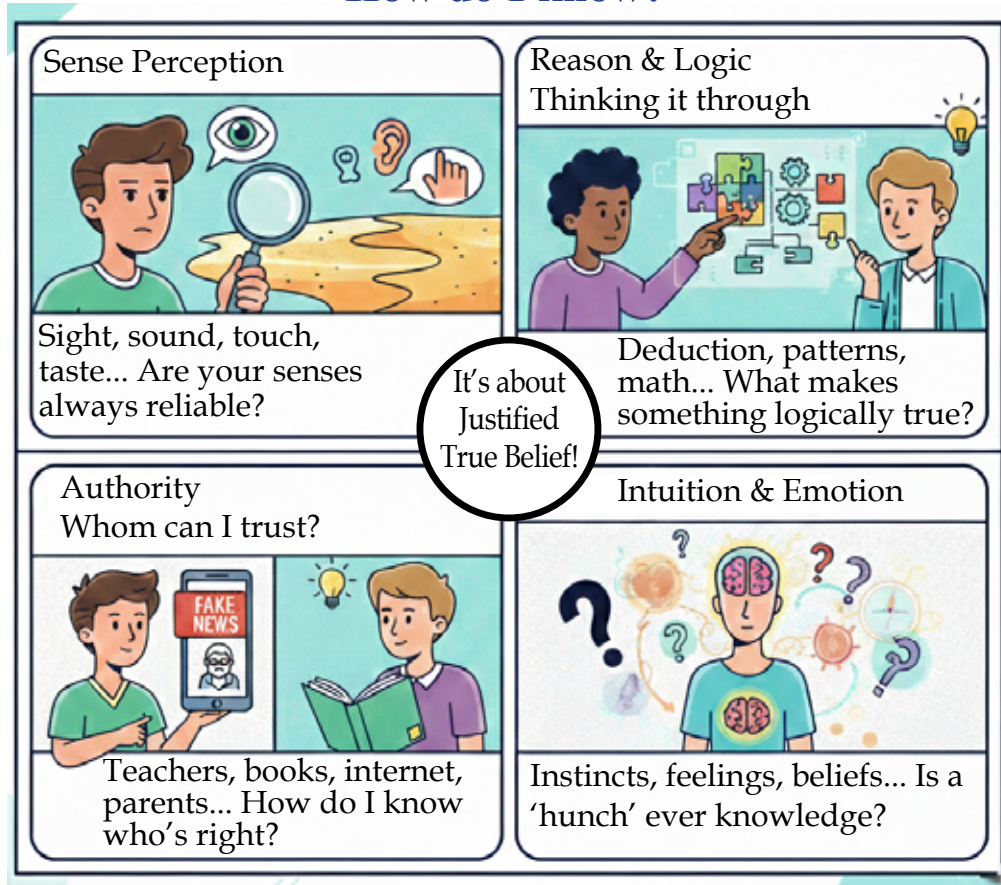
The branch of Philosophy that studies the nature of reality is called Metaphysics.

The term **metaphysics** comes from two Greek words, *meta* and *physika*, where *meta* means beyond and *physika* means nature or natural things. Thus, metaphysics literally means a *science beyond physics*. The basic question in metaphysics is ‘What is real?’ This leads to the enquiry about the nature of Reality, Existence, and Being. What is the origin and structure of the universe? Does an Ultimate Reality exist? What are time and space? What is the relationship between mind and body? These are questions that puzzle everyone, but philosophy attempts to answer them.

Branches of Metaphysics include **Ontology** and **Cosmology**. Ontology is the study of Being (that which really exists) whereas Cosmology is the study of the world (*cosmos*).

Epistemology

How do I know?



We know about the world mainly through our sense organs, reasoning, intuition, emotion, and authority.

The branch of Philosophy that studies the nature, sources, and limits of knowledge is called Epistemology.

The term **epistemology** means the *study of knowledge*. It comes from two Greek words—*episteme*, which means knowledge, and *logos*, which means reason, study, or science. Epistemology mainly asks the question, 'How do we know?' It explores the sources, nature, and limits of human knowledge. It also examines different types of knowledge. This branch of philosophy studies the relationship between the person who knows and the thing that is known. **Logic** is a part of epistemology. Logic helps us to think correctly and find the truth and the falsity of knowledge. Logic is the tool that all sciences in the world make use of in their process of enquiry.



The term epistemology was coined by a Scottish philosopher James Frederick Ferrier. He also coined the word Agnoiology, the study of ignorance



Axiology

Look at this picture.

What do you observe?

How do you feel when you see such an action?

Is it a right action?

Why do we say this action is wrong?

We say this because stealing is wrong and an unfair deed.

When we evaluate actions, behaviour, or moral choices, we are talking about values.

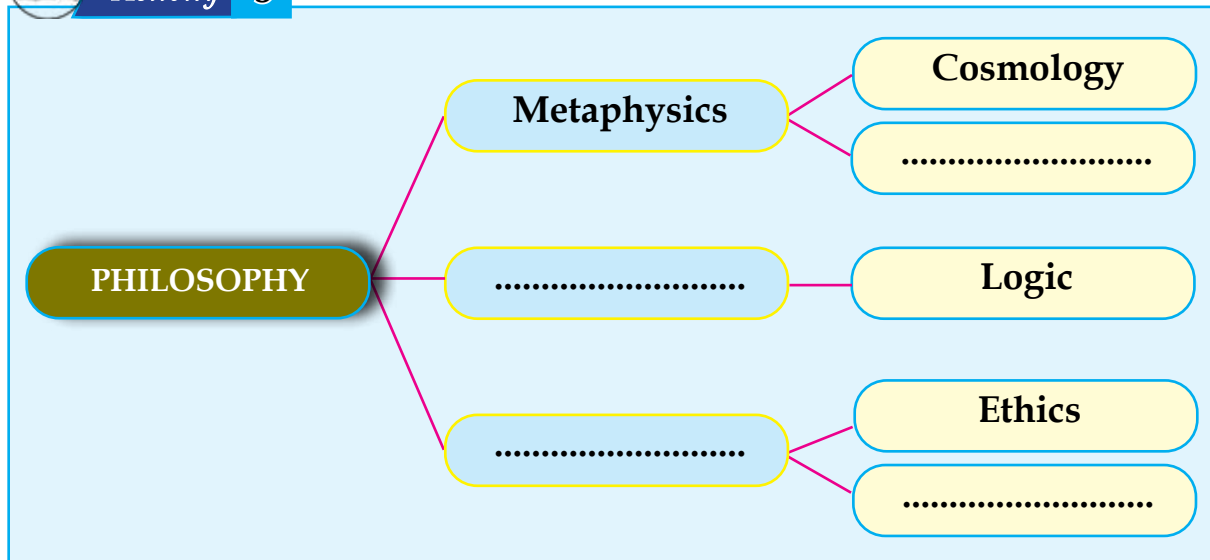
The branch of philosophy that studies values such as right, wrong, good or bad is called Axiology.



The term **axiology** is derived from the Greek words *axios* which means 'worthy' or 'of value' and *logos* which means 'reason, study or science'. The branch that focuses on moral goodness is called **Ethics or Moral Philosophy**, and the branch that studies beauty or harmony is known as **Aesthetics**. Ethics examines the ideas of right and good in personal and social behaviour. Aesthetics deals with the study of beauty and harmony found in nature and art.



Activity 5



Meaning and Definition of Logic

Read the following puzzle:



A farmer needs to transport a wolf, a goat, and a cabbage across a river. The boat can only carry the farmer and one other item at a time. The wolf will eat the goat if left alone, and the goat will eat the cabbage if left alone.

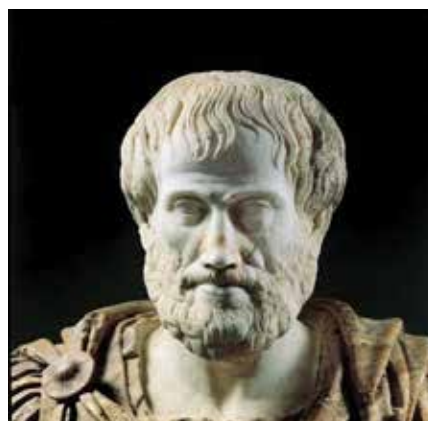

Activity 6

Rearrange the sentences in the correct order to show the farmer safely get all three across the river.

Jumbled statements of the puzzle	Order No.
The farmer returns alone.	.....
The farmer takes the goat across the river first.	1
The farmer takes the goat across the river one last time.	.....
The farmer takes the cabbage across the river.	.....
The farmer takes the wolf across the river.	.....
The farmer brings the goat back across the river.	.....
The farmer returns alone.	6

How did you solve the puzzle? What faculty did you use to solve?
It is the reasoning faculty, isn't it?

Logic is the study of correct reasoning. The foundation of logic was established by the Greek Philosopher Aristotle in the 4th century BCE. According to Aristotle, "Man is a rational animal." The ability of rational thinking is what distinguishes human beings from other animals. Human dominance over other beings is because of the faculty of reasoning. Human actions are controlled by thought, emotion, and will. When dealing with problems, we rely on thoughts. True knowledge is that which is obtained through the functioning of the intellect. Logic is not interested in the description or analysis of thought content. Logic guides the whole thought process and teaches us how to use the thought process to achieve truth. In this sense, Logic can be called the "*Science of all Sciences*".



Aristotle
(384 - 322 BCE)

The word **logic** is derived from the Greek word *logos* which means 'reason' or 'thought'. Logic is the science which investigates the general principles of valid thought. It can be defined as the study of the general conditions of valid inference.



The history of Logic outlines its development across three main independent traditions: India (Nyāya Sūtras), China (Mohist school) and Greece. While the Indian and Chinese traditions developed sophisticated systems for ethical reasoning and inference, the Greek tradition, formalized by Aristotle through the syllogism, became the bedrock of Western thought for over 2,000 years. After being preserved by Islamic and Medieval European scholars, logic was challenged in the 17th century by Francis Bacon's proposal of inductive reasoning. The field underwent its greatest revolution in the 19th and 20th centuries, transforming into symbolic and mathematical logic through the work of figures like Boole, Frege, Russell, and Gödel, which led to the creation of various non-classical logics (e.g., modal and fuzzy systems) that continue to expand the scope of reasoning today.



James Edwin Creighton
(1861-1924)

The American logician James Edwin Creighton gives us a precise definition of logic. According to him **"Logic is a science that deals with the operations of the human mind in its search for truth."**

To understand the definition of logic clearly, we should examine the important concepts in Creighton's definition of logic namely,

- i) Logic is a science.
- ii) Logic deals with operations of the human mind.
- iii) The aim of Logic is the search for truth.

i) Logic is a Science.

We have already seen that science is a systematic study of anything focusing on empirical evidence to build knowledge. Let us dwell deeper into the characteristics of science to understand how logic is a science.

A science has three definite characteristics:

- It gives us certain and sure knowledge.
- It is a systematic and organized body of knowledge.
- It studies a particular part of the universe.

Logic is a Science, because it has all the characteristics of a science.

Sciences in general have been divided into **positive science and normative science**. A positive science deals with the things as they are, while a normative science deals with things as they should be. Positive science is also known as descriptive science because it describes the facts of the world as they are, e.g., Physics, Chemistry, Economics, Biology, Psychology, etc. A normative science sets up a norm or standard to evaluate its subject matter, e.g., Ethics, Aesthetics and Logic. It is also known as regulative or evaluative science because it regulates towards a standard and evaluates the subject matter with reference to the standard.

Logic is a normative science because it sets up the norms for correct thinking. It gives us systematic knowledge regarding correct thinking. It teaches us how our thought process should be to reach the goal of truth.

ii) Logic deals with the operations of the human mind

The operations of the human mind are thinking, willing and feeling. **Logic is concerned only with the thinking process of the mind.** The three processes of thinking are **conception, judgement and reasoning**.

Conception

Conception is the process of forming a mental image of an object. For example, you see an elephant and form an idea of the elephant in your mind. When an idea is expressed in language, it is either a word or a phrase. In logic it is called a **term**. e.g., 'elephant', 'the largest land animal.'



Judgement

Looking at the elephant, a boy says, "The elephant is the largest land animal."

His friend replies, "Yes, but the elephant is not the largest animal in the world."

Now let us examine these two statements.

Both "the elephant is the largest land animal" and "the elephant is not the largest animal in the world" are judgements about the elephant. The first statement is affirmative because the term 'the largest land animal' is affirmed of the term 'elephant.' Whereas the second is negative because the term 'the largest animal in the world' is denied of the term 'elephant.'

Judgement is the process of forming a statement by which the mind affirms or denies something of something else. A judgement should have at least two ideas. If one idea is affirmed of another it is called affirmative judgement. For example, 'All animals are mortal.' If one idea is denied of another it is called a negative judgement. e.g., 'Earth is not flat.' When a judgement is expressed in language, it is a statement. In logic, it is known as a **proposition**.

Reasoning

If the judgements 'All elephants are black' and 'Jumbo is an elephant' are true, what can we infer about Jumbo?

Jumbo is black, isn't it?

This is the new judgement inferred from the given judgements. Here, reasoning helps us connect ideas.

Reasoning is the process of passing from one or more known judgements to a new judgement. For example, from the two known judgements, 'All human beings are rational' and 'Aristotle is a human being', we can draw the conclusion that, 'Aristotle is rational.' When reasoning is expressed in words, it is called an **argument**.



Activity 7

Complete the following chart.

Judgements	Terms	Affirmative/ Negative
The rose is red.	The rose, red	Affirmative
The turtle is not fast.		
A whale is a fish.		
The Earth is not flat.		


Activity 8

Read the following sets of judgements and infer the new judgement.

1. All birds have wings.
A sparrow is a bird.
 $\therefore$ _____

2. No fruits are bitter.
Mango is a fruit.
 $\therefore$ _____

3. All metals are shiny.
Silver is a metal.
 $\therefore$ _____

iii) The aim of Logic is the search for truth

Truth may be either formal or material. **Formal truth means agreement of ideas among themselves.** For example, the term 'married bachelor' is formally false because it is self-contradictory. On the other hand, a 'golden mountain' though not real is formally true because the two ideas 'golden' and 'mountain' are not contradictory to each other. **Material truth means agreement of ideas with the corresponding objects in the world outside.** e.g., the term 'mango' is materially true because in reality it corresponds to an actual fact. Material truth refers to the objects in the outside world, whereas formal truth has no reference to objects outside the mind.


Activity 9

Use ✓ and ✕ appropriately in the columns of the given table.

Terms	Formally True	Materially True
Square circle		
Flying horse	✓	✕
Red apple		
Burning ice cube		
Coconut tree		

Form and matter of thought

Logic can generally be divided into *formal logic* and *material logic*. The part of Logic which is concerned with formal truth is known as **deductive logic or deduction**. The part of Logic which is concerned with material truth is known as **inductive logic or induction**.

To understand the distinction between formal and material logic, one must have a clear idea of *the form and matter of thought*. Every material object has a certain form or shape and is made up of certain matter. There cannot be matter without form or form without matter. But the shape of things and the material may change without affecting one another.

Just as we recognise a distinction between form and matter in material objects, there is also a distinction between form and matter in thought. By form of thought we mean the way in which our mind thinks about something. By matter of thought we mean the content of the thought. The form may remain the same while the matter may change and vice versa.

Analyse the two judgements below:

- All human beings are intelligent
- All cats are sentient

These have the same form, but the matter is different.

On the other hand, the two judgements, 'All human beings are mortal', and 'No human being is immortal' are of the same matter but differ in form. Form of thought and matter of thought are inseparable. Logic deals with both form and matter. Therefore, logic is both formal and material.



Activity 10

For each pair of judgements below, identify whether they have the 'the same form but differ in matter' or 'the same matter but differ in form.'

All dogs are faithful All books are useful	Same form but differ in matter
Some students are hardworking No students are hardworking	.....
All trees are living beings All cats are animals	.....
All birds can fly Some birds cannot fly	.....

The Laws of Thought

All our thinking processes are based on some fundamental laws called **The Laws of Thought**. A law is a general truth that is applicable to everyone, everywhere and at all times. The laws of thought form the foundation for all of our rational thought processes. Without them, correct thinking is not possible. Out of the four laws of thought, three were formulated by Aristotle and the fourth by the German philosopher G. W. Leibniz. These laws are fundamental because they are taken for granted and do not require evidence to support them. They are:

1. The Law of Identity
2. The Law of Contradiction
3. The Law of Excluded Middle
4. The Law of Sufficient Reason

1. The Law of Identity

This law states that *everything is identical with itself and different from another*. Each object is equal to itself. If anything is A, then it is A. For example, a cat is a cat, not something else.

2. The Law of Contradiction

This law states that *nothing can have contradictory qualities in the same space and time*. For example, a toffee cannot be both sweet and not sweet at the same time. In other words, A cannot be both B and not B at the same time.

3. The Law of Excluded Middle

This law states that *everything must be either true or false*. Between contradictories one or the other must be true. The light is either *on* or *off*. There is no third or middle ground. In other words, A is either B or not B.

4. The Law of Sufficient Reason

This law states that *everything that exists has a sufficient reason or cause*, for why it is so and not otherwise. For example, the reason for the occurrence of day and night is the rotation of the Earth on its axis. This law is also known as **Law of Causation**. Law of causation is fundamental to all scientific experiments.



**Activity 11**

Fill in the blanks.

1. The Law of Identity states that.....
 - a) Everything must have a cause
 - b) A statement cannot be both true and false at the same time
 - c) Everything is identical with itself
 - d) A is either B or not B
2. "The colour of the hair is either black or non- black." This sentence illustrates,
 - a) The Law of Identity
 - b) The Law of Contradiction
 - c) The Law of Excluded Middle
 - d) The Law of Sufficient Reason
3. A student says "I passed SSLC and I did not pass SSLC."
Which law of thought is this statement against?

Logic and Other Sciences

One can say, beyond doubt, that Logic has a considerably wider scope by analysing its relationship with other sciences.

Logic and Psychology

Both Logic and Psychology are sciences that deal with the operations of the mind or consciousness. They study the things that goes on in one's mind. The subject matter of logic and psychology is not any object found in the physical world but the thinking process of the human mind. Thus, they agree in having thought as their common material of study. They are not independent but interdependent. Psychology depends on Logic for its systematic methods of investigation and for a better understanding of Logic, the study of Psychology is a considerable help. In spite of these points of agreement, there are important differences between Logic and Psychology.



Psychologist and Psychiatrist

A psychologist has a degree in psychology and focuses on therapy, counselling, and behavioral intervention.

A psychiatrist is a medical doctor (MBBS with specialization) who diagnoses and treats mental health disorders and can prescribe medication.

Differ in Scope:

- Logic deals only with the thinking aspect of the mind, whereas Psychology deals with all the three operations of the human mind, namely thinking, feeling, and willing. As a science of behaviour, Psychology enquires into the activities of all sorts of minds—a mind of an adult or a child or a person with mental illness. But Logic studies the thoughts of a normal adult mind only.

Differ in Aim:

- Psychology studies mental activities for the sake of knowledge about the mind, whereas Logic studies the processes of thinking with the aim of discovering truth and avoiding error.

Differ in Approach:

- Logic and Psychology deal with thought in different ways. Psychology is a positive science and it describes the thought process as it is. On the other hand, logic is normative science and provides the laws and norms of the thought process. Psychology deals with behaviour in general, whereas Logic deals with the structure of human thinking.



Activity 12

Arrange the given data in the appropriate columns.

- Positive Science
- It examines all the three mental operations-thinking, feeling, and willing
- Normative Science
- Focuses only on the normal adult mind
- It examines only the thinking process of the mind
- It studies the behaviour of all types of minds

Logic	Psychology

Logic and Ethics

Like Logic, Ethics is also a normative science. Ethics focuses on norms of right conduct, while Logic deals with the norms of correct reasoning. Ethics evaluates human conduct with the standard of goodness while Logic evaluates human thought by the standard of truth. They agree in method but differ in scope.

Logic and Aesthetics

The method of study for both Logic and Aesthetics is the same. Both are normative sciences. However, the major difference between them is that they study different fields of mental faculties. Aesthetics gives importance to emotions, while Logic gives importance to thought. The basis of aesthetic appreciation is beauty. Aesthetics is the science that studies emotions based on the ideal of beauty. Logic is the science that studies correct thinking with the ideal of truth.



Activity 13

Complete the list with their respective features.

Logic	Ethics	Aesthetics
1. Normative science	1. _____	1. _____
2. _____	2. Human conduct	2. _____
3. _____	3. _____	3. Ideal of beauty

Philosophy is an intellectual quest aimed at the self-realisation through understanding of the Reality and the Truth. Its major branches—Metaphysics, Epistemology, and Axiology—address fundamental questions about existence, knowledge, and moral values. Philosophy arises from life itself and seeks to refine, elevate, and ennoble human living. Within Philosophy, Logic plays a vital role as the tool of correct reasoning, helping us evaluate arguments, clarify abstract ideas, and maintain consistency in thought. As a major domain of Epistemology, Logic provides the structural foundation for rational thinking, and its core divisions are **formal logic** and **material logic**.

Chapter

2 TERMS AND PROPOSITIONS



Activity 1

Frame sentences connecting the images and the words given in the column below.

(Smart phones, electronic devices, modern, outdated, all, some, gadgets, are, not)

Sentences

- Some electronic devices are modern.

-

-

These images and words represent the terms used to construct the statements above. In this chapter, we discuss terms and propositions. We analyse logical propositions and their differences with grammatical sentences. It aims at classifying them into traditional propositions and modern propositions. It also examines the relation between terms with the help of diagrams.

Terms

We know that a concept expressed in language is called a **term**. The word term comes from the Latin word *terminus* which means 'boundary, limit, or end'. A **term** is the smallest unit in traditional logic. It is a word or group of words which serves as either the subject or the predicate in a logical sentence.

For example, 'Socrates is a philosopher.' Here the words 'Socrates' and 'philosopher' are terms. In order to understand a term, we have to know what a word means. A word consists of a letter or a combination of letters that carry some meaning. All terms are words but all words are not terms. Words such as *and*, *of*, *with*, and *the* are not terms.



Connotation and Denotation of Terms in Logic

In logic and language, the meaning of a term is understood through its connotation and denotation.

1. Denotation (Extension)

- *What it is: The denotation (also called extension) of a term refers to the class or group of all individual objects, persons, or events to which the term correctly applies.*
- *Simply put: It is the range or the list of actual things the word points to in the real world.*
- *Example: The denotation of the term "planet" includes Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune.*

2. Connotation (Intension)

- *What it is: The connotation (also called intension or comprehension) of a term refers to the set of characteristics, properties, or attributes shared by every member of the class.*
- *Simply put: It is the definition or the qualities implied by a word.*
- *Example: The connotation of the term "planet" includes characteristics such as orbiting a star, being large enough to be rounded by its own gravity.*

Grammatical Sentence and Logical Sentence

A sentence is a group of words that gives a complete sense. It is a verbal expression of thought. There are different kinds of sentences. They are *interrogative*, *imperative*, *exclamatory* and *declarative* sentences.

A declarative sentence is a statement that affirms or denies a fact. It is either true or false. Such declarative statements are called **propositions** in Logic. For example, the Sun is a star. This statement is either true or false. Whereas, sentences such as, 'What is your name?' (*interrogative sentence*), 'Get out' (*imperative sentence*), 'Oh! God' (*exclamatory sentence*), and the like, are not statements. These sentences are neither true nor false. Hence, they are not considered as propositions. Every proposition is either true or false. All propositions are sentences, but not all sentences are propositions.



Activity 2

Compare grammatical sentences and logical propositions.

Grammatical sentences	Logical propositions
• All sentences are not proposition	• All propositions are sentences
•	•
•	•
•	•

Propositions

Propositions are the building blocks of every argument. Hence a proposition is the basic unit of logical arguments. The word proposition is derived from the Latin word *proposito* which means *to put forth* or *a proposal* or *a statement*. Aristotle, who is regarded as the father of Logic, defines a proposition in his major work, the *Prior Analytics*. **"A proposition is a statement in which something is said regarding something else, either affirmatively or negatively."**

A logical sentence or proposition has both structure and form. Aristotle analysed propositions and explained their structure and form. It is known as **Aristotle's Analysis of Proposition**.





Aristotle's 'Prior Analytics' is a foundational text on formal logic and syllogistic reasoning. It represents the first systematic investigation of logic, and was written around 350 BCE as part of the 'Organon', a collection of his works on Logic. The book analyses and classifies different forms of syllogisms, which are logical arguments, consisting of three parts; two premises and a conclusion



Aristotle's Prior Analytics in Latin,

According to Aristotle, a proposition has three constituent parts: **the subject, the predicate, and the copula**. The **subject** is that about which something is declared. It is represented by the letter 'S'. e.g., Earth is a planet. Here, 'Earth' is the subject. The **predicate** is that which is declared of the subject. The letter 'P' is used to symbolise the predicate. In the above example, 'planet' is the predicate. The **copula** is the connecting link between the subject and the predicate. 'Is' or 'are' functions as the copula of a proposition. In the above example, 'Earth is a planet' the word 'is' is the copula.

Traditional logicians followed Aristotle's analysis of proposition. The structure of a logical proposition is, '**subject and predicate are connected by a copula**.' The proper logical form of an affirmative proposition is '**S is P**', and of a negative proposition is '**S is not P**.' However, modern logicians differ from Aristotle's analysis of proposition.



Activity 3

Identify the subject, predicate, and copula of the following propositions.

Propositions

- All fruits are sweet
- Some birds are not feathered
- Some scientists are philosophers
- Some medicines are expensive
- No human beings are perfect

Kinds of Propositions

Propositions can be classified in two ways.

- Traditional classification of propositions
- Modern classification of propositions

Let us discuss these two views of classification of propositions.

Traditional Classification of Propositions

In the traditional classification, propositions are divided into two types:

- Categorical propositions
- Conditional propositions

This classification was introduced by Aristotle and is therefore known as **Aristotelian classification of proposition**.

Categorical Propositions

A **categorical proposition** asserts something directly without any condition. The predicate is either affirmed or denied unconditionally of the subject. Categorical propositions are classified on the basis of **Quantity** and **Quality**. Based on **quantity**, propositions are either **Universal** or **Particular**. When the proposition refers to all members denoted by the subject, it is called **universal**. For example, 'All journalists are media persons' is universal because subject refers to the whole class of journalists. When the proposition refers only to a part of the subject, it is called **particular**. e.g., 'Some journalists are media persons' is a particular proposition because the subject refers to the part of the class 'journalists'.

Based on the **quality**, propositions are either **Affirmative** or **Negative**. An **affirmative** proposition is one in which an agreement is affirmed of the subject and predicate. For example, 'Some students are punctual'. A **negative** proposition indicates the lack of agreement between the subject and the predicate. e.g., 'Some students are not punctual.'


Activity 4

Identify the quantity and quality of the given propositions.

Proposition	Quantity	Quality
All exams are easy		
Some books are interesting		
No chemicals are medicines		
Some crystals are not costly		

We get four types of categorical propositions, by combining the quantity and quality.

1. Universal Affirmative
2. Universal Negative
3. Particular Affirmative
4. Particular Negative

Based on the vowels in their Latin words, '**affirmo**' and '**Nego**', these propositions are symbolically represented as A,E,I,O.

Symbol	Name of proposition	Example	Logical form
A	Universal Affirmative	All men are good	All S is P
E	Universal Negative	No men are good	No S is P
I	Particular Affirmative	Some men are good	Some S is P
O	Particular Negative	Some men are not good	Some S is not P


Activity 5

Identify the given proposition and write the other three types of categorical propositions.

Proposition	Name of proposition
Some soldiers are officers	
.....	
.....	
.....	

Conditional Propositions

A conditional proposition is a complex proposition that affirms or denies something in relation to something else conditionally.

Conditional propositions are classified into two types:

- Hypothetical propositions
- Disjunctive propositions

Hypothetical Propositions

A hypothetical proposition is a conditional proposition expressed using the clause 'If ... then'.

e.g., If you study well, then you will pass the exam.

A hypothetical proposition has two constituent parts.

- The If clause is called **Antecedent**
- The then clause is called **Consequent**.



Activity 6

Find the antecedent and the consequent from the given propositions.

1. If it rains, then the ground will be wet.

Antecedent - _____

Consequent - _____

2. If you study well, then you will get good grades.

Antecedent - _____

Consequent - _____



Activity 7

Form hypothetical propositions

1. Antecedent - You eat minimal supper.

Consequent - You will need fewer medicines.

Proposition : _____

2. Antecedent - The price of fuel is high.

Consequent - The price of commodities will be high.

Proposition : _____

Disjunctive Propositions

Disjunctive proposition is a conditional proposition. It is structured using the words 'either ... or'.

e.g., A country is either democratic or non-democratic.

The constituent parts of a disjunctive proposition are called **disjuncts**. The disjuncts of the above proposition are; 'A country is democratic', 'A country is non-democratic.'



Activity 8

Identify the disjuncts from the given propositions.

1. A person is either married or unmarried.

Disjuncts: 1.

2.

2. An alphabet is either a vowel or a consonant.

Disjuncts: 1.

2.



Activity 9

Form disjunctive propositions from the given disjuncts.

- A. Disjuncts: 1. Students are hostlers.

2. Students are day scholars.

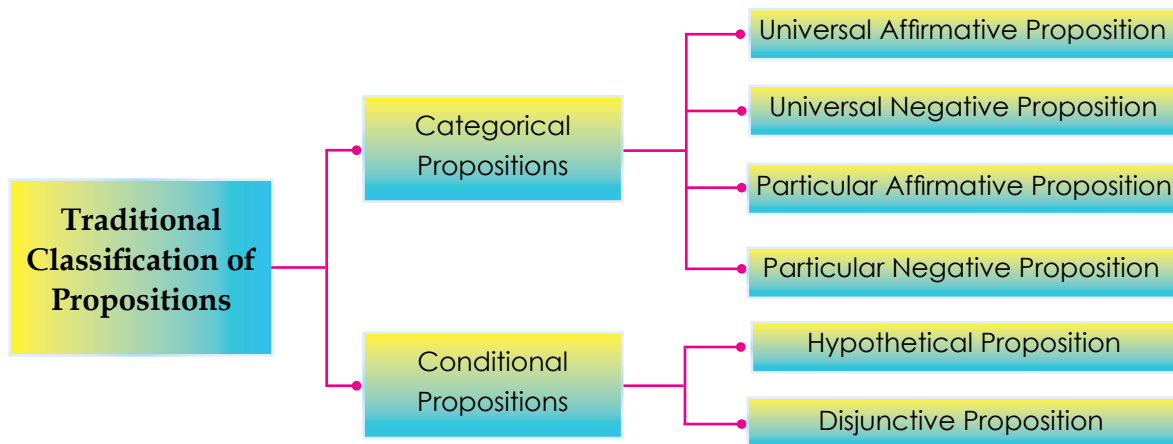
Proposition:

- B. Disjuncts: 1. The traffic light is red.

2. The traffic light is green.

Proposition:

Let us sum up the traditional classification of propositions with the help of a mind map.



Distribution of Terms in Categorical Propositions

The concept of distribution of terms plays an important role in traditional logic. **A term is said to be distributed when it refers to all the members of the group designated by a term. A term is said to be undistributed when it refers only to a part of that group.** In traditional logic, the subject and predicate of every proposition are regarded as classes.

Let us examine how the subject term and predicate term are distributed in the four-fold classification of categorical propositions.

Proposition	Symbol	Subject	Predicate
A proposition	SAP	Distributed	Undistributed
E proposition	SEP	Distributed	Distributed
I proposition	SIP	Undistributed	Undistributed
O proposition	SOP	Undistributed	Distributed



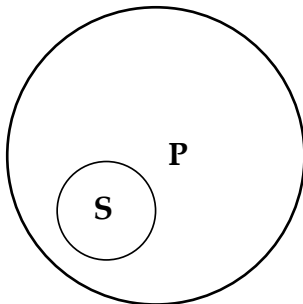
The distribution of terms in categorical propositions may be summarised in the mnemonic **ASEBINOP**. It means;

- An **A** proposition distributes the **Subject** only.
- An **E** proposition distributes **Both** the subject and the predicate.
- An **I** proposition distributes **Neither** the subject nor the predicate.
- An **O** proposition distributes the **Predicate** only.



Leonhard Euler, a Swiss mathematician, diagrammatically represented the relation between the terms (S and P) in a categorical proposition by means of circles, known as **Euler's Circles**. There are four diagrams corresponding to the four categorical propositions A, E, I, and O.

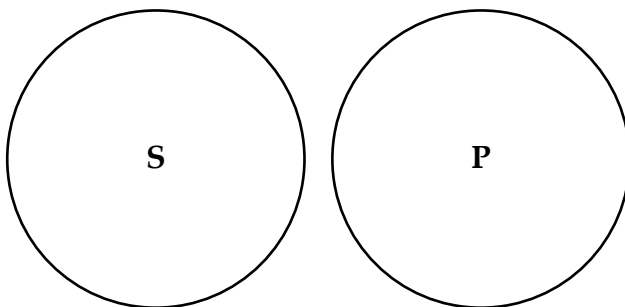
A proposition



e.g., All elephants are animals. (All S is P)

S and P are two classes. The circle S that represents the subject term is wholly included in the circle P that represents the predicate term. Here the subject is distributed because it denotes in full extent and the predicate is undistributed as it does not denote in full extent.

E Proposition



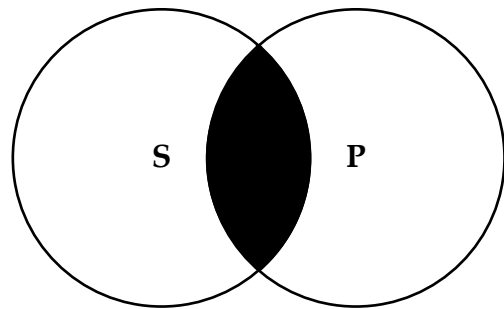
e.g., No elephants are carnivores. (No S is P)

The circle S that represents the subject term and the circle P that represents the predicate term is wholly excluded from each other. Here subject has no relation with the predicate and both are denoted in full extent. So, the subject and predicate are distributed in an E proposition.

I Proposition

e.g., Some fruits are citrus. (Some S is P)

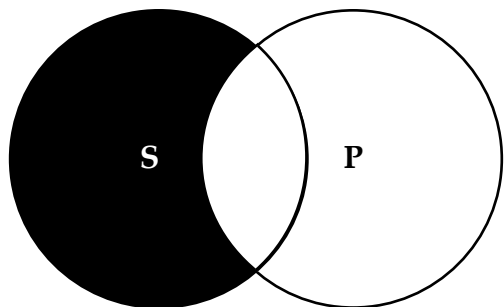
The circle S (subject term) and the circle P (predicate term) intersect each other. The shaded portion indicates that some S is included in P and vice versa. An I proposition distributes neither the subject nor the predicate because neither is denoted in full extent.



O Proposition

e.g., Some fruits are not citrus. (Some S is not P)

The circle S (subject term) and the circle P (predicate term) intersect each other. The shaded portion of S is wholly excluded from P. Here the subject is undistributed because it does not denote in full extent. Whereas the predicate is distributed as it denotes in full extent.



Activity 10

Draw Euler's circle to represent the following propositions and write the distributed terms.

Proposition	Euler's Circle	Distribution of Terms
No planets are stars		
Some machines are robots		

Modern Classification of Propositions

According to modern logicians, propositions are mainly divided into three types:

- Simple Propositions
- Compound Propositions
- General Propositions

Simple Propositions

If a grammatical sentence expresses one and only one proposition, then it is simple. ***A simple proposition contains no other proposition as its component.*** Bertrand Russell and other modern logicians use the term *atomic proposition* to refer to a simple proposition.
e.g., Rose is beautiful.

Simple propositions are divided into four types. They are:

1. Subject-less proposition
2. Subject-Predicate proposition
3. Relational proposition
4. Class-membership proposition

Subject-less Proposition

The most primitive proposition is the subject-less proposition. It has neither subject nor predicate. This type of proposition is sometimes called *exclamatory proposition* or *impersonal proposition*. It usually expresses a condition, event or necessity.

e.g., Fire!, Thief!, 'It rains.', 'It thunders.'

Subject-Predicate Proposition

A proposition that asserts a quality or an attribute that belongs to something is called a subject-predicate proposition. It has a subject-predicate form. The subject is that of which an attribute is predicated.

e.g., 'Paper is white,' 'Painting is beautiful.'

Relational Proposition

A proposition that asserts a relation between constituent terms is called a relational proposition.

e.g., Socrates is the teacher of Plato.

Class-membership Proposition

A proposition which asserts that something is a member of a given class is called a class-membership proposition.

e.g., Gandhiji is an Indian.

Messi is a footballer.

Compound Propositions

A conditional proposition is called compound in modern logic. It is a combination of two or more propositions of any kind. *A compound proposition contains other propositions as its components.* There are two main divisions of compound propositions:

1. Conjunctive proposition
2. Composite proposition

Conjunctive Proposition

A compound proposition in which simple propositions are combined by the conjunctive 'and' is called a conjunctive proposition.

e.g., Water is colourless and has no smell.

Composite Propositions

Composite propositions are formed by combining simple propositions in three ways: 'If... then', 'Either... or', and 'Not both... and'. The three composite propositions are:

1. Implicative Proposition
2. Alternative Proposition
3. Disjunctive Proposition

Implicative Proposition

A composite proposition in which simple propositions are combined by the clause 'If... then' is called an implicative propositions. In an implicative proposition, one of the constituent propositions implies the other. The constituent parts are **implicans** and **implicate**.

e.g., If oxygen is present then fire can burn.

Here, 'Oxygen is present' is the implicans and 'Fire can burn' is the implicate.

Alternative Proposition

A composite proposition in which simple propositions are combined by the words 'either... or' is called an alternative proposition. The components of alternative propositions are called **alternates**.

e.g., The number is either odd or even.

Alternates: 1. The number is odd

2. The number is even

Disjunctive Proposition

A composite proposition in which simple propositions are combined by the words 'not both ... and' is called a disjunctive proposition.

e.g., An individual is not both be present and absent at the same time, at the same place.

Here, the two constituent parts are exclusive: if one is true, the other must be false. Both cannot be true and false, at the same time. The constituents of disjunctive propositions are called **disjuncts**.

General Propositions

A general proposition asserts that one class is wholly or partly included in, or excluded from, another class. A general proposition thus makes an assertion about all or some of the members of a class. In modern logic categorical propositions are considered general proposition.

e.g., All computers are electronic devices.

No man is honest.

Some fruits are sweet.

Some flowers are not fragrant.


Activity 11

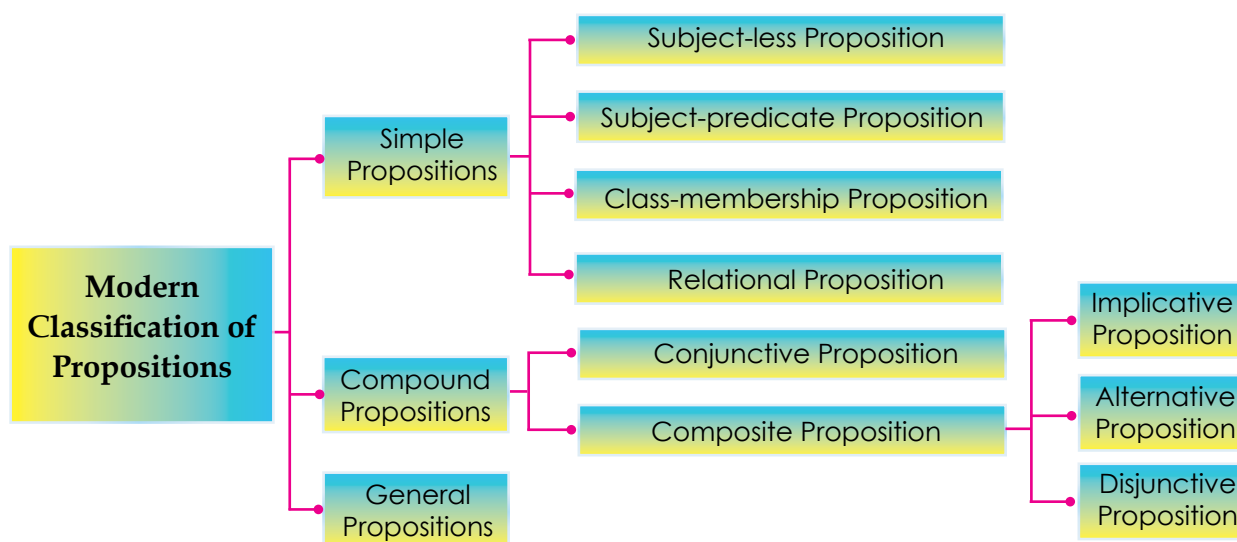
1. Complete the chart.

Components of Compound Proposition	Connecting Words	Name of the Compound Proposition
a. Poverty increases b. Crime will increase	If ... then	.....
a. An animal is a vertebrate b. An animal is an invertebrate	Either... or	.....
a. The earth is a planet b. The moon is a satellite	and	.....

2. Match the following.

Proposition	Kind of Proposition
Benyamin is the author of <i>Aadujeevitham</i>	Subject-predicate proposition
All robots are machines	Relational proposition
Sachin Tendulkar is a cricketer	General proposition
The Taj Mahal is spectacular	Class-membership proposition

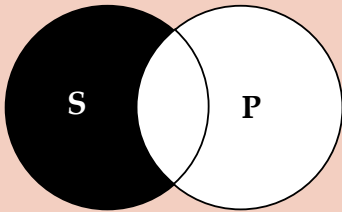
Let us sum up the modern classification of proposition.



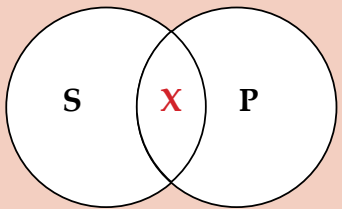


In logic, Venn diagrams are used to visually represent the relationship between two classes (usually labeled *S* for Subject and *P* for Predicate). For categorical propositions, we use two overlapping circles. The status of the classes is indicated by either shading an area (to show it is empty/contains no members) or placing an 'X' in an area (to show it contains at least one member).

A
Universal Affirmative
Proposition



I
Particular Affirmative
Proposition



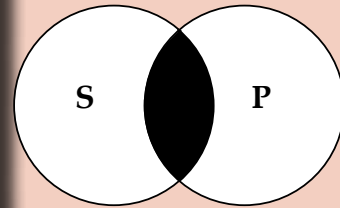
A: Shade the part of *S* that is outside of *P* (showing that no *S* exists without *P*).

E: Shade the overlapping middle section (showing that the intersection is empty).

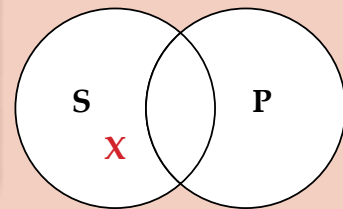
I: Place an 'X' in the overlapping middle section (showing that at least one *S* is also a *P*).

O: Place an 'X' in the part of *S* that is outside of *P* (showing that at least one *S* exists outside of *P*).

E
Universal Negative
Proposition



O
Particular Negative
Proposition



In this chapter we have learned about propositions, which are considered as the building blocks of logical arguments. Aristotelian analysis of proposition was mainly concerned with the subject-predicate relation, whereas the modern logicians considered propositions as a basic unit. A clear understanding of propositions will help us to imbibe the forthcoming chapters.

Chapter

3 INFERENCE

You are familiar with the range of grade in your SSLC Certificate. Let us examine a score indicator to analyse grade of Manu in a school level examination.

RANGE OF GRADES

A+ 90% and above : Outstanding	B 60% - 69% : Good	D+ 30% - 39% : Marginal
A 80% - 89% : Excellent	C+ 50% - 59% : Above Average	D 20% - 29% : Need Improvement
B+ 70% - 79% : Very Good	C 40% - 49% : Average	E Below 20% : Need Improvement

Eligibility for higher studies - Minimum D+ grade for each paper

The following table contains the score obtained by Manu for a particular exam. If all the scores are out of 100, find the grades of all the subjects in the table.



Activity 1

SCORE TABLE

Sl. No	Subject	Max. Score 100	Grade
1	Malayalam	96	.....
2	English	83	.....
3	Science	68	.....
4	Social Science	71	.....
5	Mathematics	57	.....

These findings could be put down in statements, such as:

*If a score is 90% and above, **then** the grade is an 'A+.'*

Manu scored 96 in Malayalam.

*The conclusion therefore is, **Manu will receive an 'A+ in Malayalam.'***

*If a score is between 80% and 89%, **then** the grade is an 'A.'*

Manu scored 83 in English.

*The conclusion therefore is, **Manu will receive an 'A' in English.***

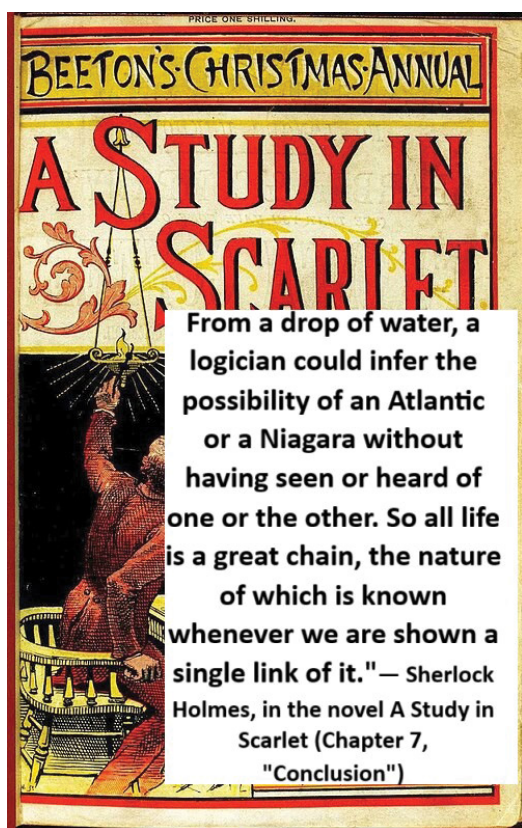
And so on ...

How did you reach the conclusions regarding the grade of the subjects that are **unknown** in the table above?

You derived the conclusions from the **known** data or evidences already provided (in the form of grade indicators and score table in

the exercise). The reasoning ability of your mind processes the known information and deduces unknown conclusions. This mental process is known as **inference**. This kind of thinking process is essential in all walk of life. Inference is the cornerstone of logic, the process of deriving a new proposition from given propositions.

This chapter explores **What Inference is** and the three primary **Kinds of Inference: Deduction, Induction, and Abduction**. **Deduction** is classified into **mediate** and **immediate** inferences but we focus on the second. Immediate inference includes **The Doctrine of Opposition of Propositions** and **The Doctrine of Education of Propositions**. By the end of this chapter, you will possess a robust framework for identifying, analysing, and constructing valid arguments, empowering you to become a more rigorous and effective thinker.

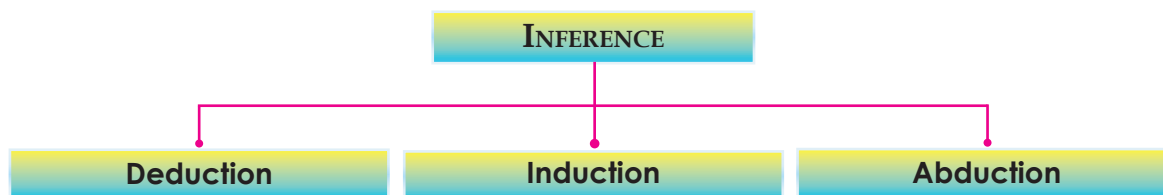


What is inference?

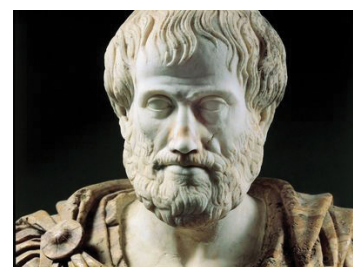
Inference is a mental process of deriving a new proposition from one or more known propositions. It is a leap from what is known to what is unknown. The truth of the new proposition is affirmed based on the truth of one or more known propositions. The new proposition or the inferred proposition is called **conclusion**, and the given propositions are called **premises**. The term inference is given both to the process of inferring and to the proposition inferred (conclusion).

Kinds of Inference

There are three kinds of inference: **Deductive Inference**, **Inductive Inference** and **Abductive Inference**.



In **deductive inference** or deduction, a conclusion is drawn from the premises. If the premises are true, the conclusion must also be true. **This is a reasoning from a general principle to a particular fact.** The focus of deduction is formal truth. In deductive inference the conclusion is less general than the given premises. Deduction was introduced by Aristotle.



Aristotle
(384 BCE - 322 BCE)

e.g., All men are mortal.

Socrates is a man.

∴ Socrates is mortal.

In **inductive inference** or induction, a general principle is derived after examining particular facts. **This is a reasoning from particular facts to a general principle.** Induction gives more importance to material truth. In inductive inference, the conclusion is more general than the premises. It was Francis Bacon who introduced induction.



Francis Bacon
(1561 - 1626)

e.g., Socrates is a man, he is mortal.

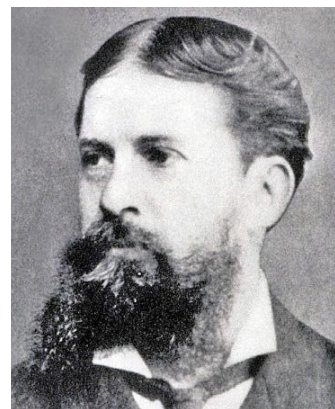
Aristotle is a man, he is mortal.

Plato is a man, he is mortal.

Alexander is a man, he is mortal.

∴ All men are mortal.

Abductive Inference, on the other hand, draws the best or most plausible explanation for a given phenomenon. It is a non-deductive inference. At the same time, it is different from inductive inference. This kind of inference provide probable truth only. Abduction is also often called "Inference to the Best Explanation." American philosopher Charles Sanders Peirce introduced Abductive reasoning.



Charles Sanders Peirce
(1839 - 1914)

e.g., The grass is wet. (observed fact)

Therefore, it probably rained last night.



History of Abductive Inference

American philosopher Charles Sanders Peirce introduced the concept of Abductive reasoning in 1865. Traditionally logical reasoning was divided into two: deductive inferences and inductive inferences. Deduction implies necessary inference whereas induction implies probable inference. According to Peirce, besides inductive inference there was another distinct type of probable inferences known as abductive inferences or retroductive inferences. He claims that these three types of reasonings were given by Aristotle in the 'Prior Analytics'.



Activity 2

Let us complete the following chart.

Deduction	Induction	Abduction
.....		Draws the best or most plausible explanation
.....		
.....		

Deduction

Deduction can be divided into **Mediate Inference** and **Immediate Inference**.



Activity 3

Read the following two instances.

Instance 1

All mammals are vertebrates.
 Lion is a mammal.

 ∴ Lion is a vertebrate.

Instance 2

All mammals are vertebrates.
 ∴ Some mammals are vertebrates.

Note down the difference between the above two inferential instances.

.....

The two instances upon which you reflected just now are examples for two kinds of deduction; the first one is a mediate inference, and the second one is an immediate inference.

Mediate inference is a logical process of drawing a conclusion from the given two propositions. We will discuss in detail about mediate inference in the chapter, 'Syllogism.'

Immediate inference is a process of drawing a conclusion from a single given proposition. The truth and falsity of the conclusion are contained in the truth and falsity of the given proposition. Immediate inference is classified on the basis of two doctrines: **Opposition** and **Eduction**.

The Doctrine of the Opposition of Propositions

Ordinarily, opposition means disagreement. But in Logic, **opposition of proposition** means the relation between two propositions having the same subject and the same predicate differing only in quality or only in quantity or in both.



Activity 4

In the second chapter 'Terms and Propositions', we have studied what quality and quantity of categorical propositions are. Considering that knowledge can you complete the following table?

Sl. No	Two different propositions	Differ in quality/quantity/both
1	A and E propositions	differ in quality only
2	A and I propositions	
3	A and O propositions	
4	E and I propositions	
5	E and O propositions	
6	I and O propositions	



Both types of immediate inference, however, rest on certain fundamental assumptions which must first be considered briefly.

They are the Law of Contradiction and the Law of Excluded Middle. According to the Law of Contradiction the same predicate cannot be both affirmed and denied of precisely the same subject. S cannot both be P and not be P. According to the Law of Excluded Middle, a given predicate must either be affirmed or denied of a given subject. S must either be P or not P. It cannot be neither, just as it cannot be both. These are fundamental assumptions on which all consistent thinking rests; all apparent exceptions rest on misunderstandings, or on quibbles. With the aid of these Laws of Thought we may now consider the opposition of propositions.

"Textbook Of Logic" - A. Wolf - Second Edition -

Kinds of Opposition

Among the categorical propositions, A, E, I, and O, certain relations of exclusion and inclusion exist. That is, the truth of some of these propositions excludes the truth of others e.g., if A proposition is True then E proposition must be False. The truth of some of these propositions includes the truth of others.

e.g., if A proposition is True then I proposition must also be True.

For example

If the proposition 'All men are mortal' (SAP) is True,
then the proposition 'No men are mortal' (SEP) is False.

In other words, if SAP is True, then SEP is False.

If the proposition 'All triangles are three sided' (SAP) is True,
then the proposition 'Some triangles are three sided' (SIP) is also True.

In other words, if SAP is True, then SIP is also True.



Activity 5

Try to determine whether the following propositions are True or False.

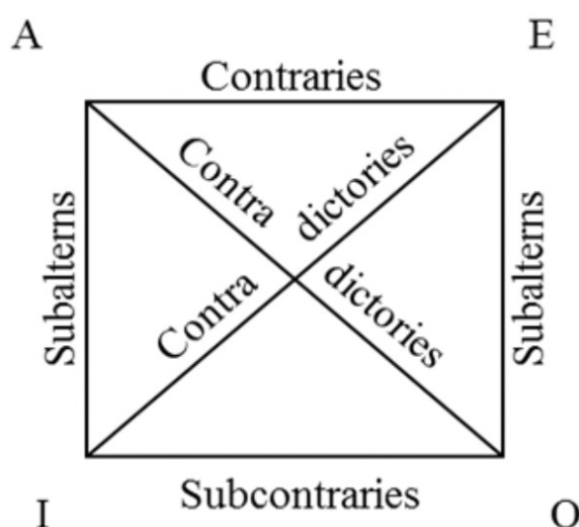
1. If the proposition 'All Indians are Asians' (SAP) is True,
Then the proposition 'Some Indians are not Asians' (SOP)
2. If the proposition 'All Indians are Asians' (SAP) is True,
Then the proposition 'No Indians are Asians' (SEP) is

According to the doctrine of opposition of propositions, there exists four types of relation between categorical propositions. These are:

- I. Contrary opposition (A and E)
- II. Subcontrary opposition (I and O).
- III. Subaltern opposition (A and I; E and O).
- IV. Contradictory opposition (A and O; E and I)

Square of Opposition

The relation between the four kinds of propositions is clearly shown in the square of opposition.



I. Contrary Opposition (A-E)

It is the relation between the two universal propositions having the same subject and the same predicate but differ only in quality. A and E are contraries. The relation between 'All men are mortal' (SAP) and 'No men are mortal' (SEP) is contrary opposition. They cannot both be True; but they may both be False.

The rules of contrary opposition

1. If the given proposition is true, then its contrary is false.

For example,

If SAP is True	⇒	SEP is False
All elephants are herbivores.		No elephants are herbivores.
If SEP is True	⇒	SAP is False
No elephants are carnivores.		All elephants are carnivores.

2. If the given proposition is false, then its contrary is doubtful.

If SAP is False	⇒	SEP is Doubtful
All doctors are surgeons.		No doctors are surgeons.
If SEP is False	⇒	SAP is Doubtful
No doctors are surgeons.		All doctors are surgeons.



Activity 6

Add more examples for contraries.

Given Proposition	Contrary

II. Subcontrary Opposition (I-O)

It is the relation between two particular propositions having the same subject and same predicate but differing only in quality. I and O propositions have subcontrary opposition. For example, the proposition 'Some men are honest' (SIP) has subcontrary relation to the proposition 'Some men are not honest' (SOP). Subcontraries can both be true, but both cannot be false.



Activity 7

Can you formulate rules for subcontrary opposition after evaluating the following examples?

If SIP is True	⇒	SOP is Doubtful
Some video games are toxic.		Some video games are not toxic.
If SOP is True	⇒	SIP is Doubtful
Some video games are not toxic.		Some video games are toxic.
If SIP is False	⇒	SOP is True
Some rivers are stagnant.		Some rivers are not stagnant.
If SOP is False	⇒	SIP is True
Some conductors are not metals.		Some conductors are metals.

Rule 1:

Rule 2:

III. Subaltern Opposition (A-I and E-O)

It is the relation between two propositions having the same subject and the same predicate differing only in quantity. In other words, it is the opposition between universal proposition and particular proposition or vice versa. A - I and E - O are subalterns.

The rules of subaltern

1. If the universal is true, then the particular is also true.

For example:

If SAP is True	⇒	SIP is True
All intoxicants are injurious to health.		Some intoxicants are injurious to health.
If SEP is True	⇒	SOP is True
No biographies are novels.		Some biographies are not novels.

2. If the universal is false, then the particular is doubtful.



Activity 8

Write suitable examples for substantiating this rule.

If SAP is False	⇒	SIP is Doubtful
e.g.,		e.g.,
If SEP is False	⇒	SOP is Doubtful
e.g.,		e.g.,

3. If the particular is true, then the universal is doubtful.



Activity 9

Complete the following to explain the above rule

If SIP is True		SAP is
e.g.,		e.g.,
If SOP is True		SEP is
e.g.,		e.g.,

4. If the particular is false then the universal is false.



Activity 10

Complete the following to explain the above rule.

If SIP is False		SAP is
e.g.,		e.g.,
If SOP is False		SEP is
e.g.,		e.g.,

IV. Contradictory Opposition (A-O and E-I)

Contradictory opposition is the strongest form of opposition. It is the relation between two propositions having the same subject and the same predicate differing both in quantity and quality. A - O and E - I are contradictories.

The rules of contradictory opposition

1. If A proposition is **True**, its contradictory **must be False**.
2. If A proposition is **False**, its contradictory **must be True**.

Let us apply these two rules of the contradictory opposition in the following table.

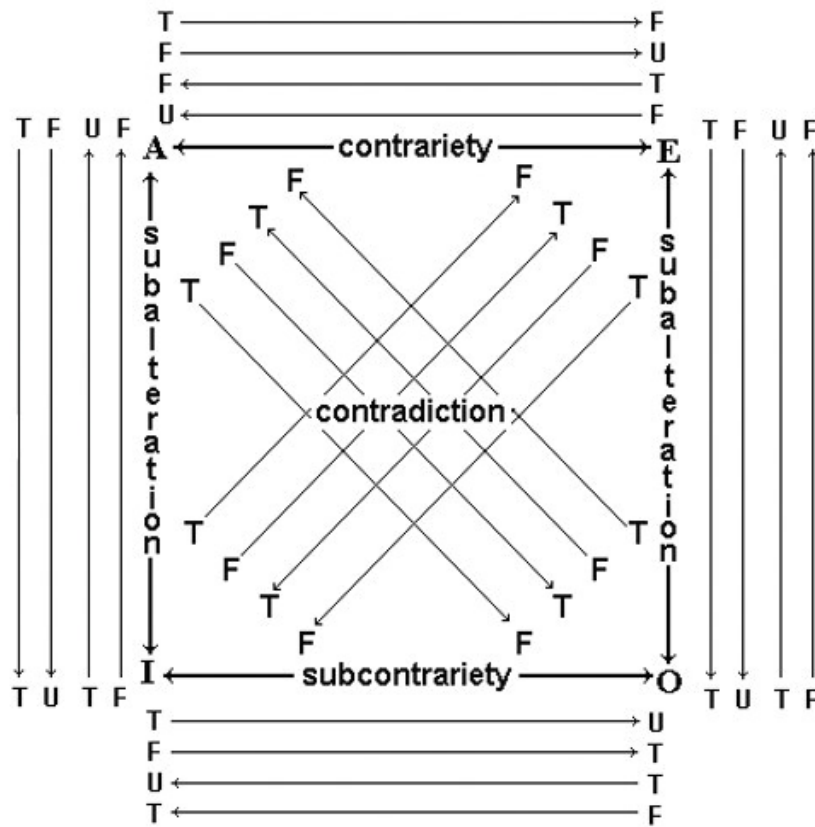

Activity 11

Write the contradictory in column B and see if it is True or False.

A		B	
Given Proposition		Contradictory Opposition	
All robots are machines. SAP	True	.....	True/ False
No men are machines. SEP	True	.....	True/ False
Some cars are electric. SIP	True	.....	True/ False
Some students are not day scholars. SOP	True	.....	True/ False

The table and the diagram below systematically summarise all the possible rules of the opposition of proposition.

If the proposition	SAP	SEP	SIP	SOP
SAP is True		False	True	False
SAP is False		Doubtful	Doubtful	True
SEP is True	False		False	True
SEP is False	Doubtful		True	Doubtful
SIP is True	Doubtful	False		Doubtful
SIP is False	False	True		True
SOP is True	False	Doubtful	Doubtful	
SOP is False	True	False	True	



(T = True, F = False, U = Uncertain/Doubtful)



Activity 12

1. Match the following.

Given proposition		Opposition	
a	If 'Some apples are oranges' is False	i	SOP is True; SEP is Doubtful
b	If 'No squares are circles' is True	ii	SAP is True; SEP is False
c	If 'Some bacteria are not pathogenic' is True	iii	SIP is False; SOP is True
d	If 'All men are equal' is True	iv	SEP is True; SIP is False

2. Which of the following statements are correct?

- i. A proposition and E proposition are contradictories
 - ii. A proposition and O proposition are contradictories
 - iii. E proposition and O proposition are contradictories
 - iv. I proposition and O proposition are contraries
 - v. I proposition and O proposition are subcontraries
- a. i, iv and v only.
 - b. i, iii and iv only
 - c. i and iv only
 - d. ii and v only

3. If 'All singers are musicians' is considered True, then choose from the options i to v.

- i. 'No singers are musicians' is False
 - ii. 'Some singers are musicians' is True
 - iii. 'Some singers are not musicians' is True
 - iv. 'Some singers are not musicians' is False
 - v. 'Some singers are musicians' is False
- a. i, ii and iii only
 - b. i, ii and iv only
 - c. i, ii, iii and iv only
 - d. ii, iii, iv and v only

The Doctrine of Education



Activity 13

Examine the following pairs of propositions and write down your observations.

- i. All voters are citizens. $\leftrightarrow$ No voters are non-citizens.
- ii. Some men are vegans. $\leftrightarrow$ Some vegans are men.
 - Do the propositions in both the pairs differ in meaning?
 - What is the difference between pair i and ii?

The **Doctrine of Eduction** refers to the process of **immediate inference** in which a conclusion is derived from a single given proposition not affecting its meaning. A conclusion is drawn from a given proposition, either by interchanging its subject and predicate and/or by using or removing negative terms. The meaning of the original proposition is retained. If the given proposition is true, its inference must be true; if the given proposition is false, its inference must also be false. It is essentially a method of rephrasing the truth of the given proposition. Hence, eduction is also known as the **logical equivalence or equipollence**.

There are two points of differences between opposition and eduction.



Activity 14

Discuss in group and note your findings.

Difference between opposition and eduction

.....

.....

.....

Kinds of Eduction

There are two principal types of eduction, and five derivative forms. The principal types are known as the **conversion** and the **obversion**. The derivative forms are obtained by combining and repeating alternately, the conversion and the obversion. They are: **obverted-converse**, **partial contrapositive**, **full contrapositive**, **partial inverse**, and **full-inverse**.

I. Conversion

Conversion is the process of immediate inference. We draw a new proposition from a given proposition, in which the original predicate becomes the subject and the original subject becomes the predicate. The given proposition is called the **convertend**, and the inferred proposition is called the **converse**.

The rules of conversion

1. Interchange the subject and the predicate.

Subject $\leftrightarrow$ Predicate

$S \rightarrow P$ becomes $P \rightarrow S$

2. The quality of the converse must be the same as the quality of the convertend. That is because if the quality is changed, the meaning of the proposition will also be changed.

If the convertend is affirmative,
the converse also must be affirmative.

Some S are P

Some P are S

If the convertend is negative,
the converse also must be negative.

No S are P

No P are S

3. The term which is undistributed in the convertend cannot be distributed in the converse. If the converse distributes the undistributed terms of the convertend, the meaning would be different.

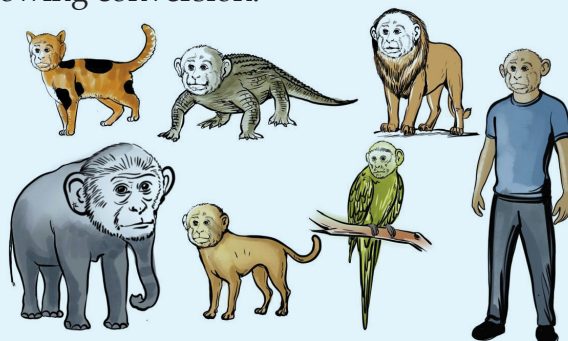


Activity 15

Evaluate the change in meaning of the following conversion.

All monkeys are animals.

All animals are monkeys.



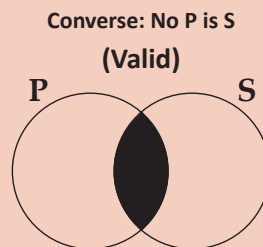
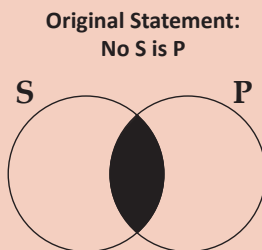
Kinds of Conversion

According to traditional logic there are two kinds of conversion, simple conversion and conversion by limitation or conversion by accidents. By **simple conversion** we mean the direct interchanging of the subject and the predicate without any other change in the form of the proposition. Both E and I proposition have simple conversion; $SEP \rightarrow PES$ and $SIP \rightarrow PIS$. Modern logicians accept simple conversion only.



Modern logicians use Venn diagrams to represent the conversion.
Conversion of Universal Negative Proposition

No S is P $\longleftrightarrow$ No P is S

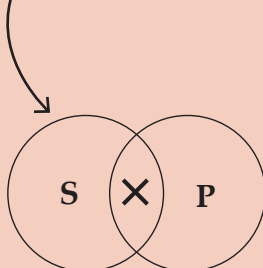


This means that the S circle and the P circle have nothing in common and the overlapped part is empty. This shows that if "No S is P," then it is also true that "No P is S." The conversion is valid.

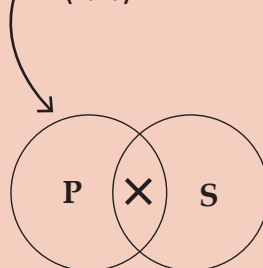


Conversion of Particular Affirmative Proposition

Original Statement:
Some S are P



Converse : Some P is S
(Valid)



This means there is at least one S that is also a P, indicated by x is in the overlap. The diagram illustrates that if "Some S are P," then it is also true that "Some P are S." The conversion is valid.

Traditional logic applies the Conversion by Limitation to 'A proposition' to validate it.

Conversion by limitation or conversion per accident is one where the quantity of the convertend is changed from universal to particular.

SAP → PIS

All monkeys are animals.

Some animals are monkeys.



Exceptions to this rule.

Singular propositions where the subject and predicate denote specific individual or object can be converted by simple conversion.

e.g., Dr. Rajendra Prasad is the first President of Republic of India.

SAP

The first President of the Republic of India is Dr. Rajendra Prasad.

PAS

A Universal Affirmative proposition in which both 'S' and 'P' are distributed also have simple conversion.

e.g., All men are rational. (SAP) → All rational beings are men. (PAS)

SOP has no converse

An 'O' proposition is a negative proposition. So the converse also should be negative. A negative proposition distributes the predicate. If SOP is converted into POS, The subject which is undistributed in the convertend, will be distributed in the converse as the predicate of a negative proposition. Thus, we will be violating the third rule of conversion namely 'the term which is undistributed in the convertend cannot be distributed in the converse'. Hence, SOP has no converse.



Activity 16

Now that you have learnt the rules and kinds of conversion, can you complete the following table.

Convertend		Converse	
SAP	All cricketers are sportsmen	PIS	.....
SEP	No dolphins are reptiles.	PES	.....
SIP	Some officers are corrupt persons.	PIS	.....
SOP	Some accused are not criminals.	.....	.....

II. Obversion

Obversion is a process of immediate inference in which, from a given proposition, we draw a logically equivalent conclusion that retains the original subject and quantity, but changes the quality by replacing the predicate term with its complement (contradictory). The given proposition is called the obvertend and the conclusion is called the obverse. The obvertend and the obverse must have the same meaning or truth value.

Example

Obvertend	————→	Obverse
SAP	————→	SEP̄
All peacocks are male.	————→	No peacocks are non-male.

The rules of obversion

1. The subject of the obverse is same as the subject of the obvertend.
2. The predicate of the obverse is the complemented predicate of the obvertend.

All peacocks are male.
No peacocks are non-male.

All peacocks are male. S A P All S are P
No peacocks are non-male. S E P̄ No S are non-P

3. Change the quality of the obvertent in the obverse while retaining the quantity.

- If the obvertend is universal affirmative, the obverse is universal negative and vice versa.

$$(A \rightarrow E) \text{ and } (E \rightarrow A)$$

- If the obvertend is particular affirmative, the obverse is particular negative and vice versa.

$$(I \rightarrow O) \text{ and } (O \rightarrow I)$$



Complemented Term = Contradictory of a term.

Term	Complemented term
Male	Non-male
Animal	Non-animal
Book	Non-book



Activity 17

Complete the following table.

Obvertend		Obverse	
SAP	All righteous are virtuous.	SEP	.....
SEP	No men are angels.	SAP	.....
SIP	Some actors are directors.	SO $\bar{P}$	.....
SOP	Some students are not punctual.	SIP	.....

III. Obverted Converse

Obverted converse is a specific form of immediate inference. It is a derivative form of eduction obtained by performing a sequence of the basic operations: conversion and obversion. Convert the given proposition, and then obvert the converse. The given proposition and the obverted converse must have the same truth value or meaning.

Given Proposition	Convert	Obvert (Obverted Converse)
S A P	P I S	P O $\bar{S}$
All S are P	Some P are S	Some P are not non-S
All robots are machines.	Some machines are robots.	Some machines are not non-robots.


Activity 18

Write one example each for SEP and SIP; then find their obverted converse.

Given Proposition	Converse	Obverted Converse
SEP No S are P	PES	PA $\bar{S}$
SIP	PIS	PO $\bar{S}$
Does an O proposition have Obverted Converse?		

IV. Contraposition

Like the obverted converse, contraposition is another specific form of immediate inference. It is also a derivative form of eduction obtained by performing a sequence of the basic operations: conversion and obversion. However, the sequence is the reverse of the obverted converse. The given proposition and its contraposition must have the same truth value or meaning. There are two types of contrapositions: **Partial Contraposition** and **Complete Contraposition**.

Operation Sequence	Derivative Form of Eduction
Given Proposition $\rightarrow$ Obvert $\rightarrow$ Convert.	Partial contraposition
Given Proposition $\rightarrow$ Obvert $\rightarrow$ Convert $\rightarrow$ Obvert	Full/Complete contraposition

The contrapositive of 'A, E, and O' are as follows;

Given Proposition	Obverse	Partial Contrapositive	Complete / Full Contrapositive
SAP	SEP $\bar{P}$	$\bar{P}$ ES	$\bar{P}$ A $\bar{S}$
SEP	SAP $\bar{P}$	$\bar{P}$ IS	$\bar{P}$ O $\bar{S}$
SOP	SIP $\bar{P}$	$\bar{P}$ IS	$\bar{P}$ O $\bar{S}$



Activity 19

Can you find why SIP does not yield a contrapositive?

.....



Activity 20

Find the partial and full contrapositive of the given propositions.

- All Nobel laureates are dignitaries.
- No dictators are democrats.
- Some farmers are not illiterates.

V. Inversion

Inversion is a specific and complex form of immediate inference. It is the most complicated derivative form of eduction obtained by performing a sequence of the basic operations: conversion and obversion. It is only valid for universal propositions. The given proposition and its inversion must have the same truth value or meaning. There are two main types of inversion: **Partial Inversion** and **Complete Inversion**.

Study the following operation sequences of both type of inversion.

Operation Sequence S A P						Derivative Form of Eduction
						
Given	Obvert	Convert	Obvert	Convert	Obvert	Complete /Full inversion
SAP	SE $\bar{P}$	$\bar{P}$ ES	$\bar{P}$ A $\bar{S}$	$\bar{S}$ I $\bar{P}$		
SAP	SE $\bar{P}$	$\bar{P}$ ES	$\bar{P}$ A $\bar{S}$	$\bar{S}$ I $\bar{P}$	$\bar{S}$ OP	Partial inversion



Activity 21

The complete inversion of SAP is $\bar{S}$ I $\bar{P}$;

Compare both and write your own definition of complete inversion.

Operation Sequence S E P →					Derivative Form of Eduction
Given	Convert	Obvert	Convert	Obvert	Partial inversion
SEP	PES	PA $\bar{S}$	$\bar{S}$ IP		
SEP	PES	PA $\bar{S}$	$\bar{S}$ IP	$\bar{S}$ OP $\bar{P}$	Complete / Full inversion

**Activity 22**

Now apply the above operation sequences and find the two types of inversion of the following propositions.

- All infants are innocent.
- No man is an island.

We have learnt the techniques for correctly deducing immediate inference in this chapter. We will proceed to learn other techniques of reasoning in the next chapter.

Chapter

4 SYLLOGISM



Activity 1

*Read the following pair of propositions.
Determine whether a connection exists between
them and write a conclusion out of them.*

All Olympic medalists are hard working athletes.

Neeraj Chopra is an Olympic medalist.

Therefore,

*There is a bridging word in the above statements that
helped you to write a conclusion.*

*Now examine the following sets of arguments and identify whether such a bridging
term exists in each case.*

Argument 1:

No fruits are flowers

Some trees are green

∴ Some trees are fruit

Argument 2:

Some doctors are surgeons

All rich persons are doctors

∴ All rich persons are surgeons

Argument 3:

All social workers are angels

Some teachers are social workers

∴ Some teachers are angels

Bridging term in Argument 1:

.....

Bridging term in Argument 2:

.....

Bridging term in Argument 3:

.....



One of the arguments has no bridging term, hence it is not valid. The remaining arguments contain bridging terms but only one is valid. The validity of arguments depends on certain conditions. This chapter discusses how to construct sound arguments.

A mediate inference is also called **sylogism**. The core of Aristotelian logic is the study of syllogism. A significant portion of our reasoning or thinking is comprised of syllogisms. They are used in everyday life to make decisions, to identify incorrect or faulty arguments, to understand consequences in politics, law, education, mathematics etc.



In Mathematics the different propositions are internally related. The truth of the subsequent follows from the truth of the precedents.

$$\begin{array}{r} (8+4) \times (2+3) \\ 12 \quad \times \quad 5 \\ \hline 60 \end{array}$$

An argument is a series of propositions, leading to a conclusion. But every set of propositions will not lead to a valid conclusion. There must be some mediation between the propositions. The bridging term in an argument function as the mediation.

Look at this conversation.



The above conversation is an example of a valid argument; the third proposition is implied in the first two propositions. Since, the first two propositions are true, the third one is also true.

Meaning and Definition of Syllogism

A **syllogism** is a **mediate inference**. We learned that a mediate inference is a process by which we arrive at conclusion from two given propositions. Thus, **syllogism can be defined as a deductive argument in which a conclusion is inferred from two given propositions**. The word *syllogism* is derived from the two Greek words: *syn* (means 'with' or 'together') and *logos* (means 'thought' or 'reason'). Etymologically, a syllogism is collecting together two propositions. According to W. S. Jevons, syllogism may be defined as "the act of thought by which from two given propositions we proceed to a third proposition, the truth of which necessarily follows from the truth of these given propositions."



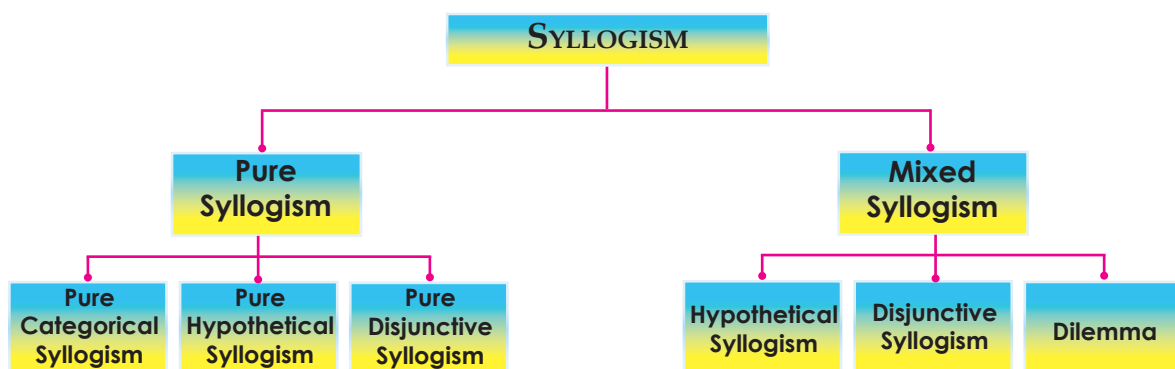
W. S. Jevons
(1835-1882)

Structure of a Syllogism

A syllogism has **three and only three propositions**, two of which are given and the third one is inferred. The two given propositions are called **major premise** and **minor premise** respectively, and the inferred proposition is called the **conclusion**.

Kinds of Syllogism

The Syllogisms are broadly of two types - **pure and mixed**.



A **pure syllogism** is a syllogism in which all the three propositions are of the same type. A **mixed syllogism** contains different types of propositions. Among the pure syllogism, the categorical syllogism is the most common. Let us discuss more on it.

Standard form of Categorical Syllogism

A categorical syllogism is a mediate inference in which the deductive argument consists of only three categorical propositions. The first two propositions are premises and the third is the conclusion. In a categorical syllogism, there are three different terms, each occurring twice. The subject of the conclusion is called the **minor term** and it is represented by the letter 'S'. The predicate of the conclusion is called the **major term** and is represented by the letter 'P'. The term which appears in both premises but not in the conclusion is called the **middle term**. It is represented by the letter 'M'. The major term occurs in the major premise and minor term comes in the minor premise. Proper order of the three propositions is

1. Major premise
2. Minor premise
3. Conclusion

e.g., All sportsmen are healthy persons – Major premise

All cricketers are sportsmen – Minor premise

∴ All cricketers are healthy persons – Conclusion

Major term – Healthy persons

Minor term – Cricketers

Middle term – Sportsmen



The Indian Syllogism, rooted primarily in the **Nyaya school of logic** and dating back to around the 6th century BCE, is a distinct form of logical argument. It is most famously known as the five-member (*pancavayava*) logical structure. This structure is used to establish truth and differs significantly from the three-part Western syllogism.

1. *Pratijna* is the proposed statement
2. *Hetu* is the reason
3. *Udaharana* is example
4. *Upanaya* is its application
5. *Nigamana* is the conclusion

Nyaya syllogism includes three terms. They are major term known as **Sadya**, middle term known as **Hetu** and minor term known as **Paksha**. Nyaya syllogism is known as **Anumana** (Nyaya Inference)



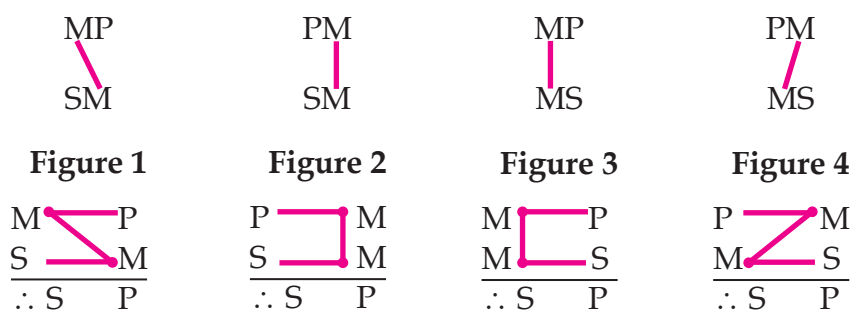
Activity 2

Identify the major term, minor term, middle term, major premise, minor premise, and conclusion in the following categorical syllogism.

All social workers are virtuous
Some social workers are reformers
∴ Some reformers are virtuous

Figure of a Syllogism

The middle term plays an important role in a categorical syllogism. It is the mediating link or the bridging term between major premise and minor premise. Without the middle term (M), no relation between major term (P) and minor term (S) is possible. **The figure of a categorical syllogism is determined by the position of the middle term in both the premises.** There are four possible arrangements of 'M' in the two premises and accordingly we have the Figures of the Syllogism as follows:



In figure 1 : the middle term is the subject of the major premise and the predicate of the minor premise.

In figure 2 : the middle term is the predicate in both premises.

In figure 3 : the middle term is the subject in both premises.

In figure 4 : the middle term is the predicate of the major premise and the subject of the minor premise.

Mood of a Syllogism

Among the four types of categorical propositions (A, E, I, and O), only three propositions can be used in an argument. **The mood of a syllogism is the arrangement of proposition on the basis of quality and quantity.** Mood is expressed by three letters representing categorical propositions in the order of occurrence in a syllogism. For example, if all the three propositions of a syllogism are universal affirmative propositions, then the mood of the syllogism is AAA.

e.g., All animals are carnivores – A
 All tigers are animals – A
 $\therefore$ All tigers are carnivores – A

Therefore, the mood of the syllogism is AAA.

The syllogism can be symbolically represented as AAA-1, where the letters represent the mood and the numeral represents the figure of the syllogism.



Since there are four types of categorical propositions and each syllogism contains only 3 such propositions, there are exactly 64 possible moods of syllogisms. Each mood can occur in each of the four figures respectively. So, there will be 256 moods. But, all of them do not yield a valid conclusion. There are only 19 valid moods and each form owns a name. The first vowel stands for the major premise, second for the minor, and third for the conclusion.

Figure I : BARBARA, CELARENT, DARII, FERIO

Figure II : CAMESTRES, CESARE, BAROCO, FESTINO

Figure III : DARAPTI, DATISI, DISAMIS, BOCARDO, FELAPTON, FERISON

Figure IV : BRAMANTIP, CAMENES, DIMARIS, FESAPO, FRESISON



Activity 3

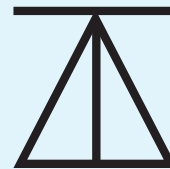
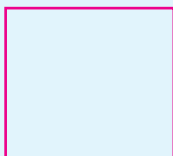
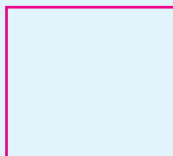
Represent the following syllogisms in the symbolic forms using the letters M, P and S. Identify their mood and figure.

Syllogism	Symbolic form	Mood & Figure
1. All medicines are useful. Some painkillers are medicine. $\therefore$ Some painkillers are useful.	$\begin{array}{c} M P \\ S M \\ \hline \therefore S P \end{array}$	 AII-1
2. All robots are machines. No men are machines. $\therefore$ No men are robots.		
3. Some poets are singers. All poets are lovers of nature. $\therefore$ Some lovers of nature are singers.		
4. All philosophers are intelligent. No intelligent beings are cowards. $\therefore$ No cowards are philosophers.		



Activity 4

Find the four figures of syllogism in the given picture.



Rules and Fallacies of Categorical Syllogism

A categorical syllogism must follow certain rules to yield a valid conclusion. Of these, six rules are fundamental, and two are supplementary. These rules are related to the structure, quantity, and quality of the syllogism. Violation of any of these rules will lead to a mistake or error in form of the argument. These errors are called **formal fallacy**. The eight rules and the fallacies that occur while violating these rules are explained below.

Rule 1: A syllogism must contain exactly three terms, each of which is used twice in the same sense throughout the argument.

Violation of this rule leads to two kinds of fallacies:

- Fallacy of four terms (quaternio-terminorum)
- Fallacy of equivocation

Fallacy of Four Term: If a syllogism consists of four distinct terms instead of three.

e.g., B is a friend of C.

A is a friend of B.

∴ A is a friend of C.

Here there are four distinct terms: (1) B (2) friend of C (3) A (4) friend of B.



Activity 5

Identify the four terms in the following syllogism.

Nothing is better than eternal happiness.

A life of luxury is better than nothing.

∴ A life of luxury is better than eternal happiness.

Fallacy of Equivocation: If a term is used in different senses within an argument, the syllogism commits the fallacy of equivocation. This may be also called the *fallacy of ambiguity* because the meaning or sense of the term is not clear. There are three forms of ambiguity.

- a. Fallacy of ambiguous major
- b. Fallacy of ambiguous minor
- c. Fallacy of ambiguous middle

If the major term is used in different senses, the syllogism commits the **fallacy of ambiguous major**.

e.g., Light is not a gaseous element.

Hydrogen is a gaseous element.

∴ Hydrogen is not light.

The major term 'light' means 'brightness' in the major premise and it means 'not heavy' in the conclusion.

If the minor term is used in different senses, the syllogism commits the **fallacy of ambiguous minor**.

e.g., No human is made of paper.

All pages are human.

∴ No pages are made of paper.

In this syllogism, minor term 'pages' means 'boy servants' in its premise and 'the one side of a paper' in the conclusion.

If the middle term is used ambiguously, the syllogism commits the **fallacy of ambiguous middle**.

e.g., Light is the opposite of darkness.

My purse is light.

∴ My purse is the opposite of darkness.

Here the middle term 'light' means 'brightness' in the major premise and 'weightless' in minor premise.



Activity 6

Find the fallacy in the following syllogisms.

Syllogism 1 : Vice is to be condemned.

Tintu is working with a vice. _____

∴ Tintu is to be condemned.

Rule 2: A syllogism must contain three and only three propositions.

This rule follows directly from the definition of a syllogism. This cannot be violated.

Rule 3: The middle term must be distributed at least once in the premises.

Violation of this rule leads to **the fallacy of the undistributed middle**.

e.g., All donkeys are mortal.
 All monkeys are mortal.
 $\therefore$ All monkeys are donkeys.

**Activity 7**

Identify the fallacy of the following syllogism.

All planets are round.

All wheels are round. _____

$\therefore$ All wheels are planets.

Rule 4: No term can be distributed in the conclusion, unless it is distributed in the premises.

In any syllogism, the conclusion cannot be more general than the premises.

The violation of this rule results in two fallacies.

- a. Illicit Major
- b. Illicit Minor.

Illicit major: When a syllogism contains major term undistributed in the major premise but distributed in the conclusion, it commits the fallacy of illicit major.

e.g., All human are selfish.
 No apes are human.
 $\therefore$ No apes are selfish.

Here the term 'selfish' is undistributed in the major premise but distributed in the conclusion. This leads to the **fallacy of illicit major**.

Illicit Minor: When a syllogism contains the minor term undistributed in the minor premise but distributed in the conclusion, it commits the **fallacy of illicit minor**.

e.g., No Indians are ungrateful.
 All Indians are Asians.
 $\therefore$ No Asians are ungrateful.

**Activity 8**

Identify the fallacy involved in the following syllogisms.

Syllogism 1: All apples are sweet.

All sweet things are oranges. _____.

∴ All oranges are apples.

Syllogism 2: Some intelligent persons are writers.

No writers are foolish. _____.

∴ No foolish beings are intelligent.

Rule 5: From two negative premises, no valid conclusion is possible.

Violation of this rule leads to the fallacy of two negative premises.

e.g., No bachelors are married.

Smith is not married.

∴ Smith is not bachelor.

Rule 6: If one premise is negative, the conclusion must also be negative.

Violation of this rule may lead to the fallacy of affirmative conclusion from a negative premise.

**Activity 9**

Construct a valid syllogism in which the conclusion is a negative proposition.

Major Premise : _____

Minor Premise : _____

Conclusion : _____



From two universal premises no particular conclusion can be drawn.

In the Boolean interpretation of categorical proposition, universal propositions do not have existential import, whereas the particular propositions do have. This rule is not considered in the Aristotelian account of categorical syllogism, because the traditional account did not give importance to material validity. From two universal propositions, only a universal conclusion is possible. Violation of this rule will lead to existential fallacy. According to this interpretation there are only fifteen moods.

Supplementary Rules

Rule 7: From two particular premises, there can be no valid conclusion.

Violation of this rule leads to **the fallacy of two particular premises**.

This is proved by examining the four possible combinations of two particular premises

I	I	O	O
<u>I</u>	<u>O</u>	<u>I</u>	<u>O</u>

= No valid conclusion is possible



The combination of I – I propositions leads to the fallacy of two particular premises.

The combination of O – O propositions leads to the fallacy of two negative premises.

The combination of I – O propositions and O – I propositions commit the fallacy of illicit major.

Rule 8: If one of the premises is particular, the conclusion must also be particular.

Violation of this rule may lead to various fallacies.

The valid combinations are AO, OA, AI, IA and EI.

A	O	A	I	E
<u>O</u>	<u>A</u>	<u>I</u>	<u>A</u>	<u>I</u>
O	O	I	I	O



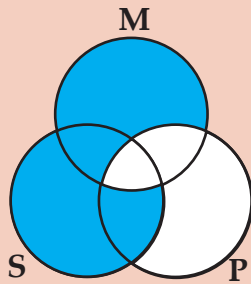
The combination of E – O propositions, and O – E propositions are invalid as they commit the fallacy of two negative premises.

The combination of I – E propositions is invalid as it commits the fallacy of illicit major.



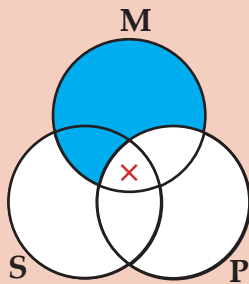
Validation of Syllogism using Venn Diagrams

Venn Diagram for AAA-1



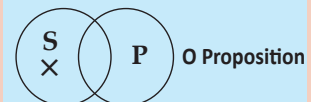
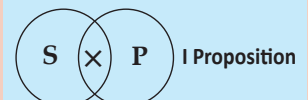
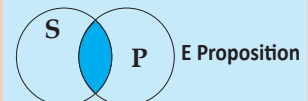
All animals are carnivores - A
 All tigers are animals - A
 $\therefore$ All tigers are carnivores - A

Venn Diagram for AII-1



All medicines are useful - A
 Some painkillers are medicines - I
 $\therefore$ Some painkillers are useful - I

Representing propositions using Venn diagram



Activity 10

Complete the chart on the Rules and Fallacies of Syllogism.

Rules	Fallacies
1.	Fallacy of Four Terms and Fallacy of Equivocation
2.	
3.	
4.	
5.	
6.	
7.	
8.	

Mixed Syllogism



Activity 11

Identify the different kinds of propositions involved in this syllogism.

If a person enjoys birthday party, then that person will be late; and if that person goes for a movie, then that person will be late.

Either the person enjoys a birthday party or goes for a movie.

∴ The man will be late.

1. Major premise: _____
2. Minor premise: _____
3. Conclusion: Categorical proposition

Mixed Syllogisms are those in which the conditional and categorical propositions are combined within the same argument. There are three kinds of Mixed Syllogism:

1. Hypothetical Syllogism
2. Disjunctive Syllogism
3. Dilemma

Hypothetical Syllogism

A **Hypothetical Syllogism** is a mixed syllogism in which the major premise is a hypothetical proposition, the minor premise and the conclusion are categorical propositions.

A hypothetical proposition consists of two parts; **antecedent** and the **consequent** joined by if...then clause.

e.g., If a man is poisoned, then he will die.

This man is poisoned.

∴ This man will die.

Hypothetical syllogism has two rules.

1. Affirm the antecedent in the minor premise and affirm the consequent in the conclusion.
2. Deny the consequent in the minor premise and deny the antecedent in the conclusion.



By applying these two rules we obtain two kinds of hypothetical syllogisms: **Modus Ponens** and **Modus Tollens**.

I. Modus Ponens or Constructive Hypothetical Syllogism

Modus Ponens is a form in which the minor premise affirms the antecedent, and the conclusion affirms the consequent.

Logical Form

If A is B, then C is D

A is B

∴ C is D



Activity 12

Construct a Modus Ponens

If you work hard, you will be successful.

∴ _____



II. Modus Tollens or Destructive Hypothetical Syllogism

Modus Tollens is a form in which the minor premise denies the consequent, and the conclusion denies the antecedent.

Logical Form

If A is B, then C is D

C is not D

∴ A is not B



Activity 13

Construct a Modus Tollens

If population increases, then unemployment increases.

∴ _____



Fallacies of Hypothetical Syllogism

The following are the two fallacies of hypothetical syllogism.

1. **Fallacy of Denying the Antecedent** occurs when we deny the antecedent in the minor premise instead of the consequent.
2. **Fallacy of Affirming the Consequent** occurs when we affirm the consequent in the minor premise instead of the antecedent.

Disjunctive Syllogism

A **Disjunctive Syllogism** is a mixed syllogism in which the major premise is a disjunctive proposition, while minor premise and conclusion are categorical propositions.

e.g., The signal light is either red or green.

It is red.

∴ It is not green.

Rules of a disjunctive syllogism

1. Affirm one alternative in the minor premise and deny the other in the conclusion.

Or

Deny one alternative in the minor premise and affirm the other in the conclusion.

2. The two alternatives must be exclusive of each other. That means, the presence of one implies the absence of the other.
3. The two alternatives must be exhaustive. That means, the two alternatives taken together must cover the whole class without omitting any part of it.

Thus, we have two kinds of disjunctive syllogism.

I. Modus Ponendo Tollens

It is a form in which one of the alternatives of the major premise is affirmed in the minor premise, and the other alternative is denied in the conclusion.

Logical Form

Either A is B or C is D

A is B

∴ C is not D

**Activity 14****Construct a Modus Ponendo Tollens**

Anu is either a socialist or a democrat.

∴ _____

II. Modus Tollendo Ponens

It is a form in which one of the alternatives of the major premise is denied in the minor premise, and the other alternative is affirmed in the conclusion.

Logical Form

Either A is B or C is D

A is not B

∴ C is D

**Activity 15****Construct a Modus Tollendo Ponens**

Logic is either a positive science or a normative science.

∴ _____

Fallacy of Improper Disjunction

Errors occur in disjunctive arguments also. Sometimes, the alternatives are neither exclusive nor exhaustive.

e.g. A student is either a good scholar or a good sportsperson

X is a good scholar

∴ X is not a good sportsperson

This argument is improper because the alternatives are not exclusive. A student can be both a scholar and a sportsperson at the same time.

e.g. Exam are either easy or difficult

It is not easy.

∴ It is difficult.

This argument is improper. Here the alternatives are not exhaustive. Exams can also be moderate, neither easy nor difficult.

Dilemma

How will you describe this situation?



A **dilemma** is a mixed syllogism in which the major premise consists of two hypothetical propositions, the minor premise is a disjunctive proposition and the conclusion is categorical or disjunctive proposition.

It is a double-grip reasoning that puzzles a person. It is a common form of argument in ordinary language. We may say that a person is in a dilemma when one must choose between two alternatives both of which are equally unpleasant.

Forms of Dilemmas

There are four different forms of dilemmas.

1. Simple Constructive Dilemma
 2. Simple Destructive Dilemma
 3. Complex Constructive Dilemma
 4. Complex Destructive Dilemma
- A dilemma is **simple** when the conclusion is a categorical proposition.
 - It is **complex** when the conclusion is disjunctive proposition.
 - It is **constructive** when the minor premise affirms the antecedents of the major premise.
 - It is **destructive** when the minor premise denies the consequent of the major premise.

I. Simple Constructive Dilemma

Logical Form

If A is B, then C is D; and if E is F, then C is D.

Either A is B or E is F.

∴ C is D.

This is a simple dilemma because the conclusion is a categorical proposition. It is constructive because the minor premise affirms the antecedents of the major premise.

Example:

If people act according to their conscience, they will be criticized; and if they follow the opinions of others, they will be criticized.

Either people act according to their conscience or follow their opinions of others.

∴ People will be criticized.

II. Simple Destructive Dilemma

Logical Form

If A is B, the C is D; and if A is B, E is F.

Either C is not D or E is not F.

∴ A is not B.

This dilemma is simple because the conclusion is a categorical proposition. It is destructive because the minor premise denies the consequents of the major premise.



Activity 16

Construct a Simple Destructive Dilemma

If X is moral, then X is honorable; and if X is moral, then X is trustworthy.

∴ _____

III. Complex Constructive Dilemma

Logical Form

If A is B, then C is D; and E is F, then G is H.

Either A is B or E is F.

∴ Either C is D or G is H.

This dilemma is complex because the conclusion is a disjunctive proposition. It is also constructive because the minor premise affirms the antecedents of the major premise.



Activity 17

Construct a Complex Constructive Dilemma

If I tell the truth, then I shall offend the people; and If I tell lies, then I shall offend my conscience.

∴ _____

IV. Complex Destructive Dilemma

Logical Form

If A is B, then C is D; and if E is F, then G is H.

Either C is not D or G is not H.

∴ Either A is not B or E is not F.

The dilemma is complex because the conclusion is a disjunctive proposition and destructive because the minor premise denies the consequents of the major premise.



Activity 18

Construct a Complex Destructive Dilemma

i) If a man is moral, he commits no evil; and if he is immoral, he bothers not.

∴ _____

ii) If he was clever, he would see his mistakes; and if he was sincere, he would acknowledge them.

∴ _____



Activity 19

Kinds of Syllogism

Pure	Mixed	
1. Pure Categorical	1. Hypothetical	a) b) Modus Tollens
2.	2.	a) Modus Ponendo Tollens b)
3.	3. Dilemma	a) b) Simple Destructive c) Complex Constructive d)



Buddhist Logic (Hetu-vidyā) Abridged

Buddhist Logic, known as **Hetu-vidyā** (meaning 'science of causes/reasons'), is the system of logic developed within the Buddhist tradition, primarily between the 5th and 7th centuries.

Hetu-vidya means 'the science of causes'. It is the analysis of cause and effect and the structure of the valid argument. It is a three- fold structured argument (Trairupa). They are:

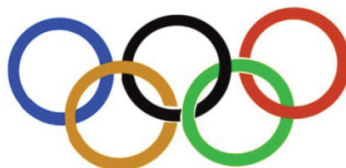
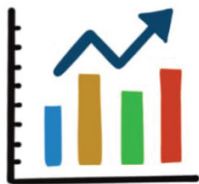
- i. The reason (hetu) is present in the subject (**paksa**) – e.g., There is smoke (hetu) because there is fire. Smoke is present on the hill (Paksa).
- ii. The reason is present in the similar cases (**sapaksa**) – e.g., Smoke is present wherever there is fire such as in the kitchen.
- iii. The reason is absent in the dissimilar cases (**vipaksa**) – e.g., Smoke is absent where there is no fire.

Therefore, the hill is on fire.

In this chapter, we have examined the standard form of different syllogisms and the rules governing their validity. Learning this chapter enriches our reasoning ability. The complexity of arguments can be minimized using symbols. We will learn more about this in the next chapter.

Chapter

5 SYMBOLIC LOGIC



Activity 1

Observe the symbols and identify them. Why do we use these symbols instead of words?

.....

.....

.....

Just as road signs and emojis act as a universal shorthand for quick communication, symbolic logic uses special characters to represent our thoughts with mathematical precision.

The objective of logic is to explain the relation between premises and conclusion in deductive arguments and to provide techniques to determine whether inferences are valid or invalid. Two methods are sought to achieve these objectives. One of them is the Classical or Traditional or Aristotelian logic which we have discussed in the previous chapter. The second method, called the Symbolic Logic is dealt in this chapter.

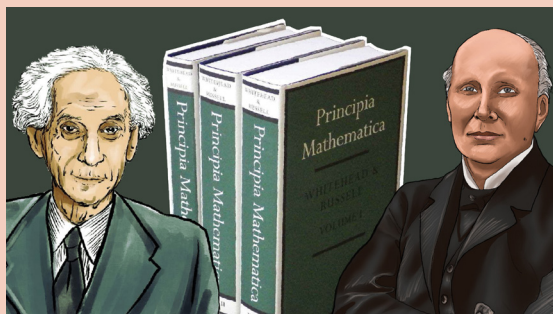
Definition of Symbolic Logic

In our daily life, we often express reasoning and arguments in ordinary language. However, such language can sometimes be vague or ambiguous. To avoid confusion and to express reasoning more precisely, symbols are used in logic. **Symbolic logic is a branch of logic in which symbols are used to represent logical expressions and arguments.** Instead of relying on ordinary language, it expresses statements and arguments through symbols. These symbols clearly show their logical relationship. Symbolic logic analyses the structure of reasoning and determines the validity of arguments.



History of Modern Logic

In the 17th century, G.W. Leibniz recognized that Aristotelian logic needed improvement, but he offered no clear direction. Only in the 19th century did mathematicians and philosophers begin fulfilling his vision, especially after the development of calculus accelerated mathematical progress. Logic too adopted mathematical methods.



Modern logicians, mostly mathematicians, expressed logical relations in mathematical form. George Boole pioneered mathematical logic by showing parallels between logical operations and algebra, creating class calculus. De Morgan and C. S. Peirce continued this mathematising trend. Meanwhile, Gottlob Frege approached logic differently, attempting to derive all of mathematics from logic, a view known as Thesis of logicism. This led to logic being treated as more fundamental than mathematics. Russell and Whitehead's Principia Mathematica further advanced this idea by presenting a comprehensive symbolic system as the basis of all mathematics. According to Basson and O' Connor, "Modern symbolic logic is a development of the concepts and techniques which were implicit in the work of Aristotle".

Symbolic logic is also called **Mathematical Logic** or **Modern Logic**. It is called Mathematical Logic because it was developed with the objective of examining the foundations of mathematics and there are many similarities between its formulae and those of mathematics.

Difference between Traditional Logic and Symbolic Logic

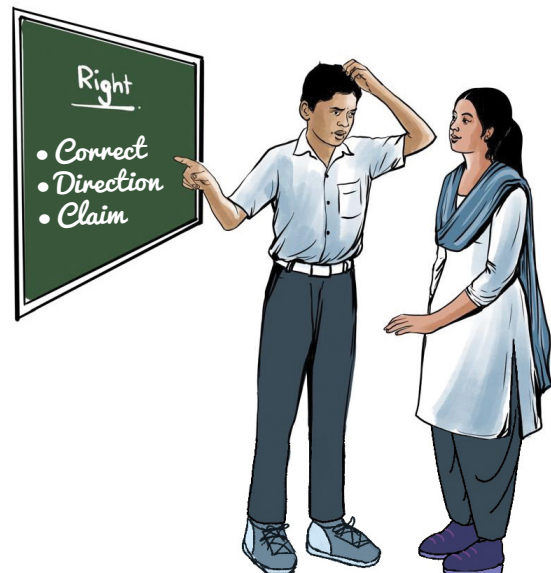
Symbolic logic does not reject any of the established principles of traditional logic, rather, it enhances them and provide a broader range of applications. However, we can find a few differences between them.

Traditional Logic	Symbolic Logic
Has an extensive history	Has a brief history
Mainly concerned with the subject-predicate relations	Mainly concerned with propositions
A 'term' is considered as the basic unit	A proposition as a whole is considered the basic unit
A fewer utilization of symbols (variables only)	A greater utilization of symbols (constants and variables)

Characteristics of Symbolic Logic

C. I. Lewis, a modern logician, presents three characteristics of symbolic logic.

1. **Symbolic representation:** Symbolic logic uses symbols and signs instead of ordinary language. This helps to avoid confusion caused by words with multiple meanings.
2. **Focus on the form of reasoning:** It deals with the form or structure of reasoning, and not the content. Logical arguments are treated like mathematical equations.
3. **Symbolic logic uses deductive method:** That is, we arrive at conclusions that must be true, if the premises are true.




Activity 2

Read the following statements and write True or False.

Statement	True/False
Symbolic Logic increases ambiguity in reasoning.	
Traditional Logic is mostly expressed in natural language.	
Symbolic Logic uses constants and variables.	
Traditional Logic is more precise than Symbolic Logic.	

Variables and Constants

In Symbolic Logic, there are mainly two kinds of symbols: **variables** and **constants**.

Does our date of birth ever change?

Does our age remain the same every year?

In the same way, in symbolic logic, the meaning of some symbols never changes, whereas some can take different values or meanings.

A **variable** is a symbol whose value or meaning varies. It can stand for any one of a given range of values. A variable is only a placeholder and, in its place, any simple proposition may be substituted. The letters of the English alphabet are used as variables. Small letters like p, q, r, s, etc. are commonly used to represent simple propositions. (Capital letters can also be used.) They are known as '**propositional variables**' because they stand indifferently for any proposition. A letter in symbolic logic stands for the proposition as a whole and not for a single term.

A **constant** is a symbol whose meaning does not change. It has a definite meaning. In mathematics, symbols like π , $\times$, $+$, $=$, $>$, $<$, etc. are constants. Their meaning is fixed and universal.

Consider the formula, Area of a circle = πr^2

π is a constant (the value of π is always 3.14)

r is a variable (value of r which is the radius of circle may change).

Logic also has its own constants whose meaning never change. These constants in logic are called logical operators, which refers to a definite ways of representing propositions.

Logical Operators:

The logical constants are also called the **truth-functional operators**. Each operator represents a kind of proposition.

Kind of Proposition	Truth-functional	Symbol (Name of symbol)
Conjunction	And	• (Dot)
Disjunction	Either...or	$\vee$ (wedge)
Conditional implication	If...then	$\supset$ (Horse shoe)
Material equivalence (Bi conditional)	If and only if	$\equiv$ (Triple bar)
Negation	Not	$\sim$ (curl/tilde)

The 'dot', 'wedge', 'horse shoe' and 'triple bar' are also called logical connectives because they are used to connect two simple propositions together. But 'curl' is not a truth-functional connective.



Activity 3

Identify the logical operators in the following truth-functions.

1.	$p \bullet q$
2.	$\sim p \equiv q$
3.	$p \supset (q \vee r)$

Truth-function

The notion of a 'function' will be familiar to the student of elementary Mathematics. A function is a relationship between an "input" and an "output" where every input leads to exactly one specific output.

For example, $y=3x+2$; here 'y' is a function of 'x' because once we choose a value for x, the value of 'y' is automatically decided. Thus if 'x' takes the value 6, the value of 'y' is 20. If it takes the value 7, the value of 'y' is 23 and so on.

In logic we can usually extend this notion of function. A **truth-function is the symbolic representation of a compound proposition of its constituent parts**. Words like 'and', 'or', 'if-then', 'if and only if', and 'not' stand for the propositional variables (here 'p', 'q', etc.) into

truth-functional expressions. They are conventionally represented as follows:

p and q	→	$p \cdot q$
p or q	→	$p \vee q$
If p then q	→	$p \supset q$
P if and only if q	→	$p \equiv q$
not p	→	$\sim p$

Symbolic logic constructs the valid expressions in logical language using its signs and symbols. **Logical syntax** are rules that tell us how to correctly combine symbols to make meaningful and valid logical statements:

For example, symbolically representing, If p then q:

$p \supset q$	✓
$\supset p q / p q \supset$	×



Activity 4

Complete the following table.

Proposition	Truth Function
The river is wide and the water is deep.	$p \cdot q$
Either Carol is a musician or Tyrell is a musician.	
If water boils, then it turns into steam.	
You can enter the club if and only if you are invited.	
It is not raining.	



Semiotics

Semiotics is the general study of signs and sign processes in communication. Syntax and Semantics are fields within Semiotics. Syntax examines the formal and structural relationship between signs to form valid expressions, without reference to meaning. Semantics focuses on assigning the meaning and truth value to these well-formed formulas under specific interpretations.



Logical Syntax

When we write sentences in English, we follow grammar. What happens if we don't follow it? In the same way, in logic, we have rules called Syntax. Every language has a syntax of its own. Logical syntax refers to formal rules governing the structure and arrangement of symbols in a logical language.

Logical Punctuation

Symbolic logic also uses a system of brackets known as **logical punctuation**. It helps us show the order of operation in an argument. Three types of brackets are used in symbolic logic.

1. Simple Bracket () : used to point out the simple unit of an argument.

Example: $p \bullet (q \vee r)$

2. Square Bracket [] : used to point out an extra unit of grouping statements besides simple brackets.

Example: $[(p \bullet q) \vee r] \supset s$

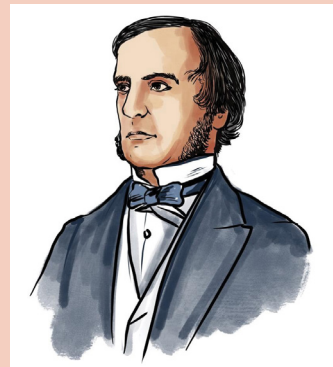
3. Set (Curly) Bracket { } : used to show a set or group of statements.

Example: $\sim\{(p \bullet q) \vee r\} \supset s$



Boolean Algebra.

*The British Mathematician George Boole was the first to establish a formal connection between logic and mathematics. His revolutionary work, *An Investigation of the Laws of Thought* laid foundation for Boolean algebra, which later became the fundamentals to modern digital devices and computer science. Boolean Algebra is a logical calculus of truth values. It deals with two values (binary variables); True or False (1 or 0). In practice, electronic engineers view the symbols: '1' to refer the values of the signal produced by an electronic switch as 'ON' or 'True'. '0' to refer the value of the signal as 'OFF' or 'False'. These symbols are called 'bits'.*



*George Boole
(1815-1864)*



Activity 5

Symbolize the given propositions.

I will study well and pass the exams, or I will fail the exams.	
---	--

If I study well, I will pass the exam; and if I use mnemonics, I will pass the exam.	
--	--

Truth Value and Truth Table

In Chapter 2, we have studied that a proposition is either true or false.

Find whether the following propositions are true or false.

1. Thiruvananthapuram is the capital city of Kerala.- _____
2. Chennai is the capital city of Karnataka.- _____

The status of any proposition as either true or false is known as the truth value of the given proposition. Truth value of a true statement is True, and the truth value of a false statement is false. Truth function of a logical statement also has the values of either true or false. Their results are represented by T for True, and F for False.

Truth table is a logical device used to demonstrate all possible truth values of a compound proposition. It displays all possible combinations of the truth values of its constituent simple propositions. The truth value of a compound proposition is determined by the truth value of its constituent parts.

2^n is the formula to find out the number of possible combinations of truth values in a compound proposition.

Here, 2 stands for the two possible truth values (T and F) of a simple proposition, and 'n' stands for the number of propositional variables. Therefore, the number of possible combinations of truth values in a compound proposition with 2 variables will be:

$$\begin{aligned}
 &2^n \\
 &= 2^2 \\
 &= 2 \times 2 \\
 &= 4
 \end{aligned}$$



Activity 6

If so, find the number of possible combinations of truth values in a compound proposition with 3 variables.

$$\begin{aligned}
 &2^n \\
 &= 2^2 \\
 &= \dots\dots\dots? \dots\dots\dots
 \end{aligned}$$

Let us consider the compound proposition, 'Rome is the capital of Italy and Paris is the capital of France' which has two constituent parts or components. A proposition with two components has four possible truth values.

Rome is the capital of Italy (p) and Paris is the capital of France (q).	
T-----	T
T-----	F
F-----	T
F-----	F

The tabular way of representing this dependence is called truth table. Propositions like conjunction, disjunction, implication, material equivalence and negation have their own truth table.

Now let us see how we can represent the truth table of different kinds of proposition.

Conjunction

A conjunctive truth-function is a compound proposition in which two or more propositions are combined into one by the constant '•' (dot). The component statements so combined are called conjuncts.

Example: The flower blossoms and its fragrance spreads. – $p \bullet q$



This truth-function can be set out as follows: The conjuncts can be substituted by 'p' and 'q' respectively.

The flower blossoms (p) and its fragrance spreads (q)	$p \cdot q$
p is true (T) and q is true (T) The flower blossoms and its fragrance spreads.	T
p is true (T) and q is false (F) The flower blossoms and its fragrance do not spread.	F
p is false (F) and q is true (T) The flower does not blossom and its fragrance spreads.	F
p is false (F) and q is false (F) The flower does not blossom and its fragrance does not spread.	F

The conjunctive proposition will be true, if and only if both the conjuncts are true. All other possibilities of conjunctive proposition will be false. Then we can represent the truth table of the conjunctive proposition as follows:

p	q	$p \cdot q$
T	T	T
T	F	F
F	T	F
F	F	F

The first two columns represent component parts. The third column represents the conjunctive truth function. The truth value of 'p and q' is determined by the truth value of its component parts 'p' and 'q'.



Activity 7

Symbolize 'Rome is the capital of Italy and Paris is the capital of England.'

Find the truth value if p is True and q is False.

Disjunction

A disjunctive or alternative truth-function is a compound proposition in which two or more propositions are combined into one using the constant ' $\vee$ ' (wedge). The component statements so combined are called disjuncts (or alternatives).

Example: Students are either hardworking or intelligent. - $p \vee q$

This truth-function can be set out as follows: The disjuncts can be substituted by 'p' and 'q' respectively.

Students are either hardworking or intelligent	$p \vee q$
p is true (T) – q is true (T) Students are hardworking is true. – Students are intelligent is also true.	T
p is true (T) – q is false (F) Students are hardworking is true. – Students are intelligent is false.	T
p is false (F) – q is true (T) Students are hardworking is false. – Students are intelligent is true.	T
p is false (F) – q is false (F) Students are hardworking is false. – Students are intelligent is also false.	F

The disjunctive proposition will be false, if and only if both the disjuncts are false. In all other possibilities the disjunctive functions will be true. Then we can represent the truth table of the disjunctive function as follows:

p	q	$p \vee q$
T	T	T
T	F	T
F	T	T
F	F	F



The term 'either...or' can be used in disjunction in both inclusive or exclusive senses. An inclusive (weak) disjunction is true in case one or the other or both disjunct are true. If both disjuncts are false their inclusive disjunction will also be false. The inclusive 'or' has the sense of possibly both. Whereas, an exclusive (strong) disjunction will be false when both the disjuncts are true or both are false. The meaning is not "at least one" but "at least one and at most one." E.g. A person is either married or bachelor. It clearly means that only one of the disjuncts can be true, and not both.

<i>Exclusive Disjunction Truth Table</i>		
p	q	$p \wedge q$
T	T	F
T	F	T
F	T	T
F	F	F

**Activity 8**

Symbolize the proposition and construct a truth table.

'The ground is either wet or dry'.

**Activity 9**

Complete the truth table

p	q	$p \cdot q$	$p \vee q$	$(p \cdot q) \vee (p \vee q)$
T	-	T	T	T
-	F	-	-	-
-	-	F	-	T
F	F	-	-	-

Implication

An implicative truth-function is a compound proposition in which two or more propositions are conjoined into one by the constant $\supset$ (Horse shoe)

Example: 'If you read, then you will gain knowledge.' $p \supset q$

This truth function can be set out as follows: The component parts of the implicative truth function can be substituted by 'p' and 'q' respectively.

If you read you will gain knowledge.	$p \supset q$
p is true (T) – q is true (T) You read is true. – You will gain knowledge is also true.	T
p is true (T) – q is false (F) You read is true. – You will gain knowledge is false.	F
p is false (F) – q is true (T) You read is false. – You will gain knowledge is true.	T
p is false (F) – q is false (F) You read is false. – You will gain knowledge is also false.	T

The implicative truth-function will be false, only the case when the antecedent is true and the consequent is false. In all other cases, the implicative function will be true. Then we can represent the truth table of the implicative function as follows:

p	q	$p \supset q$
T	T	T
T	F	F
F	T	T
F	F	T



Activity 10

1. Symbolize the proposition and construct a truth table.
If you drive a car, you must wear seat belt.
2. If X is true and Y is false, find the truth value of the given truth functions.
 - i. $(X \cdot Y) \supset Y$
 - ii. $(Y \supset X) \vee X$
 - iii. $(X \supset Y) \cdot (X \vee Y)$

Material Equivalence (Biconditional)

Material equivalence is a truth-functional connective that holds between two propositions. It asserts that the statements it connects have the same truth value. Material equivalent is defined as two statements which share the same truth value, both true or both false. This makes the biconditional a propositional connective for 'if and only if' statements. This logical relation is only occasionally used.

Example:

"I go to the movie if and only if I can acquire a ticket". $p \equiv q$

This truth-function can be set out as follows: The component parts of material equivalent truth-function can be substituted by 'p' and 'q' respectively.

I go to the movie if and only if I can acquire a ticket.	$p \equiv q$
p is true (T) – q is true (T) I go to the movie is true. – I can acquire a ticket is also true.	T
p is true (T) – q is false (F) I go to the movie is true. – I can acquire a ticket is false.	F
p is false (F) – q is true (T) I go to the movie is false. – I can acquire a ticket is true.	F
p is false (F) – q is false (F) I go to the movie is false. – I can acquire a ticket is also false.	T

Since the two statements are materially equivalent, one implies the another. Therefore, we may infer from their material equivalence that, if one component is true then the other must also be true, or if one component is false then the other must also be false. We can represent the truth table of the material equivalent truth-function as follows:

p	q	$p \equiv q$
T	T	T
T	F	F
F	T	F
F	F	T



Activity 11

Complete the truth table of given truth-functions: $r \supset (p \equiv q)$

p	q	r	$p \equiv q$	$r \supset (p \equiv q)$
T	T	T	T	T
T	T	F	—	—
T	F	T	—	—
T	F	F	F	—
F	T	T	—	—
F	T	F	—	—
F	F	T	—	—
F	F	F	T	—

Negation

The Negation of a statement in Logic is often formed by the insertion of 'not' or 'no' or 'non' in the original statement. The symbol " $\sim$ " (curl/tilde) is used to form the negation of a statement.

Example: Man is not mortal. $\sim p$; where 'p' stands for 'man is mortal' and $\sim p$ stands for 'man is not mortal'.

This truth-function can be set out as follows:

Man is mortal (p)	Man is not mortal ($\sim p$)
p is true (T)	$\sim p$ is false (F)
Man is mortal is true	Man is not mortal is false
p is false (F)	$\sim p$ is true (T)
Man is mortal is false	Man is not mortal is true

If p is true, $\sim p$ is false and if p is false, $\sim p$ is true. We can represent the truth-table of the Negative truth function as follows:

p	$\sim p$
T	F
F	T

Note: The 'curl' performs an operation as it reverses the truth value of a single proposition. Therefore, it is considered as a truth-functional operator and not as a truth-functional connective.



One can also express the negation of statement by prefixing the phrase "it is false that" or "it is not the case that". Some books use the symbol ' $\neg$ ' for negation. Consider these examples:

Not all humans are mortal.

Some humans are not mortal.

It is false that all humans are mortal.

It is not the case that all humans are mortal.

When we negate a negative proposition (double negation), we obtain the original proposition.

Example: $\sim \sim p$ is equal as p

**Activity 12**

Symbolize the following propositions using the letters p and q.

If the price of petrol is not increased, then the opposition will cancel the strike.

If the price of petrol is increased, then the opposition will not cancel the strike.

**Activity 13**

Complete the truth table.

p	q	$\sim p$	$\sim q$	$\sim p \cdot \sim q$
T	—	F	—	F
—	F	—	T	—
T	—	—	—	—
—	F	T	—	—

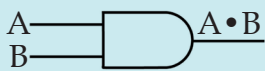
Logic Gate

A Logic Gate is a fundamental electronic circuit that performs a logical operation on one or more binary inputs to produce a single binary output (0 or 1). 0 represents False, and 1 represents True. They are the basic building block of all digital circuits from simple calculators to smartphones and advanced supercomputers. They operate based on the principles of Boolean algebra. The three basic logic gates are AND gate, OR gate and NOT gate, each with a specific set of rules for its operation that can be represented with a truth table. AND gate corresponds to the logical operator called conjunction (and). The output is True (1) only if all inputs are true. OR gate corresponds to the logical operator called disjunction (or). The output is True (1) if at least one input is true. NOT gate corresponds to the logical operator called negation (not). The output is the inverse of the input.



Logic gates are primarily implemented using diodes or transistors acting as electronic switches. All data, information and operations are represented inside a computer using these logical values. The operations performed on the Boolean values are called Logical Operators or Boolean Operators. Computers perform these operations with some electronic circuits called logic circuits. A logic circuit is made up of individual units called gates. A gate represents a Boolean Operation.

The following table shows a representation of the basic logic gates

Logic Gates	Symbol	Boolean Expression	Truth Table																		
AND		$A \cdot B$	<table><tr><th colspan="2">Input</th><th>Output</th></tr><tr><th>A</th><th>B</th><th>$A \cdot B$</th></tr><tr><td>0</td><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td><td>0</td></tr><tr><td>1</td><td>0</td><td>0</td></tr><tr><td>1</td><td>1</td><td>1</td></tr></table>	Input		Output	A	B	$A \cdot B$	0	0	0	0	1	0	1	0	0	1	1	1
Input		Output																			
A	B	$A \cdot B$																			
0	0	0																			
0	1	0																			
1	0	0																			
1	1	1																			
OR		$A + B$	<table><tr><th colspan="2">Input</th><th>Output</th></tr><tr><th>A</th><th>B</th><th>$A + B$</th></tr><tr><td>0</td><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td><td>1</td></tr><tr><td>1</td><td>0</td><td>1</td></tr><tr><td>1</td><td>1</td><td>1</td></tr></table>	Input		Output	A	B	$A + B$	0	0	0	0	1	1	1	0	1	1	1	1
Input		Output																			
A	B	$A + B$																			
0	0	0																			
0	1	1																			
1	0	1																			
1	1	1																			
NOT		$\sim A$ or $\overline{A}$	<table><tr><th>Input</th><th>Output</th></tr><tr><th>A</th><th>$\sim A$ or $\overline{A}$</th></tr><tr><td>0</td><td>1</td></tr><tr><td>1</td><td>0</td></tr></table>	Input	Output	A	$\sim A$ or $\overline{A}$	0	1	1	0										
Input	Output																				
A	$\sim A$ or $\overline{A}$																				
0	1																				
1	0																				

Advantages of Symbolic Logic

- Symbolic Logic is beneficial for exploring the foundations of Mathematics and various fields of knowledge.
- It offers a means or method to determine the validity of arguments presented in ordinary language and that cannot be evaluated through Traditional Logic.
- Studying Symbolic Logic helps us improve our reasoning skills. Rules of inference and truth tables make it scientific.
- It assists an individual in reading and writing with care.
- Symbolic Logic expresses ideas clearly and precisely. There is no place for vague or emotional language. This eliminates ambiguity and ensures accuracy.
- It forms the basis of Programming, Digital Circuits, and Artificial Intelligence.
- Since, it uses symbols instead of words, it is universally applicable. It can be understood across all languages and cultures.

Chapter

6 INDUCTION



Activity 1

Read the following scenario you may have encountered in daily life.

You wake up one morning and notice your phone (which you rely on for everything) was completely dead, even though you left it plugged in overnight. You need to know why it failed.

How will you settle on the truth (the cause of the failure)?

1 I'd just assume it's the cheap charger. It's always the charger.



2 I'd go straight to the phone store and ask the technician what happened.



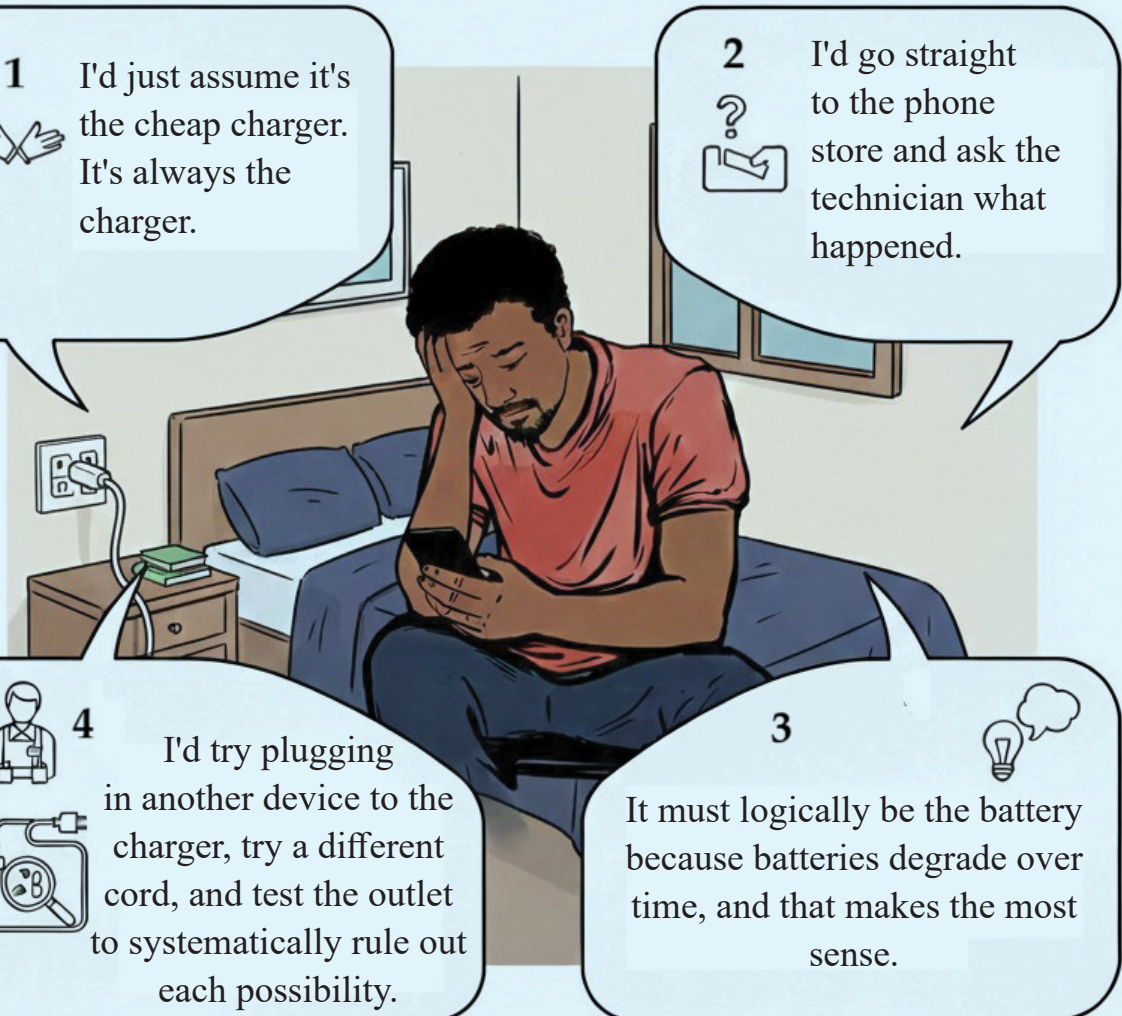
4 I'd try plugging in another device to the charger, try a different cord, and test the outlet to systematically rule out each possibility.



3



It must logically be the battery because batteries degrade over time, and that makes the most sense.



Why would you think in any of the above four manners?

- Because,
1.
 2.
 3.
 4.

1. *You cling to a belief simply because it is familiar, comfortable, or you have always believed it (ignoring new evidence).*
2. *You accept the belief based on the word of a trusted expert or established source, without personal investigation.*
3. *You accept the belief because it 'agrees with reason' or fits into your pre-existing mental framework of how things should work.*
4. *You base the belief on external, testable evidence, and follow a systematic process to eliminate hypotheses.*

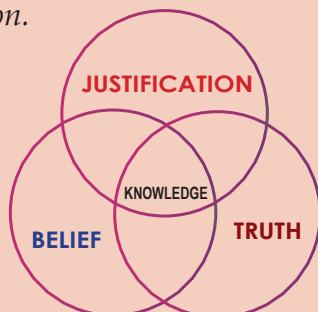
We rely on beliefs every day. This chapter on Induction is about understanding why the True Induction or the Method of Science is the most powerful and reliable tool humans have created for fixing their beliefs. As we proceed, we will realise that learning different kinds of induction, its problem, postulates, and steps of scientific induction would strengthen our scientific temperament and reasoning ability



"Knowledge is justified true belief"

-Plato-

It suggests that for a person to truly 'know' a fact, three specific criteria must be met simultaneously. They are, truth, belief and justification.



The Methods of Fixing Belief

The Methods of Fixing Belief are a philosophical framework developed by Charles Sanders Peirce in his 1877 essay, *The Fixation of Belief*. According to him individuals and communities move from a state of doubt to a stable, satisfactory state of belief.

Peirce argues that the sole object of inquiry is to settle opinion. He examines four historical methods for achieving this goal, listing them in order of their logical failure

rate. They are the **Method of Tenacity**, the **Method of Authority**, the **A Priori Method** and the **Method of Science**.

The Method of Tenacity

"When an ostrich buries its head in the sand as danger approaches, it very likely takes the happiest course. It hides the danger, and then calmly says there is no danger."

- Charles Sanders Peirce-



Many individuals around us are hiding from the truth, whether intentionally or not, reminding the proverbial ostrich policy. It is a comforting way to escape hard thinking. They find it easy to avoid thinking and deciding for themselves. These individuals ignore facts and experiences that clash with their beliefs and only accept things that make them feel good. This way of fixing belief is called the method of tenacity by Charles Sanders Peirce. **The method of tenacity can be thus defined as any individual's wilful adherence to a belief and the deliberate avoidance of anything that might cause that belief to change.**



Activity 2

Discuss in groups and evaluate the following conversation.



The Method of Authority

Instead of individuals themselves, other persons or the community or a powerful institution decides what is true. This group would constantly repeat the beliefs to everyone and dictates or indoctrinates them to the young, while outlawing and stopping all opposing ideas. Here the statements are accepted based on some form of authority, be it a person, a book, a leader, or a group. **The Method of Authority is one where an institution, a group, a cult or a powerful leader enforces a set of doctrines and suppresses all opposing views.**



Activity 3



Starved prisoners, nearly dead from hunger, in a Nazi concentration Camp

From: album entitled "Nazi War Atrocities." April 1945

Aren't they the victims of indoctrination enforced by an authority?

Discuss in group and prepare a write-up.

The A Priori Method

The third method, called **a priori**, is when people settle on an argument based on what seems 'agreeable to reason' or philosophically correct, without actually testing them against the real world. **The A Priori Method relies on intuition.** It is basically an attempt to agree on something that simply sounds good or makes the most sense to our reason, even if we do not have facts to prove

it. The history of metaphysical philosophy gives us examples for this method. Their fundamental propositions seemed 'agreeable to reason.' The knowledge gained through this method are purely subjective and not free from doubt.



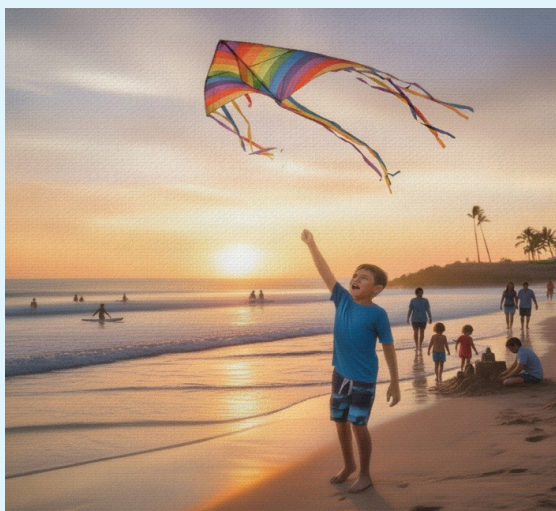
Activity 4

Let us understand the method and its limitations through the following instance.

A group of five students (A, B, C, D, and E) have worked together to create the following single, valuable painting that bagged a ₹ 10,000 prize.

Can you help them divide the prize money?

- A worked on it for 10 hours.
- B worked on it for 5 hours.
- C is the leader and organised the entire projects.
- D needs the money the most.
- E is the most talented artist, whose unique style makes the painting valuable.



Don't you think....?

- Your suggestions for the division of the prize money are grounded in certain reason.
- All those reasons seem to be true, yet contradict each other.
- All suggestions appear 'agreeable to reason'.



Activity 5

Discuss in groups and find the limitations of the three methods of fixing belief.

The Method of Tenacity	The Method of Authority	The A Priori Method

The Method of Science (or True Induction)

The Method of Science is the fourth and final method for fixing belief, because it is the only way to satisfy doubt by basing beliefs on something external and permanent. It is essentially the modern scientific method based on the hypothesis of a phenomenon. This method is called "True Induction" because it represents the only reliable and self-correcting way to generalise from observed facts. The conclusion of the phenomenon under study will be the same for all.

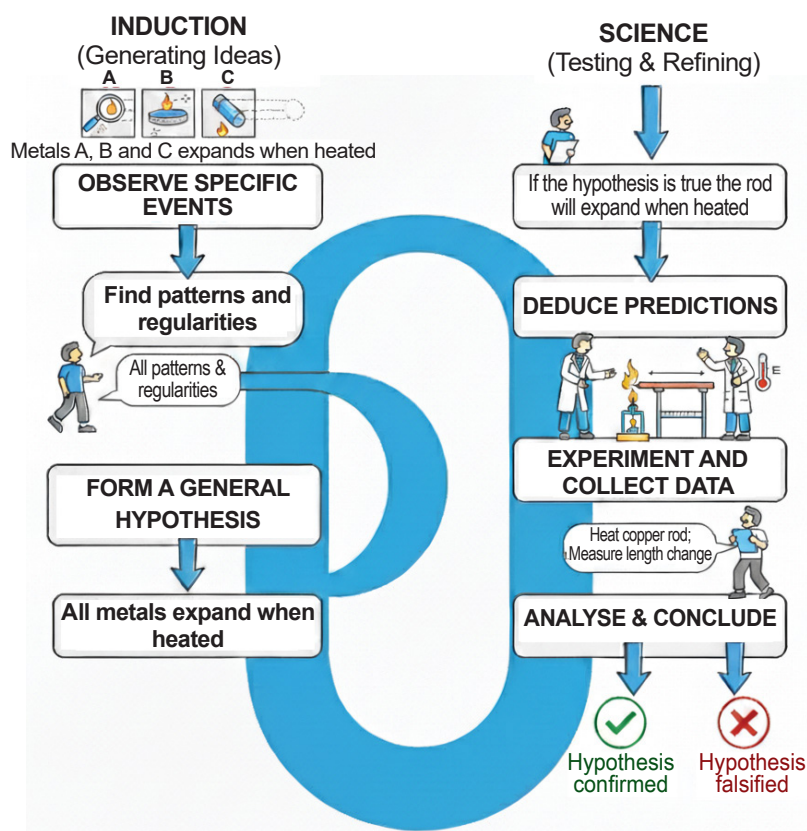
Induction

Induction (or Inductive Reasoning) is a form of logical thinking that involves drawing a general conclusion or establishing a general principle based on a series of specific observations or particular instances.

Symbolic expression of Inductive generalisation

$P_1, P_2, P_3, P_4, \dots, P_n$ are Q.
 $\therefore$ All P_s are Q.

Induction is often called material logic (or material inference) because it deals directly with the content or matter of factual evidence from the real world, rather than solely the form or structure of the argument.



Induction forms the foundation of the initial stages of the scientific method. The scientific method provides a structured framework that both utilizes and refines inductive reasoning. The scientific method helps induction by guiding observation and data collection, generating and refining hypotheses, and providing confirmation. Thus, we can say that both science and induction are reciprocally related.

RECIPROCAL RELATIONSHIP: INDUCTION FEEDS SCIENCE, SCIENCE REFINES INDUCTION



FRANCIS BACON AND INDUCTION

The *Novum Organum* (1620), or *New Instrument*, by Francis Bacon, is a seminal philosophical work that proposes a revolutionary new system of logic and method for scientific inquiry, intended to replace the ancient Aristotelian system. The book is structured into two main parts.



Francis Bacon
(1561-1626)

Book I: The Attack on Old Logic and the Idols of the Mind

Book I serves as a critique of existing philosophy and a warning about the pitfalls that block true knowledge.

Book II: The New Method (True Induction)

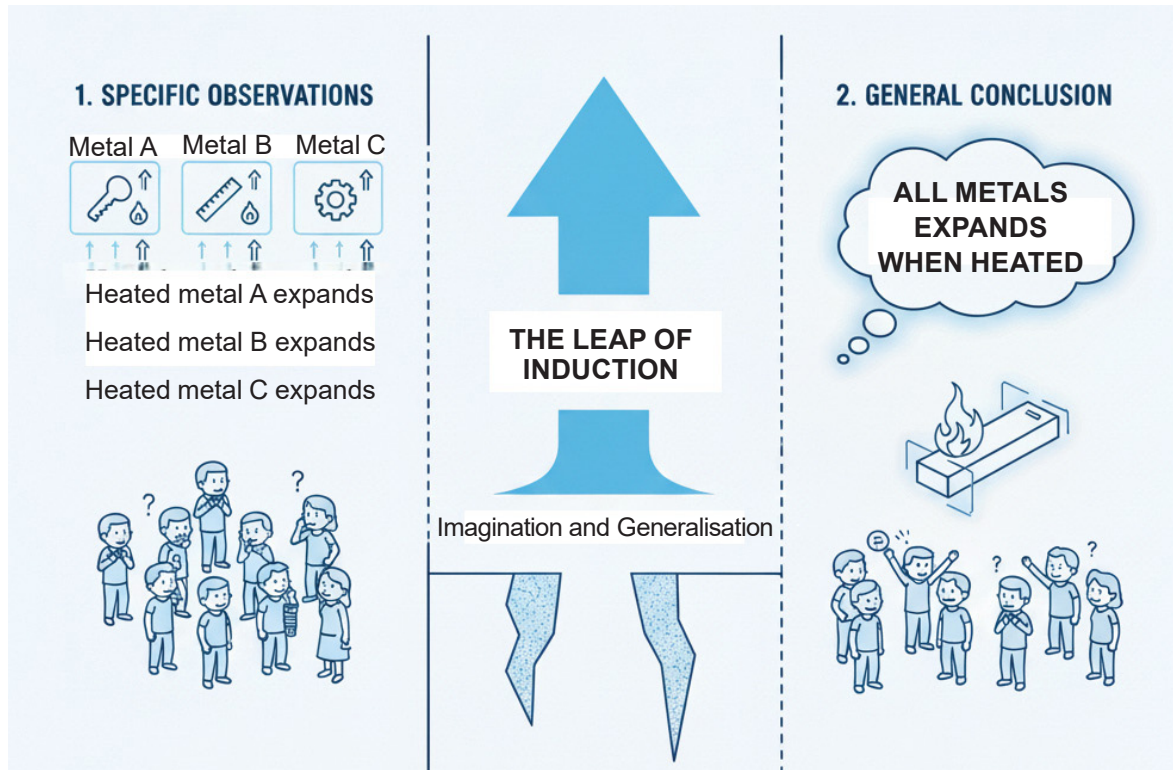
Book II lays out Bacon's alternative: the method of True Induction or Eliminative Induction, which is the foundation of the modern scientific method.

- **The Goal - Finding Forms:** The aim of inquiry is to discover the "Form" of a given "Nature" (e.g., the Form of Heat, or the essence of a thing). The Form is the underlying law or cause that governs the phenomenon.
- **Systematic Data Collection:** The process begins with systematic observation and experimentation, leading to the creation of three Tables of Instances:
 1. **Table of Presence:** Instances where the Nature (e.g., Heat) is present.
 2. **Table of Absence:** Instances that are similar to the first but where the Nature is absent.
 3. **Table of Degrees:** Instances where the Nature is present in varying degrees of intensity.
- **The Process of Exclusion:** Knowledge is advanced by using these tables to eliminate false "Forms." Any property that is absent when the Nature is present, or does not increase when the Nature increases, cannot be the Form. This eliminative process guides the intellect toward the true cause — a principle he called the "First Vintage" (a preliminary hypothesis).

Bacon's overall vision was to use this new inductive, empirical method to gain "power over nature," leading to practical discoveries and the betterment of the human condition.

Problem of Induction

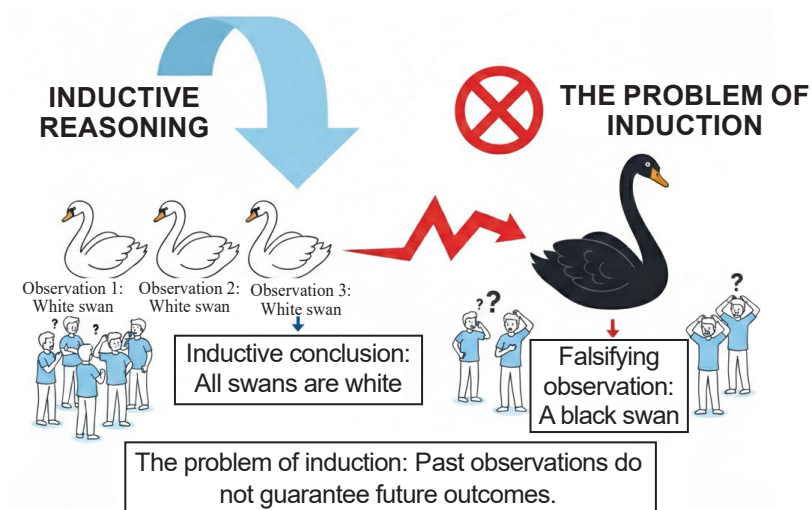
Look at the chart below. We observe some specific instances ('Heated metal A expands', 'Heated metal B expands' and 'Heated metal C expands') and jump to a general conclusion (All metals expand when heated). **This jump or leap from some to all is called the Inductive Leap.** This was identified by David Hume.



The Inductive Leap is the gap in reasoning that occurs when a person moves from observing a limited number of specific facts to asserting a broad, general conclusion or principle that applies universally or to unobserved instances.

The existence of this leap is central to the Problem of Induction in philosophy. There is always a chance that the next unobserved instance

may contradict the established pattern (e.g., the established belief of "All swans are white" get shattered at the sight of a black swan).



Despite its uncertainty, the Inductive Leap is necessary for human knowledge, as it allows us to form hypotheses, scientific laws, and causal generalisations upon which prediction and technology are built.



Activity 6

Now examine the following set of observations and formulate the strongest possible general principle.

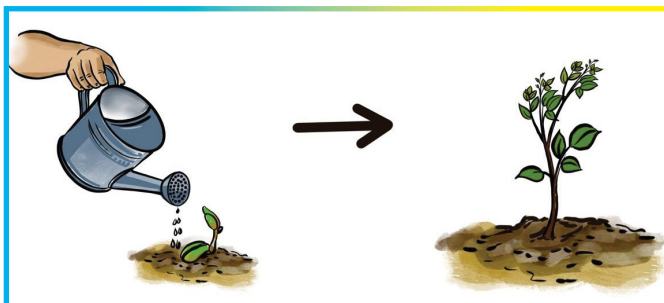
Specific Observations	General Conclusion
Case 1 Patient A, who smokes one pack of cigarettes daily, was diagnosed with lung cancer.	
Case 2 Patient B, who smokes two packs of cigarettes daily, was diagnosed with lung cancer.	
Case 3 Patient C, who smokes three packs of cigarettes daily, was diagnosed with lung cancer.	

Postulates of Induction

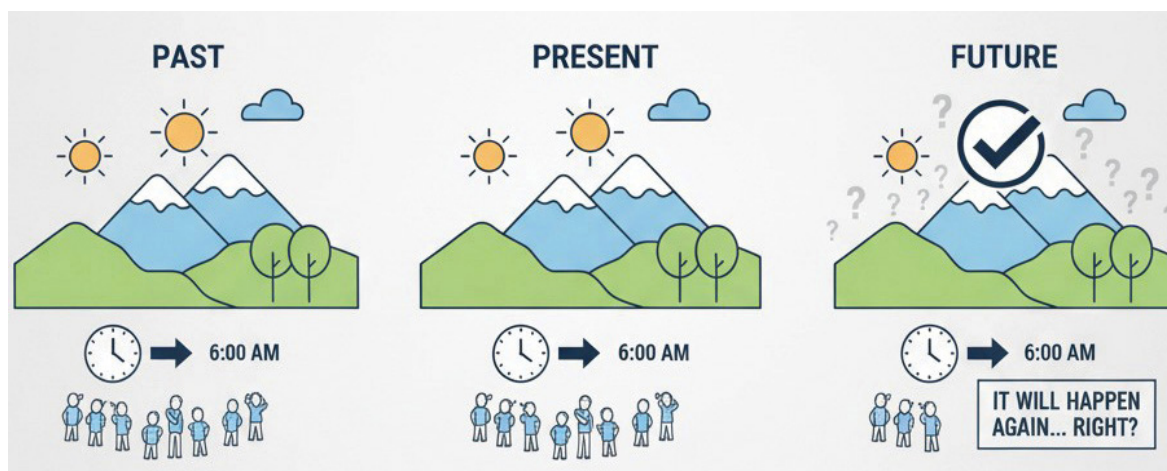
The Postulates of Induction are the elementary assumptions which are required to logically justify generalisations. The entire framework of inductive reasoning rests primarily on three core assumptions about the universe namely **the Law of Universal Causation, the Law of Uniformity of Nature and the Law of Unity of Nature**. These postulates are the fundamental axioms that allow us to move from specific observations to a general law, despite the logical jump (the Inductive Leap).

The Law of Universal Causation:

This is often considered a prerequisite for all scientific inquiry. It asserts that **every event or effect has a cause**. This law does not specify what the cause is, but rather assumes



that causes exist, making it worthwhile for scientists to search for them. This assumption is necessary for the elimination process in inductive methods.



The Law of Uniformity of Nature: This is the primary postulate of induction. It asserts that the laws and processes of nature will remain constant and consistent over time and across space. According to this law the same cause will produce the same effect under similar circumstance. In simple terms, **what happened in the past will happen again under the same circumstances in the future.** Without this assumption, no scientific experiment could

ever be replicated, and induction would be logically impossible.



The Law of Unity of Nature: This concept generally refers to the assumption that all phenomena in the universe are fundamentally interconnected and can be explained by a single, coherent set of natural laws. It suggests that the same principles governing a falling apple also govern the motion of planets, providing a philosophical basis for a unified scientific understanding. According to this postulate, though we find differences in this universe, **there is an underlying unity in nature.**



Activity 7

Suppose a scientist performs an experiment and gets a result. He repeats the experiment a week later and gets the exact opposite result.

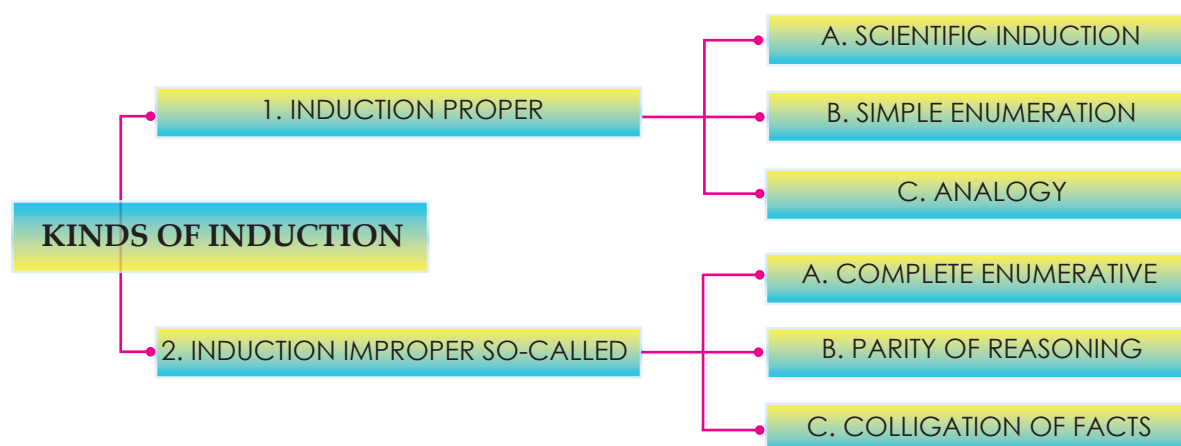
Which of the above laws has this single, specific failure challenged? Why?

.....

Kinds of Induction

While often discussed as a single concept, induction takes several distinct forms, each serving a particular purpose in building knowledge. Traditionally, induction is classified into **Induction Proper** and **Induction Improper so-called**. They are different mainly because inductive leap is present in Induction Proper, whereas it is absent in Induction Improper so-called.

The following chart demonstrates different **kinds of induction**.



Scientific Induction

Scientific Induction is the strongest method of fixing belief. It is foundational to the scientific method. **It is the process of establishing a universal law from particular instances.** It is a step-by-step procedure, characterized by systematic observation, inductive leap, and rigorous testing. It is often called **Eliminative Induction** or **Hypothetico-Deductive Method**. The conclusion is highly probable because competing explanations have been actively ruled out.

Steps of Scientific Induction

There are four stages in the process of scientific induction.

We will examine the steps of scientific induction, applying them to a real-world scenario.

I. Observation of Facts

This initial step in the inductive procedure involves gathering specific, factual data about a phenomenon through carefully controlled experience or experiment. The goal is to collect a sufficient number of instances under various conditions. Observation of facts involves analysis and elimination of data. Irrelevant facts are eliminated, and necessary ones are selected for further study.



Case Study: Health officials and epidemiologists detect a sudden, unexpected increase of severe brain infection cases in a specific area of Kerala, often among children or young adults.

Specific Facts Observed:

Fact A: Several patients present with similar severe symptoms (high fever, stiff neck, confusion, rapid deterioration).

Fact B: Laboratory tests confirm the presence of brain-eating amoeba in the cerebrospinal fluid of these patients.

Fact C: A detailed case history reveals that many of the affected individuals have a common water exposure history, such as swimming or bathing in a particular warm, stagnant freshwater source (like a pond or unchlorinated pool) in the days leading up to their illness.



II. Formation of Hypothesis

Based on the uniformity and repetition observed in the facts, a provisional explanatory statement known as a hypothesis is formulated. This statement is a tentative generalisation that attempts to explain why the observed facts occur.



Hypothesis formed: The "brain-eating amoeba," present in local warm, stagnant freshwater bodies is entering the victim's brain through the nasal passage during swimming or bathing, and causing Primary Amoebic Meningoencephalitis (PAM).



III. Verification of Hypothesis

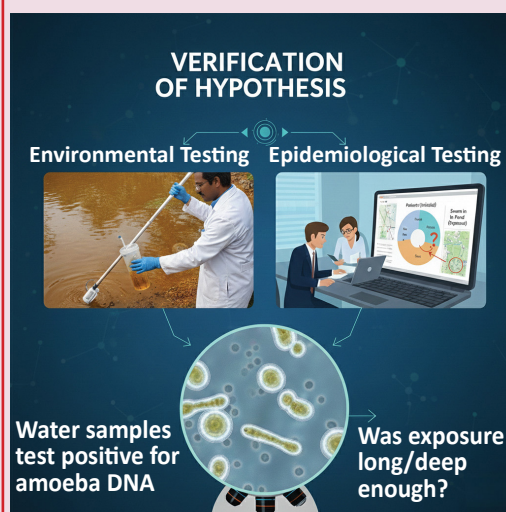
This is the critical phase where the hypothesis is tested to see if it holds true under controlled conditions and different circumstances. This involves deducing consequences from the hypothesis and then testing those consequences experimentally.



Testing: Water and sediment samples are collected from the suspected water bodies such as ponds.

Prediction (Deduction): If the hypothesis is true, these water sources should test positive for brain-eating amoeba DNA.

Epidemiological Testing: Officials look for persons with the infection who did not swim in the suspected water (to rule out the hypothesis) and non-infected people who did swim (to refine the hypothesis – Was the exposure long enough? Was it deep-diving?).



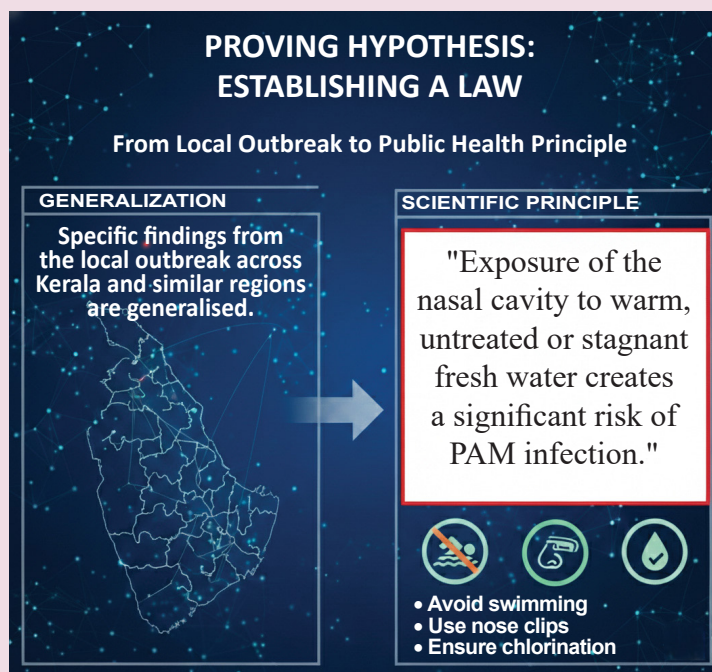
IV. Proving the Hypothesis (Establishing a Law)

In the final stage the hypothesis must be repeatedly verified. It should survive rigorous attempts at falsification. It must also offer strong predictive power. When these conditions are met, the hypothesis is accepted provisionally as an **Inductive Generalisation** or a **Scientific Law**.



Generalisation: The specific findings are generalised beyond the single local outbreak.

Scientific Principle/Law (Inductive Conclusion): It is established that, in Kerala (and similar regions), exposure of the nasal cavity to warm, untreated, or stagnant freshwater carries a significant, life-threatening risk of PAM infection. This principle forms the basis of all future public health advisories: avoid swimming in such water, use nose clips, and ensure proper chlorination of tanks and pools.



This final generalization moves beyond the original observations. It establishes a universal principle that is highly probable and predictive for all future instances, until proven otherwise.



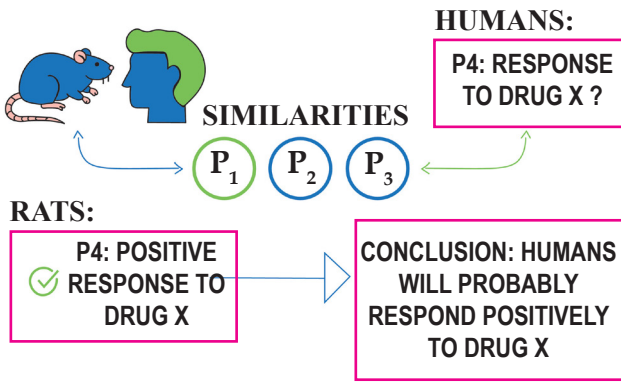
Activity 8

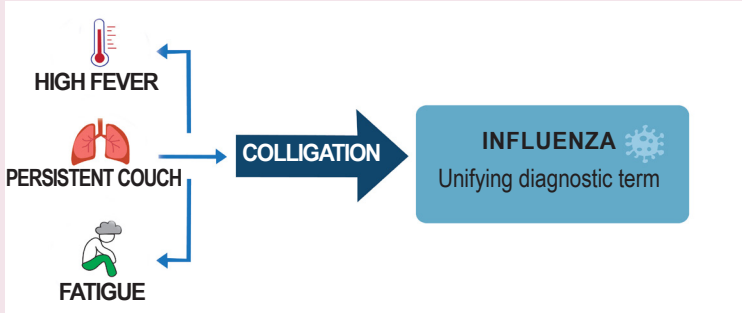
Take up a project to investigate the problem of 'Your classmate's poor performance in the recent exams'.

Apply the steps of scientific induction and finally suggest measures for solving the problem.

We shall now discuss the rest of the kinds of Induction together as they are less rigorous when compared to the Scientific Induction.

Let us explore them one by one.

Name of Induction	Description
Simple Enumeration <i>Example: Observing some zebras found so far, we generalise:</i> <i>"All zebras are striped animals."</i>	A generalisation made after observing some members of a group and assuming the rest will be the same. The conclusion is highly uncertain if not supported by proper methods. 
Analogy 	Since two or more things are similar in one or more known ways, we infer they must also be similar in some further unknown way. The strength of the argument depends on the relevance and number of known similarities. • Example: Rats and humans are similar in P_1 (liver enzymes), P_2 (cardiovascular system), and P_3 (genetic commonalities). • Rats have property P_4 (positive response to Drug X). • Conclusion: Therefore, humans probably have property P_4 (will respond positively to Drug X).

Complete Enumeration (Perfect Induction) <i>Example: All continents on Earth consist of land.</i>	A generalization made after examining every single member of a limited group. The conclusion is certain because all cases have been verified. 
Parity of Reasoning	A principle asserting that a new argument or case must have the same conclusion as a previous one because their logical structure or underlying justification is identical. This means the form of reasoning, not the content, demands consistency between the two cases. Example: If a judge rules in Case A that the principle of self-defense applies because the defendant faced imminent harm, then in a new Case B with identical circumstances, the ruling must be the same by parity of reasoning.
Colligation of Facts	Colligation of Facts is the inductive process of mentally binding together a number of separate, observed facts under a single unifying concept or term. It is primarily a descriptive act that provides structure and meaning to a set of observations, enabling further investigation. Example: A doctor observes a patient's discrete symptoms—a high fever, persistent cough, and fatigue—and colligates these individual facts under a single, unifying diagnostic term, such as influenza. This term describes the cluster of symptoms before the precise viral mechanism is confirmed. 


Activity 9

Match the **Column I** that contains 'Examples for different inductive generalisations' with the **Column II**.

Instruction: Write in Column II the letter corresponding to the type of induction

- : 'A' if Simple enumeration
- : 'B' if Induction by analogy
- : 'C' if Complete enumeration
- : 'D' if Parity of reasoning
- : 'E' if Colligation of facts

No.	I Inductive Generalisations	II (A / B / C/D / E)
1.	Every swan I have ever seen in my life, across three continents, has been white. Therefore, all swans in the world must be white.	
2.	A public health official observes scattered reports of high fever, difficulty breathing, and rapid spreading within a city. Considering these facts he infers: "There is an outbreak of a respiratory virus."	
3.	A university committee grants a fee waiver to Student A based on his financial hardship documentation and academic standing. As per the above logical justification, the committee must grant a fee waiver to Student B who has identical hardship documentation and academic records.	
4.	A librarian checks every book currently shelved on a specific small cart containing exactly 30 books to confirm if they all belong to the fiction section. Since all 30 books were individually verified, he concludes that "all books on this cart are fiction".	
5.	A new smartphone, the 'Nova 5,' is built using the same materials, runs the same operating system, and is sold by the same vendor as the reliable 'Aura 4.' Since the 'Aura 4' has a long battery life, the 'Nova 5' will also have a long battery life.	

In this chapter we have learnt that there is a reciprocal relation between induction and scientific method. Observation and experiment are inevitable processes in science. We shall learn about them in detail in the next chapter.

Chapter

7 OBSERVATION AND EXPERIMENT

Read the following generalisation reached through inductive reasoning.

"All plants grow healthy in sunlight".

How do we come to this generalisation?



We observe many plants exposed to sunlight over several days. Facts regarding this are collected. Simultaneously, plants not exposed to sunlight are also observed. The facts collected are as follows: "plants exposed to sunlight are healthy and plants not exposed to sunlight are unhealthy".

This simple experiment and constant observation help us to form the above generalisation.

Thus, we know that observation and experiment are necessary for induction. They investigate and discover truth, facts or evidence. Observation and experiment provide material ground for scientific thinking and inductive reasoning. In this chapter we discuss observation and experiment. Every branch of knowledge begins with curiosity, a desire to know why and how things happen. To find answers, we rely on these two fundamental tools of learning.

Observation: Meaning and Definition

The word '**observation**' comes from the Latin word *observare* (*ob* = *before* + *servare* = *to keep*), which means to watch, to note or to pay attention to. Hence, observation means keeping an object before the mind. Observation is watching carefully, noticing, and studying events, objects or phenomena in order to gain information or knowledge. **Observation is a deliberate or attentive perception of a phenomenon presented by nature.**

Observation and Mere Perception

Perception means sensation or simply becoming aware of something through our senses like, seeing a flower or hearing a sound. It is a passive process. Observation on the other hand is careful, deliberate and systematic act of perceiving things with a specific purpose. For example, seeing a flower you examine the flower's colour, shape, petals, etc. There are attention, analysis and interpretation in it. Observation encompasses perception, yet it incorporates mental focus and reasoning, positioning it as a more advanced and scientific process. All observations are perceptions, but not all perceptions are observations.



Activity 1

Complete the following chart.

Observation	Mere Perception
• All observations are perceptions	• All perceptions are not observations
•	•
•	•
•	•

Characteristics of Scientific Observation

Imagine you are an ornithologist, observing birds in a sanctuary.

The checklist for this observation is:

1. Should we just watch randomly or follow a plan?
2. Should we write what we feel or what we see and measure?
3. What tools can we use to observe the birds?
4. Why do we record every observed fact in a notebook?

From these factors we can conclude that observation is systematic, objective, purposeful, and selective. Instruments may also be used to support and improve observation.

These are the main characteristics of scientific observation:

1. Purposeful/Teleological
2. Selective
3. Objective
4. Instrumentation

Let us discuss them in detail.

1. **Observation is purposeful/ teleological:**

Observation is defined as a selective perception of facts with a certain purpose. It is the study of events as they occur in nature. Observation perceives things with a purpose. For example, a student watches a plant everyday to see how it grows when watered regularly. The student measures its height and counts its leaves each morning. The student's purpose is to find how water helps the plant to grow. Observation is purposeful because it is done with a clear aim.



2. **Observation is selective:** Observation is perception with definite purpose, so an observer must select only those facts which are connected with the purpose. It is not possible to observe all things at the same time. Out of the millions of facts in nature, the mind chooses only the relevant facts for the purpose. For example, take a farmer, an artist, and an ornithologist on a hilltop and ask them what they see. The farmer





is likely to notice the nature of the pasture, the artist, the beauty of the landscape; whereas the ornithologist, the variety of the birds. Thus, we can say that scientific observation is selective.

3. **Observation is objective:** It means that it is free from personal feelings, emotions or bias. A scientific observer records only what is actually seen, heard or measured, and not what they think or feel about it. It records facts exactly as they are. For example, a student observing birds in a sanctuary notes, 'there are seven birds on the first tree and three birds on the second, instead of commenting 'trees look beautiful.'



4. **Instrumentation:** Observation depends upon our sense organs, but the capacity of the sense organs is limited. Various instruments are used in observation to extend the limits of sense organs. They make observation accurate, vivid and effective. For example, binoculars, telescope, microscope, ultra sound machine, X-ray machine, thermometer, etc. are some of the instruments used in various fields for effective observation.

Essential Observational Skills

In a scientific observation, the quality of the results largely depends on the observer. Do you agree with this statement? Discuss the qualities of a good observer and list them in the pie chart below.



Activity 2

Complete the chart.



Let us discuss the essential observational skills required.

- **Knowledge:** The observer must be qualified for the task and should possess necessary knowledge in the field of study.
- **Intellectual Curiosity:** The observer must have intellectual curiosity or a spirit of enquiry.
- **Proper usage of Instruments:** The efficiency to use various instruments in observation is an essential requirement.
- **Healthy sense of Perception:** Sharp senses such as sight, hearing, touch, etc. help the observer to notice even the smallest changes or details in an event.
- **Creativity:** A creative and imaginative mind helps the observer interpret and connect facts to form new ideas or discoveries.
- **Objectivity:** An observer should be unbiased and impartial. All the instances which one comes across must be carefully observed without prejudice.
- **Open mindedness:** Openness of mind and flexibility to accept new facts and to reject faulty or mistaken views are important qualities of a good observer.
- **Patience:** Observation takes time. A good observer waits patiently to collect the facts before forming conclusions.

Different Types of Observation

Observation can be classified in various ways depending on the method, setting, and involvements of the observer.

- *Subjective and Objective observation*

All observation consists of two main components, namely, the subject who observes and the object observed. **Subjective observation** is based on one's own immediate experience, personal feelings, opinions, beliefs, interpretation and the like. Different people may observe the same thing differently. Whereas, **objective observation** is based on facts, which is free from personal feelings and can be measured and verified. For example, if we say 'the weather is very hot today' it is subjective observation. On the other hand, if we say, 'the temperature is 38°C', it is objective observation.

- *Direct and Indirect Observation*

In a **direct observation**, the observer is physically present in the process of observation. Direct observation provides immediate

awareness of a given situation. For example, a news reporter is physically present while observing and reporting an event. Whereas in an **indirect observation** the observer is not physically present in the process of observation. The observer just studies the facts already observed and recorded. For example, a viewer of a channel observes a news being reported.

- *Participant and Non-Participant Observation*

In a **participant observation**, the observer becomes part of the group or situation being studied. This helps to understand the behaviour of the group. For example, a teacher joins with the students in a group discussion to observe how they interact. In contrast, a **non-participant observation** is where the observer remains separate and does not take part in the activities. The observer only watches and records what happens. For example, a teacher observes the students' interaction without being involved in the discussion.

- *Structured and Unstructured Observation*

In a **structured observation**, the observer uses a fixed plan or schedule to record observations systematically. For example, a nurse records patient's temperature, pulse rate and blood pressure at a fixed interval. On the other hand, in an **unstructured observation** there is no fixed plan, the observer freely observes the event. For example, a nurse casually observes a patient's comfort, pain level and mood.

- *Controlled and Uncontrolled Observation*

Controlled observation is a process in which the phenomenon is under the control of the observer. For example, animals are observed in a zoo or a laboratory. **Uncontrolled observation** is made in a natural environment and is not under the control of the observer. For example, animals are observed in their natural habitat.

Advantages of Observation

Observation has wider scope: Observation has wider scope because it can be used in many fields and situations. Observation becomes a universal method for gathering knowledge and understanding reality. For example, the facts about distant objects like stars, comets, eclipses, etc. can be studied only through observation. In this sense, observation is wider in scope.

Observation is a process from cause to effect and vice versa: In observation a person can study events and understand the relationship between cause and effect. By carefully observing, one

can move from cause to effect and also from effect to cause. For example, if a drug is injected into the human body, we can observe its reaction (cause to effect). Whereas in the case of a postmortem, we can observe and discover its cause from the effect.

Observation prepares the way for experiment: It means that observation is a preparatory step for experiment. Before conducting an experiment, a researcher must carefully observe facts as they occur in nature. For example, Newton first observed the falling of the apple and then performed experiments to discover the law of gravitation.

Observation helps to study the natural and social phenomena: Observation is the best method for understanding real-life picture of the events in their natural setting. For example, a researcher observes mob behaviour during a carnival.

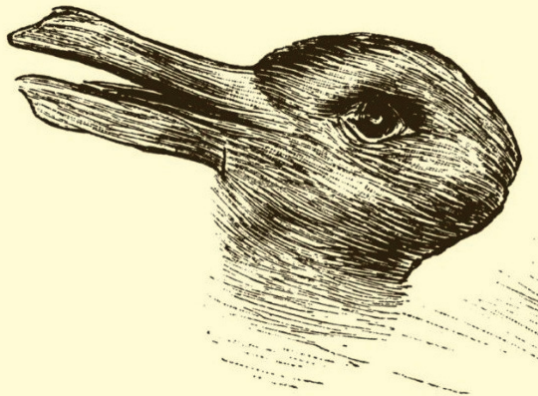
Fallacies of Observation

What do you see in the image?

A rabbit?

A duck?

Or what else?



Your brain is selecting only one interpretation of the image at a time, so you can see only one thing. It is an illusion.

Fallacies of observation are errors or biases that occur during the process of observing phenomena which can lead to incorrect conclusions. It may lead to fallacious induction. The fallacy in observation affects the purpose of inductive procedure. So, it is necessary to know the fallacies of observation, not to commit them.

J. S. Mill classifies fallacies of observation into **Positive (Mal-observation)** and **Negative (Non-observation)**.

Fallacy of Mal-observation

Mal-observation is a fallacy due to the wrong interpretation of the observed facts. In this fallacy what is perceived is misunderstood. It is a wrong or mistaken observation.



Difficulties in a Good Observation

Observation is an important step in scientific investigation, but it is not always easy or perfect. Several factors can make accurate observation difficult.

- **Complexity of the phenomenon**

- Some natural events or scientific processes are very complicated.
- They may involve many conditions that are hard to control.

- **Time Limit of the Phenomenon**

- Some phenomena occur very quickly or only for a short period.
- When the event occurs swiftly it becomes hard to observe.

- **Limitations of the Observer**

- Observers may make mistakes due to poor vision, hearing, memory or lack of attention.
- Fatigue, stress or illness can further weaken observational ability.

- **Influence of Personal Factors (Subjectivity)**

- The observer's likes, dislikes, beliefs, pride, and prejudices can distort judgment.
- When a person expects a particular outcome, they may unintentionally observe only what matches their belief.

Mal-observations are categorised into two types, **Individual Mal-observation** and **Universal Mal-observation**.



1. Individual Mal-observation

When any individual wrongly observes a thing to be something else it is **individual mal-observation**. e.g., The observation of a rope as a snake, a post for a ghost, a shell for a silver, optical illusions, mirage etc. It is the case where an individual is confused with the observed facts that lead the fallacy. This error occurs due to the individual's personal bias, lack of attention, poor eye

sight, fatigue, preconceived notions and the like. Such fallacies may lead to incorrect conclusions based on the observer's wrong perception.

2. Universal Mal-observation

Universal mal-observation is a type of observational error or illusion which is universally found with everyone. Anyone may commit such mistake under similar circumstances. It may affect all observants similarly.

e.g., The parallel railway lines appear to merge at certain point. Here even careful observation will not help in overcoming such wrong perception. The most popular example of universal mal-observation is the case of sunrise and sunset. However, scientifically there is neither literally sunrise nor sunset.



Fallacy of Non-observation

The fallacy of non-observation occurs when a person fails to observe relevant facts or instances that are essential for forming a correct judgement or conclusion. In other words, something important is overlooked or ignored.

The fallacy of non-observation occurs in two ways. They are:

1. Non-observation of essential circumstances (partial non-observation)
2. Non-observation of instances (complete non-observation)

1. Non-observation of Essential Circumstances

It happens when a person fails to notice important conditions or factors that are necessary to understand a situation correctly. Because these essential circumstances are overlooked, the observation becomes inaccurate or misleading. For example, a driver assumes a car does not start because of a dead battery and does not notice the fuel tank is empty; a teacher thinks a student is lazy not observing that the student is unwell, missing an essential circumstance.

2. Non-observation of Instances

Non-observation of instances is a fallacy in which we ignore (omit) instances which are relevant for investigation. It is a case where some instances

are omitted either intentionally or unintentionally. The argument 'No Indians are punctual' is an example of non-observation of instances. Here, from the observation of a few instances of persons who are not punctual, all Indians are blamed. This argument does not observe instances that are contrary to the conclusion.

Many superstitions are due to the non-observation of instances such as;

- Spotting a black cat is a bad omen.
- Seeing one myna is a bad luck.
- Broken mirror brings seven years bad luck.
- Good people die young.

In all these examples, people tend to remember the occasions when bad luck followed the event but ignored the occasions when nothing bad happened.



Activity 3

Read the following observations and sort the fallacies accordingly in the table below.

- Delusion of a person.
- A person thinks he is sick because he went out in rain, overlooking the fact of a viral infection.
- Trees seems to move while we travel in a bus.
- Mistaking a person for another from a long distance.
- Online classes are ineffective.
- A workman blames the tool, overlooking his inefficiency.
- Tuesday is an inauspicious day.
- The moon walks along with us.

Individual Mal-observation	Universal Mal-observation	Non- observation of Essential Circumstances	Non- observation of Instances

Experiment: Meaning and Definition



Activity 4



Take a pencil



Take a glass of water



Dip the pencil in the water



Repeat the above activity using salt water and oily water. Record your findings.

The above activity is an example for a simple experiment. The role of experiment in scientific induction is to provide specific evidences for a general conclusion.

Experiment is the process of collecting facts which are artificially produced by humans. Experiment is observation under controlled conditions. According to logicians, observation is discovering a fact and experiment is making one. The word '**experiment**' is derived from the Latin word *experimentum*, meaning a trial, a test, or a proof.



Archimedes' Eureka Moment



More than 2000 years ago, the king of Syracuse suspected that his gold crown was mixed with silver, but he did not want it damaged to check its purity. This presented a difficult problem for the Greek mathematician Archimedes, who was asked to find a solution.

One day, while stepping into a bath, Archimedes noticed that the water level rose as he stepped in it. Suddenly, he realised that objects placed in water displace an amount of water equal to their volume.

With this idea, he understood that he could compare the crown's volume to that of pure gold by measuring how much water each displaced.

Excited by his discovery Archimedes is said to have run through the streets shouting "Eureka!" meaning "I have found it."

Using his method, he showed that the crown displaced more water than an equal weight of pure gold, proving it had been mixed with a less dense metal. This simple experiment became the foundation of what we now call the principle of buoyancy, an important concept in physics and engineering.

Characteristics of an Experiment

Controlled conditions: In an experiment we have full control over the phenomenon.

Systematic: Experiments follow carefully planned procedure to ensure accuracy, reliability and consistency.

Repeatability: Experiment can be repeated any number of times. This ensures consistency of result.

Objectivity: Results are unbiased and based on facts, not personal opinions.

Measurable: Results are observed carefully and recorded for analysis.

Accuracy: Experiment gives more accurate knowledge of a phenomenon.

Merits of Experiment

Variation of factors: Experiments allow us to change one factor at a time and observe how it affects results. In experiment, we can vary or change the circumstance of the phenomenon under different conditions. For example, the effect of a medicine may be tested by varying its dosage or by administering it to a different person living under different surroundings.

Time saving: The experiments are performed under the control of the performer. Hence the problem of waiting for the occurrence of the event in nature does not arise in the case of experiment. For example, we have to wait for a long time to see a rainbow in nature. But to make a rainbow in laboratory, no waiting period is required.



Accurate knowledge: Experiment gives more accurate knowledge of a phenomenon. Precision is the watchword of science and this can be achieved by conducting experiments.

Rapid and sure progress: Experiments have made tremendous progress in extending our knowledge in every field. Experiment gives rapid and sure conclusions.

Chance for repetitions and modifications: The chance for modification and repetition is possible in experiment. It can be repeated multiple times to confirm results. If results are unexpected, it can be modified. Repetition and modification help to reduce errors and make them precise.

**Activity 5**

Complete the following comparison table.

Experiment	Observation
1. Conducted under controlled conditions	1. Conducted even under uncontrolled conditions
2. Phenomenon is made	2. Phenomenon is discovered
3.	3.
4.	4.
5.	5.
6.	6.
7.	7.

In this chapter, we have studied the two fundamental tools employed in inductive inquiry, which form the basis of all scientific investigation. The identification of a problem leads to systematic observation and experimentation with facts. In the next chapter, we shall proceed to examine the remaining steps involved in the process of scientific induction.

Chapter

8 HYPOTHESIS



Activity 1

Suggest possible reasons for the given problems.

Problem	Reason
1. The phone shows a "High Temperature Warning"	• Overuse • •
2. You are not feeling well	• Insufficient sleep • •
3. Your parent did not return home from office at the usual time	• Traffic delay • •



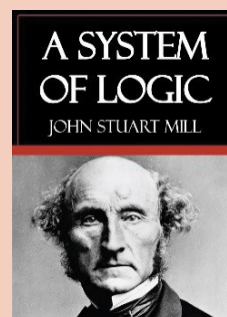
Your responses to the above activity illustrate some possible guess works regarding the causes of the problems mentioned. The human mind naturally seeks to connect known to explain the unknown facts. For example, if we find the ground wet in the morning, we may assume, "It must have rained last night." This possible explanation for the cause of a problem is called a hypothesis. In this lesson, we will learn more about hypothesis.

Meaning and Definition of a Hypothesis

The term **hypothesis** is derived from two Greek words: *hypo* and *thesis*, where *hypo* means *under, below or less than* and *thesis* means *placing*. So, literally hypothesis means something that is *placed below*. A hypothesis is a temporary statement which can claim only a lower status to a theory. It is not the real solution to the problem until verified. A hypothesis is thus a tentative guess or a provisional solution to a problem.



John Stuart Mill in his famous book *A System of Logic*, defines a hypothesis is "any supposition which we make (either without actual evidence, or on insufficient evidence) in order to endeavour to deduce from its conclusions in accordance with facts which are known to be real; under the idea that, if the conclusions to which the hypothesis leads, are known truths, the hypothesis itself either must be, or at least is likely to be, true."



A hypothesis is defined as a provisional assumption put forward as a possible explanation of facts. It is always provisional because it is based on insufficient evidence. It must be tested by observation and experiment before it can be accepted as true. A hypothesis is not merely a guess, but a reasonable assumption suggested to explain why something happens. It is a reasonable guess because it is based on previous observations, existing theories, scientific evidence, and logic. If the assumption corresponds with the real fact, then the hypothesis will be true or at least likely to be true. It is not a claim of truth but a claim for truth.

Cohen and Nagel describe a hypothesis as the initial tentative proposal that drives a scientific inquiry. It guides the scientific enquiry by serving as the starting point for research. It points to the direction in which the researcher makes observations and experiments. From the identification of the problem to finding its solution, the hypothesis serves as a bridge in the process of enquiry.



Activity 2

Read the following quotations and note the concepts you have gained regarding hypothesis.

“A hypothesis is an attempt at explanation; a provisional supposition made in order to explain scientifically some fact or phenomenon.”

Prof. Peter Coffey

“A hypothesis is a tentative supposition which is put forward for explaining the fact that cannot be understood without it.”

L. Susan Stebbing

-
-
-

Difference between Common Man's Guesswork and Scientific Hypothesis

Framing hypothesis is not the monopoly of the scientists. Even ordinary people suggest several hypotheses about everyday facts which they come across in their experiences. For example, when a theft occurs in a house, or a murder in the neighbourhood, they make several guesses about a possible culprit. However, a scientific hypothesis is different from such ordinary guesses.

Common man's guesswork	Scientific hypothesis
Factual but superficial	Based on evidences
Less precise	More precise and comprehensive
Taken for granted and not proved	Verified and proved

Sources of a Hypothesis

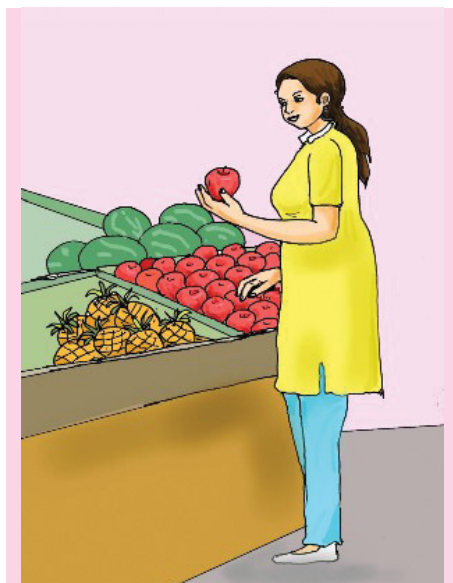
Hypotheses do not emerge from a single source. They are created by the mind based on the observations and experiences of the observer. They are the result of an attentive, creative, intuitive, and imaginative mind.

Let us discuss some important sources of hypotheses.



EARTH AND MARS – A COMPARISON		
		
Earth		Mars
23.4°	AXIAL TILT	25.2°
6,371 km	MEAN RADIUS	3,389.5 km
1	NUMBER OF MOONS	2
24 hours	DAY LENGTH	24.6 hours
Nitrogen & Oxygen	ATMOSPHERE	Carbon Dioxide, Nitrogen, and Argon

Analogy: This is one of the most fruitful ways of forming a hypothesis. It is based on the observation that two things resemble each other in some respects. When two things resemble each other, then the inquisitive mind suggests that there is some connection between them. For example, the planets Earth and Mars resemble each other in day length, seasons and terrestrial compositions. On the basis of these resemblances, one can suppose that Mars can also be inhabited by living creatures. Though not strictly true, this analogy has helped in further research.



Simple Enumeration: In chapter 6, we have studied that induction by simple enumeration suggest a possible explanation. It is regarded as another important source of hypothesis. By observing some instances of the given phenomenon, a general statement is suggested as a relation. For example, if some of these apples are ripe, then all the apples in the basket are likely to be ripe.

Profound Knowledge: It is meaningless to start thinking about a problem without having any prior knowledge about it. Hypotheses are suppositions based on previous knowledge and prior studies. A deep understanding of the field of enquiry is needed to form a good working hypothesis.

Insights: Many great scientific theories have been discovered by a sudden flash of knowledge. The framing of a good hypothesis is the work of a powerful intuition. For example, a brilliant insight enabled Alexander Fleming to discover penicillin.



Discovery of Penicillin

In 1928, Alexander Fleming, a Scottish bacteriologist, was studying *Staphylococcus* bacteria in his lab. While returning from a vacation, he observed several exposed culture plates in his lab. On one plate, he noticed a patch of green fungus surrounded by a clear zone where the bacteria had failed to grow. Instead of discarding the contaminated plate, Fleming had an instantaneous flash of insight. His intuition told him that it wasn't just a mistake. Something from the fungus was actively killing the bacteria. He realised that the fungus produced an antibacterial agent. This insight transformed a common laboratory contaminant into a potential world-changing antibiotic medicine, penicillin.



Creative Imagination: Imagination plays an important role in the formation of hypothesis. It is the ability to generate an innovative idea based on observation of facts and imagination. Every hypothesis originates in the investigator's imagination. For example, the development of periodic-table by Dmitri Mendeleev.



Mendeleev's Periodic-Table

"If elements are arranged by increasing atomic mass, their chemical properties will repeat periodically, and gaps exist for elements yet to be discovered."

Dmitri Mendeleev, a Russian chemist, was preparing a textbook and

needed a logical way to organise the 60 known elements for his students. He wrote the properties of each element (atomic mass, density, and reactivity) on separate cards and arranged them like a deck to search for patterns. At the time, these properties existed as scattered facts without a unifying framework. Mendeleev later said that the breakthrough came while he imagined the elements falling into place in rows and columns according to periodically repeating properties. This is a powerful example of the mind creatively sorting information which led to the creation of the periodic table.



Periodic Table of Elements
based on Mendeleev's Periodic Law

I		II		III		IV		V		VI		VII		VIII	
He 4.00	H 1.01	Li 6.94	Be 9.01	B 10.8	C 12.0	N 14.0	O 16.0	F 19.0							
Ne 20.2	Na 23.0	Mg 24.3	Al 27.0	Si 28.1	P 31.0	S 32.1	Cl 35.5								
Ar 40.0	K 39.1	Ca 40.1	Sc 45.0	Ti 47.9	V 50.9	Cr 52.0	Mn 54.9	Fe 55.9	Co 58.9	Ni 58.7					
	Cu 63.5	Zn 65.4	Ga 69.7	Ge 72.6	As 74.9	Se 79.0	Br 79.9								
Kr 83.8	Rb 85.5	Sr 87.6	Y 88.9	Zr 91.2	Nb 92.9	Mo 95.9	Tc (99)	Ru 101	Rh 103	Pd 106					
	Ag 108	Cd 112	In 115	Sn 119	Sb 122	Te 128	I 127								
Xe 131	Ce 133	Ba 137	La 139	Hf 179	Ta 181	W 184	Re 186	Os 194	Ir 192	Pt 195					
	Au 197	Hg 201	Tl 204	Pb 207	Bi 209	Po (210)	At (210)								
Rn (222)	Fr (223)	Ra (226)	Ac (227)	Th 232	Pa (231)	U 238									

Dobereiner's triads
 Known to Mendeleev
 Lanthanide series
 Actinide series
 ● Known to Ancients

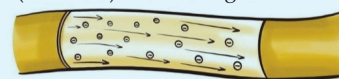


Activity 3

List the sources of a hypothesis.

- Resemblance between observed facts:
- Relation suggested by observing a few instances:
- A deep understanding of the field of enquiry:
- Ability to generate innovative ideas based on observed facts and imagination:
- A sudden flash of knowledge:

Electric Current : Charged particles (electrons) flow through a wire



Water Current : Water particles flow through a pipe



Characteristics of a Good Hypothesis

Every hypothesis is a prediction about the cause of a phenomenon. But not every prediction is a hypothesis. The English logician W. S. Jevons says, "Agreement with fact is the sole and sufficient test of a true hypothesis."

To be called a scientific hypothesis, a supposition must satisfy the following criteria:



- **Factual:** The aim of hypothesis is to offer a possible explanation of the observed facts. It cannot be independent of facts. Observation of facts is the foundation of a hypothesis.
- **Explanatory:** A good hypothesis must actually explain the phenomenon. It should make the facts about the phenomenon more intelligible and believable. It should not be absurd.
- **Self-consistent:** A good hypothesis must not contradict the other observed facts of the same phenomenon.
- **Compatible:** A good hypothesis must agree with the previously established laws. It must be compatible with the existing knowledge.



The condition of compatibility can be challenged or over-ruled at times. For example, Copernican theory of the universe. According to it the Sun is the centre of the solar system. It challenged and replaced Ptolemy's theory of the universe that the Earth was the centre of the universe which was once established and accepted as a theory.

- **Capable of deductive development:** A hypothesis must be framed in such a way that consequences can be deduced from it. It must lead to new discoveries which can later be observed.
- **Able to predict events:** In addition to clearly explaining the facts for which it is formulated, a hypothesis must also be able to predict future events.
- **Verifiable:** A scientific hypothesis must be testable through observation and experiment. Observation and experiment decide whether a speculation is true or false. If these are not possible then it cannot be considered a hypothesis. Verifiability is one of the hallmarks of a good hypothesis.
- **Falsifiable:** This is another characteristic of a good hypothesis. A hypothesis is always tentative. It shall not be dogmatic. Even when verified, it remains open to revision if new facts demand it. Science advances by improving or replacing old hypotheses.
- **Relevant:** A relevant hypothesis is one from which the facts to be explained can be deduced. The explanations must be relevant to the problem under consideration.
- **Simple:** A good hypothesis should not be unnecessarily complicated. It must explain the fact in a simpler and more efficient way. A hypothesis requiring fewer calculation and observation is considered good.



Activity 4

Find the characteristics of a good hypothesis in this word grid puzzle.

F	A	C	T	U	A	L	Q	P	R	S	T	U	V
A	E	X	P	L	A	N	A	T	O	R	Y	W	X
L	J	K	L	M	V	E	Y	Z	A	S	T	U	V
S	E	L	F	C	O	N	S	I	S	T	E	N	T
I	B	C	D	E	D	U	C	T	I	V	E	D	N
F	G	H	I	J	K	L	M	N	M	P	Q	R	A
I	W	X	Y	Z	A	B	C	D	P	F	G	H	V
A	V	E	R	I	F	I	A	B	L	E	G	H	E
B	W	X	Y	Z	S	I	M	P	E	E	A	B	L
L	J	K	L	P	R	E	D	I	C	T	I	V	E
E	D	C	O	M	P	A	T	I	B	L	E	C	R

How can we frame a good Hypothesis?



A student notices that a plant in her classroom is almost dried up. Let us help her to formulate a hypothesis.

Steps of formulating a hypothesis		
I	Ask questions such 'who,' 'what,' 'when,' 'where,' and 'why' based on observations to the identified problem.	• What happened to this plant? • Why did this plant dry out? • Does the sunlight influence plant growth?
II	Suggest answers to these questions using 'because' to explain your reasoning.	That plant is healthy because it might have received sufficient sunlight. This plant dried out because it might not have received sufficient sunlight.
III	Check whether these answers are testable and falsifiable.	Take the dried plant and place near sunlight to observe the changes.
IV	Clearly define the factors involved in the investigation	• Amount of sunlight (hours per day) • Growth of the plant (height in cm)
V	Thus, we formulate the hypothesis: 'If the plant receives more hours of sunlight each day, then it will be healthier than a plant that receives fewer hours of sunlight'	



Activity 5

Formulate a hypothesis in the manner described above for the following cases.

Case 1 : Lack of interest in studies

Case 2 : Social media addiction

Different Kinds of Hypothesis

A hypothesis plays an important role in scientific enquiry. There are different ways in which hypotheses can be used in scientific reasoning.

Working Hypothesis

A working hypothesis is a hypothesis accepted for a short period. It is an explanation used as a guide for investigation until better evidence is available. It is adopted temporarily to direct research, even if its truth is not yet established. A working hypothesis does not claim to explain facts. It is accepted only as a starting point of a new investigation. Once the necessary data are collected, a working hypothesis becomes redundant. It is legitimate, meaningful, and always verifiable. Based on the data collected, it is subject to acceptance, modification, or rejection.

For example, before establishing the actual cause of the COVID-19 pandemic, scientists would have proposed some of the following working hypotheses:

- The virus may have originated from bats.
- The virus may have spread from bats to other animals.
- The virus may have been transmitted through the air.



Rival Hypothesis

A rival hypothesis is an alternative explanation of a phenomenon. It competes with the original hypothesis to explain the same set of facts. It is not a complementary hypothesis, but one that challenges or rivals the proposed hypothesis. It helps to determine which hypothesis better fits the facts.

For example, why is the road wet?

- Two suppositions:
 1. The road is wet because it rained last night.
 2. The road is wet because the street cleaners washed it in the morning.

Crucial instance or crucial experiment is an observation or experiment used to determine which one of the two rival hypotheses is correct. The appropriate instance that leads us to a solution of the problem is known as a **crucial instance**. If the crucial instance is established by experiment it is called a **crucial experiment**. It is *crucial* because the result provides evidence that rules out one explanation and supports the other.



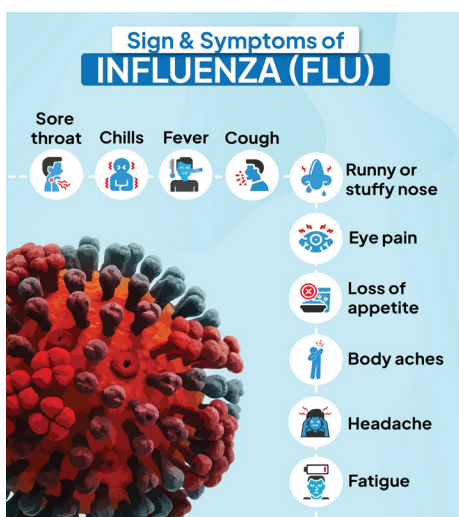
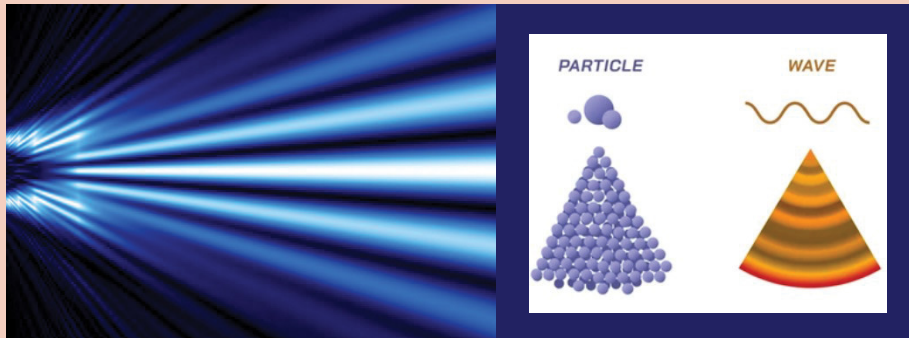
Is light a particle or a wave?

Two suppositions:

1. *If two bright spots fall on the screen, then light is a particle.*
2. *If a pattern of bright and dark bands appears on the screen, then light is a wave.*

In 1801, Thomas Young conducted the double-slit experiment. When the light passed through the slits, the pattern appeared on the screen. This supported the wave theory and refuted the particle theory.

*The double-slit experiment acted as a **crucial experiment** in deciding between two rival hypotheses. The pattern appeared on the screen was a **crucial instance**.*



False Hypothesis

A false hypothesis is a supposition which is proved false after verification. A false hypothesis will be rejected and a new hypothesis will be framed in its place to explain the phenomenon.

For example,

- The cause of influenza in 1918 was incorrectly attributed to a bacterium, which was later confirmed to be virus. Thus, the hypothesis, 'bacteria are the cause of influenza' is false.

- The cause of power failure was assumed to be load-shedding, which was later confirmed to be a circuit break. Hence, the hypothesis, 'the power failure is due to load-shedding' is false.

Barren Hypothesis

A barren hypothesis is an assumption about a phenomenon from which no observable and testable results can be deduced. It is an invalid explanation and cannot be verified or falsified. A barren hypothesis is not a legitimate one because it leads nowhere.

For example,

- I failed the exam because my enemy cursed me.
- No one lives here because the house is haunted by an evil spirit.
- The child fell ill because someone cast an evil eye upon it.



Activity 6

Read the story and identify the crucial instance.

The Wise Judgement

Two women, both claiming to be the mother of the same living infant, brought their dispute before King Solomon. One woman's baby had died during the night, and she swapped the deceased child with the living one while the true mother slept. Solomon, seeking to reveal the truth, ordered a sword to be brought and proposed dividing the living child in half, giving each woman one portion of the child. The false mother agreed to the division, but the real mother cried out, begging Solomon to give the child to her opponent rather than killing it. Recognizing her selfless love, Solomon gave her the baby, declaring her the true mother.



The crucial instance: _____



Activity 7

Form different hypotheses for a “smartphone heat-up problem”.

Working hypothesis -

Rival hypothesis -

False hypothesis -

Barren hypothesis -



Science makes use of various other hypotheses in the scientific process. Each type plays a unique role.

An Explanatory Hypothesis tries to explain the cause of a phenomenon. It is important in science and is the output of abductive reasoning.

A Descriptive Hypothesis describes the existence of certain conditions, characteristics, or phenomena. It aims to describe the pattern, rather than explain causes.

An Analogical Hypothesis is foremed by noticing a resemblance to known phenomena. It requires need stronger testing.

Ad-hoc Hypothesis: There are instances when a well-established theory is unable to explain a specific fact or collection of data. In such situations scientists attempt to preserve the theory by proposing a special hypothesis that could account for the theory's anomaly. A fact that cannot be explained by a recognised theory is explained by an Ad-hoc hypothesis.

A Null Hypothesis is a negatively stated hypothesis which states that there is no relationship between the tentative cause and effect. They are used to collect additional support for the known hypothesis and helps to avoid personal bias on the part of the investigator.

Transformation of a Hypothesis into a Law

Even a legitimate hypothesis is still a supposition. It must be verified to determine whether it is a correct explanation of the phenomenon under investigation. A hypothesis is verified either directly or indirectly. **Direct verification of a hypothesis** is the direct observation or experimentation with actual facts. Direct verification is possible when causes and effects can be observed easily by the senses. If the predicted result occurs exactly as the hypothesis suggests, it is considered directly verified. Direct verification means comparing the hypothesis itself with the fact. For example, when

the unhealthy plant is placed in sunlight, it begins to grow better, producing new green leaves and looking healthier. The observation agrees with the prediction. The role of sunlight in plant growth is thus verified.



However, in many cases direct verification is not possible. In such cases, indirect evidences are sought to verify hypothesis. The hypothesis is verified or confirmed on the basis of some facts that are observed as true. In **Indirect verification of a hypothesis**, primarily some of the conclusions are assumed as true. Consequences are then deduced and compared with actual facts. If those consequences agree with the actual facts, the hypothesis is indirectly verified.

For example,

If the aim of the intruder is to rob, then the valuables must be missing.

But no valuables are missing.

Therefore, the aim of the intruder is not to rob.



Indirect verification of a hypothesis is done by constructing a hypothetical syllogism. It is used either to confirm or to deny the rival hypothesis. The structure of the logical argument can be either Modus Ponens or Modus Tollens.

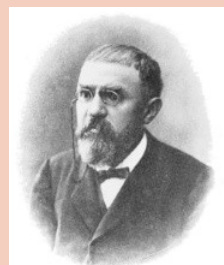
Modus Ponens	Modus Tollens
<i>If it had rained, then the road would be wet.</i> <i>It had rained.</i> <i>∴ The road would be wet.</i>	<i>If it had rained, then the road would be wet.</i> <i>The road is not wet.</i> <i>∴ It had not rained.</i>

Verification is not proof. Verification merely shows that the hypothesis explains the facts. If the evidence contradicts the facts, then the hypothesis is rejected or modified. If the evidence supports the facts, then the hypothesis is accepted and becomes a theory. **A theory is a verified hypothesis** that explains facts and unites them under one principle but still provisional.

The verified hypothesis is further tested and proved to show that it is the only adequate explanation of the given problem. It is the process of eliminating rival hypotheses. **A proved hypothesis** which expresses necessary relation between phenomena **with the highest degree of certainty is called a scientific law**. It is universally accepted and confirmed beyond reasonable doubt. For example, after verification and proving the hypothesis, we formulate the law that 'Sunlight is essential for photosynthesis'.



According to the French philosopher, Henri Poincare "There is no science without hypothesis". For him, the aim of science is prediction. Every scientific theory is a hypothesis that had to be tested. He argued that without hypothesis empirical data remains a disorganised heap, failing to yield an explanation. Even falsified hypotheses are valuable, for they throw light on unforeseen aspect of reality, driving scientific progress.



Science and Hypothesis

Hypothesis as the Logical Foundation of Research Process

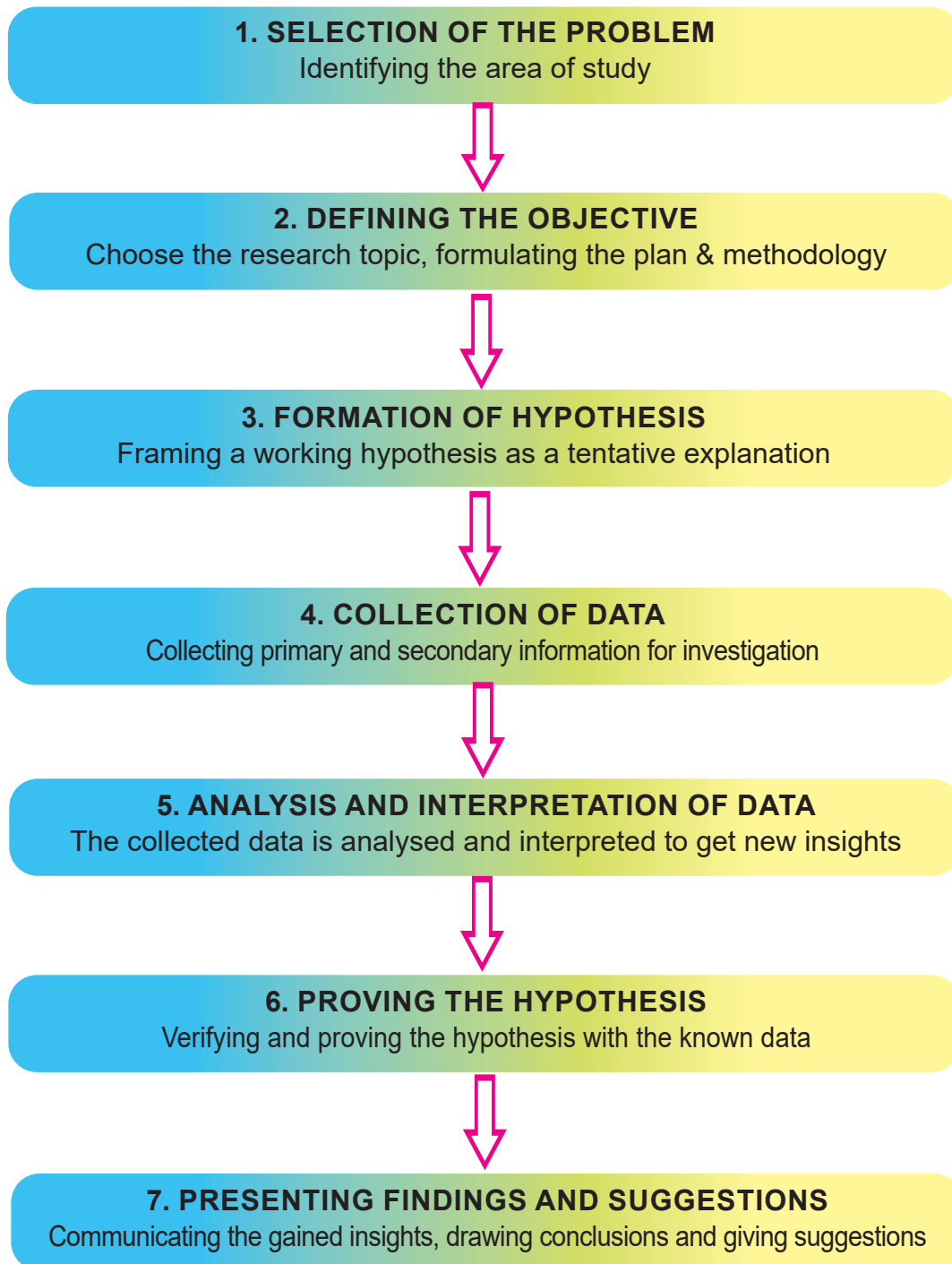
Knowledge is ever-growing but there are gaps in every field. Human beings are curious to know the unknown. Research provides a systematic method to find out the answers to the unsolved problems. The term research comes from the French word *recherche* which means *to go about seeking*. Research is a systematic search for new facts and accurate information on a specific topic in any branch of knowledge.

A hypothesis plays a pivotal role in research methodology. All systematic investigations begin with the formulation of hypotheses and conclude with their verification and proof. A well-formulated hypothesis determines the quality of good research. It guides the entire research process. Research concludes by either accepting or

rejecting the hypothesis based on the evidence gathered during the verification process.

The following are the steps in the research process.

STAGES OF RESEARCH



**Activity 8**

Read the statements below and write whether they are True (T) or False (F).

A hypothesis works as a bridge between observed facts and law	
The main objective of a hypothesis is not to deduce a conclusion	
A good hypothesis cannot guide our investigation	
A legitimate hypothesis is still a supposition unless it is verified	

From the outset of a scientific enquiry to its conclusion, the hypothesis holds significant importance. An investigation begins with a hypothesis and serves as a guiding reference for us to identify the cause of a phenomenon.

Glossary

Terms	Definitions
Phenomenon	a situation that is observed whose explanation is in question
Fact	a concrete instance of observed experience
Theory	a verified hypothesis
Law	a proven hypothesis

Chapter

9 CAUSALITY

Read the following collage:



Some of the above statements represent causes, while others represent their effects. Pair them as cause and effect relationships.



Activity 1

A	B
• The tiny seed germinated	• It grows into a big tree.
•	•
•	•
•	•

Discuss:

- Which is the cause?
- Which is the effect?

It is clear from the above activity that there is a relationship between cause and effect. In this chapter, we will understand causality, the meaning and definition of cause, the Aristotelian, modern and popular views of cause and the five methods put forward by J. S. Mill to identify cause through observation and experiment.

Meaning of Causality

Every event that people observe in the world has some reason behind it. For example, when a plant grows, when it rains, or when a bulb glows, there is something that brings about these occurrences. The general principle that events are related as cause and effect is known as **causality**. **It is the principle that every event has a cause.**

The word **causality** is derived from the Latin word *causa*, which means *reason, motive, cause, lawsuit, or judicial process*. Logicians define causality as the relation between two events in which one event is the cause that produces or brings about the other event, the effect. In other words, causality is the logical and natural connection between a cause and its effect.

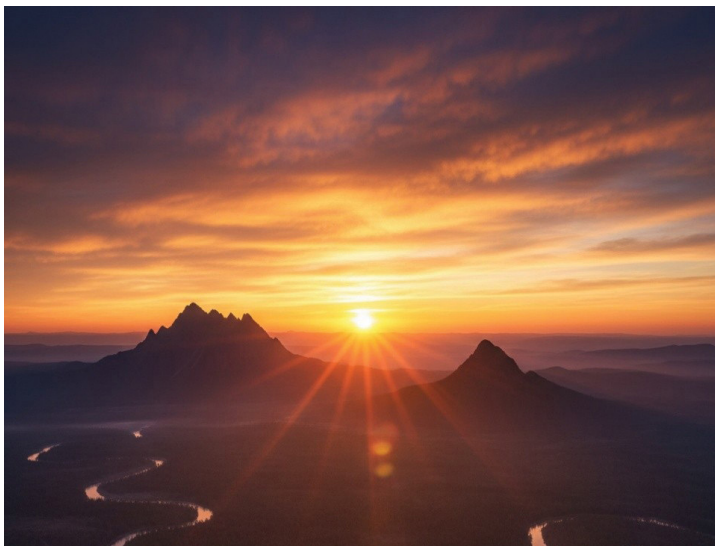
Different Views of Cause

Both the common man and the scientist agree the concept of causality, though they do not mean the same thing.

Popular View of Cause

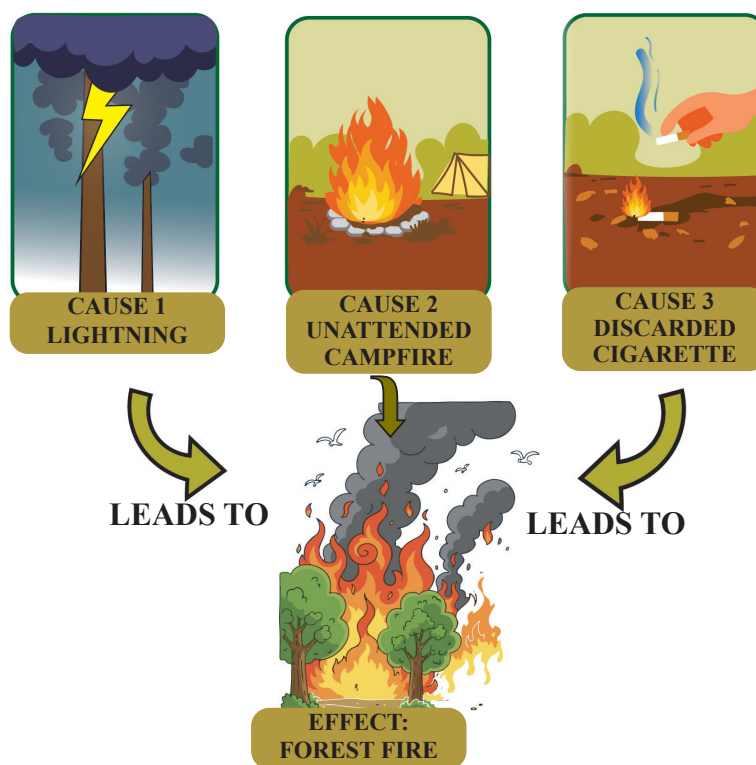
For example,

The sun rises; it becomes day.



Here, in this example, one can assume that the sunrise causes daylight based on everyday experience. The popular view of cause is based on everyday observation and direct experience, rather than in scientific or philosophic reasoning.

Plurality of Causes



The given picture illustrates that a forest fire may be caused by lightning, an unattended campfire, or discarded cigarettes.



Activity 2

Match the following effects with their possible causes.

Effect	Possible Causes
1. Flood	Accidents/ Electric shock/Heart attack
2. Illness	Consumption of Junk food/ Infection/ Lack of sleep
3. Death	Heavy rain/ Dam break/ Tsunami

These observations show that an effect need not have only one cause.

Sometimes, the same effect can be produced by different causes under different circumstances. Hence, one effect may have more than one possible cause. This is known as the **Plurality of Causes**. According to J. S. Mill, an event is not always due to one single cause. The doctrine of plurality of causes must be distinguished from the doctrine of the totality of conditions.

Aristotelian View of Cause

MATERIAL CAUSE

FORMAL CAUSE

EFFICIENT CAUSE

FINAL CAUSE



The ancient Greek philosopher, Aristotle provided a well-known classification of causes. According to him, anything that exists must have four different causes behind it.



Hamsavum Damayanthiyum

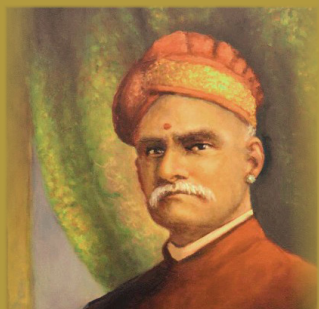
1. **Material Cause** is the substance or matter from which a thing is made or formed.

For example, the painting *Hamsavum Damayanthiyum* has paints, canvas, brushes, etc as its material cause.

2. **Formal Cause** is the form or pattern that gives shape to a thing. It is the shape, structure, or arrangement that makes a thing what it is.

For example, the formal cause of this painting is its design or structure.





Raja Ravi Varma

3. **Efficient Cause** is the efficiency of the agent or force that produces a thing. That means the efficient cause is the maker or doer or the process that brings about the existence of a thing.

Here in this example, the artist, Raja Ravi Varma is the efficient cause of the painting *Hamsavum Damayanthiyum*.

4. **Final Cause** is the purpose or goal for which a thing is made for. It explains the purpose or function a thing is meant to accomplish. In the example the purpose of the painting is to illustrate a beautiful moment from the story of *Nala and Damayanthi*.

*Illustration of
the Story of
Nala and
Damayanthi*

Aristotle's doctrine of four causes forms a cornerstone of his philosophy. His classification shows that causation is not only about physical factors but also about purpose and design. His view laid the foundation for later scientific and philosophical studies of causality.



Activity 3

1. Apply Aristotle's four causes to explain the making of a wooden table.
2. For each example given below, identify and fill in the material cause, formal cause, efficient cause, and final cause as explained by Aristotle.

No.	Example	Material Cause	Formal Cause	Efficient Cause	Final Cause
1	Clay pot	.....	.....	.....	.....
2	School building	.....	.....	.....	.....
3	Mango Tree	.....	.....	.....	.....
4	Statue of Liberty	.....	.....	.....	.....

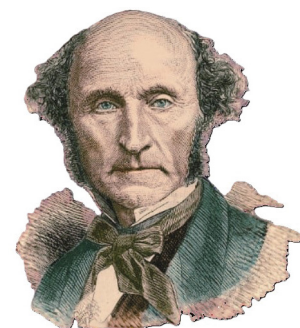
Scientific View of Cause.

According to J. S. Mill, a **cause is the invariable and unconditional or necessary antecedent of an effect**. This means that a cause is an event, or set of events which always produces the same effect

and without which the effect cannot occur. In his book, *A System of Logic*, J. S. Mill defines cause as “the sum total of conditions, positive and negative taken together, which being realised, the consequent invariably follows.”

Characteristics of a Cause

The following are the characteristics of a cause.



John Stuart Mill
(1806-1873)



- **Cause is an antecedent**

A cause precedes the effect. It means that the cause comes before the effect. For example, lighting a matchstick comes before the flame. Therefore, cause is an antecedent. But all antecedents cannot be considered as cause.

- **Cause is a real connection**

Cause and effect are not merely successive events. It is not accidental or mere temporal succession. The connection between the cause and effect must be a real dependence. For example, day follows night regularly, yet night is not the cause of day.



As Jevons says, "Sunlight may be an antecedent to the burning of a house, but it is not the cause because the house would burn equally well at night". If we mistake conjunction for connection, we commit the fallacy of post hoc ergo propter hoc means 'After this, therefore because of that.'

A before B does not mean that A causes B.

Eg: I ate ice cream, and then it started raining.

Can we say that eating ice cream caused the rain?

- **Cause is an invariable antecedent**

The effect must always follow the cause. Whenever the cause is present the effect must also be present. Whenever the cause is absent the effect must also be absent. Invariability is a necessary characteristic of a cause because of the law of the uniformity of nature. For example, heating water to 100°C will always result in the boiling of water.

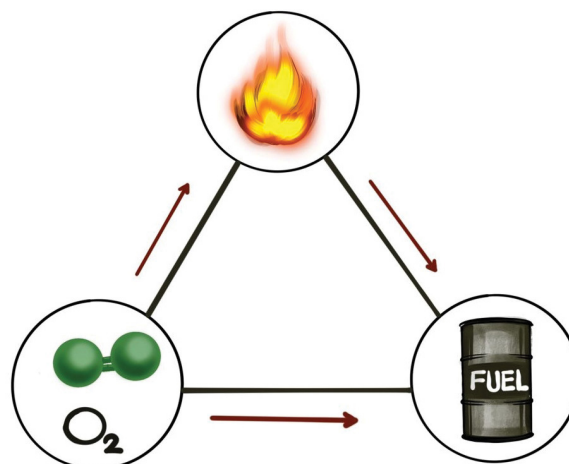
- **Cause is an unconditional or necessary antecedent**

The cause is necessary for the effect. The effect must occur whenever the cause is present. Without the cause, the effect cannot occur. A cause is unconditional when it is necessarily required for the occurrence of the effect. For example, without sunlight, photosynthesis cannot occur.

- **Cause as a necessary condition**

A necessary condition is something without which the effect cannot occur. It is essential, but by itself it may not be enough to produce the effect. A necessary condition makes the effect possible. *"You cannot have B without A"*.

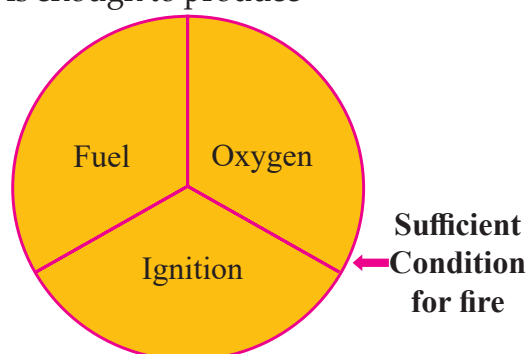
For example, Oxygen (A) is a *necessary condition* for fire (B), because without oxygen, fire cannot exist. However oxygen alone cannot produce fire. We also need fuel and ignition.



- **Cause as a sufficient condition**

A sufficient condition is an event that by itself, is enough to produce the effect. When this condition is present the effect must occur even if other conditions are absent. It can be a single or a combination of events. *"If A happens, then B will happen."* The presence of A is enough for the occurrence of B.

For example, the combination of oxygen, dry wood, and ignition (A) is a sufficient condition for fire (B). Once all these are present, the fire will definitely occur.



Necessary and sufficient conditions are interconnected. All necessary conditions together make a sufficient condition which always produces the effect.

- **Cause is a sum total of conditions.**

A cause is a combination of all conditions that produces the effect. It must include the presence of positive conditions and the absence of negative conditions for the effect to occur. For example, fire requires the presence of oxygen, fuel, and ignition together (positive conditions) and the absence of moisture or water (negative conditions) to occur.


Activity 4

Complete the table by identifying whether the condition is necessary, sufficient, or both.

Event	Condition	Necessary/Sufficient
Survival of fish	Water	.....
Fire	Oxygen	.....
Passing exam	Regular study	.....
Good health	Regular exercise, Nutritious food, Sufficient rest	.....

J. S. Mill's Experimental Methods

J. S. Mill developed a systematic set of rules to discover the causes of events scientifically. These rules are called Mill's Experimental Methods. He formulated five methods for identifying the causal connections between events.

The methods enable us to identify the cause-effect relationships by comparing different situations or noting how a change in one factor influence another. This is done by a process of analysis and elimination. The methods show us that finding a cause is not a matter of guesswork. It is a systematic process based on observation and comparison. Mill's methods are helpful in scientific research, logical thinking, and solving daily problems.


Canons of Elimination

The principles of elimination are obtained from the definition of cause. They explain the nature of causation.

- i) When the cause is present, the effect must also be present.*
- ii) When the cause is absent, the effect must also be absent*
- iii) When there is a change in the cause, there must be an equal corresponding change in the effect.*
- iv) There cannot be different causes for one and the same effect.*

The Five Experimental Methods put forward by J. S. Mill are:

1. The Method of Agreement
2. The Method of Difference
3. The Joint Method of Agreement and Difference
4. The Method of Concomitant Variation
5. The Method of Residues

1. The Method of Agreement



Canon of the Method of Agreement

J. S. Mill states the canon of this method as follows: "If two or more instances of the phenomenon under investigation have only one circumstance in common, then the circumstance in which alone all the instances agree is the cause or the effect of the given phenomenon."

The Method of Agreement is a method of observation. In this method, we observe a number of positive instances of the phenomenon. A positive instance is the one in which the phenomenon is present. We analyze them in various circumstances. The only common circumstance that is uniformly present in all the instances is considered as the cause of the given phenomenon. This method identifies cause as a necessary condition.

For example, a study is conducted on the factors influencing achievement among four students from different socio-economic and cultural backgrounds. After examining all the circumstances such as social, economical, and cultural factors, it is found that only one circumstance (time management) is common. This common circumstance is identified as the cause of the high performance of these students.




Activity 5

Table of Analysis and Elimination of Circumstances

Student	Age	Income	Region	Time Management
Amita	12	Average	Rural	Excellent
Binish	13	High	Urban	Excellent
Cinu	11	Below average	Urban	Excellent
Dilna	14	Very high	Rural	Excellent

Can you identify the common circumstance from the above table?

The common circumstance is _____.

The Method of Agreement can be symbolically represented as:

$P_1 \rightarrow ABCD$
 $P_2 \rightarrow MNCD$
 $P_3 \rightarrow QRSC$
 $P_4 \rightarrow EFGC$

The factor C is present in all the positive instances of the phenomenon P. Therefore, C is the cause of P.

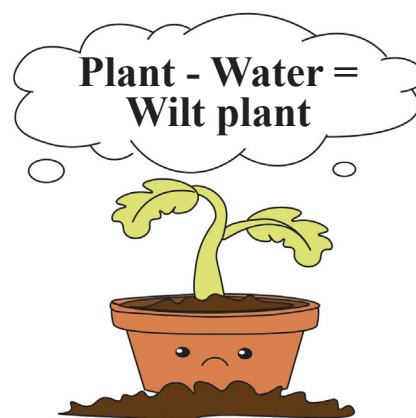
2. The Method of Difference



Canon of the Method of Difference

J. S. Mill states "If an instance in which the phenomenon under investigation occurs, and an instance in which it does not occur, have every circumstances save one in common, that one occurring only in the former, the circumstance in which alone the two instances differ, is the cause or the effect, or at least an indispensable part of the cause of the phenomenon."

The Method of Difference is mainly a method of experiment. Here we observe only two instances of the phenomenon. One is a positive instance in which the circumstance is present and the other is a negative instance in which the circumstance is absent. We then analyse the single circumstance that is present in the positive instance and absent in the negative instance. That differing circumstance is considered as the cause of the phenomenon. This method identifies the cause as a sufficient condition.



Let us understand this method through an experiment.

We notice that one of the two plants in the garden is wilting. The following table records our observation regarding the phenomenon.

Table of Analysis and Elimination of Circumstances				
Plant	Sunlight	Soil	Temperature	Water
Healthy plant	✓	✓	✓	✓
Wilt plant	✓	✓	✓	✗

The analysis of the table shows that the only differing circumstance of the phenomenon is water. Therefore, we can conclude that the lack of water is the cause of the plant's wilting.

The Method of Difference can be symbolically represented as:

Positive instance : ABC $\Rightarrow$ PQR

Negative instance : AB $\Rightarrow$ QR

When C is present P is also present.

When C is absent P is also absent.

Therefore, C is the cause of P.

3. The Joint Method of Agreement and Difference



Canon of the Joint Method of Agreement and Difference

J. S. Mill states "If two or more instances in which the phenomenon occurs have only one circumstance in common, while two or more instances in which it does not occur have nothing in common, save the absence of that circumstance; the circumstance in which alone the two sets of instances differ, is the effect, or the cause, or at least an indispensable part of the cause of the phenomenon."

The Joint Method of Agreement and Difference is a systematic effort to identify a single circumstance present in the positive instances and absent in the negative instances of a phenomenon. In this method, we consider a set of positive instances and another set of negative instances. If the common circumstance that is present in all the positive instances is found uniformly absent in all the negative instances, then that circumstance is the cause of the given phenomenon. This method identifies the cause as both a necessary and sufficient condition.

This method is simply called **the Joint Method** as it represents the application of the Methods of Agreement and Difference. The method is also called the **Double Method of Agreement**.

Let us do an extended study of the case presented in the Method of Agreement in order to understand the Joint Method.



Activity 6

Student	Age	Income	Region	Time Management	Achievement
Amita	12	Average	Rural	Excellent	✓
Binish	13	High	Urban	Excellent	✓
Cinu	11	Below	Urban	Excellent	✓
Dilu	14	Very high	Rural	Poor	✗
Elena	13	Very high	Urban	Poor	✗
Fabilo	12	Average	Rural	Poor	✗

Evaluate the table and find the reason for achievement.

Identify the common and differing circumstance in the phenomenon.

To find the cause, we consider different circumstances in both positive and negative instances. Here, achievement is present in positive instances and absent in negative instances.

The Joint Method can be symbolically represented as:

Positive instances		Negative instances	
P ₁	→ ABCD	P ₅	→ ADEC
P ₂	→ EFBG	P ₆	→ EFAG
P ₃	→ RSTB	P ₇	→ RSGT
P ₄	→ LMBN	P ₈	→ LMNO

Factor B is present in all the positive instances and absent in all negative instances.

Therefore, B is the cause of P.


Activity 7


**Pizza + Cheese +
Orange Juice**



**Burger + Cheese +
Watermelon Juice**



**Pizza + Orange
Juice**



**Burger +
Watermelon Juice**



**Fries + Cheese +
Grape Juice**



**Fries + Grape
Juice**

When stomach ache is present
all positive instances agree on?
.....

When stomach ache is absent
all negative instances agree on?
.....

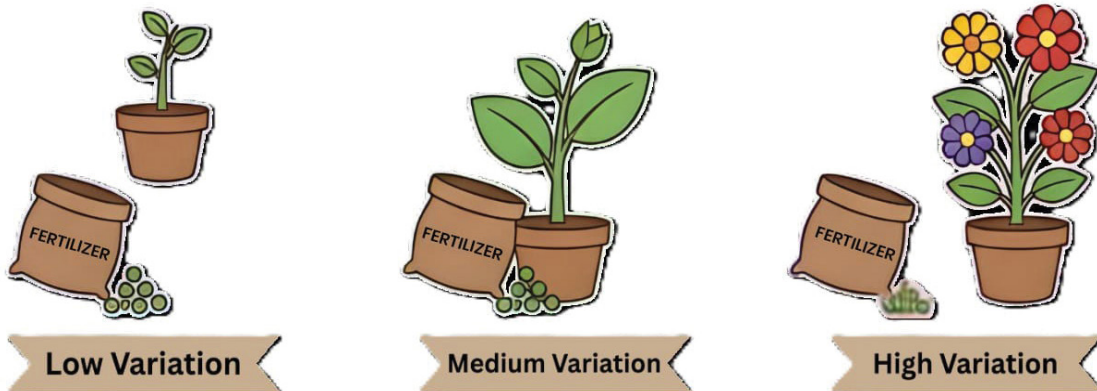
Therefore, the only common and differing factor in the
above phenomenon is



4. The Method of Concomitant Variation

Canon of the Method of Concomitant Variation

J. S. Mill state "Whatever phenomenon varies in any manner, whenever another phenomenon varies in some particular manner, is either the cause or the effect of that phenomenon, or is connected with it through some fact of causation".



Activity 8

Identify whether there is any causal relation between the quantity of fertilizer and the growth of the plant.

The Method of Concomitant Variation is a quantitative method. This means, the method allows us to determine the exact quantitative relationship between cause and effect, showing how much effect results from a given amount of cause.

The growth of the plant and the quantity of fertilizer are proportionately related.

This instance can be symbolically represented as:

$$\begin{array}{ccc}
 P_1 & \longrightarrow & C_1 \\
 P_2 & \longrightarrow & C_2 \\
 P_3 & \longrightarrow & C_3 \\
 P_4 & \longrightarrow & C_4
 \end{array}$$

In this case, we find that a change in P is followed by a corresponding change in C. Therefore, P is causally connected with C.

5. The Method of Residues



Canon of the Method of Residues

J. S. Mill states "Subduct from any phenomenon such part as is known by previous induction to be the effect of certain antecedents and the residue of the phenomenon is the effect of the remaining antecedent."

The Method of Residues is fundamentally a mathematical method. It is based upon the mathematical subtraction. Residue refers to what remains. Therefore, the Method of Residues focuses on the remaining unexplained portion of a complex phenomenon. It is a way of finding a cause by subtracting the known causes and their effects of a phenomenon and relating the remaining effect to the remaining cause.

For example, the total mark of a subject comprises of score for written test, assignment and practical exam.

A student scored a total of 90 marks

Test	→	40 marks
Assignment	→	30 Marks
Practical exam	→	?

How did you find the score for practical exam?

You simply applied the Method of Residues.

The Method of Residues can be symbolically represented as :

A B C D → Cause → P Q R S.

A → Causes → P

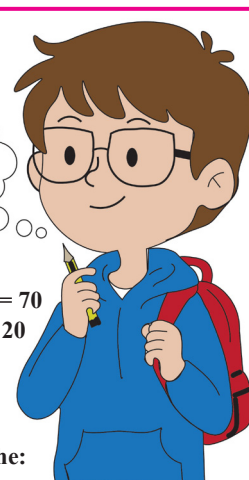
B → Causes → Q

C → Causes → R

D → Causes → ?

From the remaining event, one can infer that D is the cause of S.

TOTAL MARKS: 90



My Final Grade

Test: 40

Assignment: 30

Known Causes Combined: 40+30= 70

Subtract Known Causes : 90-70= 20

Residue: 20

This remaining 20 marks is the: PRACTICAL EXAM



The Method of Residues is widely used in scientific research. Many major scientific discoveries are made with the help of this method. It is a method of discovery. For example, using the Method of Residues, Madame Curie discovered Radium and its intense radioactivity.



Activity 9

The following table contains instances of causal relations. Name the suitable experimental method of J. S. Mill in column B

Column A: Instances	Column B: Mill's Method
A group of people drank river water and fell ill, while another group who drank filtered water did not.	
As exercise increases, Physical fitness improves.	
A student is tired despite adequate sleep, food, and exercise, the remaining factor is late-night mobile use.	
All the people who ate ice cream developed stomach pain → Ice cream is the cause.	

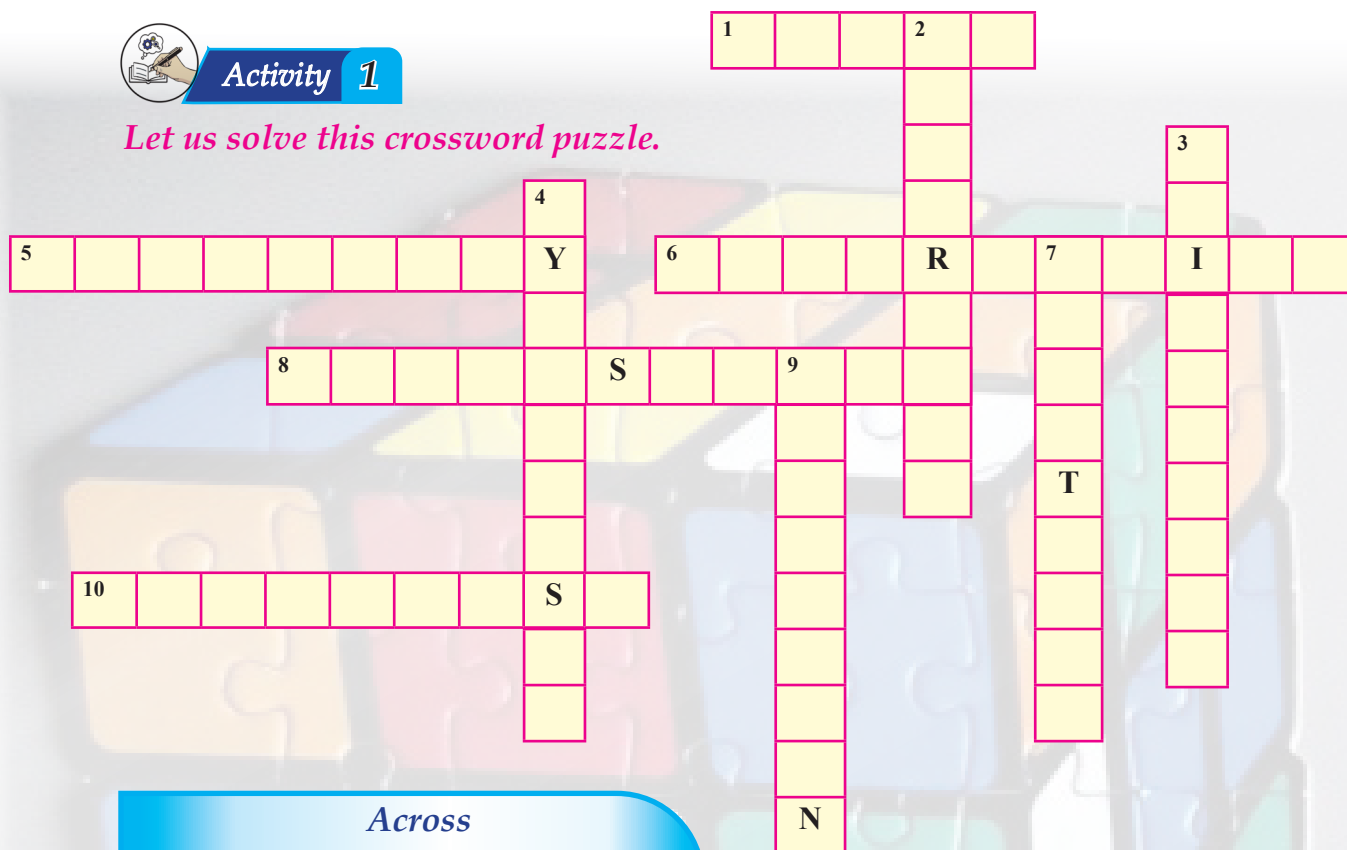
The nature of causality says that whenever the cause is present, the effect is also present, and whenever the cause is absent, the effect is also absent. The discovery of causal connections enables us to grasp the ordered nature of the universe.

Chapter 10 APPLYING LOGIC



Activity 1

Let us solve this crossword puzzle.



Across

1. Science of reasoning
5. Relation between cause and effect
6. Watching carefully with a purpose
8. Building block of logical arguments
10. Contains three and only three propositions

Down

2. A mental process of arriving at a conclusion from known judgements
3. Love of wisdom
4. A tentative supposition
7. The Father of Formal Logic
9. Proceeds from particular to general

- Was this puzzle interesting?
- How did you solve this puzzle?
- Is there any field that does not involve thinking?

In this chapter we shall discuss how logic plays an inevitable role in our daily life.

Utility of Logic

Thinking is fundamental to human beings. There is no field that doesn't involve thinking. Logic is useful both theoretically and practically. Here are some of the applications of logic in various fields of life.

• Logic in Everyday Life

Whenever people face a problem, they often use logical thinking. We apply logic in making decisions, career planning, buying things, dealing with superstitions and the like.

For example, if you find lines on your phone screen, you may attempt the following solutions for a better result, don't you?

Some steps to fix lines on the phone screen



Restart the phone



Cool down the phone



Boot into safe mode



Check for software updates



Factory reset



Professional help

Logical reasoning ensures that the decisions are based on facts and clear thinking, not just emotion or guess.

• Logic in Science and Mathematics

Logic is the toolkit that makes mathematics and other sciences reliable. Science uses logical methods to discover new truths and establish theories.

• Logic as Mental Training

Logic sharpens the mind just like exercise strengthens the body. Solving logical puzzles, riddles, and brain-teasers helps to improve concentration and reasoning skills. This intellectual gymnastics makes us better problem-solvers in all areas of life. Logical reasoning is an important assessment tool for a wide range of competitive examinations.

Complete the Sudoku
(Use numbers from 1-4)

2		4	
	3		2
1		3	
	4		1

- **Logic is useful in almost every profession.**

It is employed in the professions such as:

- Law and Criminology
- Education
- Medicine and Therapy
- Engineering
- Psychology
- Theology
- Business and Management
- Public Speaking



Activity 2

Discuss in group and prepare a write up. How is logic applied in various professions?



***Fuzzy logic** is a core application and extension of Modern Logic, developed by Lotfi A. Zadeh in 1973. It provides a way of reasoning with degrees of truth rather than the strict true/false values of Boolean logic. This approach models human-like thinking. Fuzzy logic relies on “if-then” rules derived from human experience. It is widely used in modern technologies, including household appliances, automotive anti-lock braking systems, artificial intelligence, aerospace applications, and medical diagnosis.*



- **Logic in Computer Science and Artificial Intelligence**

Computer algorithms are built on logic. The circuits inside a computer work using logic gates. In Artificial Intelligence (AI), logic is used for reasoning, decision-making, and problem-solving.

- **Logic Enhances Critical Thinking and Moral Reasoning**

Critical thinking means examining a problem from different perspective, questioning assumptions, and testing the validity and reliability of our ideas. Logic trains us to think critically. It helps us to identify the real issues behind a problem. It helps us to analyse facts by distinguishing the relevant from the irrelevant and to organise them effectively. It guides us to make moral decision by choosing the less harm and protecting the greater good.



Activity 3

Suppose your friend has been using prohibited substances and begs you not to tell anyone. If you stay silent, your friend might go into harmful habit. If you report it, your friend may face disciplinary action. How will you solve the issue? _____

Your decisions should not be under the pressure of your emotions rather, they should be based on reasons given below. What action would you take, and why?

- **Values in Conflict:**

- Honesty and fairness Vs. Empathy to a friend.

- **Reasoning Process:**

- What happens if you stay silent?
- What happens if you inform the authority?
- Is there a middle way? (e.g., warning the friend)
- Does this warning make a real change in him?

Write your decision: _____

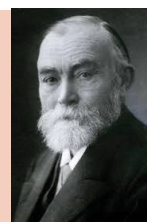
- **Logic helps to Identify Daily Life Fallacies**

People may use faulty reasoning as a tool to persuade or mislead others. **A fallacy is a poor form of reasoning. It is an error or mistake in reasoning when we violate the logical rules of reasoning.** They are weak arguments, but appear to be strong. In order to refute such arguments, knowledge about fallacies is essential.



According to logician Gottlob Frege the task of a logician is to “indicate the pitfalls laid by language in the way of the thinker.”

- Gottlob Frege



Kinds of Fallacies

Fallacies can be formal or informal. **Formal Fallacies** are errors in deductive reasoning where the form or structure of the argument is defective. It has already been explained in the chapter Syllogism.

Informal Fallacies (Material Fallacies) are errors in reasoning which depend on the content, context, or language used to persuade or mislead the audience.



Activity

Read the following conversation and evaluate the arguments in it

Customer : I like this car, but I need some more time to think before buying.

Dealer : Madam, if you don't book it today, the price will increase next week. This offer is ending soon!

Customer : Oh, but I want to compare with other models also.

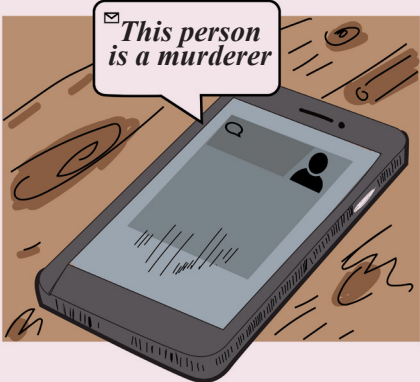
Dealer : Madam, if you wait, you'll lose this chance forever. You will have to pay a much higher price, and you'll regret it.

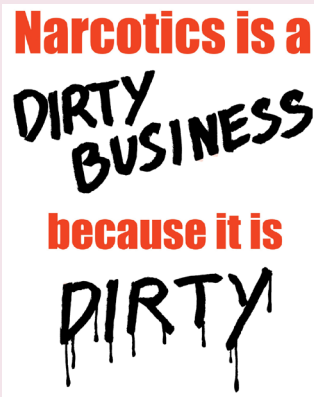
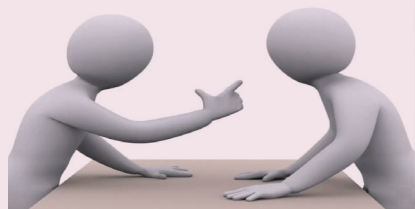
Customer : Hmm... you are forcing me to decide quickly out of the fear of missing out, not giving me real reasons.

The arguments of the dealer are examples for a fallacy. It is the fallacy of 'Appeal to force.'



Let us learn about some common informal fallacies in real life situations.

Argument	Fallacy	Explanation
An advertisement quote: 	Appeal to popularity (Ad populum)	Suggesting something as good because many people do it.
The social media says: 	The appeal to inappropriate authority	Social media is not the appropriate authority to convict a person.

Noticing a youth biker and says "All youngsters are rash riders."	Hasty generalisation	Drawing a general conclusion from a few instances. 
A football player says: "Every time I wear my lucky socks, my team wins. Therefore, my lucky socks is the reason for our victories."	After this, therefore because of this. (<i>post hoc ergo propter hoc</i>)	Correlation is mistaken for causation. 
A poster caption: 	Begging the question (Petitio Principii)	The reason provided is identical to the claim which demands further explanation.
A follower says: "Just look at your face! How could you lead us?"	Argument against the person (Ad hominem)	Attacks the opponent's physical appearance instead of their leadership. 

A fallacy in an argument does not always mean that the conclusion is false. It only shows that the reasoning is weak.

Reduction of Ordinary Sentences to Logical Sentences

The arguments we encounter in everyday speech rarely appear as standard form of syllogisms. So, they cannot always be readily tested. To test the validity of these arguments, we need to reformulate them into standard form of propositions. Putting it into standard form is called the **reduction of ordinary sentences to standard form**. A proposition formed by reduction must contain a subject, a copula, and a predicate. The sign of negation must go with the copula and the meaning of the original sentence must not change.

We can reduce almost all ordinary sentences into A, E, I, O propositions.

- Sentences containing the words **every, each, any, always** are reduced to A proposition.

e.g., Every soldier fought bravely – *All soldiers are persons who fought bravely.*

Each citizen must vote – *All citizens are persons who must vote.*

- Sentences containing the words **none, never, nothing, nobody, not one** are reduced to E proposition.

e.g., Nothing done in hurry is well done – *No acts done in a hurry are acts which are well done.*

None can live for ever – *No persons are those who can live for ever.*

- Sentences containing the words **unless, except, but, most, a few, certain, many, several, mostly, nearly, generally, often, perhaps, sometimes** are reduced to I proposition.

e.g., Many rules of logic are easy – *Some rules of logic are easy.*

A few students are ready to go – *Some students are those who are ready to go.*

- Sometimes the word not is added to sentences with words **all, every, each, any, always, most, a few, certain, many, several, almost all, all but one, except one, nearly all, majority, frequently, often, generally, perhaps, mostly, sometimes**. Such sentences are reduced to O proposition.

e.g., Every disease is not fatal – *Some diseases are not fatal.*

All that glitters is not gold – *Some things that glitter are not gold.*



<i>Ordinary sentences with words like:</i>	<i>Reduction Form</i>
Unless, except, but, most, a few, certain, many, all but one, almost all, several, mostly, nearly, generally, often, perhaps, sometimes	SIP proposition
All, every, each, any, always	SAP proposition
All, every, each, any, always, most, a few, certain, many, several, almost all, except one, all but one, nearly all, majority, frequently, often, generally, perhaps, mostly, sometimes + not ('not' makes these words Particular negative)	SOP proposition
Few, seldom, hardly, scarcely (These are negative words)	SOP proposition
Few, seldom, hardly, scarcely + not (‘not’ makes these words Particular affirmative)	SIP proposition
No, none, never, nothing, nobody, not one	SEP proposition
Alone, only, none but, none except	PAS / $\bar{\text{SEP}}$ proposition

Practicing Logical Reasoning Questions

Have you ever observed the different types of questions that are usually asked in competitive exams?

Reasoning is the practical application of logical principles. In most competitive exams like civil services, banking, law, or business administration, a large number of questions are based on reasoning ability. These questions are designed to test whether one can analyse situations, think critically and solve problems. Generally competitive examinations include analytical reasoning, verbal reasoning and non-verbal reasoning.

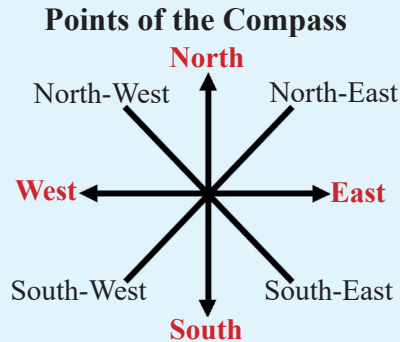
Let us practice a few of them.

1. Analytical Reasoning – It focuses on breaking down complex problems into smaller parts and tests the ability to interpret data and connect different elements. The common topics include Seating Arrangement, Blood Relations and Direction Sense Test, Puzzles and Data Sufficiency.


Activity 5

A man drives from West to East and on the way, he turns left and goes in a semi-circle around a hillock and then turns left at right angle. In which direction is he finally driving?

- A. West
- B. East
- C. North
- D. South



Answer: ----- (Instruction: This problem is a direction sense test. You need to find their final position or direction. Use direction positions and movements – NESW – North, East, South, West.)

2. Verbal Reasoning – The questions are given in words or statements to test the ability to understand, interpret, and analyse verbal information effectively. The common topics include Analogy, Syllogisms, Coding-Decoding, Logical Sequence of Words, Assertion and Reason, Situation Reaction Test.


Activity 6

If in a certain language, INDIA is coded as JOEJB, how is BHARATH coded in that code?

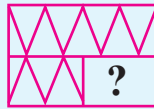
- A. CBISCBJ
- B. CIBSBUI
- C. CIBUBSJ
- D. CBASBJI

Answer: ----- (Instruction: This is a coding-decoding test. A word or phrase is coded using a specific pattern. You need to understand the pattern and apply it to the new word. Look for simple patterns first. Check if letters move by the same number of positions. Use the alphabet position method (A=1, B=2, etc.)

3. Non-Verbal Reasoning – It uses pictures, patterns, and figures instead of words to test the ability to reason with visual information. The common topics include Mirror and Water Images, Cubes and Dice, Completion of Figures and Series.


Activity 7

Which figure will complete the pattern in the given figure?

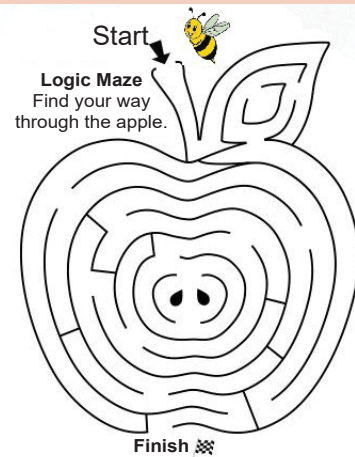


- A. B. C. D.

Answer: ----- (Instruction: A sequence of figures or patterns is shown, with a missing portion. You have to identify the underlying pattern to find the missing image or correct piece from the options to complete the pattern.)



Logical puzzles existed from time immemorial. It is believed that the recreational logical puzzles were pioneered by the English logician, Charles Lutwidge Dodgson (Lewis Carroll), the author of Alice's Adventures in Wonderland. In 1886 he published a book 'The Game of Logic' in which he describes an informal and playful style to teach the fundamentals of logic. In 1985 an American logician and a Taoist philosopher, Raymond M Smullyan, expanded the branch of logic puzzle with his book, 'To Mock a Mockingbird and other Logic Puzzles'. He popularised the 'knight and knaves' puzzle. Today popular forms of puzzles include Sudoku, Nonogram and Logic mazes.


Activity 8 Sample logical reasoning questions

Q1. Pointing to a photograph, Stephen said, "I have no brother or sister but that man's father is my father's son." Whose photograph was it?

- A. His own
B. His Son
C. His Father
D. His Grandfather



Answer: -----

(This is a blood relation type question. Instruction: Information about the relationships within a group of people is provided. You must solve problems by tracing the family tree. Draw a family tree with clear generations. Replace confusing names with simple relationships like 'my father' or 'my sister'.)



Solving Logical Reasoning Questions

We need a systematic approach to solve logical reasoning questions. Here are some general tips that helps to solve these reasoning exercises.

1. **Understand the Question Type:** Read the question carefully and identify the type of logical reasoning topic you are attempting. This prevents confusion and helps you focus on the actual problem.
2. **Collect and Organize Information:** Organizing the information is a crucial step. Write down all the facts given in the question. Look for keywords that give important clues.
3. **Apply the Correct Technique:** Each category of logical reasoning topics has its own solving method.
4. **Verify the Answer:** Always check that your solution fits all the given conditions. Use the elimination method to rule out obviously wrong options. This saves time and increases accuracy.

Q2. A, B, C, D and E are sitting on a bench. E is sitting next to A, B is sitting next to C, and C is not sitting with D, who is on the left end of the bench. B is in the second position from the right. E is to the right of A and D. E and B, are sitting together. In which position E is sitting?

- A. Between A and C
- B. Between A and B
- C. Between D and C
- D. Between B and D



Answer: -----

(This is a seating arrangement type question. Instruction: You are given a set of conditions and must arrange people or objects in a particular order, which could be linear, circular, or in a grid. Start with the most restricted person or position. Attend one condition at a time and mark impossible positions.)

Q3. If Wheels: Car, then Pages: __?

- | | |
|------------|------------|
| A. Library | B. Author |
| C. Book | D. Chapter |

Answer: -----

(This is an Analogy type question. Instruction: You have to identify the relationship between a given pair of words and find a similar relationship for another pair.)

Q4. Statements: 1. The roads were flooded. 2. Heavy rainfall in the city.

- A. Statement I is the cause and statement II is its effect.
- B. Statement II is the cause and statement I is its effect.
- C. Both the statements I and II are independent causes.
- D. Both the statements I and II are effects of independent causes.
- E. Both the statements I and II are effects of some common cause.



Answer: -----

(This is a cause-and-effect type question. Instruction: You are given two statements and must determine if one is the cause and the other is the effect, or if they are both effects of an independent cause. Check for any common connection between the statements. Identify the principal cause (main reason) and immediate cause (proximate in time) of the effect. Often the statement in present tense will be the cause and the statement in perfect or future tense will be the effect.)

Q5. A couple have four children. Two of the children have black eyes. Two of the children have brown eyes. Half of the children are girls. Which of the following statements must be true?

- A. At least one girl has black eyes.
- B. Two of the children are boys.
- C. The boys have brown eyes.
- D. The girls have black eyes.

Answer: -----

(This is a logical deduction problem. Instruction: There are complex scenarios that require breaking down information, analysing clues, and deducing the solution. Analyse the data carefully for clues. Start with absolute facts. Understand negative information. Apply restrictions systematically. Test possibilities when multiple options exist.)

Q6. Choose the correct alternative from the given ones that will complete the series.

A, D, I, P, __?

- A. A B. Y C. Z D. U

Answer: -----

(This is an alpha-numeric series question. Instruction: A sequence of numbers, letters, or both are given with a missing term. You have to identify the pattern to find the correct answer. Look for simple patterns first. Count how many elements are added or removed between the term.)

Syllogism Reasoning Questions:

These questions present two or more statements, followed by a set of conclusions. You must decide which conclusions logically follow from the given statements.



Guidelines to solve syllogistic problems

1. Identify the terms and premises from the conclusions. Proceed with one conclusion at a time. For example, if you have a conclusion like "All A are B", then the minor term is 'A' and major term is 'B'. Look for a premise that can provide the middle term for the conclusions.
2. Consider the given premises as true even if they are factually false. While solving the syllogism, strictly follow the data mentioned in the question and never assume anything more. Never assume that any of the conclusions are true without checking the logical rules for the argument.
3. There are certain logical rules that should be followed while solving the syllogism questions. They are:
 - i. Check whether the middle term is distributed. Also verify the distribution of the subject term and the predicate term of the premises.
 - ii. No + Some = Some not.
 - iii. All + All = All. If you have statements like 'All M are P' and 'All S are M', then you can conclude that 'All S are P'.
 - iv. All + No = No. If you have statements like 'All P are M' and 'No S are M', then you can conclude that 'No S are P'.
 - v. All + Some = Some. If you have statements like 'All M are P' and 'Some M are S', then you can conclude that 'Some S are P'.
 - vi. All + Some not = Some not. If you have statements like 'All P are M' and 'Some S are not M', then you can conclude that 'Some S are not P'.
 - vii. Some + No. Valid conclusion is not possible because of the fallacy of Illicit Major.
 - viii. Some + Some. Valid conclusion is not possible because of two particular premises.
 - ix. No + No / No + Some not. Valid conclusion is not possible because of two negative premises.
 - x. All + All / All + No. It cannot have a particular conclusion because of the Existential Fallacy.

**Activity 9**

Read the following statements and then decide which of the given conclusions follow. Tick (✓) the correct answer

Q1. Statements: All flowers are trees. No fruit is a tree.

Conclusions : (i) Some trees are flowers.
(ii) No fruit is a flower.

- A. Only conclusion (i) follows.
- B. Only conclusion (ii) follows.
- C. Both (i) and (ii) follow.
- D. Neither (i) nor (ii) follow.

Q2. Statements: No golden-coloured things are cheap. Some mangoes are golden-coloured things.

Conclusions : (i) Some mangoes are not cheap.
(ii) All mangoes are cheap.

- A. Only conclusion (i) follows.
- B. Only conclusion (ii) follows.
- C. Both (i) and (ii) follow.
- D. Neither (i) nor (ii) follow.



Q3. Statements: Some kings are queens. All queens are beautiful.

Conclusions : (i) All kings are beautiful.
(ii) All queens are kings.

- A. Only conclusion (i) follows.
- B. Only conclusion (ii) follows.
- C. Both (i) and (ii) follow.
- D. Neither (i) nor (ii) follow.

Q4. Statements: All roads are waters. Some waters are boats.

Conclusions : (i) All waters are boats.
(ii) Some boats are roads.

- A. Only conclusion (i) follows.
- B. Only conclusion (ii) follows.
- C. Both (i) and (ii) follow.
- D. Neither (i) nor (ii) follow.

Q5. Statements: All fish are tortoise. No tortoise is a crocodile.

**Conclusions : (i) No crocodile is a fish.
(ii) No fish is a crocodile.**

- A. Only conclusion (i) follows.
- B. Only conclusion (ii) follows.
- C. Both (i) or (ii) follow.
- D. Neither (i) nor (ii) follow.



Q6. Statements: Some bats are rats. All cats are mats. All rats are cats.

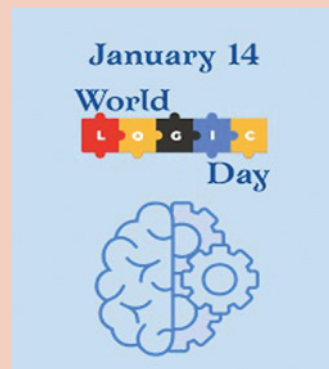
**Conclusion : (i) Some bats are cats.
(ii) All cats are rats.
(iii) All mats are bats.**

- A. (i) & (ii) follow.
- B. Only (i) follows.
- C. Only (ii) follows.
- D. (ii) & (iii) follow.



World Logic Day

World Logic Day is celebrated annually on January 14 to highlight the importance of logic in human knowledge, science, and society. Proclaimed by UNESCO in 2019, the day serves as a global reminder that clear reasoning is a fundamental tool for progress. The date was chosen to commemorate the death of Kurt Godel (Jan 14, 1978) and the birth of Alfred Tarski (Jan 14, 1901), two of the most influential logicians of the 20th century. The main reasons for celebrating this day include highlighting the practical role of logic in today's economy and innovation, promoting critical thinking, fostering international cooperation and supporting a culture of peace and mutual understanding.



Logic makes thinking systematic, consistent, clear, and precise. Just as a trained player makes fewer mistakes than an untrained one, a person who understands logic can reason better and identify errors in arguments.

Notes

This image shows a full page of white paper with horizontal dotted lines, typical of primary school writing paper. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

CONSTITUTION OF INDIA

Part IV A

FUNDAMENTAL DUTIES OF CITIZENS

ARTICLE 51 A

Fundamental Duties- It shall be the duty of every citizen of India:

- (a) to abide by the Constitution and respect its ideals and institutions, the National Flag and the National Anthem;
- (b) to cherish and follow the noble ideals which inspired our national struggle for freedom;
- (c) to uphold and protect the sovereignty, unity and integrity of India;
- (d) to defend the country and render national service when called upon to do so;
- (e) to promote harmony and the spirit of common brotherhood amongst all the people of India transcending religious, linguistic and regional or sectional diversities; to renounce practices derogatory to the dignity of women;
- (f) to value and preserve the rich heritage of our composite culture;
- (g) to protect and improve the natural environment including forests, lakes, rivers, wild life and to have compassion for living creatures;
- (h) to develop the scientific temper, humanism and the spirit of inquiry and reform;
- (i) to safeguard public property and to abjure violence;
- (j) to strive towards excellence in all spheres of individual and collective activity so that the nation constantly rises to higher levels of endeavour and achievements;
- (k) who is a parent or guardian to provide opportunities for education to his child or, as the case may be, ward between age of six and fourteen years.

CHILDREN'S RIGHTS

Dear Children,

*Wouldn't you like to know about your rights? Awareness about your rights will inspire and motivate you to ensure your protection and participation, thereby making social justice a reality. You may know that a commission for child rights is functioning in our state called the **Kerala State Commission for Protection of Child Rights**.*

Let's see what your rights are:

- Right to freedom of speech and expression.
- Right to life and liberty.
- Right to maximum survival and development.
- Right to be respected and accepted regardless of caste, creed and colour.
- Right to protection and care against physical, mental and sexual abuse.
- Right to participation.
- Protection from child labour and hazardous work.
- Protection against child marriage.
- Right to know one's culture and live accordingly.
- Protection against neglect.
- Right to free and compulsory education.
- Right to learn, rest and leisure.
- Right to parental and societal care, and protection.

Major Responsibilities

- Protect school and public facilities.
- Observe punctuality in learning and activities of the school.
- Accept and respect school authorities, teachers, parents and fellow students.
- Readiness to accept and respect others regardless of caste, creed or colour.

Contact Address:



Kerala State Commission for Protection of Child Rights

'Sree Ganesh', T. C. 14/2036, Vanross Junction

Kerala University P. O., Thiruvananthapuram - 34, Phone : 0471 - 2326603

Email: childrights.cpcr@kerala.gov.in, rte.cpcr@kerala.gov.in

Website : www.kescpcr.kerala.gov.in

Child Helpline - 1098, Crime Stopper - 1090, Nirbhaya - 1800 425 1400

Kerala Police Helpline - 0471 - 3243000/44000/45000

Online R. T. E Monitoring : www.nireekshana.org.in