LOGIC

Standard XII

The Constitution of India

Chapter IV A

Fundamental Duties

ARTICLE 51A

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 and 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 achievement;

(k) who is a parent or guardian to provide opportunities for education to his child or, as the case may be, ward between the age of six and fourteen years.

The coordination committee formed by GR No Abhyas - 2116 (Pra. Kra. 43/16) SD-4 Dated 25.4.2016 has given approval to prescrie this textbook in its meeting held on 30.1.2020 and it has been decided to implement it from the educational year 2020-21.

LOGIC

STANDARD XII

2020

Maharashtra State Bureau of Textbook Production and Curriculum Research, Pune.

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The Constitution of India

Preamble

WE, THE PEOPLE OF INDIA, having solemnly resolved to constitute India into a 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 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.

NATIONAL ANTHEM

Jana-gana-mana-adhināyaka jaya hē
        Bhārata-bhāgya-vidhātā,

Panjāba-Sindhu-Gujarāta-Marāthā
        Drāvida-Utkala-Banga

Vindhya-Himāchala-Yamunā-Gangā
        uchchala-jaladhi-taranga

Tava subha nāmē jāgē, tava subha āsisa māgē,
        gāhē tava jaya-gāthā,

Jana-gana-mangala-dāyaka jaya hē
        Bhārata-bhāgya-vidhātā,

Jaya hē, Jaya hē, Jaya hē,
        Jaya jaya jaya, jaya hē.

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.

PREFACE

Maharashtra State Bureau of Textbook Production & Curriculum Research is happy to introduce Logic textbook for standard XIIth. Logic is a science of reasoning. Though ability to reason is an inbuilt feature of human beings, the principles and methods of Logic, make students aware of their innate abilities, which they can develop further through practice.

The students at 10 + 2 level are curious and receptive, so the study of Logic will help them to sharpen their intelligence, enhance the power of reasoning, develop the skill of accurate thinking and enhance the creativity, which will help them to achieve their goals and aspirations.

The syllabus deals with topics such as Decision Procedure, Deductive proof and Quantificational Deduction, where the students will learn to first distinguish between valid and invalid argument and then to prove the validity of arguments.

Various activity-based questions and exercises given in this textbook will help students to understand the basic concepts of logic and master the methods of Logic. Q.R. code is given on the first page of the textbook. You will like the information provided by it.

The bureau of textbook is thankful to the Logic Subject Committee and Study Group, Scrutiny and Quality Reviewers and Artist for their dedication and co-operation in preparing this textbook.

Hope Students, Teachers and Parents will welcome this textbook.

(Vivek Gosavi)
Director

Maharashtra State Bureau of
Text Book Production and
Curriculum Research, Pune

Pune

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For Teachers

Logic subject committee and study group takes great pleasure in introducing logic textbook. The chapter on categorical syllogism is introduced in the textbook. After Standard XIIth, students have to take decision abour their career. They have to appear for various entrance exams for the same. Most of the entrance exams have a paper to test reasoning ability. The chapter on categorical syllogism will help students to prepare for these various entrance exams. Teacher are expected to teach this chapter keeping in mind its importance for the competitive exams. Comparison between Aristotelian Categorical Syllogism and Nyaya syllogism will enlighten students, how logic developed in India in similar way without being influenced by the Greek thought. Which will enhance pride in Students mind about India's contribution to the subject.

Chapter on traditional logic is also introduced at this level, so that students can compare traditional logic with modern logic and understand the development of logic.

Introduction of predicate logic in the textbook will help students to understand the difference between propositional logic and predicate logic, limitations of propositional logic and need for predicate logic.

The chapter, Grounds of Inductions and hypothesis highlight the importance of logic in scientific investigation.

Logic studies abstract concepts, so the important concepts in logic need to be explained step by step, in easy to understand language and by giving examples and various activities in such a way that, students can relate the subject to their experiences in life. Keeping this in mind the textbook is made activity based. Teachers are expected to make use of various examples, teaching aids and activities like debates, logical puzzles and giving examples of good arguments and fallacies from everyday experience. In this way teaching and learning can become interesting and enjoyable experience for both students and teachers.

Std XII Logic

Competency Statements

Sr. No.	Unit	Competency
1.	Decision Procedure	• To learn the method of Shorter Truth table. • To develop the ability to apply the method of shorter truth table as a test of tautology.
2.	Deductive Proof	• To learn the method of Conditional Proof. • To learn the method of Indirect Proof. • To develop the ability to apply the method of Conditional Proof and Indirect Proof to prove the validity of the arguments
3.	Predicate Logic	• To understand the need of Predicate Logic. • To learn the different types of non-compound propositions. • To learn to symbolize Singular and General propositions. • To understand the concept of Propositional function. • To learn methods of deriving propositions from propositional function. • To learn the rules and method of Quantificational Deduction. • To develop the ability to apply the method of Quantificational deduction to prove the validity of arguments.
4.	Traditional Logic	• To understand the nature and classification of propositions. • To learn the distribution of terms in A, E, I, O propositions. • To learn the types of Inferences - Mediate and Immediate. • To learn the types of Mediate Inference and Immediate Inference. • To learn the Opposition of propositions and the develop the ability to apply them. • To learn and apply the Rule of Conversion and the Rule of Obversion.
5.	Categorical Syllogism	• To understand the Nature and structure of Categorical Syllogism. • To learn figures of Categorical Syllogism. • To learn the rules of Categorical Syllogism and the fallacies. • To learn in brief about Indian logic and its comparison with categorical syllogism.
6.	Grounds of Induction	• To understand the problem of Induction. • To understand the grounds of Induction - Material and Formal. • To understand the method of Observation, its Characteristics and Fallacies. • To understand the Conditions of good observation. • To understand the method of Experiment, its Characteristics and Limitations.
7.	Hypothesis	• To define and understand the Characteristics of Hypothesis. • To understand the Origin of Hypothesis. • To understand the Conditions of Good Hypothesis. • To understand the Verification of Hypothesis.

INDEX

1 Decision Procedure

DO YOU KNOW THAT ....

- One can determine whether the statement form is tautology or not in a single row.
- One can determine the validity of many complicated arguments by merely constructing a shorter truth table.
- As in geometry, so in logic, one can decide that a statement form is a tautology by showing the impossibility of its opposite.

1.1 Decision procedure

I.M. Copi defines logic as **"The study of the methods and principles used to distinguish good (correct) from bad (incorrect) reasoning."** The two main functions in logic are - (i) To decide whether an argument is valid or invalid; and (ii) To decide whether a given statement form (truth functional form) is a tautology, contradiction or contingency. A procedure (or method) for deciding these, is called a decision procedure. The main requirement of a decision procedure is that it must be effective. To be an effective decision procedure, it must satisfy 3 conditions – reliable, mechanical and finite.

1.2 Need for shorter truth table method

We have already studied Truth Table as an effective decision procedure. Though, truth table is a simple and easy method for deciding whether a statement form is tautology or not and an argument is valid or invalid, but it has certain limitations. Truth table becomes inconvenient when a statement form involves many variables i.e. with four variables the truth table will have sixteen rows, five variables thirty two rows and so on. With the increase in number of propositional variables in a given expression, the number of rows in the truth table also increases. At such times the application of the method becomes complicated and difficult to manage and the truth table becomes very long, tedious and time consuming. We may make errors while constructing it so lot of carefulness is required. Hence we need shorter and accurate method for determining whether a statement form is tautology or not. Hence shorter truth table method is introduced.

The shorter Truth Table procedure can be carried out in a single line. In fact this is the main advantage of the shorter truth table as a decision procedure. Shorter truth table method is a quick and easy method. As it helps us to decide whether an argument is valid and whether a given statement form is tautology.

1.3 Nature of shorter truth table method

Shorter truth table is a decision procedure –

Shorter truth table method is an effective decision procedure as is satisfies all the conditions of an effective decision procedure. i.e. reliable, mechanical and finite.

The shorter truth table method is based on the principle of reductio-ad-absurdum. The principle of Reductio-ad-absurdum means to show that the **opposite of what is to be proved leads to an absurdity.** In the case of

Complete the following

p • q	p ∨ q	p ⊃ q	p ≡ q	∼ p	∼ p
T T □	□ F F	T F □	□ F T	□ T	□ F

argument we begin by assuming it to be invalid and if the assumption leads to an inconsistency then the argument is proved as valid otherwise it is invalid.

In the case of statement form we first assume it to be not a tautology and if the assumption leads to an inconsistency then the statement form is proved to be tautology or else it is not a tautology.

Since this method does not directly prove whether the argument is valid/invalid or whether the statement form is a tautology or not, it is called the **"Indirect method"**.

1.4 Shorter Truth Table Method as a test of Tautology –

The shorter truth table method is based on the basic truth tables of truth functional compound propositions.

Shorter truth table method is used to decide whether a statement form is tautology or not. Tautology is a truth functional statement form which is true under all truth possibilities of its components. While constructing shorter truth table, we assume that the statement form is not a tautology by placing the truth value 'F' under the main connective of the statement form. If we arrive at an inconsistency, then the assumption is wrong and given statement form is a tautology (tautologous). If we do not arrive at any inconsistency, then the assumption is correct and hence the given statement form is not a tautology. It is either contradictory or contingency.

This procedure involves the following steps –

(1) For determining whether a statement form is a tautology, one has to begin by assuming that it is not a tautology.

(2) For assuming statement form is not a tautology, one has to place 'F' under the main connective of the statement form.

(3) After assigning 'False' truth value under the main connective, with the help of basic truth tables, one can assign truth values to the various components of the statement form.

(4) Truth values are to be assigned to all the connectives and the variables of the statement form and every step is to be numbered.

(5) After assigning the truth value one has to check whether there is any inconsistency. Inconsistencies are of two types – (i) Violation of rules of basic truth table (ii) If a propositional variable gets both truth values i.e. True as well as False.

(6) An inconsistency will prove that the given statement form is a tautology. If there is no inconsistency, it will prove that the statement form is not a tautology.

(7) We mark the inconsistency with a cross "x" below it.

(8) Write whether the given statement form is a tautology or not a tautology.

Following example demonstrates the procedure.

Example 1 (p • p) ⊃ p

(1) One has to assume that the given statement form is 'not a tautology' by writing 'F' under the main connective '⊃'. We mark the assumption 'F' with a star as shown below.

(p • p)	⊃	p
	F	
	*	

(2) The next step is to assign values by using basic truth tables. Since in the example, implication is assumed to be false, the antecedent has to be true and consequent has to be false. So we assign values as follows and number the steps.

(p • p)	⊃	p
T	F	F
(1)	*	(1)

(3) In the next step one has to assign truth values to the component statements of the antecedent. The antecedent is ‘p • p’ is true. Conjunction is true when both its conjuncts are true. So one has to assign values as follows and number them.

(p	•	p)	⊃	p
T	T	T	F	F
(2)	(1)	(2)	*	(1)

(4) Next step is to find out whether these assumption leads to any inconsistency. In the above example one gets inconsistent values for ‘p’. We indicate inconsistency by ‘x’ mark as shown below.

(p	•	p)	⊃	p
T	T	T	F	F
(2)	(1)	(2)	*	(1)
x		x		x

In the above example there is inconsistency in step number 1 and 2. So the assumption is wrong. Hence the given statement form is a tautology.

Example 2 (p • ∼ q) ∨ (q ⊃ p)

(1) To begin with, one has to assume that the given statement form is ‘not a tautology’, by writing ‘F’ below the main connective ‘∨’ (Disjunction). We mark the assumption “F” with a star as shown below.

(p	•	∼	q)	∨	(q	⊃	p)
				F			
				*			

(2) The next step is to assign truth values by using basic truth tables. Since in the example disjunction is assumed to be false, both the disjuncts will be false.

(p	•	∼	q)	∨	(q	⊃	p)
	F			F		F	
	(1)			*		(1)	

(3) The next step is to assign truth values to the components of both the disjuncts and number them. In case of 1st disjunct “•” (conjunction) is the main connective and it is false. Conjunction is false under three possibilities, so we should not assign values to its components. We try to get truth values of the second disjunct which is “q ⊃ p”. Implication is false only under one condition i.e. when its antecedent is true and its consequent is false. So one has to assign values to its components and number them as shown below.

(p	•	∼	q)	∨	(q	⊃	p)
	F			F	T	F	F
	(1)			*	(2)	(1)	(2)

(4) Since one knows the truth values of both ‘p’ and ‘q’, the same truth values can be assigned to the components of the left disjunct, as shown below and number them.

(p	•	∼	q)	∨	(q	⊃	p)
F	F	F	T	F	T	F	F
(3)	(1)	(5)	(4)	*	(2)	(1)	(2)

(5) Next step is to see whether these truth values lead to any inconsistency. In the above example, there is no inconsistency. The assumption is correct. Hence the given statement form is not a tautology.

Example 3 (p ⊃ ∼ q) ≡ ∼ (q • p)

One has to assume that the given statement form is ‘not a tautology’ by writing ‘F’ under the main connective ‘≡’ (equivalence). Equivalent statement is false under two possibilities. – (1) The first component is true and the second is false. And (2) The first compoment is false and second is true. We have to solve the example by assuming both the possibilities.

1st possibility

(1) Considering the first possibility, values are assigned in the given example as follows.

$(p \supset \sim q) \equiv \sim (q \bullet p)$

T F F

1 * 1

(2) The next step is to assign truth values to the components of equivalence and number them. In case of first compoment "⊃" is the main connective and it is true. Implication is true under three possibilities, so we should not assign values to its components. We try to get truth values of the second compoment which is '$\sim (q \bullet p)$'. We already placed 'F' below '∼'. When negation is false, conjunction has to be true. Accordingly one has to assign values to its components as shown below.

$(p \supset \sim q) \equiv \sim (q \bullet p)$

T F F T T T

1 * 1 3 2 3

(3) Since one knows the truth values of both 'p' and 'q', the same truth values can be assigned to the variables in the first component and also to the negation of the variable 'q' as shown below.

$(p \supset \sim q) \equiv \sim (q \bullet p)$

T T F T F F T T T

4 1 6 5 * 1 3 2 3

x

(4) There is inconsistency in step number 1 as it violates the rule of implication. So the assumption is wrong. Hence the given statement form is a tautology, in the case of first possibility.

Now let's consider the second possiblity

2 nd possibility

(1) $(p \supset \sim q) \equiv \sim (q \bullet p)$

F F T

1 * 1

Considering the second possiblity, truth values are assigned as follows.

The next step is to assign truth values to the components of equivalence. In case of first component '⊃' is false. So truth values are assigned as follows.

(2) $(p \supset \sim q) \equiv \sim (q \bullet p)$

T F F T F T

2 1 2 3 * 1

'∼ q' is 'F' so 'q' will be 'T'

Since one knows the truth values of both 'p' and 'q', the same truth values can be assigned to the variables in the second component as shown below.

(3) $(p \supset \sim q) \equiv \sim (q \bullet p)$

T F F T F T T F T

2 1 2 3 * 1 5 4 6

x

There is inconsistency in step number 4 as it violates the rule of conjunction. So the assumption is wrong. Hence the given statement form is a tautology in the case of second possibility as well

In above example we get inconsistency in both the possiblities. So in both the possiblities it is a tautology and therefore, the given statement form is a tautology. It should be noted that if one of the possibilities is not a tautology, then the statement form is not a tautology. To be tautology, the statement form must be tautology under every possibility.

Example 4 $(p \vee \sim q) \bullet (\sim p \supset q)$

One has to begin by assuming the above statement form to be 'not a tautology' by writing 'F' below '•'. Conjunction is false under three possibilities. –

(1) First conjunct is True and second conjunct is False;

(2) First conjunct is False and second conjunct is True; and

(3) Both the conjuncts are false.

This problem is to be solved considering all the three possibilities.

1st possibility

(p ∨ ∼ q) • (∼ p ⊃ q)

F T T F F   T F F F

4 1 6 5   *   2 3 1 2

There is no inconsistency. The assumption is correct. Hence in this possiblity the given statement form is not a tautology.

2nd possibility

(p ∨ ∼ q) • (∼ p ⊃ q)

F F F T F   T F T T

2 1 2 3   *   6 4 1 5

There is no inconsistency. The assumption is correct. Hence in this possibility too the given statement form is not a tautology.

3rd possibility

(p ∨ ∼ q) • (∼ p ⊃ q)

F F F T F   T F F T

2 1 2 3   *   6 4 1 5

x

There is an inconsistency in step number 1 as it violates the rule of implication. So the assumption is wrong and a statement form is a tautology in case of this possibility. Out of three possibilities, the statement form is not a tautology in the case of two possibilities and is a tautology in the case of one possibility. Hence, the given statement form is not a tautology.

If we get 'not a Tautology' in the first possibility, then the whole expression will be 'not a Tautology' and there is no need to check further possibilities.

Example 5 (p • q) ∨ (p ∨ q)

F F F   F   F F F

3 1 3   *   2 1 2

There is no inconsistency, therefore the given statement form is not a tautology.

Example 6 (p • ∼ q) ⊃ ∼ q

T T T F   F F T

3 1 3 4   * 1 2

x   x

There is inconsistency in step Number 2 and 4, therefore the given statement form is a tautology.

Example 7 [(p ⊃ q) • q] ⊃ ∼ p

T T T T T F F T

4 3 5 1 3 * 1 2

There is no inconsistency. Therefore the given statement form is not a tautology.

Example 8 (p ⊃ q) ⊃ [(p ∨ r) ⊃ (q ∨ r)]

T T F   F   T T F   F   F F F

6 1 7   *   5 2 4   1   3 2 3

x

Since there is inconsistency in step number 1. Therefore the given statement form is a tautology.

Example 9 ∼ (∼ p ∨ q) ∨ (q ∨ ∼ p)

F   F T T F   F   F F F T

1   7 5 2 6   *   3 1 3 4

x x x

> Assign the correct truth value
>
> (1) (p ⊃ q) ⊃ [(p ⊃ r) ⊃ q]
>
> □   F   □
>
> *
>
> (2) ∼ [(∼ p ∨ q) • (∼ q • r)]
>
> F   □

Summary

- Shorter truth table method is a decision procedure.
- It is an effective decision procedure because it is reliable, finite and mechanical.
- It is a convenient method.
- It is used to test whether a statement form is a tautology or not a tautology.
- It is an indirect method.
- It is based on the principle of reductio-ad-absurdum.
- It is based on the basic truth tables of truth functional compound statements.

Basic Truth Table

Negation

~	p
F	T
T	F

Conjunction

p	•	q
T	T	T
T	F	F
F	F	T
F	F	F

Disjunction

p	∨	q
T	T	T
T	T	F
F	T	T
F	F	F

Implication

p	⊃	q
T	T	T
T	F	F
F	T	T
F	T	F

Equivalence

p	≡	q
T	T	T
T	F	F
F	F	T
F	T	F

Exercises

Q. 1. Fill in the blanks with suitable words from those given in the brackets :

(1) Shorter truth table is an ………. method. *(direct/indirect)*

(2) ………. method is based on the principle of reductio-ad-absurdum. *(Truth table/ Shorter Truth Table)*

(3) If both the antecedent and the consequent of an implicative statement are false then the statement is ………. . *(true/false)*

(4) If inconsistency is obtained after assuming the given statement form to be false, then the statement form is proved to be ………. *(tautology/ not a tautology)*

(5) When both the components of a disjunctive statement are false then the truth value of the statement is ………. . *(true/ false)*

(6) When we deny tautology, we get ………. . *(contradiction/ contingency)*

(7) If ‘p’ is true then ‘∼p’ is ………. . *(true/ false)*

(8) Shorter truth table is a ………. . *(decision procedure/ deductive proof)*

(9) Equivalence is ………. when both its components are false. *(true/ false)*

(10) ………. is a symbol used for negative statement. (• / ∼)

Q. 2. State whether the following statements are true or false.

(1) A negative statement is false when its component statement is true.

(2) If a conjunctive proposition is false both its components must be false.

(3) ‘•’ is a monadic connective.

(4) Inconsistency in a shorter truth table is obtained when a rule of basic truth table is violated.

(5) Shorter truth table method is inconvenient than truth table method.

(6) Truth table is based on the principle of reductio-ad-absurdum.

(7) Shorter truth table does not directly prove whether a statement form is a tautology or not.

(8) Contingency is always true.

(9) If the consequent is true then the implicative statement must be true.

(10) Contradictory statement form is always false.

(11) ‘ p ∨ ∼ p’ is a tautology.

Q. 3. Match the columns :

	(A)		(B)
(1)	Shorter Truth Table	(a)	Always true
(2)	Truth Table	(b)	Always false
(3)	Contradiction	(c)	Direct Method
(4)	Tautology	(d)	Reductio-ad-absurdum

Q. 4. Give logical terms for the following :

(1) A statement form which is always true.

(2) A decision procedure based on reductio-ad-absurdum.

(3) A statement form which is true under all truth possibilities of its components.

(4) A decision procedure which is an indirect method.

(5) Statement having antecedent and consequent as its components.

(6) A statement form which is false under all possibilities.

(7) A statement form which is true under some possibilities and false under some possibilities.

Q. 5. Use shorter truth table method to test whether the following statement forms are tautologous.

(1) $[(p \supset \sim q) \cdot q] \supset \sim p$

(2) $(\sim p \cdot \sim q) \cdot (p \equiv q)$

(3) $(p \supset q) \supset (\sim q \supset \sim p)$

(4) $(p \cdot q) \vee (q \supset p)$

(5) $(p \cdot p) \vee \sim p$

(6) $(q \supset \sim p) \vee \sim q$

(7) $(\sim p \supset q) \cdot (\sim p \cdot \sim q)$

(8) $[(\sim p \vee \sim q) \cdot q] \supset \sim p$

(9) $(p \supset \sim q) \vee (\sim q \supset p)$

(10) $\sim p \vee (p \supset q)$

(11) $(p \supset q) \equiv (\sim p \vee q)$

(12) $(\sim p \cdot \sim q) \supset (q \supset \sim p)$

(13) $(p \vee q) \supset \sim (p \cdot q)$

(14) $\sim (p \vee q) \equiv (\sim p \cdot \sim q)$

(15) $(\sim p \cdot q) \supset (q \supset p)$

(16) $(q \supset p) \cdot \sim p$

(17) $\sim (p \cdot q) \vee (p \supset \sim q)$

(18) $(\sim p \supset q) \cdot (\sim q \supset p)$

(19) $p \supset [(r \supset p) \supset p]$

(20) $p \supset (p \vee q)$

(21) $(p \vee p) \equiv \sim p$

(22) $\sim (p \supset \sim q) \supset (q \cdot p)$

(23) $p \cdot \sim (p \supset \sim p)$

(24) $\sim [p \supset (\sim q \vee p)]$

(25) $(p \cdot q) \equiv (\sim p \supset \sim q)$

2 Deductive Proof

DO YOU KNOW THAT ....

- If someone offers you a ticket to Europe tour or Asia tour then Logic is on your side, if you accept the ticket for Europe but not Asia, You can prove the Conclusion by showing that its denial is impossible.
- When an idividual says '6 + 4' is same as '4 + 6' then that individual is using the rule of Logic.

2.1 Formal Proof of Validity :

There are two types of methods used by the logicians, for deciding or proving the validity of arguments.

1) Decision Procedure such as Truth Table Method, Shorter truth table method, Truth tree etc. are used to decide validity of arguments.

2) Methods that are not Decision procedure such as Deductive proof, Conditional proof, Indirect proof are used to prove validity of arguments.

Truth-table is a purely mechanical method for deciding whether an argument is valid or invalid, however it is not a convenient method when an argument contains many different truth-functional statements. In such cases there are other methods in Logic for establishing the validity of arguments and one of the method is the 'Method of Deductive Proof'.

The Deductive Proof is of three types. They are :

(1) The Direct Deductive Proof

(2) Conditional Proof

(3) Indirect Proof

In the Method of Direct Deductive Proof, the conclusion is deduced directly from the premises by a sequence of Elementary valid argument forms. The Elementary valid argument forms, used for this purpose are called the 'Rules of Inference'; we have already dealt with direct deductive proof and we know that the Direct Deductive proof is based on nine rules of inference and ten rules based on rule of replacement as follows.

Rules of Inference :

(i) Rule of Modus Ponens (M.P.) $p \supset q$ p $\therefore q$	(ii) Rule of Modus Tollens (M.T.) $p \supset q$ $\sim q$ $\therefore \sim p$
(iii) Rule of Hypothetical syllogism (H.S.) $p \supset q$ $q \supset r$ $\therefore p \supset r$	(iv) Rule of Disjunctive syllogism (D.S.) $p \vee q$ $\sim p$ $\therefore q$
(v) Rule of Constructive Dilemma (D.D.) $(p \supset q) \cdot (r \supset s)$ $p \vee r$ $\therefore q \vee s$	(vi) Rule of Destructive Dilemma (D.D.) $(p \supset q) \cdot (r \supset s)$ $\sim q \vee \sim s$ $\therefore \sim p \vee \sim r$

(vii) Rule of Conjunction (Conj.) p q $\therefore p \cdot q$	(viii) Rule of Simplification (Simp.) $p \cdot q$ $\therefore p$
(ix) Rule of Addition (Add.) p $\therefore p \vee q$	

Rules based on the rule of Replacement:

(i) Rule of Double Negation (D.N.) $\sim \sim p \equiv p$	(ii) De-Morgan's Law (De. M.) $\sim (p \cdot q) \equiv (\sim p \vee \sim q)$ $\sim (p \vee q) \equiv (\sim p \cdot \sim q)$
(iii) Associative Laws (Assoc.) $[(p \cdot q) \cdot r)] \equiv [p \cdot (q \cdot r)]$ $[(p \vee q) \vee r)] \equiv [p \vee (q \vee r)]$	(iv) Distributive Laws (Dist.) $[p \cdot (q \vee r) \equiv [(p \cdot q) \vee (p \cdot r)]$ $[p \vee (q \cdot r) \equiv [(p \vee q) \cdot (p \vee r)]$
(v) Commutative Law (Comm.) $(p \cdot q) \equiv (q \cdot p)$ $(p \vee q) \equiv (q \vee p)$	(vi) Rule of Transposition (Trans.) $(p \supset q) \equiv (\sim q \supset \sim p)$
(vii) Rule of Material Implication (M. Imp.) $(p \supset q) \equiv (\sim p \vee q)$	(viii) Rule of Material Equivalence (M. Equi) $(p \equiv q) \equiv [(p \supset q) \cdot (q \supset p)]$ $(p \equiv q) \equiv [(p \cdot q) \vee (\sim p \cdot \sim q)]$
(ix) Rule of Exportation (Export.) $[(p \cdot q) \supset r] \equiv [p \supset (q \supset r)]$	(x) Rule of Tautology (Taut.) $p \equiv (p \cdot p)$ $p \equiv (p \vee p)$

2.2 Conditional Proof

The method of Conditional Proof is used to establish the validity of arguments, when the conclusion of an argument is an implicative (conditional) proposition. The method of Conditional Proof is based upon the Rule of Conditional Proof.

The Rule of Conditional Proof enables us to construct shorter proofs of validity for some arguments. Further by using it, we can prove the validity of some arguments which cannot be proved by using the above nineteen rules.

The Rule of Conditional Proof may be expressed in a simple way :

"By assuming the antecedent of the conclusion as an additional premise, when its consequent is deduced as the conclusion, the original conclusion will be taken to have been proved".

While using Conditional Proof, it should be noted that the conclusion can be any statement equivalent to a conditional statement. In such a case, first the equivalent conditional statement is derived and then the Rule of Conditional Proof is used. **However, in this chapter, we will use Conditional Proof only when the conclusion is a conditional statement.**

To illustrate let us construct a Conditional Proof of Validity for the following argument :

Example : 1

~ M ⊃ N

∴ ~ N ⊃ M

The proof may be written as follows :

1.	~ M ⊃ N	/ ∴ ~ N ⊃ M	
2.	~ N	Assumption	
3.	~ ~ M	1, 2 . M.T.	
4.	M	3 . D.N.	

Here the step 2 is the antecedent of the conclusion. It is used as an assumption. (The assumption should be indicated by bent arrow.)

From the premise 1 and the assumption, one has deduced the consequent of the conclusion by the Rule of M.T.

However the proof is not complete. One has yet to arrive at the conclusion. To do so one more step remains to be taken, i.e. to write down the conlcusion, '~ N ⊃ M'.

The proof is now written by adding step 5 thus :

1.	~ M ⊃ N	/ ∴ ~ N ⊃ M	
2.	~ N	Assumption	
3.	~ ~ M	1, 2 . M.T.	
4.	M	3. D.N.	
5.	~ N ⊃ M		2 - 4, C.P.

The conclusion step 5 has not been deduced from the assumption. So the conclusion lies outside the scope of the assumption. i.e. the scope of the assumption ends up with the last step which follows from step 4. To mark this out clearly the device of a bent arrow ( ) is used. The head of the arrow points at the assumption and its shaft runs down till it reaches the last statement which is deduced on its basis, then the arrow bends inwards and discharges (closes) the assumption. The last step i.e. step 5, where the conclusion is written, will lie outside the scope of assumption.

The proof may now be written down as :

1.	~ M ⊃ N	/ ∴ ~ N ⊃ M	
2.	~ N		
3.	~ ~ M	1, 2 . M.T.	
4.	M	5 . D.N.	
5.	~ N ⊃ M		2 - 4, C.P.

The head of the arrow indicates that step 2 is an assumption. So the word "assumption" need not be written as the justification.

If the conclusion has a compound proposition with more than one conditional statement as its components, then the antecedents of all the conditional statements can be assumed as additional premises.

Let us take an example of this type :

Example : 2

1.	(X ∨ Y) ⊃ Z		
2.	A ⊃ (B • C)	/ ∴ (X ⊃ Z) • (A ⊃ B)	
3.	X		
4.	X ∨ Y		3, Add.
5.	Z		1, 4 M.P.
6.	X ⊃ Z		3 - 5, C.P.
7.	A		
8.	(B • C)		2, 7, M.P.
9.	B		8, Simp.
10.	A ⊃ B		7 - 9, C.P.
11 .	(X ⊃ Z) • (A ⊃ B)		6, 10 Conj.

Here the scope of the assumption in step 3 is independent of the scope of assumption in step 7.

Hence assumption in step 7 lies outside the scope of the assumption in step 3.

But in the next example-3 given below, the scope of one assumption lies within the scope of the other assumption.

Example : 3

1. $(M \bullet N) \supset O$ / $\therefore \sim O \supset (M \supset \sim N)$
2. $\sim O$
3. $\sim (M \bullet N)$ 1, 2 . M.T.
4. $\sim M \vee \sim N$ 3, De.M.
5. M
6. $\sim \sim M$ 5, D.N.
7. $\sim N$ 4, 6 . D.S.
8. $M \supset \sim N$ 5-7, C.P.
9. $\sim O \supset (M \supset \sim N)$ 2-8, C.P.

Here the assumption at step 5, lies within the scope of the assumption of step 2.

Give justifications for each step of the following formal proofs of validity by the method of conditional proof.

1. $(P \bullet Q) \supset S$ / $\therefore \sim S \supset [P \supset (\sim Q \vee T)]$
2. $\sim S$
3. $\sim (P \bullet Q)$
4. $\sim P \vee \sim Q$
5. P
6. $\sim \sim P$
7. $\sim Q$
8. $\sim Q \vee T$
9. $P \supset (\sim Q \vee T)$
10. $\sim S \supset [P \supset (\sim Q \vee T)]$

2.3 Indirect Proof :

The methods of Direct Deductive Proof and Conditional Proof have one thing in common while using them we deduce the conclusion from the premises. The method of Indirect Proof is completely different from these methods.

The method of Indirect Proof is based on **the principle of reductio-ad-absurdum**. Here one assumes the opposite of what is to be proved and this leads to an absurdity. i.e. this method consists in proving the conclusion by showing that its negation leads to contradiction.

An Indirect Proof of validity for an argument is constructed by assuming the negation of the conclusion as an additional premise. From this additional premise, along with original premise/s a contradiction is derived. A contradiction is a conjunction in which one conjunct is the denial of the other conjunct. Eg. '$A \bullet \sim A$', '$(A \vee B) \bullet \sim (A \vee B)$', are contradictions.

By assuming the negation of the conclusion, we obtain a contradiction. This shows that the assumption is false. The assumption is the negation of the conclusion. Since the assumption is false, the original conclusion is taken to be proved.

When this method of proof is used, the validity of the original argument is said to follow by the rule of Indirect proof. **Unlike conditional proof the method of Indirect proof can be used irrespective of the nature of the conclusion.**

Let us construct an Indirect proof of validity for the following argument :

Example : 1

1. $\sim M \vee N$
2. $\sim N$ / $\sim M$
3. $\sim \sim M$ I.P.
4. N 1, 3 D.S.
5. $N \bullet \sim N$ 4, 2 Conj.

In the above proof, the expression 'I.P' shows that the Rule of Indirect Proof is being used. In the above example, we first assume the negation of the conclusion then by using rules of inference and rules based on the rule of replacement, we arrive at a contradiction.

The last step of the proof is a contradiction, which is a demonstration of the absurdity derived by assuming $\sim \sim M$ in the step 3. This contradiction is formally expressed in the last step exhibits the absurdity and completes the proof.

Let us construct few more Indirect Proof of validity for the following arguments :

Example : 2

1.	M ⊃ T	
2.	G ⊃ T	
3.	M	/ ∴ T
4.	~ T	1.P.
5.	~ M	1, 4. M. T.
6	M • ~ M	3, 5 Conj

Example : 3

1.	(B • D) ∨ E	
2.	C ⊃ ~ E	
3.	F ⊃ ~ E	
4.	C ∨ F / ∴ B • D	
5.	~ (B • D)	..... I.P.
6.	E	1,5 D.S.
7.	(C ⊃ ~ E) • (F ⊃ ~ E)	2, 3 Conj.
8.	~ E ∨ ~ E	7,4 C.D.
9.	~ E	8, Taut.
10.	E • ~ E	6, 9 Conj.

Example : 4

1.	(Q ∨ ~ P) ⊃ S	/ ∴ Q ⊃ S
2.	~ (Q ⊃ S)	..... I.P.
3.	~ (~ Q ∨ S)	2, m. Imp.
4.	~ ~ Q • ~ S	3, De. M
5.	~ ~ Q	4, Simp.
6.	Q	5, D.N.
7.	Q ∨ ~ P	6, Add.
8.	S	1, 7 M.P.
9.	~ S • ~ ~ Q	4, Com.
10.	~ S	9, Simp.
11.	S • ~ S	8,10 Conj.

In the fourth argument given above, the conclusion is a conditional statement. So the method of Conditional Proof could have been used. Infact the proof would have been shorter.

Give justifications for each step of the following formal proofs of validity by the method of Indirect proof :

1.	(H ∨ K) ⊃ (N • B)	
2.	B ⊃ ~ C	
3.	C	/ ∴ ~ H
4.	~ ~ H	
5.	H	
6.	H ∨ K	
7.	N • B	
8.	B • N	
9.	B	
10.	~ C	
11.	C • ~ C	

Summary

There are three types of Deductive Proofs :

(1) Direct Deductive Proof : In this method conclusion is derived directly from the premises.

(2) Conditional Proof : This method is used only when the conclusion of an argument is a conditional statement. In this method the antecedent of the conclusion is taken as an additional premise and the consequent of the conclusion is deduced with the help of the required rules of Inference and rules based on the rule of replacement.

(3) Indirect Proof : This method is preferably used when the conclusion of an argument is other than a conditional statement. In this method we assume the negation of the conclusion as an additional premise.

From this, along with the original premises, we obtain a contradiction. And this is taken to be the proof of validity of arguments.

Exercises

Q. 1. Fill in the blanks with suitable words from those given in the brackets:

(1) [(p ⊃ q) • p] ⊃ q is the rule of .... *(Modus Ponens / Modus Tollens)*

(2) The rule of .... consists in interchanging the antecedent and the consequent by negating both of them. *(Commutation / Transposition)*

(3) The rule of Addition is based on the basis truth table of .... *(Conjunction / Disjunction)*

(4) The .... can be applied to the part of the statement. *(rules of inference / rules based on rule of replacement)*

(5) ~ (~ p ∨ q) ≡ ...., according to De. Morgan's Law. *((p • ~ q) / (~ p • q)*

(6) (p ⊃ q) ≡ (~ p ∨ q) is the rule of .... *(Material Implication / Material Equivalance)*

(7) The method of .... is used only when the conclusion of an argument is an implicative statement. *(Conditional Proof / Indirect Proof)*

(8) In the method of ...., we assume the negation of the conclusion as an additional premise. *(Conditional Proof / Indirect Proof)*

(9) The rule of .... states that if an implication is true and its consequent is false, then its antecedent must also be false. *(M.P./ M.T.)*

(10) (p • p) ≡ p is the rule of .... *(Simplification / Tautology)*

(11) The method of .... is based on the principle of reductio-ad-absurdum. *(Conditional Proof / Indirect Proof)*

Q. 2. State whether the following statements are true or false.

(1) The rule of Disjunctive Syllogism can be applied to the part of the statement.

(2) ~ ~ p ≡ p is the rule of Tautology.

(3) When the denial of the conclusion leads to contradiction, the argument is proved to be valid in the method of indirect proof.

(4) Conditional Proof decides whether the argument is valid or invalid.

(5) Indirect proof is constructed for establishing the validity of arguments.

(6) Conditional proof is a mechanical procedure.

(7) (p ∨ q) ≡ (q ∨ p) is Commutative Law.

(8) The rule of inference can be applied to the whole statement only.

(9) The Elementary valid arguments forms are called the rule of Replacement.

Q. 3. Match the columns :

	A		B
(1)	Elementary valid argument forms	(a)	Antecendent of the conclusion is assumed.
(2)	Conditional Proof	(b)	Principle of reductio-ad absurdum.
(3)	Indirect Proof	(c)	Rule based on rule of replacement.
(4)	De. Morgan's Law	(d)	Rules of Inference

Q. 4. Give Logical Terms for the following :

(1) The rules that can be applied only for the whole statement.

(2) The elementary valid argument forms.

(3) The method of establishing the validity of an argument by assuming the negation of the conclusion.

(4) The deductive proof which is based on the principle of reductio-ad-absurdum.

(5) The method which is used to establish the validity of argument, only when its conclusion is an implicative statement.

Q. 5. Construct Conditional proof or Indirect proof of validity for the following arguments:

(1) $\sim A \; / \therefore A \supset B$

(2) 1. $(L \vee M) \supset (P \bullet Q)$

2. $\sim P \quad / \therefore \sim L$

(3) 1. $(S \bullet A) \supset R$

2. $\sim R$

3. $A \quad / \therefore \sim S$

(4) 1. $Q \vee (P \vee R) \; / \therefore \sim Q \supset [\sim R \supset (P \vee S)]$

(5) 1. $A \vee (B \supset D)$

2. $A \supset C$

3. $B \quad / \therefore \sim C \supset D$

(6) 1. $D \supset E$

2. $D \vee G \quad / \therefore E \vee G$

(7) 1. $W \supset L$

2. $T \supset (\sim P \bullet L)$

3. $W \vee T \quad / \therefore L$

(8) 1. $T \vee B$

2. $(T \vee N) \supset (L \bullet S)$

3. $\sim S \quad / \therefore B$

(9) 1. $R \supset (Q \supset P)$

2. $S \supset R$

3. $T \supset Q$

4. $\sim P \quad / \therefore S \supset \sim T$

(10) 1. $(A \vee B)$

2. $(C \vee D) \supset E$

$/ \therefore [\sim A \supset (B \vee F)] \bullet (D \supset E)$

(11) 1. $(G \supset H) \supset J$

2. $\sim J \quad / \therefore G$

(12) 1. $L \supset (M \vee N)$

2. $T \vee L \quad / \therefore \sim M \supset (\sim T \supset N)$

(13) 1. $A \supset B$

2. $C \supset D \quad / \therefore (A \bullet C) \supset (B \bullet D)$

(14) 1. $K \vee (T \bullet \sim W)$

2. $W \vee S \quad / \therefore K \vee S$

(15) 1. $A \vee (B \supset C)$

2. $C \supset D$

3. $\sim D$

4. $B \vee E \quad / \therefore \sim A \supset E$

(16) 1. $P \supset (Q \supset R)$

2. $(Q \bullet S) \vee W \quad / \therefore \sim R \supset (P \supset W)$

(17) 1. $(A \bullet B) \vee C$

2. $(C \vee D) \supset E$ / $\therefore$ $\sim A \supset E$

(18) 1. $\sim K \vee G$

2. $G \supset I$

3. $\sim I$ / $\therefore$ $\sim K$

(19) 1. $D \supset E$ / $\therefore$ $D \supset (D \bullet E)$

(20) 1. $F \supset (G \supset H)$

2. $G \supset (H \supset J)$ / $\therefore$ $F \supset (G \supset J)$

(21) 1. $R \supset (S \bullet T)$

2. $(S \vee U) \supset W$

3. $U \vee R$ / $\therefore$ W

(22) 1. $(P \vee Q) \supset [(R \vee S) \supset T]$

/ $\therefore$ $P \supset [(R \bullet U) \supset T]$

(23) 1. $(A \supset B) \bullet (C \supset D)$

2. $\sim B$ / $\therefore$ $(A \vee C) \supset D$

(24) 1. $(K \vee G) \supset (H \bullet I)$

2. $(I \vee M) \supset O$ / $\therefore$ $K \supset O$

(25) 1. $(R \bullet R) \supset Q$

2. $Q \supset \sim R$ / $\therefore$ $\sim R$

(26) 1. $\sim P \supset S$

2. $\sim Q \supset P$

3. $\sim Q \vee \sim S$ / $\therefore$ P

(27) 1. $(\sim P \vee Q) \supset S$ / $\therefore$ $\sim S \supset \sim Q$

(28) 1. $\sim F \supset (G \supset \sim H)$

2. $L \vee \sim F$

3. $H \vee \sim M$ / $\therefore$ $\sim L \supset (G \supset \sim M)$

(29) 1. $B \supset C$

2. $D \supset E$

3. $(C \bullet E) \supset G$ / $\therefore$ $(B \bullet D) \supset G$

(30) 1. $U \supset (W \vee X)$

2. $\sim \sim U \bullet \sim X$

3. $(Y \vee W) \supset Z$ / $\therefore$ Z

(31) 1. $D \supset G$

2. $D \vee H$ / $\therefore$ $G \vee H$

(32) 1. $\sim (P \supset Q) \supset \sim R$

2. $S \vee R$ / $\therefore$ $\sim S \supset (\sim P \vee Q)$

(33) 1. $J \supset K$

2. $\sim (K \bullet L)$

3. L / $\therefore$ $\sim J$

(34) $(P \vee Q) \supset R$

2. $\sim R \vee S$

3. $\sim P \supset T$

4. $\sim S$ / $\therefore$ T

(35) 1. $C \vee (W \bullet S)$

2. $C \supset S$ / $\therefore$ $\sim W \supset S$

(36) 1. $(A \vee B) \supset C$

2. $(B \vee C) \supset (A \supset E)$

3. $D \supset A$ / $\therefore$ $D \supset E$

(37) 1. $R \supset (\sim P \vee \sim Q)$

2. $S \supset T$

3. $T \supset Q$

4. P / $\therefore$ $S \supset \sim R$

(38) 1. $A \supset (B \supset C)$

2. B

3. $(E \supset T) \supset K$

/ $\therefore$ $(A \supset C) \bullet (T \supset K)$

3 Predicate Logic

Frege's... discovery of qualification, the deepest single technical advance ever made in logic.

- ***Read the following argument.***

  All scientists are intelligent.

  All intelligents are creative.

  Therefore all scientists are creative.
- Is this argument valid?
- Test validity of this argument by using the method of truth table, shorter truth table, direct deductive proof. C. P and, I. P.
- What answer do you get?

3.1 Need for Predicate logic

The logic we have studied so far is known as propositional logic. The methods that we have studied in propositional logic like, Truth table, Shorter truth table, Direct deductive proof, C.P. and I.P. cannot decide or prove validity of all arguments. These methods can be used only for those arguments whose validity depends upon the ways in which simple statements are truth-functionally combined into compound statements. The branch of logic which deals with such type of arguments is called Propositional logic.

In Propositional logic a proposition is taken as one unit. It does not involve analysis of the proposition. It does not take into consideration how terms in the propositions are related. However there are certain types of arguments whose validity depends upon the inner logical structure of the non-compound statements it contains. Methods of propositional logic are not adequate in testing validity of such arguments. Let us take an example -

All singers are creative.

Mahesh is a singer.

Therefore, Mahesh is creative.

In propositional logic by using propositional constants one can symbolize the above argument as follows –

S

M / ∴C

It is obvious that the above given argument is valid but it cannot be proved to be valid by the methods of propositional logic. The method of truth table on the contrary shows that the argument is invalid. All the three statements involved in the argument are non-compound statements. The inner logical structure of these statements and the relation between the terms involved in the statements is important in deciding the validity of this argument. The relation between the class of singer and the class of creative people is stated in the first premise. It states that the class of singers is included in the class of creative people i.e. whoever is a singer is also creative. The second premise states that the individual Mahesh belongs to the class of singer and therefore in the conclusion it is validly inferred that Mahesh also belongs to the class of creative people. When the argument is symbolized in propositional logic as stated above the inner logical structure of the statements and the relation between the terms involved is not revealed. It is therefore necessary to symbolize the argument in such a way that the inner logical structure of the statements is revealed and then one can prove validity of such arguments. The branch of logic which deals with such types of arguments is known as Predicate logic or Predicate calculus.

Like propositional logic, in predicate logic a proposition is not taken as one unit. The propositions are analyzed and symbolized to reveal, how the terms in the propositions are related with each other. However, Predicate logic is not totally different from propositional logic. The methods and notations of propositional logic are used in predicate logic so far as they are applicable to the non-compound statements with which it deals. If a formula is valid in propositional logic, the corresponding formula in predicate logic will also be valid. Though predicate logic includes propositional logic and is based on it, predicate logic goes beyond propositional logic since it reveals the logical structure of the propositions and the relation between the different terms of the proposition.

Can you recognize and state how the following non compound propositions differ from each other? How can we classify them?

Everything is beautiful.

Ashish is smart.

All birds have wings.

Some children are brilliant.

Nilesh is not tall.

No farmer is rich.

Nothing is permanent.

Some things change.

Some mobile phones are not expensive.

Some things are not attractive.

3.2 Types of Propositions

The non compound propositions; whose inner logical structure is significant in proving validity of arguments in Predicate logic are of two types – (1) Singular propositions and (2) General propositions

Singular Propositions :

Singular proposition makes an assertion about a particular/specific individual. **Singular Proposition states that an individual possesses or does not possess a certain property/ attribute (quality).** Thus we get two types of singular propositions, affirmative singular propositions and negative singular propositions. **Affirmative singular proposition states that an individual possesses a certain property,**

For example : Sunita is a dancer.

Here ‘Sunita’ is a subject term and ‘dancer’ is a predicate term. **Negative singular proposition states that an individual does not possess a certain property,**

For example : London is not an American city.

The word ‘individual’ here refers not only to persons but to anything like a city, a country, an animal or anything of which an attribute can be significantly predicated and the ‘property’/ ‘attribute’ may be an adjective, a noun or even a verb. Following are some examples of singular propositions -

(1) Sahil is a good writer.

(2) This Dog is not a wild animal.

(3) Ashok is not a politician.

(4) Thames is not an Indian river.

(5) Nikita is an athlete.

General Proposition :

General propositions make an assertion about class/classes. General propositions are broadly classified into two types – (1) General propositions making an assertion about one class and (2) General propositions making an assertion about two classes or giving relation between two classes. Each type is further classified into Universal and Particular (Existential) general proposition. Universal general proposition makes an assertion about all members of a class where as a particular general proposition makes an assertion about some members of a class. Universal general proposition can be either affirmative or negative. Similarly particular/existential general proposition can also be either affirmative or negative. Thus altogether we get eight types of general propositions as given below.

General propositions

One class	Two classes
(1) Universal affirmative e.g. Everything is interesting	(1) Universal affirmative (A proposition) e.g. All fruits are sweet
(2) Universal negative e.g. Nothing is useless	(2) Universal negative (E proposition) e.g. No living being is immortal
(3) Existential affirmative e.g. Some things are beautiful	(3) Particular affirmative (I proposition) e.g. Some children are creative
(4) Existential negative e.g. Some things are not clean	(4) Particular negative (O proposition) e.g. Some cities are not crowed

3.3 Symbolization of singular and general propositions

Symbolizing singular propositions :

The two important components of any singular propositions are – (1) Name of an individual (2) Property / Attribute. Two different symbols are used for symbolizing these components namely Individual constant and Predicate constant. **An Individual constant is a symbol which stand for the name of an individual.** Small letters of English alphabet 'a' to 'w' are used as individual constants. **Predicate constant is a symbol which stands for the particular property/attribute.** Capital letters of English alphabet 'A' to 'Z' are used as predicate constants. While symbolizing a singular proposition, the symbol for the property is written to the left of the symbol for the name of an individual

For example : the singular proposition, 'Suraj is wise' is symbolized as 'Ws', here 'W' stands for the attribute 'wise' and 's' stands for the name of an individual i.e. Suraj. A negative singular proposition is symbolized by placing '∼' before the statement,

For example : the statement 'Makarand is not cunning', is symbolized as '∼ Cm'.

While symbolizing it is necessary to follow the same two restrictions which we follow while symbolizing propositions in propositional logic namely:

(1) The same individual constant should be used for symbolizing the name of an individual if it occurs again in the same argument or proposition. Similarly the same predicate constant should be used for symbolizing the name of property if it occurs again in the same argument or proposition.

(2) In the same argument or proposition, different individual constants and predicate constants should be used for different names of individual and property respectively.

Before we learn symbolization of general propositions it is necessary to learn about two more important symbols used in predicate logic i.e. Individual variable and Predicate variable. **Individual variable is a symbol which stands for any individual whatsoever.**

Individual variable does not stand for any specific individual. It is only a **place marker** which marks the place of an individual. It can be replaced by a proper name of an individual or by an individual constant. The small letters 'x', 'y', 'z' of English alphabet are used as individual variables. ***For example,*** the proposition 'Mohini is beautiful' is about the specific individual. But in place of the name of a particular individual i.e. Mohini if we leave a blank space keeping the rest of the statement same, we shall get the expression – '---------------- is beautiful'. The blank space here is just a place marker that marks the place of an individual, so in place of blank space we can use individual variable 'x' and we will get the expression – 'x is beautiful' which can be symbolized as 'Bx'. Similarly **Predicate variable is a symbol which stands for any property/attribute whatsoever.** It can be replaced by any name of property or predicate constant. The Greek letters ϕ (phi) and ψ (psi) are used as predicate variables. ***For example,*** in the expression Surekha is -----, blank space marks the place of some property, where we can use predicate variable say 'ϕ' and we will get an expression - 'Surekha is 'ϕ', which can be symbolized as 'ϕs'. In predicate logic such expressions are called Propositional function. We shall learn in detail about the concept of propositional function later in the chapter.

Symbolize the following singular propositions :

(1) Nilesh is a singer.

(2) John is an engineer.

(3) Ramesh is not a science student.

(4) Hemangi is smart and Hemangi is creative.

(5) Zarin is beautiful.

(6) Amit is an actor but Amit is not a dancer.

(7) Neena is Indian or Neena is American.

(8) New york is not an Australian city.

Symbolizing General propositions :

As stated earlier, general propositions are broadly classified into two types – (1) General propositions making an assertion about one class and (2) General propositions making an assertion about two classes or giving relation between two classes. Let us first learn to symbolize general propositions making an assertion about one class.

(I) Symbolizing General propositions about one class

General propositions can either be universal or existential. These two types are further classified into affirmative and negative propositions. Thus we get four types of general propositions about one class and they are symbolized as stated below.

(1) Universal affirmative proposition :

The proposition 'Everything is perishable', for instance, is of this type. To symbolize this proposition let us first convert it into logical terminology. This proposition affirms the property 'perishable' of everything. In the logical terminology it can be expressed as follows -

Given anything, it is perishable

The expressions 'anything' and 'it' stand for any individual whatsoever. So we shall use individual variable in place of these words as follows –

Given any x, x is perishable.

In logic the expression 'Given any x' is customarily symbolized by the symbol '(x)'. This symbol is called 'Universal quantifier'. By using predicate constant 'P', 'x is perishable' can be symbolized as 'Px'. Accordingly the whole statement will be symbolized as –

(x) Px

The statement is to be read as, 'Given any x, x is perishable'. If we replace predicate constant 'P' by predicate variable then we get the form of such type of statements as given below –

(x) ϕx

(2) Universal negative proposition :

The Proposition 'Nothing is everlasting' is of this type. The property 'everlasting' is denied of all things. In logical terminology the statement may be expressed as –

Given anything, it is not everlasting.

By using individual variables instead of the expressions 'thing' and 'it' we rewrite the statement as –

Given any x, x is not everlasting.

By using universal quantifier, predicate constant 'E' and the symbol for negation, we symbolize the whole statement as follows –

$(x) \sim Ex$

The form of such type of propositions is – $(x) \sim \phi x$

(3) Existential affirmative proposition :

The below given statements are of this type.

(1) Something is beautiful.

(2) Dogs exist.

The first proposition affirms the property 'beautiful' of some things. In logic the expression 'some' means at least one. Accordingly the statement can be expressed in logical terminology as follows –

There is at least one thing such that, it is beautiful.

By using individual variable in place of 'thing' and 'it', the statement can be rewritten as –

There is at least one x such that, x is beautiful.

The symbol '$(\exists x)$' is used for the expression. 'there is at least one x such that'. The symbol is called 'Existential quantifier'. By using existential quantifier and predicate constant 'B' for the property 'beautiful' we symbolize the whole statement as given below –

$(\exists x)\ Bx$

This is to be read as –

'There is at least one x such that x is beautiful.' The form of such type of statement is – $(\exists x)\ \phi x$

The second statement, 'Dogs exist' affirms the existence of at least one dog. The statement can be expressed in logical terminology as follows –

There is at least one thing such that, it is a dog.

By using individual variable the statement can be rewritten as –

There is at least one x such that, x is a dog.

By using existential quantifier and predicate constant 'D' we symbolize the whole statement as given below –

$(\exists x)\ Dx$

This it to be read as –

'There is at least one x such that, x is a dog.' The form of such type of statement is - $(\exists x)\ \phi x$

(4) Existential negative proposition :

The following statements are of this type.

(1) Something is not good.

(2) There are no giants.

The first proposition denies the property 'good' of some things. It states that there is at least one thing which is not good. The statement can be expressed in logical terminology as follows –

There is at least one thing such that it is not good.

By using individual variable the statement can be rewritten as –

There is at least one x such that, x is not good.

By using existential quantifier and predicate constant 'G' for the property 'good' we symbolize the whole statement as given below –

$(\exists x) \sim Gx$

This is to be read as –

'There is at least one x such that x is not good.' The form of such type of statement is - $(\exists x) \sim \phi x$

The second proposition 'There are no giants' denies existence of giants. 'Existence' is not a property/attribute. So the statement cannot be translated in logical terminology as the first statement. The proposition states that there is not even one giant. The correct translation of the statement in logical terminology is as given below –

It is not the case that, there is at least one x such that, x is a giant. This correctly expresses the statement's meaning that there is not even one giant.

By using the symbol for negation, existential quantifier and predicate constant 'G' we can symbolize the whole statement as –

$\sim(\exists x)\ Gx$

This is to be read as –

'It is not the case that, there is at least one x such that, x is a giant'. The form of such type of statement is - $\sim(\exists x)\ \phi x$

(II) Symbolizing General propositions about two classes

General propositions about two classes are also of four types namely –

(1) Universal affirmative or 'A' proposition.

(2) Universal negative or 'E' proposition.

(3) Particular affirmative or 'I' proposition.

(4) Particular negative or 'O' proposition.

Let's symbolize such types of proposition.

(1) Universal affirmative or 'A' proposition:

The proposition 'All women are attractive', for example is of this kind. This proposition states the relation between two classes namely – the class of 'women' and the class of 'attractive'. It is a universal affirmative proposition because in this proposition the property 'attractive' is affirmed of all women. This statement is expressed in logical terminology as given below -

Given anything, if it is a woman then it is attractive.

The terms 'thing' and 'it' stand for any individual whatsoever. So we can replace them by individual variable say 'x'. Accordingly the statement can be rewritten as –

Given any x, if x is a woman then x is attractive. By using the symbol universal quantifier for the expression 'Given any x', predicate constant 'W' for 'woman', 'A' for 'attractive' and the connective '$\supset$' we symbolize the whole proposition as follows –

$(x)\ (Wx \supset Ax)$

By replacing predicate constants by predicate variables we can get the form of such type of propositions as --- $(x)\ (\phi x \supset \psi x)$

(2) Universal negative or 'E' proposition :

The proposition 'No child is wicked' is an example of Universal negative or 'E' proposition. This proposition states the relation between two classes namely – the class of 'children' and the class of 'wicked'. It is a Universal negative proposition because here the property 'wicked' is denied of all children. In logical terminology this statement may be expressed as –

Given anything, if it is a child then it is not wicked.

By using individual variable instead of 'thing' and 'it', we express this statement as –

Given any x, if x is a child then x is not wicked.

By using universal quantifier, predicate constants and the connective '⊃', the whole statement is symbolized as follows –

$(x)\ (Cx \supset \sim Wx)$

The form of 'E' proposition is – $(x)\ (\phi x \supset \sim \psi x)$

(3) Particular affirmative or 'I' proposition:

In particular affirmative or 'I' proposition a property is affirmed of some members of a class. The proposition 'Some men are rich', for example, is a particular affirmative or 'I' proposition. This proposition states the relation between two classes namely – the class of 'men' and the class of 'rich'. It is a particular affirmative proposition as the property 'rich' is affirmed of some members of the class of 'men'. This proposition can be stated in logical terminology as –

There is at least one thing such that, It is a man and it is rich.

The statement can be expressed by using individual variables as follows –

There is at least one x such that, x is a man and x is rich.

The whole statement is symbolized as follows by using existential quantifier, predicate constants and the symbol for connective 'and'.

$(\exists x)\ (Mx \cdot Rx)$

The form of 'I' proposition is $(\exists x)\ (\phi x \cdot \psi x)$

(4) Particular negative or 'O' proposition :

The proposition 'Some animal are not wild', for instance is an 'O' proposition. This proposition states the relation between two classes namely – the class of 'animals' and the class of 'wild'. It is a particular negative proposition as the property 'wild' is denied of some members of the class of 'animals'. This proposition can be translated in logical terminology by using individual variable as follows :

There is at least one x such that, x is an animal and x is not wild

The whole statement is symbolized as follows by using existential quantifier, predicate constants and the symbols for connective 'and' and 'not'

$(\exists x)\ (Ax \cdot \sim Wx)$

The form of 'O' proposition is -- $(\exists x)\ (\phi x \cdot \sim \psi x)$

General propositions do not always use the expressions – 'All', 'No' and 'Some'. Apart from these words there are many other words in English language which express these propositions. Some common expressions in English language which indicate these types of propositions are given in the following table.

'A' proposition : Affirmative sentences with words 'all', 'every', 'each', 'any', 'always', 'whatever', 'invariable', 'necessarily', 'absolutely'

'E' proposition : Statements with words 'no', 'never', 'not at all', 'not a single', 'not even one', 'none'

'I' proposition : Affirmative statements with words 'most', 'many', 'a few', 'certain', 'all most all', 'several', 'mostly', 'generally', 'frequently', 'often', 'perhaps', 'nearly always', 'sometimes', 'occasional'

Negative statements with 'few', 'seldom', 'hardly', 'scarcely', 'rarely'

'O' proposition : When affirmative statements which contain words indicating 'I' proposition are denied we get 'O' proposition.

Affirmative statements with the word 'few', 'seldom', 'hardly', 'scarcely', 'rarely'

When 'A' proposition is denied we get 'O' proposition.

Give examples of affirmative and negative singular proposition and symbolize them.

Give examples of all eight types of general propositions and symbolize them.

Propositional Function

Propositional function is an important concept in predicate logic. 'Deepa is an artist' and 'Suresh is a sportsman', are propositions. They are either true or false. However the expressions, 'x is an artist' or 'Ax' and 'Suresh is ϕ' or 'ϕs' are not propositions as they are neither true nor false. Such expressions are called Propositional functions. **A propositional function is defined as an expression which contains at least one (free/real) variable and becomes a proposition when the variable is replaced by a suitable constant.**

Free variable is one which falls beyond the scope of a quantifier. It is neither a part of a quantifier nor preceded by an appropriate quantifier.

Bound variable is one which is a part of a quantifier or preceded by an appropriate quantifier. For example, 'Everything is expensive' is symbolized as – (x) (Ex). This is a proposition and not a propositional function as both the variables occurring in the expression are not free but bound. In '(x)' variable 'x' is a part of the quantifier and in 'Ex'; 'x' is preceded by an appropriate quantifier. The expression, '(y) (Dx)' however is a propositional function because though the 'y' being part of the quantifier is a bound variable, 'x' in the expression is free variable as it is neither a part of a quantifier nor preceded by an appropriate quantifier. Similarly following expressions are also propositional functions – 'Bx', Mx, ψx or 'ϕx' here both the variables 'x' and 'ϕ' are free/real.

Propositional function may be either simple or complex. Simple propositional function is one which does not contain propositional connectives. For example –

(1) x is big. (Bx)

(2) y is smart (Sy)

(3) Mukund is ϕ (ϕm)

Propositional functions which contain propositional connectives are called complex propositional functions. For example –

(1) x is not a philosopher. – ($\sim$ Px)

(2) x is a doctor and x is a social worker. (Dx $\cdot$ Sx)

(3) x is either an actor or x is a dancer. (Ax $\vee$ Dx)

(4) If x is a man then x is rational. (Mx $\supset$ Rx)

Distinction between Proposition and propositional function

Proposition	Propositional function
(1) A proposition does not contain any free variable.	(1) A propositional function contains at least one free variable.
(2) A proposition has a definite truth value it is either true or false.	(2) It is neither true nor false.
(3) A proposition can be interpreted.	(3) A propositional function cannot be interpreted.
(4) e.g. Akash is handsome - Ha	(4) e.g. x is handsome - Hx

Can you recognize which of the following expressions are propositions and which are propositional function?

(1)	Cx	*(7)*	$Ta \cdot Fa$
(2)	$Ma \supset Sa$	*(8)*	ϕs
(3)	$(x)\ (Fx \supset Ny)$	*(9)*	$(x)\ (Gx \supset \sim Kx)$
(4)	$(z)\ (Az \supset \sim Tz)$	*(10)*	$(x)\ (Rx \supset Px)$
(5)	$(x)\ (Ay \supset \sim Wx)$	*(11)*	$Rx \supset Px$
(6)	$By \cdot \sim Hx$	*(12)*	$Ms \vee Kd$

3.4 Methods of obtaining propositions from propositional function –

In the last section we learned that a propositional function is an expression which contains at least one (free/real) variable and becomes a proposition when the variable is replaced by a suitable constant. Thus one can obtain propositions from propositional functions by replacing variables by suitable constants. As there are two types of propositions namely singular and general propositions, there are two ways of obtaining propositions from propositional functions. (1) Instantiation (2) Quantification

(1) Instantiation

The process of obtaining singular propositions from a propositional function by substituting a constant for a variable is called Instantiation. For instance, 'x is a logician'/ 'Lx', is a propositional function. From this propositional function by replacing an individual variable 'x' with the proper name of an individual eg 'Aristotle' or with a symbol for the proper name(i.e. an individual constant) say 'a', we can obtain a singular proposition as follows- 'Aristotle is a logician'/ 'La'.

Individual variable 'x' can be replaced by any name of an individual or by an individual constant. By replacing 'x' by 'Newton' / 'n', we shall get a singular proposition as—'Newton is a logician'/ 'Ln'. Each singular proposition obtained from a propositional function in this manner is a substitution instance of that propositional function. A propositional function is neither true nor false; however every substitution instance of it is either true or false. The first singular proposition, 'Aristotle is a logician;, is true whereas the second proposition; 'Newton is a logician', is false.

A propositional function is either simple or complex. In case of a complex propositional function, the substitution instances obtained are truth- functions of singular propositions. For example 'x is a dancer and x is an engineer'/ ($Dx \cdot Ex$)is a complex propositional function. By replacing 'x' by proper name eg Ketan or individual constant 'k' we get a substitution instance which is a truth- function of a singular propositions as follows –

'Ketan is a dancer and Ketan is an engineer' / ($Dk \cdot Ek$)

(2) Quantification or Generalization

The process used to obtain general propositions from a propositional function is called Quantification or Generalization. **Quantification or Generalization is a process of obtaining a general proposition from a propositional function by placing an Universal or Existential quantifier before the propositional function.** As there are two types of general propositions, quantification is of two types. (1) Universal Quantification/ generalization. (2) Existential Quantification/ generalization.

The Process of universal quantification / generalisation is used to obtain a universal general proposition from a propositional function whereas existential general propositions are obtained by the process of Existential Quantification/ generalization from a propositional function.

(1) Universal Quantification / generalization :

The process of Universal Quantification consists in obtaining an universal general proposition by placing an universal quantifier before the propositional function. For example the expression 'x is 'gorgeous' or 'Gx' is a propositional function. Here the property 'gorgeous' is asserted of an individual variable 'x'. If we assert this property of all x then we shall get an universal general proposition as follows –

'Given any x, x is 'gorgeous'

(x) Gx

Universal general proposition thus obtained may be either true or false. **The universal quantification of a propositional function is true if and only if all its substitution instances are true.**

(2) Existential Quantification / generalization :

The process of Existential Quantification consists in obtaining an existential general proposition by placing an existential quantifier before the propositional function. For example in propositional function – 'x is noble' or 'Nx', the property 'noble' is asserted of an individual variable 'x'. by asserting this property of some 'x' we can obtain existential general proposition as given below –

'There is at least one x such that, x is noble'

($\exists$x) Nx

Existential general propositions obtained by the process of Existential Quantification may be true or false. The existential quantification of a propositional function is true even if one of its substitution instance is true.

3.5 Quantificational Deduction

After having learned how to symbolize non compound propositions i.e. singular and general propositions, one can symbolize the arguments which contain such non compound propositions and prove their validity. The method used to prove validity of such arguments is called Quantificational Deduction.

Like Deductive Proof, the Quantificational Deduction consists in deducing the conclusion of an argument with the help of certain rules. The difference between the two is that in case of the Quantificational Deduction, along with 19 rules of inference we require four more rules of quantificational deduction. This is because symbolization of arguments containing non compound propositions involves use of propositional functions and quantifiers; hence their validity cannot be proved by 19 rules of inference only.

The four rules of quantificational deduction are :

(1) Universal Instantiation (UI)

(2) Universal Generalization (UG)

(3) Existential Generalization (EG)

(4) Existential Instantiation (EI)

These rules are necessary since quantifiers are used while symbolizing general propositions. The rules of UI and EI are used to infer truth functional compound statements from general propositions. Once they are changed into truth functional compound statements, we can apply 19 rules of inference to derive the conclusion. The rules of UG and EG are used for inferring general propositions from truth functional compound statements.

Rules of Quantification (Primary version)

(1) The rule of Universal Instantiation (UI)

The rule of Universal Instantiation (UI) enables us to obtain truth functional compound statement from universal general proposition. This rule is based on the nature of universal general proposition. As the universal quantification of a propositional function is true if and only if all its substitution instances are true, the rule of UI states that, any substitution instance of a propositional function can be validly inferred from its universal quantification. In simple words it means, what is true of all members of a class is true of each member of that class. The symbolic representation of the rule is -

$(x)(\phi x)$

$\therefore \phi \nu$

(Where 'ν' is any individual symbol)

The rule of UI allows us to derive two types of inferences. The Greek letter 'ν' (nu) in rule, may stand for either a specific / particular individual (individual constant) or an arbitrarily selected individual. From the fact that what is true of all members of a class is true of each member of that class, it follows that this member can either be a specific member or an arbitrarily selected individual. ***For example,*** from the universal general proposition, 'everything is beautiful', one can infer a proposition about specific individual eg, 'Rita is beautiful' or may infer that any arbitrarily selected individual is beautiful. The symbol 'y' is used for an arbitrarily selected individual and a particular individual is symbolizes by individual constant. Accordingly symbolic representations of these two inferences are as given below –

(1) $(x)(\phi x)$ (2) $(x)(\phi x)$

$\therefore$ Br $\therefore$ By

Let us now take the argument, we had taken in the beginning of the chapter and construct formal proof of validity for it by using the rule UI

All singers are creative.

Mahesh is a singer.

Therefore, Mahesh is creative.

We first symbolize the argument as follows:

(1) $(x)(Sx \supset Cx)$

(2) Sm / $\therefore$ Cm

Now we can apply the rule of U I to the first premise –

(1) $(x)(Sx \supset Cx)$

(2) Sm / $\therefore$ Cm

(3) $Sm \supset Cm$ 1, U I

After inferring truth functional compound statement from general statement, by rule of UI rules of inference can be applied. By applying the rule of M.P. to the statement 3 and 2 we can infer the conclusion. Thus the validity of the argument is proved.

(1) $(x)(Sx \supset Cx)$

(2) Sm / $\therefore$ Cm

(3) $Sm \supset Cm$ 1, U I

(4) Cm 3,2 M.P.

While applying the rule of UI one has an option of taking any individual constant or arbitrarily selected individual – 'y'. From the nature of premises and the conclusion one can decide whether to take an individual constant or 'y'. in the above example the conclusion and the second premise is about specific individual Mahesh (m) so we used the same individual constant, which enabled us to apply rule of M.P. to derive the conclusion, which would not have been possible if we had used 'y' or any other constant other than 'm'.

(2) Universal Generalization (UG)

The rule of Universal Generalization (UG) allows us to derive a universal general proposition from a truth functional compound statement. One can validly infer that what is true of all members of a class is true of each member of that class but one cannot in the same fashion say that what is true of a specific individual of a class is true of all the members of that class. For instance, we cannot say that Aurobindo is a philosopher therefore all men are philosophers. However one can say that, what is true of a man in general (i.e. without considering any specific qualities) is true of all men. To take an example, one can validly infer that a man is rational therefore all men are rational. From this it follows that, from statement which is about an arbitrarily selected individual one can infer a universal general statement. So the rule of UG is stated as follows –

Universal quantification of a propositional function can be validly inferred from its substitution instance which is an arbitrarily selected individual. The symbolic representation of the rule is –

ϕy

∴ (x) (ϕx)

(where 'y' denotes any arbitrarily selected individual.)

Let us now construct formal proof of validity for the following argument by using both the rules of UI and UG.

All men are honest.

All honest people are good.

Therefore, all men are good.

Let us first symbolize the argument as follows –

(1) (x) (Mx ⊃ Hx)

(2) (x) (Hx ⊃ Gx) /∴ (x) (Mx ⊃ Gx)

Next step is to apply the rule of UI to step no.1 and 2 then derive the conclusion by the rule of H.S and apply the rule of UG to step 5 to get the conclusion as shown below. While applying UI it is necessary to take 'y' in the place of 'x' because the conclusion is a universal general proposition and to get conclusion we will have to use the rule of UG at the end, which is possible only if we take 'y'

(1)	(x) (Mx ⊃ Hx)	
(2)	(x) (Hx ⊃ Gx)	/∴ (x) (Mx ⊃ Gx)
(3)	My ⊃ Hy	1, UI
(4)	Hy ⊃ Gy	2, UI
(5)	My ⊃ Gy	3, 4, H.S
(6)	(x) (Mx ⊃ Gx)	5, UG

(3) Existential Generalization (EG)

The rule of EG is used to get an existential general proposition from a truth functional compound statement. Existential general proposition makes an assertion about some members of a class. The term 'some', means 'at least one' in logic. So unlike the rule of UG, in case of the rule of EG one can validly infer that, what is true of a specific individual of a class is true of some individuals of that class. One can also infer existential general proposition from a statement about an arbitrarily selected individual. The rule of EG is stated as follows –

The existential quantification of a propositional function can be validly inferred from any of its substitution instance. The symbolic form of the rule is –

$\phi\nu$

∴ (∃x) (ϕx)

(Where 'ν' is any individual symbol)

To take an example we can infer a proposition, 'some are handsome' from a statement about specific individual eg, 'Anil is handsome' or about an arbitrarily selected individual. These may be symbolically expressed as follows –

(1)	Ha	(2)	Hy
∴	(∃x) (Hx)	∴	(∃x) (Hx)

Let us construct formal proof of validity for the following argument.

(1)	(x) (Dx ⊃ Ax)	
(2)	(x) (Dx)	/ ∴ (∃x) (Ax)
(3)	Da ⊃ Aa	1, UI
(4)	Da	2, UI
(5)	Aa	3, 4, M.P.
(6)	(∃x) (Ax)	5, EG

We can also construct a formal proof of validity for this argument by using 'y' in place 'a' as follows -

(1)	(x) (Dx ⊃ Ax)	
(2)	(x) (Dx)	/ ∴ (∃x) (Ax)
(3)	Dy ⊃ Ay	1, UI
(4)	Dy	2, UI
(5)	Ay	3, 4, M.P.
(6)	(∃x) (Ax)	5, EG

(4) Existential Instantiation (EI)

The rule of Existential Instantiation states that from the existential quantification of a proposition function we may infer the truth of its substitution instance. The rule enables us to infer a truth functional compound statement from an existential general proposition.

Existential quantification of a propositional function is true only if it has at least one true substitution instance. As what is true of some members of a class cannot be true of any arbitrarily selected individual of that class, the substitution instance cannot be an arbitrarily selected individual. From the statement 'some men are caring', one cannot infer that any arbitrarily selected man is caring. The truth functional statement that we drive can be about a particular individual only, but we may not know anything else about that person. So while applying the rule of EI one must take that individual constant which has not occurred earlier in the context. The symbolic form of this rule is as given below –

$(\exists x)\ (\phi x)$

$\therefore \phi \nu$

(Where 'ν' is an individual constant, other than 'y', that has not occurred earlier in the context.)

Let us take an example –

(1)	(x) (Bx ⊃ ∼ Px)	
(2)	(∃x) (Px · Tx)	/ ∴ (∃x) (∼Bx)
(3)	Pa · Ta	2, EI
(4)	Ba⊃ ∼ Pa	1, UI
(5)	Pa	3, Simp.
(6)	∼ ∼ Pa	5, D.N.
(7)	∼ Ba	4, 6, M.T.
(8)	(∃x) (∼ Bx)	7, EG

The important point one needs to remember here is that, when in an argument, one has to use both rule of UI and EI, the rule of EI should be used first. This is because for use of EI there is a restriction that, only that individual constant should be used which has not occurred earlier in the context. In the above argument if UI was used first, then while applying EI we could not have taken the same individual constant and with different constants we could not have arrived at the conclusion.

Let us take some more examples –

(I)	(1)	(x) (Mx ⊃ Px)	
	(2)	(x) (Px ⊃ Tx)	
	(3)	Md	/ ∴ (∃x) (Tx)
	(4)	Md ⊃ Pd	1, UI
	(5)	Pd ⊃ Td	2,UI
	(6)	Md ⊃ Td	4,5, H.S.
	(7)	Td	6,3, M.P.
	(8)	(∃x) (Tx)	7, EG

(II)

(1)	$(x)(Bx \supset Px)$	
(2)	$(\exists x)(Bx \cdot Tx)$	
(3)	Bd	$/ \therefore (\exists x)(Px \cdot Tx)$
(4)	$Ba \cdot Ta$	2, EI
(5)	$Ba \supset Pa$	1, UI
(6)	Ba	4, Simp.
(7)	Pa	5, 6, M.P.
(8)	$Ta \cdot Ba$	4, Com.
(9)	Ta	8, Simp.
(10)	$Pa \cdot Ta$	7, 9, Conj.
(11)	$(\exists x)(Px \cdot Tx)$	10, EG

(III)

(1)	$(x)(Tx \supset Nx)$	
(2)	$(x)(Nx \supset Bx)$	
(3)	$(x)(Bx \supset \sim Ax)$	
(4)	$(\exists x)(Px \cdot Tx)$	$/ \therefore (\exists x)(Px \cdot \sim Ax)$
(5)	$Pa \cdot Ta$	4, EI
(6)	$Ta \supset Na$	1,UI
(7)	$Na \supset Ba$	2,UI
(8)	$Ba \supset \sim Aa$	3, UI
(9)	$Ta \supset Ba$	6, 7 H.S.
(10)	$Ta \supset \sim Aa$	9, 8, H.S.
(11)	Pa	5, Simp.
(12)	$Ta \cdot Pa$	5, Com.
(13)	Ta	12, Simp.
(14)	$\sim Aa$	10, 13, M.P.
(15)	$Pa \cdot \sim Aa$	11, 14, Conj.
(16)	$(\exists x)(Px \cdot \sim Ax)$	15, EG

Summary

- In Propositional logic a proposition is taken as one unit. It does not involve analysis of proposition.
- Predicate logic involves analysis of proposition. It deals with certain types of arguments whose validity depends upon the inner logical structure of the non-compound statements it contains.
- The non compound statements in Predicate logic are of two types – Singular propositions and General propositions.
- Singular propositions states that an individual possesses or does not possess a certain property/ attribute (quality).
- Singular propositions are of two types – affirmative singular propositions and negative singular propositions
- General propositions make an assertion about class.
- General propositions are classified into two types – (1) General propositions about one class and (2) General propositions about two classes.
- Each type is further classified in to Universal affirmative, Universal Negative, Particular (Existential) affirmative, Particular (Existential) Negative.

- A propositional function is defined as an expression which contains at least one (free/real) variable and becomes a proposition when the variable is replaced by a suitable constant.
- The process of obtaining a singular proposition from a propositional function by substituting a constant for a variable is called Instantiation.
- Quantification and Generalization is a process of obtaining a general proposition from a propositional function by placing a universal or Existential quantifier before the propositional function.
- Quantification is of two types. (1) Universal Quantification/ generalization. (2) Existential Quantification/generalization
- The Quantificational Deduction consists in deducing the conclusion of an argument from its premises with the help of certain rules.
- Rules of quantificational deduction are – (1) Universal Instantiation (U I), (2) Universal Generalization (U G), (3) Existential Generalization (E G), (4) Existential Instantiation (E I)
- The rules of UI and EI are used to infer truth functional compound statements from general propositions.
- The rules of UG and EG are used for inferring general propositions from truth functional compound statements.

Exercises

Q. 1. Fill in the blanks with suitable words from those given in the brackets :

(1) ……….is an individual variable. *(ψ, x)*

(2) ……….is a predicate variable. *(A, ϕ)*

(3) Individual ………. stands for a specific individual. *(Constant, Variable)*

(4) The process of ………. helps to derive singular proposition. *(Quantification, Instantiation)*

(5) General propositions are obtained by the process of ………. . *(Instantiation, Generalization)*

(6) A ………. is neither true nor false. *(Propositional function, Proposition)*

(7) A predicate constant stands for ………. property. *(any, specific)*

(8) An individual variable stands for ……….. *individual (specific, any)*

(9) ………. proposition is Universal Negative proposition. *(E, O)*

(10) ………. is a Universal Quantifier. *[(x), (∃x)]*

(11) ………. is either true or false. *(Proposition/ propositional function)*

(12) The expression 'Given anything' is an ………. Quantifier. *(Existential/ Universal)*

(13) In ………. logic proposition is taken as one unit. *(propositional/predicate)*

(14) Propositions are analyzed in ………. logic. *(propositional/predicate)*

(15) ………............ Proposition states that an individual possesses or does not possess a certain property/ attribute. *(singular/ general)*

Q. 2. State whether the following statements are true or false.

(1) The expression 'Given anything' is an Existential Quantifier.

(2) A singular proposition can be obtained from a propositional function by the process of Instantiation.

(3) A general proposition can be obtained from a propositional function by the process of Quantification.

(4) The rule of UG says that what is true of the whole class is true of each member of the class.

(5) The rule of EG says that what is true of an arbitrary object is true of all the members of a class.

(6) The rule of EG says that an Existential Quantification of a propositional function can be validly inferred from its substitution instance.

(7) (ϕ) is a universal Quantifier.

(8) In the formal proof of validity by quantificational deduction, if both the rule UI and EI are to be used then E.I. should be used first.

(9) The rules of UI and EI are used to drop quantifiers from general propositions.

(10) The rules of UG and EG are used for inferring general propositions from truth functional compound propositions.

(11) In predicate logic proposition is taken as one unit.

(12) Singular propositions make an assertion about class.

(13) Proportional function contains at least one bound variable.

(14) Singular proposition states that an individual possesses or does not possess a certain property/attribute.

Q. 3. Match the columns :

	(A)	(B)
(1)	Proposition	(a) a
(2)	Propositional function	(b) (x) Sx
(3)	Individual variable	(c) B
(4)	Predicate constant	(d) x
(5)	Universal quantifier	(e) Hx
(6)	Individual constant	(f) (x)

Q. 4. Give logical terms :

(1) Branch of logic in which proposition is taken as one unit.

(2) Branch of logic that involves analysis of proportion.

(3) Proposition which states that an individual possesses or does not possess a certain property/attribute.

(4) Proposition which makes an assertion about class.

(5) An expression which contains at least one (free/real) variable and becomes a proposition when the variable is replaced by a suitable constant.

(6) The process of obtaining a singular proposition from a propositional function by substituting a constant for a variable.

(7) The process of obtaining a general proposition from a propositional function by placing a universal or Existential quantifier before the propositional function.

(8) The symbol which stand for the name of an individual.

(9) The symbol which stands for a particular property/attribute.

(10) The symbol which stands for any individual whatsoever.

(11) The symbol which stands for any property/ attribute whatsoever.

(12) The variable which is neither a part of a quantifier nor preceded by an appropriate quantifier.

(13) The variable which is either a part of a quantifier or preceded by an appropriate quantifier.

Q. 5. Give reasons for the following.

(1) When both U.I. and E.I. are used in a proof, E.I. should be used first.

(2) The rule of U.G. allows us to infer universal general proposition only from an arbitrarily selected individual.

(3) One cannot derive a statement about an arbitrarily selected individual from an existential general proposition while using the rule of E.I.

(4) Rules of inference and replacement along with C.P. and I.P. are not sufficient to prove validity of all argument.

(5) Propositional function is neither true nor false.

(6) Quantifiers are not used while symbolizing singular propositions.

Q. 6. Explain the following.

(1) The Rule of UI.

(2) The Rule of UG.

(3) The Rule of EG.

(4) The Rule of EI.

(5) Method of Instantiation.

(6) Method of Quantification.

(7) The difference between Propositional logic and Predicate logic.

(8) Distinction between Singular proposition and General proposition.

(9) Distinction between Proposition and propositional function.

(10) The nature of Quantificational Deduction.

(11) Singular Proposition in modern logic.

(12) Propositional function.

Q. 7. Symbolize the following propositions using appropriate quantifiers and propositional functions.

(1) No animals lay eggs.

(2) Everything is valuable.

(3) Some shopkeepers are not straightforward.

(4) A few homes are beautiful.

(5) Hardly any enterprise in the city is bankrupt.

(6) There are elephants.

(7) Unicorns do not exist.

(8) Few bureaucrats are honest.

(9) A few teenagers like swimming.

(10) Not a single pupil in the class passed the test.

(11) All singers are not rich.

(12) Every child is innocent.

(13) Few men are not strong.

(14) Dodos do not exist.

(15) Nothing is enduring.

(16) Some thing is elegant.

(17) All men are sensible.

(18) Not all actors are good dancers.

(19) Rarely business men are scientists.

(20) Not a single story from the book is fascinating.

(21) All tigers are carnivorous animals.

(22) No book is covered.

(23) Some shops are open.

(24) Some shares are not equity.

(25) Air Tickets are always costly.

(26) Cunning people are never caring.

(27) Several banks are nationalized.

(28) Hardly children are interested in studies.

(29) Whatever is durable is worth buying.

(30) Not a single ladder is long.

Q. 8. Construct formal proofs of validity for the following arguments.

(1) (1) (x) (Ax ⊃ ∼ Px)
(2) (∃x) (Ox · Px) /∴(∃x)(Ox · ∼Ax)

(2) (1) (x) (Cx ⊃ ∼ Kx)
(2) (x) (∼ Yx ⊃Ax)
(3) (x) (∼ Kx ⊃ ∼ Yx) /∴(x)(Cx ⊃ Ax)

(3) (1) (x) (∼Ax ⊃ ∼ Sx)
(2) (x) (Jx ⊃ ∼Ax)
(3) Ja / ∴ ∼ Sa

(4) (1) (x) (Dx ⊃ Sx)
(2) Dc
(3) Wc /∴ Sc · Wc

(5) (1) (x) (Tx ⊃ Ax)
(2) (∃x) (Mx)
(3) (x) (Ax ⊃ ∼ Mx)
/ ∴ (∃x) (∼ Ax · ∼Tx)

(6) (1) (x) (Mx ⊃ Sx)
(2) (x) (Nx ⊃ Lx)
(3) ∼ Sa · Na / ∴∼ Ma · La

(7) (1) (x) (Px ⊃ Sx)
(2) (∃x) (Px · Lx)
(3) Pa / ∴ (∃x) (Sx · Lx)

(8) (1) (x) (Tx ⊃ Nx)
(2) (x) (Nx ⊃ Mx)
(3) Td / ∴ Ad ∨ Md

(9) (1) (x) (Tx ⊃ Rx)
(2) (∃x) (Tx · Nx)
(3) (x) (Rx ⊃ Kx) / ∴ (∃x) (Rx · Kx)

(10) (1) (x) (Nx ⊃ Hx)
(2) ∼Hm · Cm / ∴ (∃x) (Cx· ∼ Nx)

(11) (1) (x) [(Qx ∨ Rx) ⊃ Tx]
(2) (x) Qx / ∴(x) Tx

(12) (1) (x) [(Jx ∨ Kx) ⊃ Lx]
(2) Ka
(3) (∃x) ∼ Lx / ∴ (∃x) ∼ Jx

(13) (1) (x) [Dx ⊃ (Hx · ∼ Kx)]
(2) (x) (Hx ⊃ Px)
(3) Dg / ∴ (∃x) (Px · ∼ Kx)

(14) (1) (x) (Hx ⊃ Gx)
(2) (∃x) (Hx · Lx) / ∴ (∃x) (Lx · Gx)

(15) (1) (x) (Ux ⊃ Wx)
(2) (x) Ux
(3) (∃x) Zx / ∴ (∃x) (Wx · Zx)

(16) (1) (x) [Px ⊃ (Qx ⊃ Rx)]
(2) (x) (Rx ⊃ Tx)
(3) (x) Px / ∴ (x) (Qx ⊃ Tx)

(17) (1) (x) [Ix ⊃ (Px · ∼ Lx)]
(2) (x) (Px ⊃ Qx)
(3) Pd
(4) (∃x)Ix / ∴(∃x) (Qx · ∼ Lx)

(18) (1) (x) [Ax ⊃ (Rx ∨ Tx)]
(2) (x) Ax
(3) (∃x) (Sx · ∼ Tx) / ∴ (∃x) (Sx · Rx)

(19) (1) (x) [Ax ⊃ (Bx ⊃ Fx)]
(2) (∃x) (Ax· Bx) / ∴ (∃x) Fx

(20) (1) (x) (Dx ⊃ ∼ Gx)
(2) Db
(3) (∃x) [Dx · (Gx ∨ Kx)] / ∴ (∃x) Kx

(21) (1) (x) (Fx ⊃ Gx)
(2) (x) (Gx ⊃ Hx) / ∴ (x) (Fx ⊃ Hx)

(22) (1) (x) (Ax ⊃ Bx)
(2) (x) ∼ Bx / ∴ (x) ∼ Ax

(23) (1) (x) (Hx ⊃ Px)
(2) (x) (Px ⊃ Tx) / ∴ Hy ⊃ Ty

(24) (1) (x) (Bx ⊃ Kx)
(2) (∃x) ∼ Kx / ∴ ∼ Bt

(25) (1) $(x)(Nx \supset Rx)$

(2) $(\exists x)(Qx \cdot \sim Rx)$ $/ \therefore (\exists x)(Qx \cdot \sim Nx)$

(26) (1) $(x)[Fx \supset (Lx \cdot Ox)]$

(2) $(x)\, Fx$ $/ \therefore (\exists x)\, Ox$

(27) (1) $(x)(Mx \supset Nx)$

(2) $(x)(Nx \supset Rx)$ $/ \therefore (x)(Mx \supset Rx)$

(28) (1) $(x)(Ax \supset Bx)$

(2) $(x)(Bx \supset Cx)$

(3) $(x)(Cx \supset Dx)$ $/ \therefore (x)(Ax \supset Dx)$

(29) (1) $(x)[Cx \supset (Fx \supset Gx)]$

(2) Cp $/ \therefore \sim Gp \supset \sim Fp$

(30) (1) $(x)(Dx \supset \sim Gx)$

(2) $(\exists x)[(Dx \cdot (Gx \vee Kx)]$ $/ \therefore (\exists x)\, Kx$

4 Traditional Logic

4.1 Nature of Propositions in Traditional Logic :

The Greek Philosopher Aristotle is the founder of Traditional Logic. According to Aristotle proposition consists of terms. **A Term is defined as a word, or group of words which stands as the subject or predicate of a logical proposition.**

For example :

(1) Intelligent people are creative.

(2) Bhumika is the tallest girl in the class.

(3) Tejas is clever.

In the first proposition, the subject term 'Intelligent people', is a group of words. In the second proposition the predicate term 'tallest girl', is a group of words and in the third example both the subject term 'Tejas' and predicate term 'clever' , are single words.

Term is a part of speech representing something, but it **is neither true nor false.** e.g. man, animal, mortality etc. However the **proposition which consists of terms, is either true or false.** An inference can be drawn on the basis of the existing relation between these terms. According to Aristotle, all propositions either assert or deny something. That about which assertion / denial is made, is called the 'Subject term' and that which is asserted / denied of subject is called the **'Predicate term'**. Terms may refer to a whole class, or some members of a class.

For example :

(1) All cows are animals.

(2) Some students are not Successful.

In the first proposition, 'cows' is the subject term and 'animals' is the predicate term. In the second proposition, 'students' is the subject term and 'successful' is the predicate term.

The first proposition, asserts that 'All cows are animals'. while the second proposition denies that 'Some students are successful.'

Terms are constituents of a proposition. The two terms i.e. the subject and predicate of the proposition are unified by the means of a **copula**. Thus a proposition has three constituent elements, namely : subject, predicate and copula. The order of the three elements in a proposition is Subject-Copula-Predicate.

Eg. 'All apples are red'.

In the above example 'Apples' is the subject, 'red' is the predicate and the word 'are' which unifies both 'apple' and 'red' is the copula.

4.2 Traditional Classification of Propositions

In Traditional Logic Propositions are classified into two categories :

(1) Conditional Proposition

(2) Categorical Proposition

4.2.1 Conditional Proposition :

A Conditional proposition is one in which the assertion is made subject to some expressed condition. For example : 'If diesel oil is brought near fire, it will explode'.

In this example 'occurrence of explosion' is subject to the condition of 'diesel oil being brought near fire'.

Conditional Propositions are of two kinds :

(i) Hypothetical Proposition

(ii) Disjunctive Proposition

(i) Hypothetical Proposition :

A hypothetical proposition is one which presents a condition together with some consequence which follows from it.

In a hypothetical proposition there are two propositions. The proposition which states the condition and the proposition which expresses the consequence. The proposition which states the condition is called the antecedent and that which expresses the consequence is called the consequent.

For example : 'If metal is heated, it expands. In this example, it does not refer to any actual instance of metal being expanded when heated, but it only states the condition that if the condition is fulfilled, the consequences will follow.

(ii) Disjunctive Proposition : A Disjunctive proposition is one which states alternatives. This proposition asserts that the alternatives are mutually exclusive or inclusive.

For example :

(1) A line is straight or curved.

(2) Either Ganesh will sing or dance.

In the first example the alternatives are mutually exclusive. If we affirm that 'the line is straight', then we must deny 'it is curved' and vice versa. But in the second example the alternatives are not mutually exclusive but inclusive. By affirming the alternative that 'Ganesh will sing', we cannot deny that 'Ganesh will dance'.

4.2.2 Categorical Propositions :

Categorical proposition is a proposition of relationship between two classes referred to as the class of subject term and the class of predicate term.

By a **'class'** Aristotle means a collection of all individuals, objects etc that have some specified characteristic in common. A categorical proposition affirms or denies a predicate of a subject absolutely. i.e. without any condition. It is unconditional Proposition. **For example :** 'All Chillies are pungent'. The pungency of chilly is not determined by any condition.

Every Categorical proposition has both quality and quantity. Quality of Categorical proposition means that the propositions either assert something or deny something. It is either an Affirmative or Negative proposition. A Categorical proposition is affirmative when its predicate term is affirmed of the subject term and it is negative when its predicate term is denied of the subject term.

For example :

(1) Some people are honest.

(2) No Elephants are carnivorous animals.

The first proposition is affirmative, as in this proposition, the predicate term 'honest' is affirmed of the subject term 'people' and the second proposition is negative, as in this proposition, the predicate term 'carnivorous animals' is denied of the subject term 'Elephants'.

Every Categorical proposition has quantity. A Categorical proposition may assert or deny something about the predicate term. The assertion or denial may refer to either entire (whole) class or some members (part) of the class of subject term. A Categorical Proposition is either Universal or Particular.

It is universal when it refers to all members of the class of the Subject term and it is Particular when it refers to some members of the class of the Subject term.

For example :

(1) All chess players are logical.

(2) Some languages are difficult.

The first proposition is Universal, as in this proposition the subject term i.e. 'the class of chess players' refers to the entire class to which it applies and the second proposition is Particular, as in this proposition the subject term i.e. 'the class of langueages' refers to some members of the class to which it applies.

Classification of Categorical Propositions

According to quality, propositions are classified into Affirmative and Negative and according to quantity, they are classified as Universal and Particular. Thus on the basis of these two principles of quality and quantity, there are four kinds of propositions. This is called the 'Traditional scheme' of Propositions. It is also called as Four fold classification of propositions. The four kinds of propositions included in Traditional scheme are as follows :

(1) Universal Affirmative ('A' Proposition) :

When the proposition is universal in quantity and affirmative in quality, it is called Universal Affirmative proposition. This proposition asserts that the whole of one class i.e. the class of subject term is included in another class i.e. the class of Predicate term. Eg. 'All Teachers are qualified'. This proposition asserts that every member of the class of subject term, 'Teachers', is a member of another class of predicate term, 'qalified persons'. Any Universal Affirmative proposition can be written schematically as follows : 'All S is P'. Where the letters 'S' and 'P' represent the subject and predicate terms, respectively. This proposition is also called as 'A' proposition. It affirms that the relation of inclusion holds between two classes and says that the inclusion is complete. (i.e. universal) All members of class 'S' are said to be, also the members of class 'P'. In other words class S is wholly included in class 'P'.

(2) Universal Negative ('E' Proposition) :

When the proposition is universal in quantity and negative in quality, it is called Universal Negative proposition. This proposition asserts that the whole of one class i.e. the class of subject term is excluded from another class i.e. the class of Predicate term. Eg. No lions are Tigers. This proposition asserts that every member of the class of subject term, 'Lions', is not a member of another class of predicate term, 'Tigers'. Any Universal Negative proposition can be written schematically as follows : 'No S is P'. Where 'S' and 'P' represent the subject and predicate terms, respectively. This proposition is also called as 'E' proposition. It denies the relation of inclusion between two classes universally. No members of class 'S' are members of class 'P'. This proposition asserts that class of subject term, S is wholly excluded from class of predicate term 'P'.

(3) Particular Affirmative ('I' Proposition) :

When the proposition is particular in quantity and affirmative in quality, it is called Particular Affirmative Proposition. This proposition asserts that Some members of one class i.e. the class of Subject term are included in another class i.e. the class of predicate term. Eg. 'Some books are amusing'. This proposition asserts that some members of the class of subject term 'books' are included in another class of predicate term 'amusing'. Any Particular Affirmative proposition may be schematically written as 'Some S is P', which says that atleast one member of class of subject term 'S' is also the member of the class of predicate term 'P'. This proposition is also called as 'I' Proposition. It affirms the relation of inclusion between two classes partially. It asserts that the class of subject term, 'S' is partially included in class of predicate term 'P'.

(4) Particular Negative ('O' Proposition) :

When the Proposition is particular in quantity and negative in quality, it is called Particular Negative Proposition. This proposition asserts that some members of one class i.e. class of subject term are excluded from another class i.e. the class of predicate term. Eg. Some animals are not wild. This proposition asserts that some members of the class of subject term, 'animals' are excluded from another class of predicate term 'Wild beings'. Any Particular Negative proposition may be schematically written as 'Some S is not P', which says that atleast one member of the class of subject term 'S' is not the member of the class of predicate term 'P'. This proposition is also called as 'O' Proposition. It denies the relation of inclusion between two classes partially. It asserts that the class of subject term, 'S' is partially excluded from the class of predicate term 'P'.

Singular Proposition :

There is another sub-class of propositions, on the basis of quantity. This is singular proposition. A Singular proposition is one in which the predicate is affirmed or denied of a single definite individual. It means the subject of a Singular proposition is a singular term. Traditional logicians considered singular proposition to be Universal Proposition. This is because in a singular proposition, the affirmation or the denial is of the whole subject. A Singular Affirmative proposition is treated as Universal Affirmative proposition i.e. 'A' Proposition and a Negative Singular proposition is considered as Universal Negative Proposition i.e. 'E' Proposition.

For example :

(1) Smruti is smart.

(2) Yogesh is not a coward.

The first example is a Singular Affirmative proposition. It is considered as 'A' proposition in Traditional logic and the second example is a Singular Negative proposition. It is considered as 'E' proposition in traditional logic.

Propositions in ordinary language :

One already knows that a typical Categorical proposition uses the words 'all' or 'some' to denote the quantity of the subject. However in everyday life, one does not always use these words. Ordinary language has variety of words, that denote these quantities.

For example :

(1) Parents are always caring.

(2) A few voters are patriotic.

Different words indicating 'A', 'E', 'I', 'O' propositions are given in the table below :

Categorical Propositions	**Words used in a proposition**
A	All, every, any, each, always, absolutely, necessarily, invariably, whichever, whoever, whatever etc.
E	No, Not a single, Not even one, never, Not at all, none etc. (These words have Negative meaning)
I	Some, A few, many, most, several, generally, frequently, occasionally, Perhaps, often, certain, all most all, nearly always, etc.
O	Hardly, rarely, scarcely, seldom, few, etc. (These words have negative meaning)

When 'A' proposition is negated, we get 'O' proposition.

When 'I' proposition is negated, we get 'O' proposition.

When 'O' proposition is negated, we get 'I' proposition.

4.3 Distribution of terms in Categorical Propositions

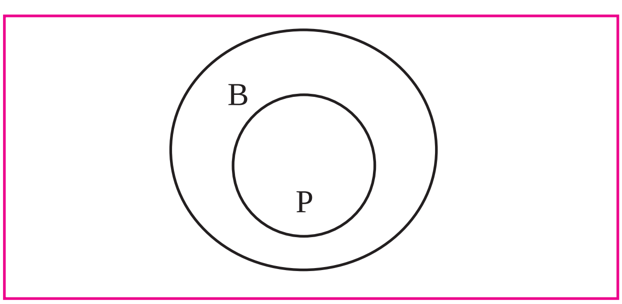
A Categorical proposition may refer to all members of the class or some members of the class. Distribution of term is determined by its reference to class. **The term of proposition is distributed when the proposition refers to the entire class to which it applies and the term of a proposition is undistributed when it refers to the part of the class to which it applies.** Thus each term of a proposition is either distributed or undistributed.

Distribution of terms in Categorical Propositions are as follows :

(1) Distribution of terms in Universal Affirmative / 'A' Proposition :

'A' Proposition is an Universal Affirmative Proposition. Its symbolic form is 'All S is P'. e.g. All parrots are birds. The above example indicates that the class of subject term 'parrots', is wholly included in another class of predicate term, 'birds'. So the subject term of 'A' Proposition is distributed. whereas the class of predicate term 'birds' is not wholly included in the class of subject term 'parrots'. Only part of the class of predicate term, 'birds' is included in the class of subject term, 'parrots'. So the predicate term of 'A' Proposition is undistributed.

Distribution of terms in Universal Affirmative/ 'A' Proposition is well explained by Logician Euler in the following diagram.



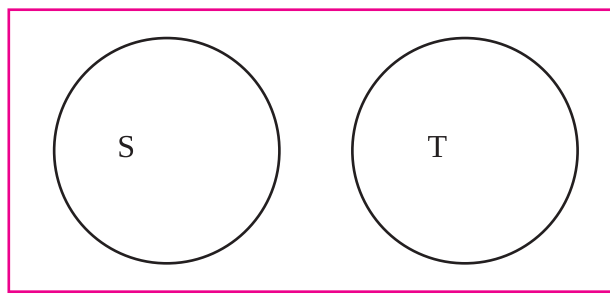
'P' indicates the class of parrots and 'B' indicates the Class of birds.

Hence the subject term is distributed but the predicate term is undistributed in 'A' proposition.

(2) Distribution of terms in Universal Negative / 'E' Proposition :

'E' Proposition is an Universal Negative Proposition. Its symbolic form is 'No S is P'. e.g. No Squares are triangles. In this example the class of subject term squares is wholly excluded from another class of predicate term, 'triangles'. So the subject term of 'E' Proposition is distributed. The class of predicate term 'Triangles' also refers to the entire class. The class of predicate term 'triangles' is also wholly excluded from the class of subject term 'squares'. So the predicate term of 'E' Proposition is also distributed.

Distribution of terms in Universal Negative 'E' Proposition is well explained by Logician Euler in the following diagram.



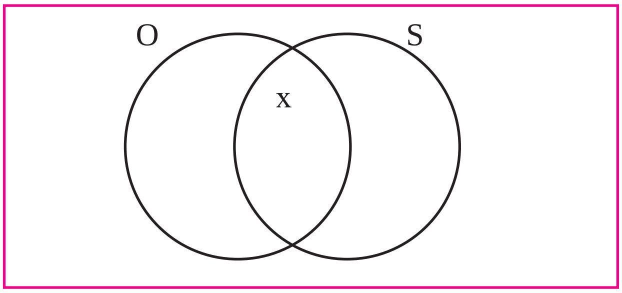
'S' indicates the class of squares and 'T' indicates the class of Triangles.

Hence both the subject term and the predicate term are distributed in 'E' Proposition.

(3) Distribution of terms in Particular Affirmative / 'I' Proposition :

'I' is a Particular Affirmative Proposition. Its symbolic form is 'Some S is P'. e.g. Some Oranges are sour fruits. In this example the class of subject term, 'Oranges' is partially included in another class of predicate term, 'sour fruits'. So the subject term of 'I' proposition is undistributed. The class of predicate term 'sour fruits' is also partially included in the class of subject term 'Oranges'. So the predicate term of 'I' proposition is also undistributed.

Distribution of terms in Particular Affirmative 'I' Proposition is well explained by Logician Euler in the following diagram.



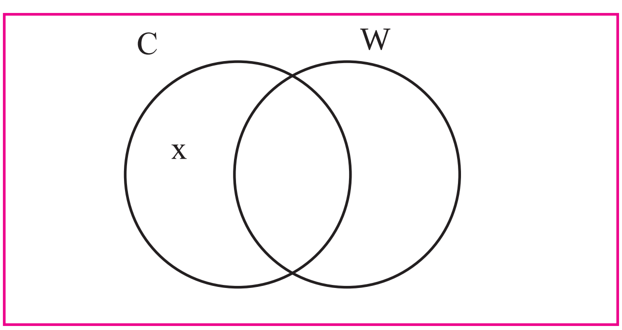
'O' is the class of oranges and 'S' is the Class of sour fruits. 'x' indicates that it is the member of both the classes.

Hence both the subject term and the predicate term are undistributed in 'I' Proposition.

(4) Distribution of terms in Particular Negative / 'O' Proposition :

'O' is a Particular Negative Proposition. Its symbolic form is 'Some S is not P'. e.g. Some cats are not white animals. In this example the class of subject term, 'cats' is partially excluded from another class of predicate term, 'white animals'. So the subject term of 'O' proposition is undistributed, but the class of predicate term 'white animals' is wholly excluded from the class of subject term 'cats'. So the predicate term of 'O' proposition is distributed.

Distribution of terms in Particular Negative 'O' Proposition is well explained by Logician Euler in the following diagram.



'C' indicates the class of cats and 'W' is the class of whit animals. 'x' indicates that it is the member of the class of cats but is not the member of the class of white animals.

Hence the subject term is undistributed in 'O' Proposition, whereas the predicate term is distributed in 'O' Proposition.

Complete the following table.

Categorical Proposition	Subject term	Predicate term
A		
E	Distributed	
I		Undistributed
O		

4.4 Types of Inference

Inference is the process of deriving the conclusion on the basis of observed facts.

For example : After observing the flooded streets, one can derive a conclusion that it might have rained heavily.

Inference is of two types, namely Inductive and Deductive Inference. Traditional Logic explains the difference between Inductive inference and Deductive Inference as follows :

In Inductive inference, one proceeds from particular to general proposition.

e.g. The general proposition that 'All cherries are red', is derived on the basis of observation of few cherries which are red.

In Deductive inference, one proceeds from general to particular proposition.

For example :

All Indians are intelligent.

Rajvi is an Indian

Therefore Rajvi is intelligent.

Deductive inference is of two types :
(1) Immediate (2) Mediate

4.4.1 Immediate Inference :

Immediate inference is a kind of Deductive inference in which the conclusion is drawn directly from one premise without the mediation of any other premise.

Traditionally there are two types of Immediate Inferences :

(1) Inference by Opposition of Propositions and

(2) Inference by Eduction.

(1) Inference by Opposition of Propositions:

Opposition of Propositions is the relation between any two kinds of Categorical propositions having the same subject and predicate terms, but differing in either quantity, quality or both quantity and quality. Considering A, E, I, O in pairs we get four kinds of oppositions, which are correlated with some important truth relations, as follows :

(1) Contradicatory relation [Contradictories] :

Two standard forms of categorical propositions that have the same subject and predicate terms, but differ from each other in both quantity and quality are contradictories. Thus 'A' Proposition and 'O' Propositions are contradictories.

For example : 'All lawyers are fighters' is an 'A' Proposition and 'Some lawyers are not fighters is 'O' Proposition.

Similarly 'E' Proposition and 'I' Propositions are contradictories.

For example : 'No pilots are Marine Engineers', is 'E' Proposition and 'Some pilots and Marine Engineers', is 'I' Proposition.

Both the contradictories cannot be true together and the contradictories cannot be false together.

Contradictory relation can be shown in the table as follows :

A	O
T	F
F	T

E	I
T	F
F	T

O	A
T	F
F	T

I	E
T	F
F	T

(2) Contrary relation [Contraries] :

Traditinally, a pair of Universal Propositions having the same subject and predicate terms but which differ in quality are contraries. Thus 'A' Proposition and 'E' Proposition are contraries.

For example : 'All artists are creative persons', is 'A' Proposition and 'No artists are creative persons', is 'E' Proposition.

The contraries cannot be true together, but may be false together.

Contrary relation can be shown in the table as follows :

A	E
T	F
F	?

E	A
T	F
F	?

(3) Sub-Contrary relation [Sub-Contraries] :

Traditionally, a pair of Particular Propositions having the same subject and predicate terms but which differ in quality are Sub-contraries. Thus 'I' Proposition and 'O' Proposition are Sub-contraries.

For example : 'Some rich men are handsome', is 'I' Proposition and 'Some rich men are not handsome', is 'O' Proposition.

The Sub-contraries may be true together, but cannot be false together.

Sub-contrary relation can be shown in the table as follows :

I	O
T	?
F	T

O	I
T	?
F	T

(4) Sub-Altern relation :

When two Categorical propositions with the same subject and predicate terms, agree in quality but differ in quantity, are called corresponding propositions. Thus 'A' Proposition and 'I' Propositions are corresponding.

For example : 'All branded things are expensive', is 'A' Proposition and 'Some branded things are expensive', is 'I' Proposition. Both these propositions are corresponding propositions.

Similarly 'E' Proposition and 'O' Propositions are corresponding propositions.

For example : 'No Monkeys are donkeys', is 'E' Proposition and 'Some Monkeys are not donkey' is 'O' Proposition.

This opposition between an Universal proposition and its corresponding Particular proposition is known as Sub-altern. In any such pair of corresponding propositions, **the Universal proposition is called subalternant and the Particular proposition is called sub-alternate.** In sub-altern relation the subalternants (Universal propositions) imply their corresponding sub-alternates (Particular propositions). If universal proposition in any one pair is true then its corresponding Particular proposition is also true and if universal proposition in any one pair is false then its corresponding Particular proposition is doubtful.

If Particular proposition in any one pair is true then its corresponding Universal proposition is doubtful and if the Particular proposition in any one pair is false then its corresponding Universal proposition is also false.

Sub-alteration relation can be shown in the table as follows :

A	I
T	T
F	?

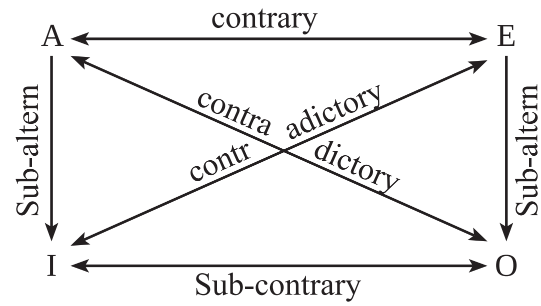
I	A
T	?
F	F

E	O
T	T
F	?

O	E
T	?
F	F

Traditional Logician Aristotle has shown the relation between four kinds of Categorical Propositions in a square as shown below :

sub-alternant **sub-alternant**



Sub-alternate **Sub-alternate**

Traditional square of opposition of propositions.

Examples of opposition of propositions :

1. Any Philosopher is wise [Given proposition - ['A']

   Contradictory : (O) Some Philosophers are not wise.

   Contrary : (E) No Philosopher is wise.

   Sub-altern : (I) Some Philosophers are wise.

2. Not even one man is perfect. [Given propsotion - ['E']

   Contradictory : (I) Some men are prefect.

   Contrary : (A) Every man is perfect.

   Sub-altern : (O) Some men are not perfect.

3. Several metals are heavy. [Given proposition - ['I']

   Contradictory : (E) No metals are heavy.

   Sub-Contrary : (O) Several metals are not heavy.

   Sub-altern : (A) All metals are heavy.

4. A few students are not regular. [Given proposition - 'O']

   Contraditcory :

   (A) All students are regular.

   Sub-contrary :

   (I) A few students are regular.

   Sub-altern :

   (E) No students are regular.

1. All diplomats are liberal.
   Contradictory :
   ____
   Contrary :
   ____
   Sub-altern :
   ____
2. No cats are dogs.
   Contradictory :
   ____
   Contrary :
   ____
   Sub-altern :
   ____
3. Some musicians are singers.
   Contradictory :
   ____
   Sub-contrary :
   ____
   Sub-altern :
   ____
4. Some thin people are not healthy.
   Contradictory :
   ____
   Sub-contrary :
   ____
   Sub-altern :
   ____
5. Every child is innocent.
   Contradictory :
   ____
   Contrary :
   ____
   Sub-altern :
   ____
6. Not a single game is enjoyable.
   Contradictory :
   ____
   Contrary :
   ____
   Sub-altern :
   ____
7. A few lectures are monotonous.
   Contradictory :
   ____
   Sub-contrary :
   ____
   Sub-altern :
   ____
8. Many movies are not tragedies.
   Contradictory :
   ____
   Sub-contrary :
   ____
   Sub-altern :
   ____
9. Executives are always stressed.
   Contradictory :
   ____
   Contrary :
   ____
   Sub-altern :
   ____
10. Ascetics are never materialistic.
   Contradictory :
   ____
   Contrary :
   ____
   Sub-altern :
   ____

(2) Eductions :

Eductions are those forms of immediate inferences in which, one deduces the conclusion, by interchanging the positions of the subject term and the Predicate term of the Premise. i.e. if the Premise is true, Conclusion is also true and if the Premise is false, the conclusion is also false.

There are seven kinds of Eductions. two of which are fundamental. The basic Eductions are : (1) Conversion and (2) Obversion

1. Conversion :

Conversion is a process of immediate inference in which, predicate term of the premise becomes the subject term of the conclusion and the subject term of the premise becomes the Predicate term of the conclusion. Thus in conversion the subject term and the predicate term are interchanged. The original proposition/premise is called the 'Convertend' and Inferred proposition/conclusion is called Converse.

There are certain rules of Conversion as follows :

(i) The Rule of Quality :

The quality of the converse (conclusion) must remain the same as the original proposition (premise). If the premise is affirmative, the conclusion must be affirmative and if the premise is negative, the conclusion must be negative.'

(ii) The Rule of Distribution :

No term is distributed in the converse (Conclusion) unless it is distributed in the original proposition (Premise). If a term is undistributed in the premise, then it must remain undistributed in the conclusion.

Conversion can be explained with the help of examples as follows :

(1) Converse of 'A' Proposition as per the rule of quality can be either 'A' or 'I'. However the converse of 'A' proposition cannot be 'A'.

For example : 'All roses are red'.

It's converse cannot be 'All red flowers are roses' because the rule of distribution is violated. Therefore the converse of 'A' Proposition is 'I' Proposition,

For example : 'All roses are red'.

This is 'A' Proposition. Converse of 'A' Proposition is 'I' Proposition i.e. 'Some red flowers are roses'.

(2) Converse of 'A' Proposition remains 'A' Proposition, when the denotation of both the terms, i.e. the subject term and the predicate term is the same.

For example : 'The shortest Atricle in this magazine, is the best'.

This is Singular affirmative Proposition, but it is considered as Universal affirmative proposition ('A' Proposition) in Traditional Logic. In this proposition the subject term is 'shortest' and the predicate term is 'best', denotation of both these terms is the same. When one infers converse from this proposition, one merely interchanges the position of the subject term and the predicate term. The converse of this proposition is 'The best Article in this Magazine is shortest'. i.e. the converse of 'A' remains 'A'.

(3) Similarly the converse of 'A' Proposition will remain 'A' Proposition, when the predicate term is the definition of the subject term or peculiar quality possessed by the subject term.

For example : 'Man is a rational animal.'

The converse of this proposition is 'Rational animal is man'. In this case also the converse of 'A' remains 'A', As it is the definition of 'Man' that he is a 'rational animal', When converse of any proposition remains the same proposition it is called as **'Simple Converse'**.

(4) Converse of 'E' Proposition is 'E' Proposition. It is called as Simple Converse.

For example : 'No Ladyfingers are leafy vegetables'. The converse of this proposition is 'No leafy vegetables are Ladyfingers.

(5) Converse of 'I' Proposition is 'I' Proposition. It is also called as Simple Converse.

For example : 'Some actors are dancers. Converse of this proposition is some dancers are actors.'

(6) Converse of 'O' Proposition is not possible. Because according to the rule of Quality, the quality of converse must remain the same. 'O' is a negative proposition so its converse must be negative. i.e. either 'O' or 'E' Proposition. In both these cases, the subject term which is undistributed in the premise of 'O' proposition, gets distributed in the conclusion as it becomes the predicate of 'O' / 'E' proposition in the conclusion.

1. Hexagon means six sided polygon.

   Converse : ________________

2. Any Chickoo is ripe

   Converse : ________________

3. No crows are sparrows.

   Converse : ________________

4. Many Ladies are hardworking.

   Converse : ________________

5. Few voters are present.

   Converse : ________________

6. All Tigers are wild.

   Converse : ________________

7. Not a single cupboard is wooden.

   Converse : ________________

8. Hardly children are extroverts.

   Converse : ________________

9. Indians are generally vegetarians.

   Converse : ________________

10. A few teachers are strict.

    Converse : ________________

Complete the following table:

Convertend	Converse
A - All S is P	I - Some P is S
E - No S is P	
I - Some S is P	
O - Some S is not P	

(2) Obversion :

Obversion is a process of inference in which the subject term in the conclusion remains the same, as the subject term in the premise, but the predicate of the conclusion is complement (contradictory) to the predicate term in the premise. Thus in Obversion only the predicate term is changed. The original proposition/premise is called the 'Obvertend' and Inferred proposition/conclusion is called Obverse.

There are certain rules of Obversion as follows :

(i) Rule of Quality :

The quality of the Obverse (conclusion) must change from the original proposition (premise). If the premise is affirmative, the conclusion must be negative and if the premise is negative, the conclusion must be affirmative.

(ii) Rule of Quantity :

The quantity of the Obverse (conclusion) must remain the same as the original proposition (premise). If the premise is Universal proposition, the conclusion must also be Universal proposition and if the premise is a particular proposition, the conclusion must be a particular proposition.

(iii) Rule of Predicate term :

The Predicate term of Obverse (conclusion) must be complementary (contradictory) to the Predicate term of the original proposition (premise).

Obversion can be explained with the help of examples as follows :

(1) Obverse of 'A' Proposition is 'E' Proposition.

For example :'All residents are voters'. Its Obverse is 'No residents are non-voters'.

(2) Obverse of 'E' Proposition is 'A' Proposition.

For example : No Umpires are partial. Its Obverse is 'All Umpires are non-partial'.

(3) Obverse of 'I' Proposition is 'O' Proposition.

For example : Flowers are generally colourful. Its Obverse is 'Flowers are generally not non-colourful'.

(4) Obverse of 'O' Proposition is 'I' Proposition.

For example : Mostly houses are not spacious. Its Obverse is 'Mostly houses are non-spacious'.

1. All Journalists are writers.
   Obverse : ____________________
2. No Lions are herbivorous.
   Obverse : ____________________
3. A few subjects are interesting.
   Obverse : ____________________
4. Some producers are not rich.
   Obverse : ____________________
5. Every mother is anxious.
   Obverse : ____________________
6. Not a single stick is straight.
   Obverse : ____________________
7. Many books are expensive.
   Obverse : ____________________
8. Occasionally students are punctual.
   Obverse : ____________________
9. All Gadgets are modern.
   Obverse : ____________________
10. Several Teachers are good speakers.
    Obverse : ____________________

Complete the table given below :

Obvertend	**Obverse**
A - All S is P	E - No S is non-P
E - No S is P	
I - Some S is P	
O - Some S is not P	

4.4.2 Mediate Inference :

Mediate Inference is a kind of Deductive inference in which the conclusion is derived from two or more premises considered jointly. **Syllogism is a form of Deductive inference, but it is a Mediate inference, in which the conclusion is derived from only two premises taken jointly.** There are three kinds of Syllogism. They are as follows :

(1) Hypothetical Syllogism,

(2) Disjunctive Syllogism,

(3) Categorical Syllogism.

(1) Hypothetical Syllogism :

Hypothetical Syllogism is a deductive argument in which both the premises are hypothetical propositions, where the consequent of the first proposition is same as the antecedent of the second proposition. From this one can derive a conclusion which is also a hypothetical proposition, that contains the antecedent of the first and consequent of the second proposition.

For example : If the country is kept clean, then tourists will visit the country in large numbers.

If tourists visit the country in large numbers, then the country will progress financially.

Therefore if the country is kept clean, the country will progress financially.

(2) Disjunctive Syllogism :

Disjunctive Syllogism is a deductive argument, in which the first premise is a disjunctive proposition which states alternatives and the second premise is the denial of the first alternative of the disjunctive proposition. From this one can derive the conclusion which is the affirmation of second alternative of the disjunctive proposition.

For example : Either Logicians are Philosophers or Mathematicians.

Logicians are not Philosophers.

Therefore Logicians are Mathematician.

(3) Categorical Syllogism :

Categorical Syllogism is defined as a deductive argument consisting of three categorical propositions that together contain exactly three terms, each of which occurs in exactly two of the constituent propositions.

For example : No doctors are lawyers.

Some professors are lawyers.

Therefore some professors are not doctors.

Summary

The Greek Philosopher Aristotle is the founder of Traditional Logic.

Term is defined as a word or group of words which stands as the subject and predicate of a logical proposition.

A proposition has three elements subject - copula - predicate.

Traditionally proposition is classified into (1) Conditional proposition and (2) Categorical proposition.

Conditional propositions is of two types :

(1) Hypothetical proposition and (2) Disjunctive proposition.

(2) Categorical proposition is classified into four kinds namely A, E, I, O.

On the basis of quantity the propositions are classified as Universal and Particular.

On the basis of quality the propositions are classified as Affirmative and Negative.

Thus there are four kinds of propositions :

(1) Universal Affirmative, (2) Universal Negative, (3) Particular Affirmative, and (4) Particular Negative.

In ‘A’, the subject term is distributed and the predicate term is undistributed.

In ‘E’, both the subject term and the predicate term are distributed.

In ‘I’, both the subject term and the predicate term are undistributed.

In ‘O’, the subject term is undistributed whereas the predicate term is distributed.

A term is distributed when it refers to the entire clas and it is undistributed when it does not refers to the entire class but to the part of the class.

Inference are of two types (1) Immediate and (2) Mediate.

Immediate Inference is of two types (1) Opposition of Proposition and (2) Eduction.

Opposition of proposition is the relation between categorical propositions having the same subject and predicate but differing in quantity, quality or both quantity and quality. There are four kinds of oppositions:

(1) Contradictory, (2) Contrary, (3) Sub-contrary and (4) Sub-altern.

Eduction is of two types : (1) Conversion and (2) Obversion

In Conversion the subject and predicate are interchanged.

The quality of the converse remains the same and no term is distributed in converse until it is distributed in the premise.

Thus : In Categorical proposition,

Converse of SAP is PIS.

Converse of SEP is PES.

Converse of SIP is PIS.

Converse of SOP is not possible.

In Obversion the predicate of the obverse is complementary to the original proposition.

In Obversion the quantity of Obverse remains the same but its quality changes.

Thus : Obverse of SAP is SE$\bar{P}$.

Obverse of SEP is SA$\bar{P}$.

Obverse of SIP is SO$\bar{P}$.

Obverse of SOP is SI$\bar{P}$.

Categorical Propositions	Converse	Obverse
A (S → P)	I (P → S)	E (S → non - p)
E (S → P)	E (P → S)	A (S → non - p)
I (S → P)	I (P → S)	O (S → not non - p)
O (S → P)	Not possible	I (S → non - p)

Syllogism is a Mediate inference. It is of three types :

(1) Hypothetical Syllogism and (2) Disjunctive Syllogism, (3) Categorical Syllogism

Exercises

Q. 1. Fill in the blanks with suitable words from those given in the brackets :

(1) .... is the founder of Traditional Logic. *[Aristotle / Plato]*

(2) In ...., the conclusion is derived from only two premises taken jointly. *[Syllogism / Eduction]*

(3) .... is a Conditional proposition. *[Disjunctive / Categorical]*

(4) In .... proposition both the terms are Distributed. *[E / I]*

(5) A term is ...., when it refers to the entire class. *[Distributed / Undistributed]*

(6) .... Inference is a kind of Deductive inference in which the conclusion is derived from two or more premises considered jointly. *[Mediate/ Immediate]*

(7) .... is an Immediate Inference.

[Opposition of Propositions / Syllogism]

(8) In ...., the predicate is complementary to the predicate of the original proposition. *[Conversion / Obversion]*

(9) There is a relation of ...., between 'A' and 'I' propositions. *[Sub-altern / Sub-contrary]*

(10) .... cannot be true together, but they may be false together. *[Contraries / Sub-contraries]*

(11) When denotation of both the terms is same in a proposition, the Converse of 'A' is .... *[A / I]*

(12) 'Agricultural land is scarcely available', is a .... proposition. *[I / O]*

(13) In Traditional Logic, Singular propositions are treated as .... proposition. *[Universal/ Particular]*

(14) In .... Proposition, the subject is undistributed, whereas the predicate is distributed. *[A / O]*

(15) .... proposition is one which presents a condition together with some consequence which follows from it. *[Hypothetical / Disjunctive]*

Q. 2. State whether the following statements are True or False :

(1) In Categorical proposition, Obverse of 'A' Proposition is 'E' Proposition.

(2) 'A' proposition is contradictory to 'E' Proposition.

(3) In Sub-altern relation, the universal propositions imply their corresponding particular propositions.

(4) In Conversion, the quality of the proposition changes.

(5) 'O' Proposition stands for Particular Negative Proposition.

(6) Converse of 'E' Proposition is 'E' Proposition, and it is called as Simple Converse.

(7) Conditional proposition is a proposition of relationship between two classes referred to as the class of subject term and the class of predicate term.

(8) Obversion is a kind of Eduction.

(9) Syllogism is an Inductive inference.

(10) Inference is the act of deriving the conclusion on the basis of observed facts.

(11) Two sub-contraries cannot be true together.

(12) 'All Indians are brain workers', is Universal Affirmative proposition.

(13) In Obversion, no term is distributed in the conclusion, unless it is distributed in the premise.

(14) Term can be neither true nor false.

(15) Coverse of 'O' Proposition is 'I' Proposition.

Q. 3. Match the columns :

	(A)		(B)
(1)	Mediate Inference	(a)	Particular Affirmative Proposition
(2)	Immediate Inference	(b)	Categorical syllogism
(3)	Categorical Proposition	(c)	Relation between two Universal Proposition
(4)	Contrary	(d)	Eduction

Q. 4. Give Logical terms for the following :

(1) A word used in Categorical proposition.

(2) A word which unifies the subject and predicate in a logical proposition.

(3) The term about which assertion is made.

(4) A proposition is one in which the assertion is made subject to some expressed condition, according to traditional logic.

(5) A proposition which states alternatives, according to traditional logic.

(6) A proposition of relationship between two classes referred to as the class of subject term and the class of predicate term, according to traditional logic.

(7) A singular Negative proposition in Traditional Logic.

(8) Categorical Proposition in which the Subject term is Distributed, but the Predicate term is undistributed.

(9) Deductive inference in which the conclusion is drawn directly from one premise without the mediation of any other premise.

(10) An Immediate Inference which shows relation between Categorical Propositions.

(11) A proposition in which the predicate is affirmed or denied of single definite individual.

(12) An Eduction in which the subject term and the predicate terms are interchanged.

(13) An Eduction in which the quality of the proposition changes.

(14) A mediate inference in which the conclusion is drawn from only two premises.

(15) The opposition between an universal proposition and its corresponding particular proposition.

Q. 5. Give Reasons :

(1) Sub-contrary of 'I' proposition is 'O' proposition.

(2) Singular Proposition is called an Univeral Proposition in Traditional Logic.

(3) Converse of 'O' Proposition is not possible.

(4) Obverse of 'A' Proposition is 'E' Proposition

(5) Converse of 'A' Proposition is 'I' Proposition, when it is a general Proposition.

Q. 6. Explain the following :

(1) Traditional scheme of Categorical Proposition.

(2) Distribution of Terms in 'A' Proposition.

(3) Distribution of Terms in 'E' Proposition.

(4) Distribution of Terms in 'I' Proposition.

(5) Distribution of Terms in 'O' Proposition.

(6) Contradictory relation of Categorical propositions.

(7) Contrary relation of Categorical propositions.

(8) Sub-contrary relation of Categorical propositions.

(9) Relation of Sub-altern in Categorical propositions.

(10) Rule of Conversion.

(11) Rule of Obversion.

Q. 7. Give Oppositions of the following propositions :

(1) All red vehicles are BEST buses.
[Contradictory, Contrary]

(2) No crows are white.
[Contrary, Sub-altern]

(3) Some Citizens are patriotic.
[Contradictory, Sub-contrary]

(4) Some mistake are not forgivable.
[Sub-contrary, Sub-altern]

(5) Any fruit is nourishing.
[Contrary, Sub-altern]

(6) Not a single creature is useless.
[Contradictory, Sub-altern]

(7) Many Philosophers are Philanthropist.
[Sub-contrary, Sub-altern]

(8) A few males are not dominating.
[Contradictory, Sub-altern]

(9) Every mango is sweet.
[Contradictory, Sub-altern]

(10) Not even one resource is sufficient.
[Contrary, Contrdiction]

(11) Children often eat Junk food.
[Contradictory, Sub-altern]

(12) Children seldom play out-door games.
[Sub-contrary, Contradictory]

(13) Several Air-hostesses are beautiful.
[Sub-altern, Sub-contrary]

(14) None of the rich are generous.
[Contrary, Contradictory]

(15) Whoever works is paid.
[Contrary, Sub-altern]

(16) Victory is frequently celebrated.
[Sub-contrary, Contradictory]

(17) Some grapes are not green.
[Sub-altern, Sub-contrary]

(18) All Indians are Intelligent.
[Sub-altern, Contradictory]

(19) Games are never borring.
[Contrary, Sub-altern]

(20) Some chemicals are poisonous.
[Sub-altern, Contradictory]

(21) Hardly students study.
[Sub-contrary, Contradictory]

(22) All pilots are smart.
[Contrary, Contradictory]

(23) A few yogis are intuitive.
[sub-contrary, Sub-altern]

(24) Diamonds are always precious.
[Contrary, Contradictory]

(25) No Circles are Triangles.
[Contradictory, Sub-altern]

(26) Theist are always religious.
[Contrary, Contradictory]

(27) Some doctors are not rich.
[Sub-contrary, Sub-altern]

(28) Every Journalist is present.
[Contradictory, Contrary]

(29) No donkeys are fast runners.
[Contradictory, Sub-altern]

(30) Any professor is post graduate.
[Sub-altern, Contrary]

Q. 8. Give Converse and Obverse of the following :

(1) All Indians are Patriotic.

(2) No Managers are Engineers.

(3) Most Actors are famous.

(4) Some flowers are not fragrant.

(5) Every Exam is challenging.

(6) Not a single class-room is bright.

(7) Some leaders are social reformers.

(8) A few leaves are not green.

(9) Any attendance is mandatory.

(10) Many mobile games are addictive.

(11) Some Taxies are not black.

(12) Toys are always colourful.

(13) Salesmen are never introvert.

(14) Some singers are not dancers.

(15) Any Professor is knowledgeable.

(16) Some arguments are valid.

(17) Not even one lady is old.

(18) Most high-ways are broad.

(19) Some families are not nucler.

(20) All sports-men are energetic.

(21) No illiterates are employed.

(22) Some websites are informative.

(23) Some pens are not blue.

(24) Efforts are never wasted.

(25) Every proposition is a sentence.

(26) Some actors are great scientists.

(27) A few artists are feminists.

(28) No social workers are managing directors.

(29) All medicines are not bitter.

(30) Not a single radio jockey is a football player.

5 Syllogism

In the previous chapter we have studied the meaning of Mediate inference. We already know that Syllogism is an mediate inference. In this chapter we will deal with Categorical Syllogism.

Categorical Syllogism in general is a deductive argument, in which the conclusion cannot assert more than what is asserted in the premises.

Let us have two categorical propositions as premises.

Some Indians are Honest.

No Indians are fools.

Which conclusion given below is the correct one, that follows from the above two premises?

1. Some Indians are fools.
2. Some honest persons are not fools.

5.1 Categorical Syllogism

The theory of Categorical Syllogism was put forward by Aristotle.

Categorical syllogism is defined as a deductive argument consisting of three categorical propositions that together contain exactly three terms, each of which occurs in only two of the constituent propositions.

According to Aristotle, Categorical Syllogism is an argument in which the middle term stands in a certain relation to the other two terms. i.e. the Subject term and the Predicate term.

It is a mediate inference in which the conclusion is deduced from two given propositions.

For example :

All fruits are ripe.

All apples are fruits.

Therefore all apples are ripe.

In the above syllogism the first two propositions are the premises and the third proposition is the conclusion.

As a mediate inference, syllogism differs from immediate inference. Unlike eductions and opposition of propositions, the conclusion of syllogism is deduced from the two premises taken jointly. It is not deducted from each of the premises, separately.

5.2 Structure of Categorical Syllogism :

In a Categorical syllogism, the constituent propositions are analysed into terms. The predicate term of the conclusion is called **the major term**. It is represented by **'P'** and the Subject term of the conclusion is called the **minor term**. It is represented by **'S'**. The term which occurs in both the premises, but not in the conclusion is called the **middle term**. It is represented by **'M'**.

The premise in which the major term occurs is called **major premise** and the premise in which the minor term occurs is called **minor premise**. Middle term relates the major and minor terms. The relation between the middle term and the other two terms is either of affirmation or negation.

Categorical Syllogism is a formal inference. Its validity does not depend on the content of, either the premise or the conclusion. Hence syllogistic argument can be represented symbolically, and its validity is decided on the basis of formal relation between the premises and the conclusion. **If the premises imply the conclusion, the inference is valid and if they do not imply the conclusion, the inference is invalid.**

The validity of Categorical syllogism does not depend on the order of the constituent propositions in an given argument. But when the syllogism is reduced to its logical form the constituent propositions are expressed in certain order as follows :

Major Premise

Minor Premise

Conclusion

5.3 Figures of Categorical Syllogism

Categorical Syllogisms differ from each other depending upon the position of the middle term in the premises. The middle term may stand as the subject or the predicate in the premises. There are three kinds of syllogism depending on the position of middle term in the premises. They are called figures. Galen has added the fourth figure to the syllogism. Thus there are four figures of syllogism. **Figures of syllogism is the form of syllogism as determined by the position of the middle term in the premises.**

The figures of Categorical syllogism are as follows :

***Figure - I* :** It is the form of Categorical syllogism in which the middle term stands as the subject of major premise and predicate of minor premise.

M P

S M

∴ S P

***Figure - II* :** It is the form of Categorical syllogism in which the middle term stands as the predicate in both the premises i.e. major and minor premise.

P M

S M

∴ S P

***Figure - III* :** It is the form of Categorical syllogism in which the middle term stands as the subject in both the premises, i.e. major and minor premise.

M P

M S

∴ S P

***Figure - IV* :** It is the form of Categorical syllogism in which the middle term stands as the predicate in the major premise and as a subject in minor premise.

P M

M S

∴ S P

5.4 Rules of Categorical Syllogism

Traditional logicians observed that one can test the validity of syllogistic arguments by applying certain rules. A Categorical syllogism whose conclusion is drawn in accordance with these rules would be valid. If the Categorical syllogism violates any of these rules, it would be invalid. A violation of any one rule is a mistake, of specific kind. So when a Categorical syllogism is invalid, it is said to commit a fallacy. It is a mistake in the form of an argument, so it is called as formal fallacy. Each of these formal fallacies has a traditional name, explained below:

Rule : 1 Rules of structure :

(1) Syllogism in general must contain three and only three propositions.

Syllogism is defined as a kind of mediate inference, consisting of two premises which together determine the truth of the conclusion. This definition shows that a syllogism has two premises and one conclusion. i.e. it has, in total only three propositions. **If the number of premises are more than two, then its ceases to be a syllogism.**

For Example :

All men are mortal.

All men are animals.

All animals are living beings.

Therefore all living beings are mortal.

The above argument has three premises and a conclusion. i.e. total four propositions so the argument is fallacious and such fallacy is called as **Argument of Sorites.**

(2) There must be three and only three terms in a Categorical syllogism

Every valid categorical syllogism must involve three terms - no more and no less. If more than three terms are involved, the Categorical syllogism is invalid. The fallacy thus committed is called the fallacy of four terms. This happens especially when one of the terms is ambiguous. i.e. it is used in two different senses. Actually speaking the word is ambiguous, not the term. A term has definite and fixed meaning. A word becomes a term when it stands as subject or predicate in a proposition. When the word becomes a term, it cannot have more than one meaning. **When the term is used ambiguously it is called the fallacy of Equivocation.**

For example :

Any bell **rings**.

Some **rings** are beautiful.

Therefore Some bells are beautiful.

In the above example the Middle term 'Rings' is ambiguous, it means 'sound' in the Major premise and 'ornament in the Minor premise.

The fallacy of equivocation may be committed with regard to any of the three terms. These are called fallacy of : (1) Ambiguous major, (2) Ambiguous middle and (3) Ambiguous minor.

Distribution of terms in Categorical propositions:

Categorical Propositions	Subject term	Predicate term
A	Distributed	Undistributed
E	Distributed	Distributed
I	Undistributed	Undistributed
O	Undistributed	Distributed

Rule : 2 Rules of Distribution of Terms :

(1) The middle term must be distributed atleast once in the premises.

The function of middle term in a Categorical syllogism is to unite the major term and the minor term. The middle term cannot perform this function, unless it is distributed atleast once in the premises. A term is distributed when it refers to the whole class and is undistributed when it refers to the part of the class.

The violation of this rule commits the fallacy of **Undistributed middle.**

For Example :

(i) All metals are **heavy**.

All stones are **heavy**.

Therefore All stones are metals.

In the above argument the middle term, i.e. 'heavy' stands as the predicate of 'A' proposition, in both the premises. So in both the premises the middle term 'heavy' is undistributed. Since the middle term is not distributed, it is possible that the part of the middle term which is related to the major premise may not be the part which is related to the minor premise. That is why the middle term is not able to perform its function of relating two terms. So the fallacy of Undistributed middle is committed.

(2) No term can be distributed in the conclusion, unless it is distributed in the premise.

When a term is distributed in the conclusion but not distributed in the premises, means that the conclusion has gone beyond the evidence in its premises and the argument being deductive is therefore invalid. This mistake is called **the fallacy of illicit process of terms.**

There are two terms in the conclusion. These are the minor term and the major term.

Accordingly the two types of fallacies that arise are :

(1) Fallacy of illicit minor,

(2) Fallacy of illicit major.

1. Fallacy of illicit minor :

For example :

(i) No cowards are brave. (Major Premise)

All cowards are **unreliable**. (Minor Premise)

Therefore no **unreliable** people are brave.

The minor term 'unreliable' is undistributed in the minor premise since it is the predicate of 'A' proposition, but it is distributed in the conclusion, being the subject of 'E' proposition. Hence the Fallacy of illicit Minor is committed.

2. Fallacy of illicit Major :

When the major term is distributed in the conclusion but not distributed in the major premise, the fallacy of illicit major is committed.

For example :

(i) All mammals are **animals** (Major Premise)

No mammals are birds (Minor Premise)

Therefore no birds are **animals**.

In the above argument the major term 'animals is undistributed in the Major premise.' but it is distributed in the conclusion. Hence the **fallacy of illicit major is committed.**

State which formal fallacy is committed in the Syllogistic argument, given below? Why?

No men are quadruped.

Some men are tall.

Therefore no tall beings are quadruped.

____

____

Rule : 3 Rules of Quality :

(1) No conclusion can be drawn from two negative premises.

Any negative proposition i.e. 'E' and 'O' denies the class inclusion. It asserts that all/some members of one class are excluded from the other class. i.e. the subject or predicate of the conclusion is wholly or partially excluded from the class of Middle term in negative premises. **Two premises asserting exclusion cannot justify the relation between the premises and the conclusion** and therefore the argument is invalid. This fallacy is as named as **fallacy of Negative premises** (or Exclusive premises.)

For example :

(i) No Lotus are roses. (Negative)

Some flowers are not roses. (Negative)

Therefore some flowers are not Lotus.

Since in the above argument conclusion is drawn from two negative premises so the rule is violated and the fallecy of Negative Premises is committed.

(2) When either of the premises is negative, the conclusion must be negative and vice versa.

In the negative propositions, one of the two classes, S or P, is wholly or partly excluded from each other. Whereas in affirmative propositions, one of the two classes S or P, is wholly or partly included in the other. Affirmative proposition can be inferred only if the premises asserts the existence of a third class which includes the first class, that has the second class already included in it. This is possible only when both the premises are affirmative propositions.

When the above rule is violated then the **fallacy of drawing an affirmative conclusion from a negative premise is committed.**

For example :

No artists are hardworking. (Negative)

Some potters are artists

Therefore some potters are hardworking. (Affirmative)

Since in the above argument the major premise is negative, but the conclusion is affirmative so the argument is Invalid, fallacy of an affirmative conclusion from a negative premise is committed.

(3) When both the premises are affirmative then the Conclusion must be affirmative & vice versa.

For example :

All men are animals.

All animals are mortal.

Therefore all men are mortal.

State which formal fallacy is committed in the Syllogistic argument, given below? Why?

All Indians are Asians.

No Asians are American.

Therefore all Americans are Indians.

____

____

5.5 Aristotelian Syllogism and Indian Nyaya Syllogism

In Indian logic, Inference is called Anumana and is defined as that cognition which presupposes some other cognition. It is knowledge (mana) which arises after (anu) other knowledge. Indian logicians generally make distinction between inference for one self (Swartha) and inference for others (Parartha) i.e. inference used for demonstrating truth for other people. In inference for oneself we do not require any formal presentation of the different propositions of an inference. It is a psychological process. Inference for others is a syllogism. For Nyaya school of Indian philosophy inference consists of five propositions/members (Avayavas) and is for demonstrating truth for others, The five propositions of Nyaya syllogism are -

1. Statement of the proposition to be proved. (Pratijna)
2. Statement of the reason. (Hetu)
3. Statement of the universal proposition called Vyapti along with an example. (Udaharan)
4. Statement of the presence of the mark/ hetu i.e. reason in the case in question. (Upanaya)
5. Conclusion proved. (Nigaman)

The following is a typical example of Nyaya syllogism -

1. This hill has fire. (Pratijna)
2. Because it has smoke. (Hetu)
3. Wherever there is smoke there is fire as in the kitchen. (Udaharan)
4. This hill has smoke which is invariably associated with fire. (Upanaya)
5. Therefore this hill has fire. (Nigaman)

Like Aristotelian syllogism, the Nyaya syllogism also has three terms. The major term is called sadhya, the minor term is called paksha and the middle term is called ling or hetu. In the above example, hill is the minor term, fire is the major term and smoke is the middle term. From the presence of smoke in the hill as qualified by the knowledge that wherever there is smoke there is fire, one proceeds to infer the presence of fire on the hill. The knowledge of universal concomitance i.e. invariable association of smoke with fire is known as vyapti.

Aristotelian syllogism and Nyaya syllogism both have three terms, however, they differ in number of propositions it contains. Aristotelian syllogism has three propositions whereas Nyaya syllogism has five propositions. According to many Indian as well as western logician this difference is a nominal difference and both the syllogisms are fundamentally similar. The difference lies more in the form than in the essence. Out of five propositions is Nyaya syllogism, two appear redundant. One can reduce the Nyaya syllogism to three propositions either by removing first two or last two propositions as given below.

(A)

1. Wherever there is smoke there is fire as in the kitchen. (Udaharan) - Major premise

2. This hill has smoke which is invariably associated with fire. (Upanaya) - Minor premise

3. Therefore this hill has fire. (Nigaman) - Conclusion

(B)

1. This hill has fire. (Pratijna) - Conclusion

2. Because it has smoke. (Hetu) - Minor premise

3. Wherever there is smoke there is fire as in the kitchen. (Udaharan) - Major premise.

The first syllogism (A) resembles the Aristotelian syllogism in the first figure.

Apart from the similarities there are also some differences between Aristotelian and Nyaya Syllogism. These are as given below.

(1) Aristotelian syllogism is deductive and formal. Nyaya syllogism is deductive - inductive and formal and material at the same time. For Nyaya thinkers deduction and induction are two aspects of the same process and cannot be separated. Inference according to Nyaya, is neither from the universal to the particular nor from the particular to the universal, but from the particular to the particular through the universal.

The udaharan or example (...as in the kitchen) in the third proposition is a unique feature of Nyaya syllogism which illustrates the truth that, the universal major premise is the result of a real induction based on the law of causation. The udaharan shows how deduction and induction are inseparable in Nyaya syllogism and also how it is both formal and material.

Udaharan is also a very strong point as Dr. Radhakrishnan says, against the argument that the Nyaya syllogism is influenced by the Greek thought. Secondly we find development of the Nyaya inference before Aristotle. The similarities between the two are due to parallel development of thought.

(2) In the Aristotelian syllogism, though connected by the middle term, the major and the minor terms stand apart in the premises. In the Nyaya syllogism all the three terms stand synthesized in the upanaya i.e. fourth proposition.

(3) Propositions of Aristotelian syllogism are nothing more than the absolutely necessary constituent parts of an inference. Propositions of Nyaya syllogism on the other hand constitute a fully reasoned out argument whose parts follow one after another in their natural sequence.

(4) The Nyaya syllogism is expository and rhetorical. It is the actual method followed in debate and therefore more useful in discovering the conclusion. The Aristotelian syllogism on the other hand is analytical and better fitted to test validity of inference.

Summary :

The theory of Categorical syllogism was put forward by Aristotle Syllogism is a mediate inferenc It contains three propositions.

In syllogistic argument the conclusion is drawn from two premises taken jontly.

Categorical syllogism has three terms. Minor term i.e. subject, Major term i.e. Predicate and the Middle term. The function of middle term is to connect major and minor term.

Syllogistic argument is a deductive infernece, and has formal validity.

Galen added fourth figure to Categorical syllogism.

Therefore there are four figures of Categorical syllogism :-

Figure - I

$$\begin{array}{rcc} & M & P \\ & S & M \\ \hline \therefore & S & P \end{array}$$

Figure - II

$$\begin{array}{rcc} & P & M \\ & S & M \\ \hline \therefore & S & P \end{array}$$

Figure - III

$$\begin{array}{rcc} & M & P \\ & M & S \\ \hline \therefore & S & P \end{array}$$

Figure - IV

$$\begin{array}{rcc} & P & M \\ & M & S \\ \hline \therefore & S & P \end{array}$$

Rules of Categorical syllogisms :

There are four rules of Categorical syllogism given by Aristotle.

Rule - 1 Rules of structure :

(1) Syllogism must contain three and only three propositions.

(2) There must be three and only three terms in a syllogism.

Rule - 2 Rules of Distribution of terms :

(1) The middle term must be distributed atleast once in the premises.

(2) No term can be distributed in the conclusion, unless it is distributed in the Premise. i.e. [Subject term or Predicate term]

Rule - 3 Rules of Quality :

(1) No conclusion can be drawn from two negative premises.

(2) When one of the premise is negative, the conclusion must be negative and vice versa.

(3) when both the premises are Affirmative the conclusion must be affirmative vice versa.

If the syllogistic argument violates any of these rules, then it commits the formal fallacy.

Seven Formal fallacies in Categorical Syllogism are as follows :

(1) Fallacy of Argument of Sorites

(2) Fallacy of Four terms. (Equivocation).

(3) Fallacy of undistributed Middle.

(4) Fallacy of illicit Minor

(5) Fallacy of illicit Major

(6) Fallacy of Negative Premises (Exclusive) Premises.

(7) Fallacy of Drawing an Affirmative conclusion from a Neagtive premise.

Aristotalian Logic and Nyaya Logic :

In Indian logic, Inference is called Anumana and is defined as that cognition which presupposes some other cognition. It is knowledge (mana) which arises after (anu) other knowledge.

For Nyaya school of Indian phiolsophy inference consists of five propositions/members (Avayavas) and is for demonstrating truth for others, The five propositions of Nyaya syllogism are -

(1) Statement of the proposition to be proved. (Pratijna)

(2) Statement of the reason. (Hetu)

(3) Statement of the universal proposition called Vyapti along with an example. (Udaharan)

(4) Statement of the presence of the mark/hetu i.e. reason in the case in question. (Upanaya)

(5) Conclusion proved. (Nigaman)

Both Nyaya and Aristotelian Syllogism has three terms unlike Aristotelian, Nyaya has five propositions but both are essentially similar.

One can reduce the Nyaya syllogism to three propositions either by removing first two or last two propositions.

Apart from the similarities there are also some differences between Aristotelian and Nyaya Syllogism. These are as given below.

1. Aristotelian syllogism is deductive and formal. Nyaya syllogism is deductive - inductive and formal and material at the same time.

2. In the Aristotelian syllogism, though connected by the middle term, the major and the minor terms stand apart in the premises. In the Nyaya syllogism all the three terms stand synthesized in the upanaya i.e. fourth proposition.

3. Propositions of Aristotelian syllogism are nothing more than the absolutly necessary constituent parts of an inference, but Nyaya Syllogism constitute of fully reasoned out argument in natural sequence.

4. The Aristotelian syllogism is good for testing the validity of inference, where as Nyaya syllogism being an actual method followed in debate, is more useful in discovering the conclusion.

Complete the following :

Sr. No.	Basic Rules of Categorial Syllogism	Rules of categorical syllogism when violated	Formal Fallacies committed
1	Rule of Structure	(1) It must contain three and only three propositions	
		(2)	Fallacy of Four terms (Equivocation)
2	Rule of Distribution of terms	(1) The middle term must be distributed atleast once in the premises	
		(2)	Fallacy of illicit Minor
		(3) The predicate term is not distributed in the conclusion, Unless it is distributed in the major premise.	
3	Rule of Quality	(1)	Fallacy of Negative Premises
		(2) When either of the premise is negative, the conclusion must be neagtive.	

Write all possible combinations of following propositions, where the fallacy of illicit Major, illicit Minor and Undistributed Middle is committed.

Hard-workers are successful.

Ambitious persons are hard-workers.

Therefore ambitious persons are successful.

Exercises

Q. 1. Fill in the blanks with suitable words from those given in the brackets :

(1) Syllogism is a .... infernece. *(Mediate / Immediate)*

(2) Syllogism has .... terms. *(Two / Three)*

(3) .... of the conclusion is called the major term in syllogism. *(Subject / Predicate)*

(4) .... term occurs in both premises and does not occur in the conclusion. *(Subject / Middle)*

(5) The first premise of syllogistic argument, when reduced to logical form is .... premise. *(Major / Minor)*

(6) .... contains both subject term and predicate term in categorical syllogism. *(Premise / Conclusion)*

(7) When any rule of syllogism is violated, the argument commits .... fallacy. *(Non-formal / Formal)*

(8) Fallacy of .... is committed, when one of the term is used in two different senses. *(Equivocation / illicit process)*

(9) When the subject term is undistributed in the premise but is distributed in the conclusion, fallacy of .... is committed. *(illicit Major / illicit Minor)*

(10) In the third figure of syllogism, the middle term stands as the .... in both the premises. *(Subject / Predicate)*

(11) An argument with four propositions is called .... *(Argument of Sorites / Fallacy of Equivocation)*

(12) For Nyaya school of Indian philosophy inference consists of .... propositions. *(five / three)*

(13) Aristotelian syllogism and Nyaya syllogism both have .... term. *(five / three)*

(14) Statement of the proposition to be proved is called .... by Nyaya logicians. *(Prtijna / Hetu)*

(15) Statement of the reason is called .... by Nyaya logicians. *(Hetu / Upanaya)*

(16) .... syllogism is better fitted to test validity of inference *(Nyaya / Aristotelian)*

Q. 2. State whether the following statements are True or False :

(1) The validity of syllogism depends upon the order in which the three constituent propositions are expressed.

(2) The conclusion in syllogistic argument depends upon the manner in which the terms are related in the premises.

(3) The AAA combination of proposition in figure - I commits the fallacy of undistributed middle.

(4) Validity of syllogism depends upon the content of an argument.

(5) In a valid syllogism the premises imply the conclusion.

(6) The rule of syllogism states that when only one premise is affirmative, the conclusion must be affirmative.

(7) In a valid syllogism the middle term must be distributed atleast once in the premise.

(8) The premise in which the predicate occurs is called the major premise.

(9) In a syllogism constituent propositions are analysed into terms.

(10) The relation between the middle term and the other two terms is negative in 'A' and 'I' Propositions.

(11) Indian logicians make distinction between inference for one self (Swartha) and inference for others (Parartha)

(12) Statement of the universal proposition along with an example is called Upanaya.

(13) Statement of the presence of the mark/hetu i.e. reason in the case in question is called Udaharan.

(14) Conclusion proved in Nyaya syllogism is called Nigaman.

(15) Statement of the universal proposition called Vyapti.

Q. 3. Match the columns :

	(A)		(B)
(1)	The major term	(a)	Hetu
(2)	The minor term	(b)	Sadhya
(3)	The middle term	(c)	Paksha

Q. 4. Give logical terms for the following

(1) An argument in which the middle term stands in a certain relation to the other two terms.

(2) A formal fallacy committed, due to ambiguous term.

(3) The predicate term of the conclusion in Categorical syllogism.

(4) The subject term of conclusion in Categorical syllogism.

(5) The term which occurs in both the premises, but not in the conclusion.

(6) The premise in which the predicate term occurs.

(7) The premise in which the subject term occurs.

(8) That cognition which presupposes some other cognition.

(9) Inference used for demonstrating truth for other people.

(10) Statement of the proposition to be proved.

(11) Statement of the reason.

(12) Statement of the universal proposition along with an example.

(13) Statementr of the presence of the mark/hetu i.e. reason in the case in question.

(14) Conclusion proved in Nyaya syllogism.

(15) The major term in Nyaya syllogism.

(16) The minor term in Nyaya syllogism.

(17) The middle term in Nyaya syllogism.

Q. 5. Give reason for the following :

(1) Middle term must be distributed atleast once in the premises.

(2) No conclusion can be drawn from two negative premises.

(3) A term cannot be distributed in the conclusion unless it is distributed in the premise.

(4) Out of five propositions in Nyaya syllogism, two appear redundant.

(5) The udaharan or example in the third proposition is a unique feature of Nyaya syllogism.

Q. 6. Explain the following :

(1) The Rule of structure in syllogism.

(2) The fallacy of Undistributed Middle.

(3) The fallacy of illicit Process in syllogism.

(4) Figures of Syllogism.

(5) Resemblance between Aristotelian and Nyaya syllogism.

(6) Distinction between Aristotelian and Nyaya syllogism.

Q. 7. Recognize with reasons the formal fallacies committed in the following Categorical syllogisms :

(1) All Indians are reformers
All reformers are brave
Therefore all brave men are Indians.

(2) Some wrong things are not worth studying
All calculations are wrong
So No calculations are worth studying.

(3) Some TV channels give informative news.
No Magazines give informative news.
Therefore No magazine is a TV channel.

(4) No athletes are trained hard.
Some film stars are not athletes.
Therefore some film stars not trianed hard.

(5) Water is a liquid.
Ice is water.
Therefore ice is a liquid.

(6) All sportsmen are well Groomed.
No lazy men are sportsmen.
Therefore some lazy men are not well groomed.

(7) Some grapes are not sweet.
No Mangoes are sweet.
Some mangoes are not grapes.

(8) Some animals are tall.
No men are tall.
Therefore Some men are not animals.

(9) All wooden things are painted.
Some boxes are wooden.
Therefore All boxes are painted.

(10) All mammals are warmblooded
No fish are mammals
Therefore Some fish are warmblooded

(11) Some birds are not ugly.
No birds are colourful.
Therefore No colourful things are ugly.

(12) Some enthusiasts show poor judgement
All those who show poor judgement make frequent mistakes.
None who make frequent mistakes deserves.
Therefore some enthusiasts do not deserve.

(13) No potters are accountants.
Some artists are potters.
Therefore some artists are Accountants.

(14) All circles are geometrical Figures.
All Triangles are geometrical figures.
Therefore all circles are Triangles.

(15) The end of life is perfection of life.
Death is the end of life.
Therefore death is perfect of life.

(16) No Europeans are black.
Some Europeans are not short.
Therefore some black people are not short.

(17) All Indians are generous.
All rich people are not Generous.
Therefore all rich people are Indians.

(18) All Philosophers are wise.
No ordinary men are Philosophers.
Therefore No ordinary men are wise.

(19) All fishes are marine animals.
All fishes swim.
Therefore all those which swim are marine animals.

(20) Some oranges are sour.
Some ornages are not ripe.
Therefore No ripe things are sour.

(21) Some reporters give correct news.
All reporters are impartial.
No impartial persons give correct news.
Therefore some reporters are not impartial.

(22) All cats are wild.
No dogs are wild.
Hence all cats are dogs.

(23) All games are interesting.
Some games are not enjoyable.
Therefore some enjoyable things are not interesting.

(24) Some games are not Interesting.
Some games are challenging.
Therefore No challenging things are interesting.

(25) All men are rational.
No Idiot is rational.
Some animals are rational.
Therefore some men are animals.

(26) All hardworkers are paid.

Some employees are not paid.

Therefore no employees are hardworkers.

(27) No Indians are Americans.

No Americans are Russians.

Therefore No Indians are Russians.

(28) All Indians are brain workers.

Some Indians are not software engineers.

Therefore All software engineers are brain workers.

(29) No illiterates are graduates.

Some graduates are not teachers.

Therefore some teachers are not illiterates.

(30) All men are rational beings.

All rational beings are mortal.

All mortals have life.

Therefore all men have life.

❖ ❖ ❖

6 Grounds of Induction

DO YOU KNOW THAT ....

- There is a difference between perception and observation.
- Observation needs training.
- Science involves experiments that can be repeated by others.

Introduction

The aim of the scientific investigation is to understand the nature of the universe. When a scientist observes nature, certain facts are clear to him; whereas certain facts are not. They explain these problems by discovering different laws and establishing theories. Laws in science are established by induction, which proceed from observed to unobserved, known to unknown, where the evidence is about some cases but the conclusion is about all cases, such **a leap from 'some to all' is called as an Inductive Leap** which makes the conclusion of an argument probable. Hence there is a need to justify Inductive Leap.

Inductive leap is justified on two grounds, namely, formal grounds of induction and material ground of induction

(a) Formal Grounds of induction

Principle of uniformity of nature and Principle of Causation are called 'Formal grounds of Induction'.

(i) The principle of uniformity of nature :

It states that there is an order in nature. Whatever happens once will always happen again under similar circumstances. So on the basis of this principle; it is justified in arguing that what is true of some case of a kind is true of all the cases of that kind.

(ii) The principle of causation

It states that some events in nature are causally connected and causal relation is invariable i.e. the same cause always leads to the same effect.

Thus on the basis of these two principles, the Inductive Leap is justified.

(b) Material Grounds of induction :

The aim of induction in science is to arrive at laws or theories on the basis of particular facts. Science aims at establishing the material or empirical truth of laws. For this, formal ground is not enough. Material truth of empirical laws is established by the methods of observation and experiment. Therefore these methods are called material grounds of induction. They provide the initial data to scientist for enquiry.

6.1 Observation

The word observation is derived from two Greek words, **'Ob' means 'before' and 'server' means 'To keep'.** So observation literally means 'keeping something before the mind'.

One gets knowledge of the world around us through the five sense organs. Whenever one looks around one notices many objects and their qualities. This is perception. **Perception is to become aware of objects and events that happen to come to our notice.** There is no definite purpose in perception and it is not deliberately chosen. So perception differs from observation due to these characteristics.

For example : when one passes by a corridor besides a chemistry laboratory, one becomes aware of some smells; one listens and hears sounds of various kinds. But this is not observation. It is mere perception.

Observation is defined as selective perception of facts with a certain purpose.

So every observations is perception but every perception is not observation unlike perception observation is purposive and selective.

6.2 Difference between observation and Perception :

Observation	Perception
(1) It has a definite purpose.	(1) It is without any definite purpose.
(2) It involves selection of facts.	(2) There is no selection of facts.
(3) Everything that is observed is Perceived.	(3) Everything that is perceived is not observed

6.3 Characteristics of observation :

Observation is done by common man as well as scientist but the scientific observation is systematic. It is the foundation of scientific investigation.

Following are the characteristics of observation.

(1) Observation is purposive :

When the scientist proceeds to observe nature he does so with a definite purpose. The main purpose is to collect data or facts, on the basis of which one can either prove or disprove a theory.

Thus it is purposive. e.g. Discovery of Neptune.

(2) Observation is selection of significant facts :

Observation is selective. Selection of facts is determined by the observer's purpose. From the countless facts in the world, scientists select to observe only those facts which are relevant to the problem under study. He observes only those significant facts that would help him to either establish or reject the suggested hypothesis.

(3) Observation is selection of a significant aspect of fact :

Facts are vast and complex. There are many aspects to facts. It is neither necessary nor possible to observe all the aspects of facts. The observer therefore focuses attention only on the significant aspects of a fact, which are relevant to the hypothesis under consideration.

For example : When a doctor visits his patient he observes his blood pressure, temperature, heart beats etc., as they are significant aspects for patient's health. Whereas a friend or a relative of the patient equally concerned about him may not observe these aspects. So though the fact (the patient) observed is the same, the aspect of facts considered significant can differ with each observer.

(4) The observer has to neglect the illusory aspects of a fact :

Our sense organs are means of observing facts. Sometimes our senses can deceive us and we may experience illusions.

For example : A stick looks bent when a part of it is immersed in water. This experience is an illusory aspect of fact and one should overlook it as a matter of optical illusion which is due to the refraction of sun rays. This needs to be neglected during observation.

(5) Use of instruments in observation :

Observation depends on one's sense organs. But the capacity of the sense organs is limited, so various instruments are used in science to extend the limits of sense organs.

For example : Telescope, Microscope, Sonography, X-ray etc.

6.4 Conditions of good observation :

Good observation is important in scientific investigation. Erroneous or bad observation can lead to wrong conclusion in science. It is therefore necessary to know the conditions of good observation which are as follows:

(1) Mental set and intellectual condition :

The observer should have inquisitiveness and craving for knowledge. Scientist should be mentally alert, attentive, active, free from prejudices, scientist must possess intellectual abilities to understand, explore and explain natural phenomena. To avoid bias and prejudices, the observer should observe all the facts and record them, whether they appear to be important or not. Test of 'public verifiability' and 'general consensibility' are another way of avoiding bias and partial observation. This means the observational record of one scientist is checked and verified by other scientists or one can make some more observations.

The scientist should also have openness and patience to wait for favourable conditions to occur under which observation is possible.

(2) Limitation of sense organs and instruments :

If the sense organs are defective, one cannot observe correctly. The conclusions derived on the basis of such observation will not be reliable. So the sense organs should be healthy.

Sense organs have limited range of perception. ***For example :*** One cannot perceive an object very clearly, if it is too far such as planets or too minute particle like bacteria in water. In such cases use of powerful scientific instruments becomes necessary and valuable.

Even the powerful instruments used in science have certain limitations. Therefore while doing observation scientist should consider the limitations of both sense organs as well as instruments.

(3) External conditions :

The scientist should take into account all possible external conditions under which observation is done. The external conditions or the environment can affect the observation of the fact.

For example : During winter season, due to excess fog, one may not be able to see the road

The observation is accurate, if the observer is aware of the external conditions and is able to assess their influence on the observation.

(4) Training in the techniques of observation :

Accurate or good observation is a necessary condition of scientific inquiry. For scientific observation, training in the techniques of observation is necessary.

Training helps scientists in following ways :

(a) It helps the observer to know what to observe, when to observe, where to observe and how to observe.

(b) It also helps them in deciding, when, how and which scientific instruments are to be used.

6.5 Fallacies of observation :

Correct and precise observation is the key to success in scientific investigation. If conditions of good observation are not satisfied it can result in erroneous or fallacious observation.

Fallacies of observation

↓

- Non observation
  - Neglect of instance
  - Neglect of operative conditions
- Mal observation

There are two types of fallacies that occur in observation.

(A) Fallacies of Non- observation :

Fallacy of non-observation arises when an observer overlooks or ignores the relevant facts or circumstances, which should have been observed.

There are two ways in which this fallacy may occur.

(1) Fallacy of Non observation due to the neglect of instances :

Neglect of instances is a fallacy in which either knowingly or unknowingly the observer, overlooks the relevant instances for investigation. Neglect of instances can take place due to various reasons :

(i) Due to unfavorable physical conditions. ***For example :*** Non-observation of Sun during solar eclipse.

(ii) Due to narrow range of experience. ***For example :*** Human beings cannot hear sounds below the range of about 20 Hertz, which the bats can hear.

(iii) Due to biased attitude.

For example : It is human tendency to consider and give importance to those facts which are in favour and ignore those which are unfavourable.

(2) Fallacy of Non observation due to neglect of operative Conditions :

This fallacy consists in neglecting essential and relevant circumstances and conditions responsible for the occurrence of a phenomenon. Instead of the real cause some other conditions are considered as the cause of a particular effect.

For example : Digby's sympathetic powder :-

In the 17th Century, Digby's sympathetic powder attracted great attention. When a person was wounded, the instructions were, 'to keep the wound clean and to rub the powder to a knife or a sword'. It was found that the wound was cured. This made people believe that, 'applying the powder to a knife or sword', was the cause of curing the wounds. But the real cause was 'keeping the wound clean', which was neglected.

(B) Fallacy of Mal-Observation :

Fallacy of Mal-observation consists in interpreting sense impressions wrongly. In such cases of observation, an object is observed as something else. This is the fallacy of misinterpretation. In short **it is the fallacy of mistaking one thing for another thing.**

For example : Mistaking a rope as a snake.

Mal-observation arises due to following reasons:

(a) Unfavorable physical conditions :

For example :

(1) Perception of a mirage in a desert, where one interprets sand as water.

(b) Observer's lack of experience :

If the observer is not experienced, he may wrongly interpret the sense impression.

For example :

(1) A baby plays with one's own image in the mirror, thinking that .there is another baby, and a baby cannot distinguish between person and the image due to lack of experience.

(c) The peculiar mental state of the observer:

A peculiar mental state of the observer may result in wrong interpretation of the sense impression.

For example : After watching a horror movie, the person waking up in the middle of the night may misinterpret white shirt hanging in the room as a ghost due to fear.

6.6 Experiment :

Experiment is also a material ground of Induction. **Experiment is defined as 'observation under conditions controlled by the investigator'.**

In observation, the facts are observed under natural conditions. The facts can be observed just once because we have no control over natural conditions. Hence the investigator prefers to observe those facts, which are under his control.

Observation gives us information, but it may not be always adequate or sufficient to study the phenomenon thoroughly, so scientists perform experiments.

Experiment is keen, careful, systematic observation made under conditions artificially created and controlled by the investigator.

6.7 Nature of Experiment :

Experiment is conducted with a definite purpose. The purpose of any experiment is to find out the effect of one factor on another factor.

A variable is a factor that can change.

There are three kinds of variables :

(i) Independent variable.

(ii) Dependent variable.

(iii) Relevant / Controlled variable.

(i) Independent variable :

Independent variable is that factor whose effect the experimenter wishes to study. Hence by keeping the other conditions or factors constant, only independent variable is varied. (increased decreased or withdrawn) and then its effect is studied.

For example : If one is trying to determine which type of laundry soap removes the most dirt, one would test a variety of different kinds of soaps. The type of soap would be the Independent variable and one would change it each time when one conducts an experiment.

(ii) Dependent variable :

The effect of independent variable is called dependent variable. Thus it is a variable which gets affected by the independent variable.

For example : when one tests each type of laundry soap, one will measure, how much dirt is left. The amount of dirt remaining each time when one does the experiment, would be the dependent variables.

(iii) Relevant or Controlled variable :

The experimenter keeps the relevant or controlled variable constant. **Relevant or controlled variable is one which has a capacity to influence the dependent variable.** It can affect the outcome of the experiment.

For example : Apart from the type of soap, there are other relevant variables which can influence the removal of dirt from the clothes. Unless these variables are controlled, the result will not be accurate. Hence the experimenter has to keep all the relevant or controlled variables constant such as the amount of water, water temperature, the time spent in washing, the amount of soap, the amount of dirt on clothes etc., and see the effect of independent variable (Type of soap) on dependent variable. (Removing of maximum dirt from the clothes)

6.8 Characteristics of Experiment :

(1) Experiment is a deliberately undertaken :

Experiment is deliberately conducted either to collect data or to explore a relationship, or to test a hypothesis.

(2) Experiment involves setting up an artificial situation :

If the scientist wants to observe different aspects of the phenomenon carefully, he cannot do so in the natural setting because the phenomenon is surrounded by many circumstances which are complex and are accompanied by many conditions some of which are irrelevent and obstructing.

So the experimenter creates an artifical sitiuation where he can find out the effect of one factor at a time by keeping other relvant factors constant.

For example : A coin is observed to fall faster than feather in air. But to prove that the weight of object has no relation with the acceleration with which the object falls to the ground, the scientist had to set up an artificial condition. i.e. he eliminated 'air' which is an irrelevant and obstructing condition and a vaccum was created, then the coin and feather was found to fall with equal acceleration in vaccum.

(3) Experiment involves systematic variation of conditions :

When scientists conduct an experiment they wish to find out the effect of one factor at a time. Hence there is a need to conrol all other relevant factors except the factor whose effect one wants to study. This factor is then increased or decreased to determine it's exact influence.

(4) Experiment can be repeated :

The experimenter can repeat the experiment, because the experimenter has control over the conditions this is an important characterstic of experiment. The experiment can be repeated by any one, any place & at any time to confirm the result of the experiment.

Distinction between Observation and Experiment

	Observation		Experiment
(1)	Observation is defined as selective perception of fact with a definite purpose.	(1)	Experiment is defined as observation under conditions controlled by the investigator.
(2)	Observation is natural as events are observed only in natural setting as they occur in nature.	(2)	Experiment is artificial as it is done in an artificial settings where the conditions are pre-determine, pre-arranged and controlled by the investigator.
(3)	In observation, the observer is the slave of nature because he can observe events only when they occur in nature.	(3)	In experiment, experimenter is the master of his experiment as he can bring changes according to his will and convenience.
(4)	In observation, the observer goes from both cause to effect and also from effect to cause.	(4)	In experiment the investigator goes only from cause to effect.
(5)	Scope of observation is wider than experiment because it can be done in all fields. Secondly observation is needed before conducting the experiment, during the experiment and also after the experiment to confirm the result of experiment.	(5)	Scope of experiment is narrower than observation because sometimes it is not possible to conduct experiment.
(6)	Observation cannot be repeated as the same phenomenon does not occur again in the nature.	(6)	Experiment can be repeated to confirm the results. It can be conducted any time, any place as per the convenience of the experimenter.
(7)	In observation scientist's personal bias, belief's etc., can affect the observation therefore observation is said to be subjective.	(7)	In experiment there is a little scope for experimenter's biasness, beliefs etc., it is said to be objective in nature.

Summary

Scientist uses inductive arguments to establish generalizations (laws) as well as theories. Inductive arguments involve inductive leap which is justified by the principle of uniformity of nature and the principle of causation which are called ‘formal grounds of induction’.

Science aims at establishing the material truth of a generalization or law which is assured by material grounds. An observation and experiment are means of collecting facts in science, they are called ‘material grounds of Induction’.

Observation is different from the perception of object. Perception means becoming aware of objects which happens to come to our notice. Perception is not selective and it is not grounded by any purpose. **Observation** on the other hand is, **‘Selective perception of facts with a certain purpose’.**

Characteristics of observation :

(1) Observation is purposive.

(2) Observation is selection of significant facts.

(3) Observation is selection of a significant aspects of fact.

(4) Observation is to neglect the illusory aspects of a fact.

(5) Use of instruments in observation.

Conditions of good observation :

(1) Mental set and Intellectual condition.

(2) Limitation of sense organs and instruments.

(3) External conditions.

(4) Training in the techniques of observation.

Fallacies of observation

They are of 2 types :

(1) Fallacy of Non-observation –

(a) Neglect of instance

(b) Neglect of operative conditions

(2) Fallacy of Mal -Observation

Experiment :

Experiment is keen, careful, systematic observation made under conditions artificially created and controlled by the investigator.

Characteristics of Experiment :

(1) Experiment is deliberately undertaken.

(2) Experiment involves setting up of an artificial situation.

(3) Experiment involves systematic variation of conditions.

Exercises

Q. 1. Fill in the blanks with suitable words from those given in the brackets :

(1) Observation and experiment are the ………. grounds of induction.

(Formal, Material)

(2) In ………., we perceive the things with a definite purpose.

(Observation, perception)

(3) Observation is ………. to facts.

(Faithful, Unfaithful)

(4) The fallacy of ………. consists of misinterpretation of facts.

(Mal observation, Non- Observation)

(5) The method of ………. is said to be used when facts are studied in natural conditions.

(Observation, Experiment)

(6) ………. means becoming aware of objects which happens to come our notice.

(Observation, Perception)

(7) Observation should be ………..

(Bias, Impartial)

(8) Neglect of operative conditions gives rise to the fallacy of ………. .

(Non-observation, Mal-observation)

(9) Illusions give rise to the fallacy of ………..

(Non-observation, Mal-Observation)

(10) Experiment involves setting up of ………. condition.

(Natural, artificial)

(11) In ………., phenomenon is deliberately produced.

(Experiment, Observation)

(12) Observation is done under ………. settings.

(Natural, Artificial)

(13) In non-observation, the operative conditions are neglected due to ………..

(Fear, Bias)

(14) In ………., the object is present before the observer, yet he observes it wrongly.

(Illusion, Neglect of relevant instances)

(15) ………. means observation with alteration of conditions.

(Perception, Experiment)

(16) ………. can be repeated.

(Observation, Experiment)

(17) In ………., the observer is the slave of nature.

(Observation, Experiment)

(18) In ……….,, we go from both, ‘ Cause to effect ’ and ‘Effect to cause’.

(Observation, Experiment)

(19) ………. is a factor whose effect the experimenter wishes to determine.

(Dependent variable, Independent variable)

(20) 'Mirage in a desert' is an example of ………. .

(Mal-observation, Non-observation)

(21) ………. gives more precise and accurate results.

(Experiment, Observation)

(22) In experiment, the conditions are ………..

(Controlled, Invariable)

(23) ………. is purposive.

(Perception, Observation)

(24) ………. involves selection of significant facts.

(Perception, Observation)

(25) When we neglect relevant facts, we commit the fallacy of ………. .

(Non-observation, Mal-Observation)

(26) ………. is justified by formal and material grounds of Induction.

(Deductive leap, Inductive leap)

(27) The principle of causation and the principle of uniformity of nature are ………. grounds of induction.

(Formal, Material)

Q. 2. State whether the following statements are true or false.

(1) Observation is not purposive.

(2) Perception is purposive.

(3) The fallacy of non-observation consists in neglecting or overlooking relevant facts.

(4) The fallacy of non-observation of instances is committed when the relevant circumstances are neglected.

(5) When we neglect the essential conditions responsible for particular phenomenon we commit the fallacy of non-observation of circumstances.

(6) The fallacy of mal-observation consists in neglecting the relevant instances.

(7) When the phenomenon is misinterpreted, it is called the fallacy of mal-observation.

(8) There is no observation in experiment.

(9) In observation, the investigator has control over the phenomenon.

(10) In experiment, the experiments has control over the phenomenon.

(11) In experiment, variation of factors is possible.

(12) In observation, the investigator can isolate the factors.

(13) There are certain areas in which the experiments are morally undesirable.

(14) Observation is artificial while experiment is natural.

(15) The good observer should be impartial and unbiased.

(16) The use of scientific instruments improve the quality of observation.

(17) Repetition is an advantage of experiment.

(18) Observation always comes prior to experiment.

(19) In experiment, we can proceed from effect to cause.

(20) Causation is a formal ground of induction.

(21) Experiment is a formal ground of induction.

Q. 3. Match the columns :

	(A)	(B)
(1)	Mal-observation	(a) Misinterpretation of sense data
(2)	Non observation	(b) Neglecting relevant facts
(3)	Observation & Experiment	(c) Formal Grounds of induction
(4)	The principle of causation	(d) Material Grounds of induction

Q. 4. Give logical terms for the following.

(1) Perception with a definite purpose.

(2) The fallacy of observation in which one neglects or ignores relevant facts.

(3) The fallacy of observation in which one misinterprets sense impressions.

(4) Observation under conditions controlled by the investigator.

Q. 5. Answer in brief.

(1) Differentiate between Observation and Perception.

(2) What are the conditions of good observation?

(3) Explain the fallacy of Non-observation.

(4) Explain the fallacy of Mal-observation.

(5) What are the characteristics of experiment?

Q. 6. Answer the following.

(1) What is observation? Explain characteristics of observation.

(2) What is experiment? Explain nature of experiment.

(4) Explain the differences between observation and experiment.

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7 Hypothesis

7.1 Introduction

In scientific method, one of the important step is **formulation of a hypothesis** when scientists are faced with a situation or a problem which they are not able to understand and explain then the scientific inquiry begins.

Scientific investigation may be either in the field of natural sciences like physics, chemistry or social sciences like Sociology, Anthropology etc., when scientist observe nature they come across certain facts, events or situations which they are not able to explain. These are problems faced by scientist. Feeling of a problem is the starting point of scientific investigation. Next important step is to formulate a hypothesis. **Unless a hypothesis is formed scientific investigation cannot proceed further. Thus, hypothesis gives a direction to scientific investigation and is an important step in scientific investigation.**

It is therefore necessary to know what hypothesis is and how it is established in science.

7.2 Definition and Nature of hypothesis

Scientist's investigation begins with the formation of hypothesis. The word hypothesis is derived from the Greek word **'hypo'** which means **'under'** and **'thithenai'** means **'to place'**.

Coffey defines hypothesis as "An attempt at explanation, a provisional supposition made in order to explain scientifically some facts or phenomenon."

In simple words **hypothesis is defined as a tentative solution given to the problem.**
For e.g - Since childhood, Edward Jenner had heard that in spite of getting cow pox blisters on their hands, milkmaids did not develop small pox. To explain this situation, he formulated a hypothesis that 'the pus in the blisters might have protected the milkmaids from small pox.' This was a provisional supposition. **Thus hypothesis is a guess work as to how facts are connected.**

7.3 Characteristics of Hypothesis

(1) It is an important stage in scientific investigation :

Every scientific investigation starts with the problem for which scientist intends to find solution. He begins by assuming a possible explanation on the basis of which he starts investigation. **Hypothesis is like guiding post** which gives direction to scientific investigation. No scientific investigation is possible without hypothesis. Unless a hypothesis is formed scientists would not know what facts to observe and what experiments to conduct in order to find the solution to the problem.

For example : Discovery of Neptune.

Astronomers had calculated the orbit of planet Uranus, on the basis of the gravitational pull of then known planets. But, in 1820, scientists Bouvard observed that there was a deviation in this calculated orbit. Astronomers **advanced the hypothesis that there is a planet beyond Uranus** which is disturbing the gravitational force of Uranus.

The great Berlin telescope was turned towards that direction and they found the planet. This planet was named Neptune. Hence the hypothesis was verified to be true.

(2) Attempts at explanation

Hypothesis is an attempt at explaining observed facts which scientist are unable to explain. Hypothesis does not explain the fact unless it is verified to be true. On the basis of this possible explanation the investigator proceeds to collect data through observation and may use the experiment to verify it. Once the hypothesis is verified it becomes the explanation of the problem.

(3) Provisional :

Every hypothesis is always provisional in character. It is suggested as a likely solution. It is merely a tentative supposition or suggestion or simply a claim to explain the fact. It may turn out to be a right explanation or may turn out to be a wrong one. There is no finality about the solution provided by it.

(4) It is an organising principle -

The aim of science is to understand and explain facts. This is done by introducing order in facts.

In fact there is an order in nature but this order cannot be perceived the way in which one can perceive facts. One has to find out this order. This is what science attempts to do. At initial stage of scientific inquiry one fails to understand the connection between innumerable facts and events in nature. Facts appear to be scattered, isolated and unrelated to each other. But once the hypothesis is verified to be true, the order among the facts is revealed. Therefore, **it is an organising principle.**

For example : Before Newton discovered the theory of gravitation, there appeared to be no connection between facts like - freely falling objects, movements of planets, phenomena of tides. His theory of gravitation revealed the connection between these apparently unrelated facts and showed that they were all due to gravitation.

(5) Result of rational activity :

In order to solve the problem, hypothesis is suggested but no problem can be solved without rational thinking. **So, hypothesis is said to be the result of rational activity.**

(6) Result of keen and creative imagination -

Every hypothesis originates out of a problematic situation. However, to perceive and solve the problem is not easy. Hypothesis is the result of the scientist's keen and creative imagination.

For example : In the year 1795, Nicolas Appert observed that Napoleon Bonapart regularly shipped food for his military. But the food would spoil by the time it reached its destination. Nicolas wondered about the why and how of this event. A thought came to his mind that if the food is boiled and sealed in a glass jar with a cork then it may not get spoilt. He conducted an experiment to test this hypothesis and found that the food did not get spoilt, as the germs in the food were killed by boiling the food and also outside germs could not enter the food as the glass jar was sealed with the cork.

Inventor of the food preservation process (Canning)

This hypothesis which resulted from Nicolas Appert's creative imagination lead to the invention of canned food.

7.4 Origin / suggestion of hypothesis :

Hypothesis is a tentative supposition that is formulated in order to solve the problem and to explain the related fact and phenomena. However, there are no rules that guide how to formulate a hypothesis. Study of various discoveries by scientist give us clues as to how hypotheses are suggested to scientist. Following are some important factors which may suggest hypothesis to scientist.

(1) Keen and creative imagination :

Investigators creative imagination is the mother at all inventions / discoveries. Every hypothesis has its source in imaginative mind of the scientist. This is the reason why common person cannot suggest a good hypothesis.

For example : Every farmer must have observed apples falling on the ground but it was Newton's creative imagination which led to the discovery of the theory of gravitation.

(2) Painstaking work :

Though keen imagination is the most important factor of thinking of hypothesis, along with it, painstaking work of scientist is also important. Without hardwork only with keen imagination rarely any discovery can take place in science. Scientist may have to work for months and years together to find a solution to the problem.

For example : Kepler is said to have considered nineteen wrong hypothesises before he hit upon the right hypothesis that "planets revolve in elliptical orbits".

(3) Adequate and wide knowledge :

It means that investigation and painstaking work must be backed by adequate knowledge of the subject in which the investigation is being done.

For example : Diseases of silk worms

Louis Pasteur was the only scientist in France, who could cure the disease of the silk worm, as he had adequate knowledge of diseases in general, though he had no knowledge of silk worms.

(4) Insight :

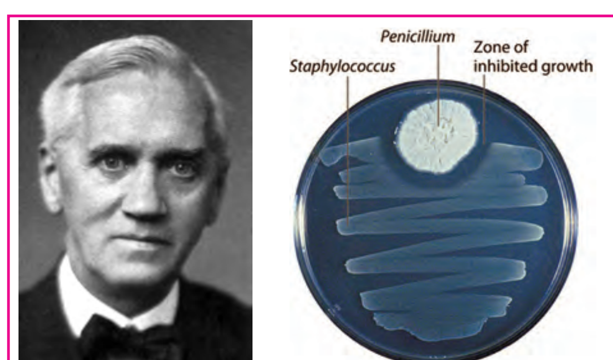
Scientist work hard to solve the problem but it may not always give a solution to the problem. Sometimes the right solution comes as a sudden flash of lightening called as insight.

For example : when Archemedes jumped into the tub containing water and observed that water was thus thrown out of the tub, he got the solution to his problem. He then framed a hypothesis that 'when a body is partially immersed in water, it loses weight and the loss of the weight of the body is equal to the water thrown out of the tub.' This hypothesis struck his mind as a sudden flash of insight.

(5) Chance / Accident :

Chance too plays its part in suggesting a fruitful hypothesis. Some of the great discoveries take place due to the chance observations. However, great discoveries are never accidental. The so called accident is merely a chance observation which a scientist is able to use due to his specialised knowledge and creative imagination.

For example : the discovery of penicillin by Alexander Fleming was the outcome of chance observation. In September 1928, before proceeding on week's vacation Alexander Fleming had started some germ cultures. On his return, he examined these cultures. He picked up one dish from the window ledge, and found that the culture had been spoiled. There were other bacterias in it. As he was about to throw it away he observed that, around a small patch of mould, there were no germs. **This suggested to his mind the hypothesis that the mould was giving out some substance which was preventing germs from growing in its neighbourhood.** That led to the discovery of penicillin.



Alexander Fleming could take advantage of the "chance" observation, because he had specialized knowledge about Lysozyme. (Lysozyme is a natural property by which germs are destroyed). Sir Alexander Fleming used to demonstrate that tears from the eye possess the property of lysozyme. He would, take in a test tube, a solution containing germs. Then he would take a tear from the eye and drop it in to the solution. Suddenly the solution would become clear. The germs were destroyed.

Alexander Fleming could understand why there were no germs around the mould, because he was familiar with lysozyme. So we see that a chance observation merely provides an opportunity of coming across the phenomenon. But a trained mind is required to understand the significance of the unexpected occurance.

(6) Induction per simple enumeration and Analogy -

These are common mans methods of arriving at conclusion. Sometimes these conclusions may suggest hypothesis to scientist.

When a generalization is supported by positive instances and no contrary instance has been observed, the method of simple enumeration is said to be used.

An analogy is an inference in which the conclusion is drawn on the basis of observed resemblances.

For example : Conclusion of Lowells's analogy of Earth and Mars, that there is life on Mars has become a hypothesis in science.

7.5 Conditions of good hypothesis :

Hypothesis is a guess work and need to be tested or verified only then it is accepted. But verifying each and every hypothesis becomes a laborous, time consuming and complicated process.

Hence, scientists do not verify each and every hypothesis. They select few hypotheses for further verification. **These selected few hypotheses are not true solution to the problem but they are the ones which the scientist think worth considering.**

Such worth considering hypothesis is called a good hypothesis and such good hypothesis are said to have scientific value. A hypothesis is considered to be good if it satisfies certain conditions as follows ...

(1) Relevance :

A hypothesis must be relevant. The function of hypothesis is to explain the facts which have become a problem. It can serve this purpose only if the hypothesis is relevant to the problem.

A relevant hypothesis is one from which the facts to be explained can be deduced as a logical consequences. As per this definition when the hypothesis is proposed, one may not know whether it is relevant. Scientist may have to observe more facts to determine whether it is relevant. Therefore, the condition of relevance only means that in the light of specialised knowledge, the scientist genuinely believes that the hypothesis is relevant.

For example : Hypothesis suggested by followers of Galen is a good example of irrelevant hypothesis. Galen theory suggested that human thigh bones are curved. Later Vasalius proved that human thigh bones are straight. He did this by dissecting human bodies which was not allowed at the time of Galen. One of the Galen's follower however could not accept this theory. So he suggested a hypothesis that, in natural conditions the bones are curved and the narrow trousers worn in those days were responsible for straightness of bones. It is very obvious that this hypothesis is irrelevant. These type of trousers have nothing to do with shape of bones.

(2) Hypothesis must be self-consistent :

Hypothesis must not be inconsistent. There must be no contradiction among its differnt elements.

For example, the hypothesis of "living ghost" or that of "weightless matter" is inconsistent.

(3) Hypothesis must be testable :

According to Irving Copi, the important condition of good hypothsis is testability or verifiability. One of the important conditions of scientific hypothesis. In order to confirm a hypothesis, it has to be verified.

For example : A hypothesis related to ghost, evil etc. are now regarded as unscientific. They are not empirically verifiable. Thus a good hypothesis is said to be testable or verifiable. Hypothesis is verifiable means it is capable of being shown to be either true or false.

Verification is a process by which a hypothesis is confirmed. However there is no time limit within which a hypothesis is verified. So hypothesis should be verifiable in principle.

For example : the ultimate destruction of life on Earth is a good hypothesis, it cannot be verified today. But it is verifiable in principle.

(4) Hypothesis must be compatible with pre-established knowledge :

The goal of science is to establish a deductive system. One of the conditions of a system is consistency i.e. all laws included in a system must be compatible with one another.

If a new hypothesis is not compatible with established laws then it's chances of being true are very less. It is therefore said that a good hypothesis is one which is compatible with previously established laws. However sometimes it is also possible that the new hypothesis which is inconsistent with established laws turns out to be correct in that case the previously established law turns out to be incorrect.

For example : The Copernicus system overthrew the Ptolemic system, even though the Ptolemic system was well established.

(5) Hypothesis must have explanatory power :

A good hypothesis is not only capable of explaining those facts for which it is proposed but also can explain some more facts.

For example : Newton's law of Gravitation not only explained the falling of an apple to the ground but also the planatory motions and phenomenon of tides.

(6) Hypothesis must have predictive power :

If the researcher deduces more consequences from the hypothesis, then it is said that the hypothesis has greater predictive power. From this predictive power it becomes clear that a given hypothesis is not a scientists fancy of mind and is based on facts.

(7) Hypothesis must be simple :

Scientist prefer the simpler of the rival hypothesises but they define simplicity in different ways. According to one view, **a simpler hypotheses is one which makes the minimum number of independent assumptions.** It explains facts without being vague, obscure, ambiguous and complex ideas. Sometimes, it so happens that the researcher has to choose from the rival hypothesis. In such a situation, he chooses the hypothesis on the basis of its simplicity.

Historically, the most important pair of such hypothesis were those of Ptolemy and Copernicus. Ptolemy put forth a theory that the earth is in the centre and the Sun and other planets revolve round the earth. On the other hand, Copernicus put forth a hypothesis that the Sun is in the centre and the earth and other planets revolve round the Sun. Both the hypotheses were equally good. The Copernican hypothesis was simpler than Ptolemic hypothesis and it was accepted, as it hardly made any number of independent assumptions

7.6 Verification of hypothesis -

A hypothesis is a tentative solution. When a hypothesis is formulated and known to be good, next step in scientific investigation is its verification.

Verification of a hypothesis consists in finding out whether it agrees with facts. If it agrees with the facts, it is confirmed. If it does not agree with facts, it may be rejected or modified.

Kinds of Verification :

There are two ways of verifying a hypothesis. These are Direct Verification and Indirect Verification. **Hypotheses that are verified directly are termed as empirical hypotheses or instantial hypothesis and those which are verified indirectly are termed as theoretical or non-instantial hypotheses.**

(1) Direct Verification :

It consists in observing the facts to which the hypothesis refers. Here we are appealing to facts directly. **Direct Verification may be either by observation or by experimentation.**

$$H \longrightarrow F_1\ F_2\ F_3$$

When actual observation shows that things referred in a hypothesis are actually found existing then it is called direct verification by observation.

For example : Discovery of Neptune.

When hypothesis is verified by experiment in laboaratory, it is called direct verification by experimentation.

For example : While explaining the phenomenon that "Nitrogen from air was heavier than Nitrogen from other sources", Rayleigh's hypothesis that "there may be some unknown gas present in air" was verified directly by performing an experiment. An unknown gas was isolated from Nitrogen obtained in the air. This gas was named Argon. The presence of this gas confirmed the hypothesis. Hence the hypothesis was accepted as it could explain why Nitrogen from air was heavier than Nitrogen from other sources.

(2) Indirect verification :

Most of the scientific hypotheses cannot be verified directly. **Such hypotheses are called non-instantial hypothesis. They can be verified indirectly.**

Indirect verification consist in deducing the consequences from a hypothesis and testing those consequences by appeal to facts.

Thus, two steps are involved in indirect verification -

(A) Deductive development of hypothesis - Deductive development of hypothesis means by assuming hypothesis as true certain consequences are deduced from the hypothesis.

(B) To find out whether the anticipated or predicted consequences take place. If the predictions come true, the hypothesis is said to be indirectly verified.

In indirect verification, the consequences are tested either by observation or by experiment.

For example : Kon - Tiki Expedition

It was observed that there are certain similarities between the ancient customs of natives of South sea Islands and the inhabitants of South America, inspite of the distance between them. Some sociologists proposed the hypothesis that the natives of the South sea Islands came from South America.

This hypothesis cannot be verified directly so to verify it indirecly scientist deduced the consequences that, if it is true that the people travelled from South America to South sea island then they must have travelled by sea route using primitive kind of a boat.

This hypothesis was confirmed by conducting an experiment. Scientists undertook a trip in such a boat. The prevailing currents carried them to the destination. They arrived on the islands after a little over hundred days.

Limits of verification -

Verification shows that "C" is the cause of "E" but does not show that "C" is the only cause of "E". It shows that the hypothesis explains the observed fact quite well but does not show that it is the only explanation for the observed facts.

Most of the hypotheses are verified indirectly in science.

In direct verification there is hardly any doubt about truth of the hypotheses. But in indirect verification if hypothesis is accepted as true, our argument commits the fallacy of affirming the consequent as explained below :

If H is true then C_1, C_2, C_3 should take place

C_1, C_2, C_3 take place

$\therefore$ H is true

Indirect verification only shows that hypothesis may be true becuase it does not rule out the possibility that same consequences can take place due to some other reason, other than the hypothesis.

It is therefore necessary to prove the hypothesis. In proof of a hypothesis we attempt to show that the consequences can take place only due to the proposed hypothesis. The form of such an argument is as follows and it is not fallacious.

If and only if H, then C_1, C_2 , C_3 take place.

C_1, C_2, C_3 take place

$\therefore$ H

Thus proof of hypothesis consists in showing that no other hypothesis can explain the facts. In other words it is the only possible hypothesis which can explain the facts.

Kon - Tiki Museum Oslo

Summary :

Nature of hypothesis

A hypothesis is a tentative supposition put forward for explaining facts that cannot be understood without it.

Charcteristic of Hypothesis -

(1) It is an important stage in the scientific investigation.

(2) Attempts at explanation

(3) Provisional

(4) It is an organising principle

(5) Result of rational activity

(6) Result of keen and creative imagination

Origin of hypothesis

(1) Keen and creative imagination

(2) Painstaking work

(3) Adequate and wide knowledge

(4) Insight

(5) Chance

(6) Induction per simple enumeration and Analogy

Conditions of good hypothesis -

(1) Relevance

(2) Hypothesis must be self-consistent -

(3) Hypothesis must be testable -

(4) Hypothesis must be compatible with pre-established knowledge

(5) Hypothesis must have explanatory power

(6) Hypothesis must have predictive power

(7) Hypothesis must be simple

Verification of hypothesis

(1) Direct Verification

(2) Indirect Verification

Limits of verification

It shows that ‘C’ is the cause of ‘E’, but does not show that ‘C’ is the only cause of ‘E’.

Exercises

Q. 1. Fill in the blanks with suitable words from those given in the brackets :

(1) A guess or a supposition as to how facts are connected is called .... *(Hypothesis/ Law)*

(2) .... verification consists in confirming the deduced consequences. *(Direct / Indirect)*

(3) When a generalization is supported by positive instance and no contrary instance has been observed, the method of .... is said to be used. *(Simple Enumeration /Anology)*

(4) Hypothesis is a .... solution to the problem. *(tentative / permanant)*

(5) .... of hypothesis consists in finding out whether it agrees with facts. *(Verification / proof)*

Q. 2. State whether the following statements are true or false.

(1) A hypothesis must be inconsistent with the fundamental assumption.

(2) The hypothesis verified directly are called theoretical hypothesis.

(3) A hypothesis is said to be simpler when it makes minimum number of assumptions.

(4) Hypothesis is a tentative suggestion.

(5) Hypothesis is an important stage in scientific investigation.

Q. 3. Match the columns :

	(A)		(B)
(1)	Origin of hypothesis	(a)	indirectly verified
(2)	Conditions of good hypothesis	(b)	keen imagination
(3)	Analogy	(c)	Verifiability
(4)	Non-Instantial hypothesis	(d)	suggests a hypothesis to the scientist.

Q. 4. Give logical term for the following :

(1) A hypothesis from which the facts to be explained can be deduced as a logical consequence.

(2) Verification of hypothesis which consist of deducing consequence from the hypothesis and examining them.

(3) A tentative solution to the problem.

(4) A good power of reasoning where solution to a problem strike all of a sudden and unexpectedly.

(5) A hypothesis which makes minimum number of indenpendent assumptions.

Q. 5. Explain the following :

(1) Explain with an illustration, direct verification of hypothesis by observation.

(2) Explain with an illustration, direct verification of hypothesis by experiment.

(3) Explain Indirect verification of hypothesis with an example.

(4) Explain with an illustration characteristics of hypothesis.

Q. 6. Answer the following :

(1) Explain with an illustration the factors that can suggest a hypothesis to the scientist.

(2) Explain with an illustration origination of hypothesis.

(3) Explain Direct verification of hypothesis with examples.

(4) Explain with an illustration the conditions of good hypothesis.

Glossary

Singular Proposition : states that an individual possesses or does not possess a certain property / attribute (quality).

Affirmative singular proposition : states that an individual possesses a certain property.

Negative singular proposition : states that an individual does not posess a certain property.

General propositions : make an assertion about a class or a classes.

An Individual constant : is a symbol which stands for the name of an individual.

Predicate constant : is a symbol which stands for a particular property.

Individual variable : is a symbol which stands for any individual whatsoever.

A propositional function is defined as an expression which contains at least one free variable and becomes a proposition when the variable is replaced by a suitable constant.

Simple propositional function is one which does not contain propositional connectives.

Complex Propositional function propositional functions which contain propositional connectives are called complex propositional functions.

Free variable is one which falls beyond the scope of a quantifier. It is not preceded by an appropriate quantifier.

Bound variable is one which is preceded by an appropriate quantifier.

Instantiation is the process of obtaining singular proposition from a propositional function by substituting a constant for a variable.

The method of Quantification or Generalization is a process of obtaining a general proposition from a propositional function by placing a Universal or Existential quantifier before the propositional function.

The process of Universal Quantification consists in a obtaining a universal general proposition by placing a universal quantifier before the propositional function.

The process of Existential quantification consists in obtaining an existential general proposition by placing an existential quantifier before the propositional function.

Quantificational Deduction consists in deducing the conclusion of an argument from its premises with the help of certain rules.

Perception To become aware of objects and events that happens to come to our notice.

Observation selective perception of facts with a certain purpose.

Experiment observation under conditions controlled by the investigator.

The fallacy of non - observation is overlooking or ignoring relevant facts.

Negelct of instances Overlooking relevant instances, either unknowingly or due to the observer's bias.

Neglect of operative conditions considering the unessential, irrelevant conditions to be the cause of an effect.

Mal - observation wrong interpretation of sence impressions.

Term is word or group of words which stands as the subject or predicate of a logic proposition.

Anumana is that cognition which pre supposes some other cognition.

Pratijna : statement of the propositions to be proved in Nyaya syllogisim

Hetu statement of reasons in Nyaya syllogism.

Upanaya statement of the presence of mark.

Nigaman conclusion proved.

Vyapti knowlege of universal con comitance.

Conditional Proposition (Traditional logic) is one in which the assertion is made subject to some expressed condition.

Categorical Propostion is a proposition of relationship between two classes, class of subject term and class of predicate term.

Conversion is a process of immediate inference in which the subject term and predicate term are interchanged.

Obversion is a process of immediate inference in which the subject term remains the same but the predicate term in the conclusion is complementary to the original predicate term in the premise.

Paksha : The Minor term is Nyaya Syllogism.

Sadhya : The Major term is Nyaya Syllogism.

Ling : The Middle term is Nyay Syllogism.

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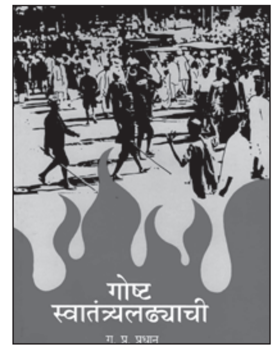

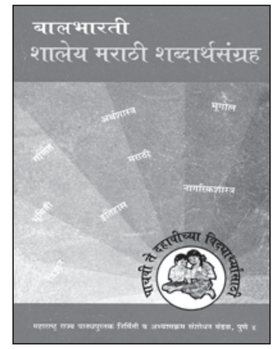

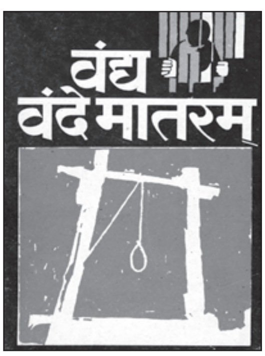

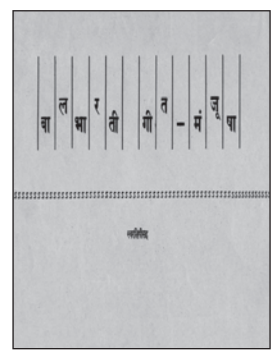

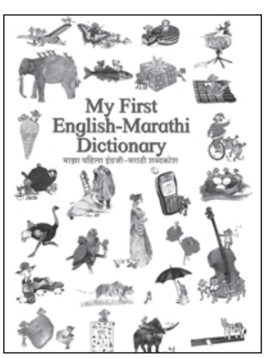

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