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(SERIES - I)



Class XI



CENTRAL BOARD OF SECONDARY EDUCATION

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INTRODUCTION TO SCIENTIFIC METHOD AND LOGICAL REASONING

Class XI

Editor : S.R. BHATT



**CENTRAL BOARD OF SECONDARY EDUCATION
PREET VIHAR, DELHI - 110092**

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Board of Contributors

S.R. Bhatt

Krishna Jain

Ashwani Kumar

Manju Pandit

Sneh Khosla

Anita Khosla

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 ² [unity and integrity of the Nation];

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

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

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, 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.

भारत का संविधान

उद्देशिका

हम, भारत के लोग, भारत को एक '[सम्पूर्ण प्रभुत्व-संपन्न समाजवादी पंथनिरपेक्ष लोकतंत्रात्मक गणराज्य] बनाने के लिए, तथा उसके समस्त नागरिकों को:

सामाजिक, आर्थिक और राजनैतिक न्याय,
विचार, अभिव्यक्ति, विश्वास, धर्म
और उपासना की स्वतंत्रता,
प्रतिष्ठा और अवसर की समता

प्राप्त कराने के लिए, तथा उन सब में, व्यक्ति की गरिमा और '[राष्ट्र की एकता और अखण्डता] सुनिश्चित करने वाली बंधुता बढ़ाने के लिए दृढ़संकल्प होकर अपनी इस संविधान सभा में आज तारीख 26 नवम्बर, 1949 ई० को एतद्वारा इस संविधान को अंगीकृत, अधिनियमित और आत्मार्पित करते हैं।

1. संविधान (बयालीसवां संशोधन) अधिनियम, 1976 की धारा 2 द्वारा (3.1.1977) से "प्रभुत्व-संपन्न लोकतंत्रात्मक गणराज्य" के स्थान पर प्रतिस्थापित।
2. संविधान (बयालीसवां संशोधन) अधिनियम, 1976 की धारा 2 द्वारा (3.1.1977 से), "राष्ट्र की एकता" के स्थान पर प्रतिस्थापित।

भाग 4 क मूल कर्तव्य

51 क. मूल कर्तव्य - भारत के प्रत्येक नागरिक का यह कर्तव्य होगा कि वह -

- (क) संविधान का पालन करे और उसके आदर्शों, संस्थाओं, राष्ट्रध्वज और राष्ट्रगान का आदर करे;
- (ख) स्वतंत्रता के लिए हमारे राष्ट्रीय आंदोलन को प्रेरित करने वाले उच्च आदर्शों को हृदय में संजोए रखे और उनका पालन करे;
- (ग) भारत की प्रभुता, एकता और अखंडता की रक्षा करे और उसे अक्षुण्ण रखे;
- (घ) देश की रक्षा करे और आह्वान किए जाने पर राष्ट्र की सेवा करे;
- (ङ) भारत के सभी लोगों में समरसता और समान भ्रातृत्व की भावना का निर्माण करे जो धर्म, भाषा और प्रदेश या वर्ग पर आधारित सभी भेदभाव से परे हों, ऐसी प्रथाओं का त्याग करे जो स्त्रियों के सम्मान के विरुद्ध हैं;
- (च) हमारी सामाजिक संस्कृति की गौरवशाली परंपरा का महत्त्व समझे और उसका परीक्षण करे;
- (छ) प्राकृतिक पर्यावरण की जिसके अंतर्गत वन, झील, नदी, और वन्य जीव हैं, रक्षा करे और उसका संवर्धन करे तथा प्राणिमात्र के प्रति दयाभाव रखे;
- (ज) वैज्ञानिक दृष्टिकोण, मानववाद और ज्ञानार्जन तथा सुधार की भावना का विकास करे;
- (झ) सार्वजनिक संपत्ति को सुरक्षित रखे और हिंसा से दूर रहे;
- (ञ) व्यक्तिगत और सामूहिक गतिविधियों के सभी क्षेत्रों में उत्कर्ष की ओर बढ़ने का सतत प्रयास करे जिससे राष्ट्र निरंतर बढ़ते हुए प्रयत्न और उपलब्धि की नई उंचाइयों को छू ले।

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Foreword

*P*hilosophy is a systematic reflection on our lived experiences with a view to be profited from it. This systematization consists in critical and regulated reasoning. For this purpose the science of logic has been evolved both in Indian and Western traditions. Of course, the capacity to reason is innate in a child but with proper education it can be refined. That is why study of logic has been prescribed. Since logic is foundational to critical thinking, its study forms a part of the syllabus for class XI. The present book has been prepared keeping that in view.

I express my heartfelt gratitude to Prof. S.R. Bhatt, Convener of the CBSE course committee in Philosophy for taking up the lead in developing the textbook and guiding his team members. My sincere thanks are due for Dr. Krishna Jain, Shri Ashwani Kumar, Dr. Manju Pandit, Dr. Sneha Khosala & Dr. Anita Khosala for writing different chapters for the book.

Ms Sugandh Sharma, Education Officer, CBSE deserves special mention for initiating the work and bringing out the textbook in present shape.

The Hindi version of the textbook will also be shortly brought out by the Board. The principals are requested to bring this book to the notice of concerned students and teachers.

VINEET JOSHI
CHAIRMAN

Preface

The present book is written in conformity with the Philosophy syllabus of class XI of Central Board of Secondary Education.

Science has influenced and affected our entire worldly life. It has made tremendous contributions to make life easy, smooth and comfortable. Its positive uses have proved to be boon and blessings. All scientific discoveries and achievements are based on methodical and planned enterprise which is known as scientific method. This method is based on inductive reasoning and discovery of causal connections regulating the cosmic processes. In this introductory book, basic elements of scientific method and inductive reasoning are worked out by the learned contributors in Part I.

Part II deals with logical reasoning. For a ratiocinative human mind the importance of Logic as a science and art of correct reasoning need not be stated. All of us carry out critical thinking and encounter arguments in our day-to-day experience. Of course a child learns critical thinking and valid reasoning naturally but a systematic cultivation of these processes is desirable. To construct sound arguments of one's own and to evaluate arguments of others are needed for a smooth and successful living. For this Logic is helpful. Among the benefits of study of logic is to acquire competence and thereby confidence in constructing and adducing our own arguments for any particular cause and also in evaluating arguments of others, in being mindful of the possible intrusion of fallacies and the deterrent methods to avoid them. Logic helps in every walk of life and in every domain of knowledge and action. It is particularly used in all intellectual activities.

To realize the benefits of Logic one must thoroughly understand the basic concepts and processes of correct reasoning and be able to apply them to concrete life situations. This requires a study of Logic and its central principles. To promote this objective this text presents a simple and foundational account of the different types of reasoning processes for a beginner. So it is intended to be a primer of elementary Logic.

The material is arranged here in keeping with the CBSE syllabus for class XI. By getting the feedback from the students and teachers it should be possible to revise it. If need be the syllabus can be revised and accordingly the text can be improved to make it more useful. It is hoped that this book will initiate the young minds in the study of the concerned subject.

The text deals with western and Indian modes of doing Logic in deductive and inductive patterns. There is scope for enlargement of Indian content which can be done later on. In Indian mode there is a definite ontological commitment, direct or indirect, but the process of formalization is undertaken in both Indian and western modes. Logic is a developing science and various new forms of Logic have come up. The science of Logic has undergone many developments and great advances. Their nature and scope have also changed considerably. It should be possible to incorporate them in subsequent editions of this text after suitable revision of the syllabus. At present only syllogistic, propositional (sentential), and predicate forms have been taken up in the western context. In Indian thought inductive mode of thinking has been given threadbare analysis and that may also be considered in detail when enlargement is undertaken.

The present work is a collective enterprise. It has been a pleasure for me to work with Dr. Krishna Jain, Shri Ashwani Kumar, Dr. Manju Pandit, Dr. Sneha Khosla and Dr. Anita Khosla for writing different chapters. All of them are seasoned teachers of Logic and Philosophy in Delhi University. On behalf of CBSE and on my own behalf I express our gratefulness to them for sparing their valuable time in spite of their busy schedule in their academic work. I wish to express my gratitude to Ms Sugandh Sharma, Education Officer of CBSE, for initiation to write and for encouragement and assistance. Without her motivation and kind support this text would not have seen the light of the day. Special thanks are due to Mr. Sanjay Sharma of Multigraphics for nice printing

S.R.Bhatt

Former Professor and Chair
Department of Philosophy,
Delhi University

Convenor of the Course
Committee in Philosophy,
CBSE

Unit 1

Methods of Natural and Social Sciences

What is science?

Science is a methodical approach to study the natural and social world. Science asks basic questions such as how does the world work? How did the world come into existence? What was the world in the past, what is it like now and what will it be in future? These questions are answered with the help of observation and experiments. The data received is analyzed and interpreted with the help of logic. Scientific knowledge is systematic, unified and organized. Science attempts to bring particular facts under general laws forming parts of a consistent whole. It collects as many facts as possible and then seeks to unify them by finding out their mutual relations and inter connections. Science employs special means and methods to render true and exact knowledge.

The task of a scientist is to discover facts but a haphazard collection of facts cannot be said to constitute a science. A geographer, for example, may be interested in describing the exact configuration of a particular coastline or a geologist in more precise nature of rock strata in a particular locality, but in more advance science basic descriptive knowledge of this or that particular fact is of little importance. The scientist is eager to search out more general truths, of which particular facts are instances and for which they constitute evidences. Isolated particular facts may be known by direct observation but the scientist seeks more than a mere record of phenomena. He seeks to formulate general laws which state the patterns of all such occurrences in a systematic way. A scientist is engaged in a search of the natural laws according to which all particular events occur. Particular facts challenge the scientist to unify and explain them by discovering their lawful connections, and plurality of general laws challenge the scientist to unify and explain them by discovering a still more general principle that subsumes the several laws as special cases. This can be made clear by the following examples:

The Italian Physicist - Galileo Galilei (1564- 1642) formulated the laws of falling bodies which gave a general description of the behavior of bodies near the surface of the earth.

The German Astronomer - J.Kepler (1571-1630) formulated the laws of planetary motion describing the elliptical orbits travelled by the planets around the sun. Their discoveries were great achievements but were still separate and isolated.

Sir Isaac Newton (1642-1727) unified and explained celestial mechanics (Kepler) and terrestrial mechanics (Galileo) by the theory of gravitation and gave three laws of motion. He showed that both are deducible within the framework of a single more fundamental theory of gravitation. Thus, the scientists do not merely want to know the facts but also want to explain them by devising theories. The theories incorporate the natural laws that govern events, and the principles that underlie them.

1. Practical value of science

Science may be said to have great value both as practical and theoretical pursuits. Modern science has changed almost every aspect of our lives although it has been in existence for only a few

hundred years. Improvements in farming, manufacturing, communication, transportation, health, hygiene and in our standards of living, are the direct results of practical application of the technology. Scientific progress in the understanding of the genetic make up of human beings promise new cures for terrible diseases. However, some of the practical results of science are not so cheerful. We have harnessed nuclear power but the destructive power of nuclear weapon has become a menace to civilization. Computers enhance our power yet threaten our privacy. The industrial pollution which accompanies industrial revolution threatens the very habitability of the globe. The practical value of science lies in the life made easier by technological advances based on the scientific knowledge

2. Theoretical value of science

The laws and principles discovered in scientific investigations have a value apart from any practical utility they may possess. This intrinsic value is the satisfaction of curiosity, the fulfillment of the desire to know. Aristotle wrote long ago that "to be learning something is the greatest of pleasures not only to the philosopher but also to the rest of the mankind, however small their capacity for it" (Aristotle, Poetics 1448b). Scientific knowledge does not merely give its possessor power to satisfy his various practical needs, but also fulfills the desire to know. Science is not merely an instrument to control nature, it is also an instrument to know and understand the mysteries of nature as well.

Nature and Aim of Scientific Methods

How does a scientist work? What are his methods and what is his methodology? These are important questions and answers to these questions are equally important. In a very simple term one can say a scientist works like a detective. He (detective) uses all techniques, devices and means to solve his case. A detective is a dispassionate and keen observer. He uses empirical reasoning (induction) as well as formal reasoning (deduction) to reach to a testible and verifiable conclusion. The pattern of scientific inquiry is just the same.

As we have seen the aim of a scientist (natural as well as social) is to find general laws. For this he makes use of two logical processes Induction and Deduction. Induction and Deduction are not contradictory logical procedures but are rather complimentary to one another. We must then know what is an inductive procedure and what is a deductive procedure.

What is Induction?

Induction is a process of inference in which we draw universal statements or scientific laws on the basis of particular facts. Experiences furnish us with particular facts and not with universal truths. Experiences inform us that some men whom we know are dead. But on the basis of these few instances we draw a universal conclusion that all men are mortal. This is inductive procedure. For example :

Ram is mortal.

Shyam is mortal.

Gita is mortal.

Therefore, all men are mortal.

In the above argument conclusion is more general than the premises. One learns by experience the qualities of individual things and with inductive procedure we draw universal conclusions like, "All men are mortal", "In all cases water rusts iron", "All material bodies attract one another" and so on. In all these cases the number of instances observed is very small compared to the full number of which the statement is made.

Induction relies on two fundamental principles, viz., the Law of Uniformity of Nature and the Law of Causation. These laws are called the formal grounds of Induction.

Formal Grounds of Induction

(a) The Law of Uniformity of Nature

The Law of Uniformity of Nature has been expressed in various forms such as, "Nature is uniform", "The future resembles the past", "Nature repeats itself". These various expressions mean that Nature behaves in the same way under the similar circumstances.

If the same circumstances occur the same events will follow. In other words, if water quenched our thirst or fire burnt us in the past under certain circumstances, water will quench our thirst and fire will burn us in future under similar circumstances. Thus, relatively speaking the Law implies that there is no such thing as whim or caprice in Nature.

At first sight Nature does not appear to be uniform. It is true that in Nature various kinds of phenomena occur but all these phenomena depend for their occurrences on certain conditions and if these conditions occur then the phenomena will occur. Consequently, corresponding to the various departments of Nature, there are laws. There is not one uniformity or law governing the whole universe but there are various uniformities or laws governing the various departments of Nature. And these are not distinct but are parts of one system. Hence we speak of Unity of Nature. The law of Uniformity of Nature is a postulate or formal ground of induction. It forms the very basis of all inductive generalizations that from the particular facts we draw universal conclusion.

(b) The Law of Causation

The Law of Causation is second formal ground of inductive generalization. It states, "Every event has a cause" or as J.S. Mill puts it, "Every phenomenon which has a beginning must have a cause". It is the guiding principle of inductive generalizations. This Law guarantees the formal truth of inductive generalization. According to some logicians causation is a special kind of uniformity. According to certain other logicians Law of Causation and Law of Uniformity of Nature are two distinct laws and they together constitute the formal grounds of Induction.

Material Grounds of Induction

Induction is the process of establishing universal laws on the basis of particular facts. It must, therefore, begin with the observation of concrete phenomena. This is the only ultimate way of getting facts. These facts are supplied by observation and experiment.

1. The term observation literally means keeping something before the mind, and should be distinguished from careless perception. Observation involves perception but it should be distinguished from perception without a purpose. Observation is regulated perception. Before we

undertake observation, we have a definite object in view and we direct our attention accordingly. We withdraw our attention from what is not relevant to our purpose and concentrate on what is connected with the object in view. Hence observation is necessarily selective. Observation should not be confused with unconscious inference. We should always distinguish clearly between facts which we really observe and what we infer from the facts observed. Observation is regulated perception of natural events under natural conditions. For example, an astronomer observes an eclipse of the moon or sun in order to determine the cause of the phenomenon. He watches the eclipse as it occurs and cannot control the attendant circumstances, he can watch the phenomenon with his naked eye or through a telescope. In both cases it is observation.

2. Experiment is an artificial reproduction of events under controlled conditions pre-arranged and selected by ourselves, A scientist experiments. He manipulates a fact in certain ways, introduces or removes conditions to see what will happen. Experiment is a kind of observation, but it has very special advantages from the point of view of science. It is observation under controlled conditions which we ourselves have pre-arranged. We can vary the conditions at will and produce them as often as we like. In observation we wait for an event to happen in the ordinary course of nature. When it happens, it is surrounded by complicated set of circumstances and it is impossible to say which of these are essential to its production. In experiment we produce the event under conditions which we have ourselves prearranged and carefully selected. Thus, we interfere with Nature, and force it to answer our questions. The purpose of experiment is thus to eliminate what is irrelevant.

There is no real opposition between observation and experiment. They are not different in kind. In both we study the nature of phenomena, ascertain their causes and explain the conditions of their happening. They differ only in degree. Observation precedes experiment and it has a wider scope than experiment. In observation we can proceed both from the cause to the effect and from effect to the cause but in experiment we can only proceed from the cause to the effect, On the other hand, experiment enables us to multiply our instances indefinitely whereas in observation we are at the mercy of Nature. Experiment often enables us to isolate the phenomenon we are studying which is not possible in observation.

The Inductive Procedure - its different steps or stages.

Logicians have recognized certain well defined steps or stages in our progress from particular facts to general Laws. Broadly speaking, there are following well marked stages, viz., Observation (including Experiment, Analysis and Elimination), Formation of Hypothesis, Generalization and Verification.

1. The first stage in the inductive inquiry consists in observation; observation is well regulated perception of circumstances for a certain definite purpose. Before proper observation begins we should have an idea as to what the fact is which we seek to explain. Hence observation presupposes definition. As observation is undertaken for a definite purpose, therefore, it necessarily involves Analysis and Elimination. Analysis means breaking up a complex fact into its constituent factors. Analysis reveals that some factors of the complex whole are merely accidental and irrelevant, having no bearing on the subject matter, while others are essential factors relevant to the enquiry.

The next step is Elimination. Elimination means exclusion or rejection of accidental and irrelevant circumstances, as distinguished from essential circumstances which point to a causal connection.

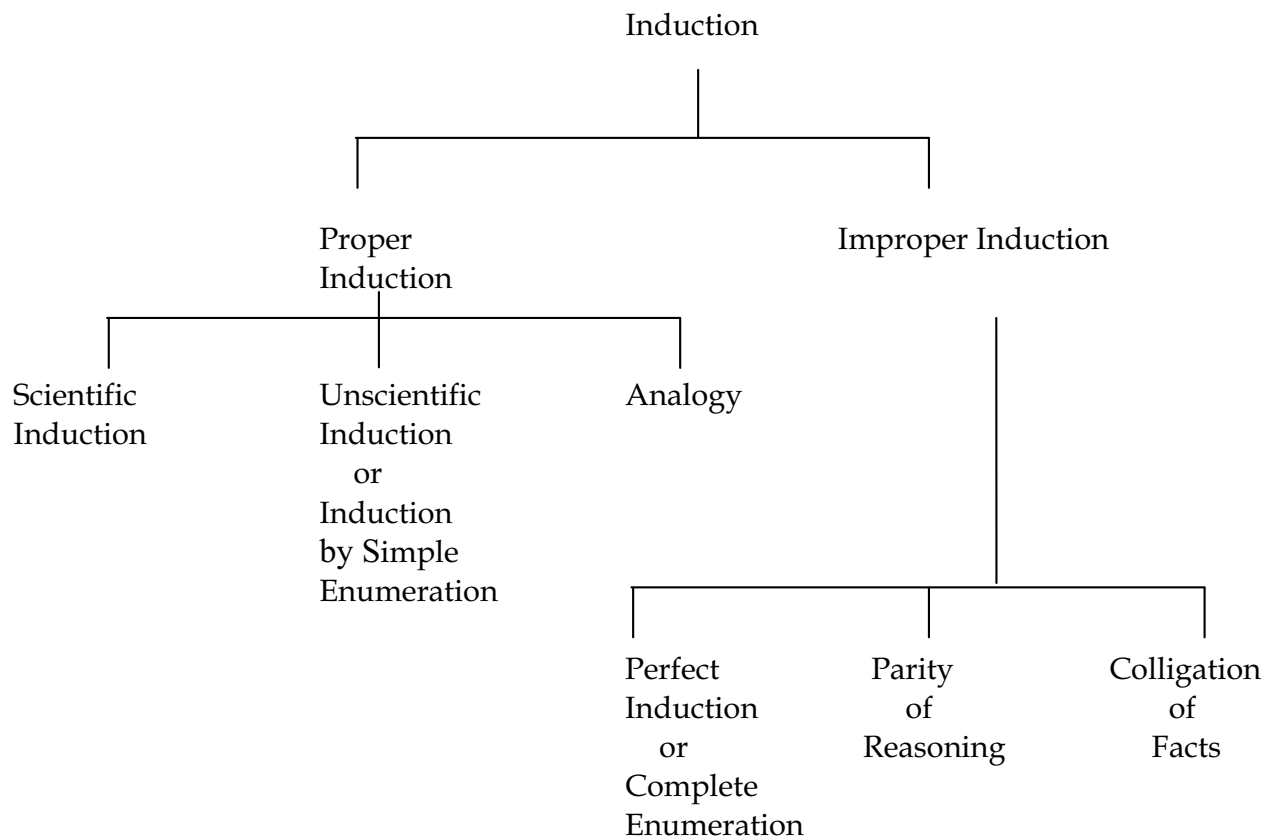
2. Formation of Hypothesis. A hypothesis means a provisional supposition. At first it appears that there are several possible explanations of the phenomenon under investigation. The real explanation is to be sought for among those possible explanations. That which appears to be the most probable is provisionally selected for further investigation and others are rejected or held in reserve.
3. Generalization: The next step is Generalization or inference of a general proposition on the basis of observation of particular instances. When we find that a particular hypothesis explains the phenomenon under investigation in several instances, we infer that it will be an adequate explanation in all similar cases under all circumstances. This generalization is made possible by the employment of the Experimental Methods which enable us to establish a causal connection when it is already suggested by a hypothesis.
4. Verification: Verification means examining whether the general proposition which is arrived at is really true by appealing to known facts. It involves deducing consequences from the general proposition and examining whether they agree with actual facts.

Let us attempt to illustrate the application of the Inductive Method in its different states, with reference to a concrete instance of scientific inquiry. Suppose the scientist wants to find out the cause of a particular disease, say, malaria fever.

To start with we define what malaria fever is. Before any investigation is undertaken we must have an idea of what we seek to explain. We note its symptoms, viz., high temperature, headache, a thirst for water, nausea etc. Now proper observation begins. It is observed that persons of different ages, different habits, living in different places, under different climatic conditions, in different seasons are subject to the attack of the disease. We attempt to observe conditions and circumstances which precede, accompany and follow the attack of the disease. We observe what different places are visited by the person suffering, what food he eats, his physical constitution, clothes he wears etc. The field of our observation should be large so that all possible conditions are investigated. In other words, we vary the circumstances. Then we analyze the conditions and mark the relevant conditions and discard the irrelevant or accidental conditions. For example, age of the person is not essential and what he eats is not relevant factor. We eliminate accidental circumstances. Next we frame a hypothesis. This disease may be due to some bacilli absorbed through food, drink or breathed through nostrils or infection may be carried by insects like mosquitoes, flies or bugs.

The most probable hypothesis may be that the infection is carried by mosquitoes. We, then, generalize and say, "All cases of malaria fever are due to mosquito bite". Then we verify the general proposition by observing that people having this disease have been living in mosquito infected places. The breed of mosquitoes is further verified and we reach the conclusion that "Anopheles mosquitoes are the cause of malaria fever".

Types of Induction



Proper Induction

Proper Inductions follow the inductive procedure in establishing the general statement. The ideal form of induction is known as Scientific Induction.

- (1) Scientific Induction establishes a general proposition, based on observation of particular instances, in reliance on the principles of the Uniformity of Nature and the Law of Causation. It establishes a proposition. A proposition explicitly states a relation between two terms. The inductive proposition seeks to prove a connection between two terms. For example, we prove the connection between 'Man' and 'Mortality' and establish the inductive general statement, "All men are mortal."
- (2) The proposition established is a general proposition in which the predicate is affirmed or denied of an indefinite multitude number of individuals, e.g., "All men are mortal". Here the term 'mortal' is affirmed of all men who constitute an indefinite number of individuals.
- (3) The inductive general proposition established is a proposition based on actual experience. It is not a mere analysis of the subject term but also adds something new to our knowledge.

- (4) Scientific Induction is based on observation of facts of particular instances. For example, the general proposition "All men are mortal" is based on the observation of particular cases of death of persons we have come across. Thus, Induction aims at material truth. The general proposition established by Induction must conform to the actual state of things.
- (5) In Scientific Induction there is an 'Inductive leap'. In other words, there is a leap from the known to the unknown, from the observed cases to the unobserved cases. This passage from the known to the unknown, from the observed to the unobserved, involves some hazard or risk. According to Mill and Bain, this 'Inductive leap' or hazard constitutes the very essence of Induction. If this characteristic is not present then the process is not called Induction. This characteristic follows from the circumstances that Induction establishes a general proposition which embraces a large and indefinite number of unobserved facts. But the so-called unknown is partially known because it resembles the latter.
- (6) Scientific Induction is based on two presuppositions viz. the Law of Causation and the Law of Uniformity of Nature. These two fundamental principles are called postulates or assumptions of Induction.
 - (i) Law of Causation states "Every event must have a cause". In Scientific Induction, for example, a causal connection is proved between 'heat' and 'expansion' and the general proposition "All metals when heated expand" is established.
 - (ii) Scientific Induction is also based on the principle of Uniformity of Nature. This principle states that under similar conditions, the same cause produces the same effect. Where we find that there is a causal connection between 'heat' and 'expansion', we further assume that this causal relation will be true in all cases, under similar circumstances in the future.

Thus, Scientific Induction establishes general proposition, on the evidences of particular instances, in reliance on the Principle of Causation and the Uniformity of Nature. 'Inductive leap' or the leap from the known to the unknown is the essence to Scientific Induction.

Induction by Simple Enumeration / Unscientific Induction

Induction by simple enumeration is the establishment of a general proposition on the ground of mere uniform or uncontradicted experiences without any attempt at explaining a causal connection. For example, so far as our experience goes we have seen only white swans. We have never come across a swan of any other color, nor have we ever heard that anyone else ever has. On the strength of these uniform or uncontradicted experiences we arrive at the general proposition "All swans are white". The fact that we have not observed contrary instances does not prove that they are not there and that they may not come to light at any time. The moment black swans were sighted in Australia the proposition "All swans are white" became false. When we observe large number of positive cases, without any negative one, we start expecting that the next one would be like them. This is a psychological and not

logical expectation. This is a general proposition based on observation of particular instances and there is an 'Inductive leap' from known to unknown, but this leap is based on a loose application of the principle of Uniformity of Nature, and not on the strength of a causal connection. We have not discovered or proved any causal connection between whiteness and swans. If we could do so, it would be an instance of Scientific Induction. However, we do believe that the unobserved cases will be like the observed ones.

This form of Induction is Proper Induction because there is in it an 'Inductive leap' from known to the unknown. But it is unscientific induction because there is no knowledge of any causal connection. It is called Induction by Simple Enumeration because the conclusion is drawn on the basis of mere enumeration or counting of instances. Our popular generalizations are often induction of this form.

Value of Induction by Simple Enumeration

It has been said that the conclusions of Induction by Simple Enumeration are merely probable, while those of Scientific Induction are certain. This is not true. All inductions give probable knowledge though probability is a matter of degrees. It can go from zero to what very nearly approaches scientific certainty.

The value of Induction by Simple Enumeration depends upon two considerations:

- a. The more the number of instances greater the probability.
- b. The absence of negative instances when experiences are of wide range shows that the conclusion possesses a high degree of probability.

Induction by Simple Enumeration is the starting point of Scientific Induction because in it we do have a vague belief that there is a necessary connection.

Analogy

Analogy is a weak form of Induction. Analogy is a kind of inference which proceeds from particular to particular. It is based on imperfect similarity and is only probable in character. The ground of inference in Analogy is resemblance.

A symbolic example:

A resembles B in certain properties, viz., x,y,z

B further possesses the property m

Therefore, A possesses the property m, even though no connection is known to exist between m and common properties x,y,z.

A concrete example :

Mars resembles the Earth in certain respects, viz., in being a planet, possessing similar atmosphere, land, sea, polar regions, temperature (neither too hot or too cold for life) revolving round the sun and borrowing light from the sun. The Earth possesses the further property of life. Therefore, Mars possesses the property of being inhabited.

According to logicians Analogy possesses the main characteristic of Induction, i.e., an 'Inductive leap' from the known to the unknown. Hence it is a sub-division of Proper Induction. But it differs from Scientific Induction in certain points. These differences are:

- (a) In Analogy we proceed from particular to particular whereas Scientific Induction establishes a general proposition.
- (b) Scientific Induction is based on knowledge of a causal connection, while in Analogy there is no such knowledge.
- (c) But we can say Analogy is a stepping stone to Scientific Induction

Improper Induction

Induction improperly so-called are those processes of reasoning which differ from Induction Proper in essential characteristics, though superficially they have the same appearance. They can be called processes which simulate Induction. There are three types of these processes, viz.

(1) Perfect Induction or Complete Enumeration

Perfect Induction is the establishment of a universal proposition on an examination of all the particular instances covered by it. For example, January, February, March... December, each month contains less than 32 days. Therefore, all months of the English year contain less than 32 days each.

Perfect Induction is possible only when there are limited number of particulars. It is also called Complete Enumeration. In Perfect Induction, there is no 'Inductive leap' and hence there is no real inference. The proposition arrived at is general only in appearance.

It is said that Perfect Induction gives dependable conclusion because all instances are examined. But the question is, can enumeration like this furnish scientific certainty? It cannot. But it helps in sciences and common life. It helps us in making comprehensive statements which are essential to the progress of science.

(2) Induction by Parity of Reasoning

Induction by Parity of Reasoning is a process of inference in which we establish a general proposition on the ground that the same reasoning which established a particular case will

establish every other similar case coming under the general proposition. In this similarity or parity is the ground of passing from a particular case to a general proposition. This is illustrated in Geometrical Proofs. For example, we draw ABC the diagram of a triangle on a piece of paper and prove that the sum of its three angles is equal to two right angles. Having proved this with the help of this diagram, we establish the general proposition - "All triangles have their three angles as equal to two right angles" - because the same reasoning which applies to this diagram will apply to every other diagram of a triangle which we may draw.

In Parity of Reasoning the essential characteristic of Proper Induction, i.e., reliance on observation of fact is not present. Geometrical figures are abstract conceptions. They are in no way inductive, they are purely deductive in character. In geometry we start with certain axioms and definitions and proceed deductively to draw conclusions from them. Thus the so-called Induction by Parity of Reasoning is not induction at all because it is a purely deductive process.

(3) Colligation of Facts

According to J.S. Mill, colligation of facts is another process which is improperly identified with Induction. To colligate literally means to bind together, and the expression 'Colligation of Facts' means the binding together or mental union of a number of observed facts by means of a suitable notion. For example, a navigator sailing in the midst of the ocean discovers land; he cannot at first determine whether it is a continent or an island. He coasts along it, and after a few days he finds he has completely sailed round it. He then declares it to be an island. This is colligation of facts because the navigator brings together, under the notion of an island, the set of facts observed by him. It is not correct to regard Colligation of Facts as Induction because colligation is practically the same as conception or the process of forming general notions while Induction establishes a general proposition. In colligation there is no inference at all. Certain facts are observed and brought together under a notion which we already possess. There is no 'Inductive leap' from the known to the unknown. In colligation we merely describe observed facts and there is no attempt at explanation by proving causal connection among them, whereas in Induction this connection is proved. Colligation is sometimes deductive. Thus, colligation may be called 'a process subsidiary to Induction' or 'a necessary preliminary to Induction'.

Besides Induction, Scientific Method includes deductive process of inference as well. Let us see what is deductive procedure?

What is Deduction?

In deduction we infer a conclusion from a given set of premises. Deduction begins with a given whole and infers from it the qualities of its parts. For example,

All men are mortal.

Ram is a Man.

Therefore, Ram is mortal.

In Deduction we infer from given universal truth (premises), either particular conclusion or a conclusion of equal generalization as that of premises. But in no case the conclusion in deductive reasoning goes beyond premises.

Difference between Induction and Deduction

In Induction, as we have seen, we infer more comprehensive conclusion than the premises whereas in Deduction we infer less or of equal strength of conclusion as of our premises.

Indeed like analysis and synthesis Deduction and Induction mutually imply each other. Neither gives a complete account of knowledge of any object without the other. The work of the one is not over before the other begins. The process of acquiring knowledge involves both Deduction and Induction. Induction first completes the work of establishing the universal propositions or premises and Deduction then explains the particulars in the light of that universal proposition. Not only do Deduction and Induction mutually involve one another they also proceed to the same ultimate principle. They differ in their starting point and not in their principle. Thus, the purpose of science is to explain, and we are said to explain a thing when either we show that it is an instance of a law or an element in the system, or the effect of a cause, or the means to an end etc. We cannot explain anything by itself. We have to connect it to other things within a system. The process involved in such explanation includes both Deduction and Induction.

The starting point is different in the two processes. In Deduction we start with general principles, while in Induction we start with the facts of observation. In Deduction we proceed from general principles to its consequences while in Induction we discover a general principle. In other words, the real process of inference in each case is the same, viz., an insight into the connection of facts according to some general principles. Scientific Method needs both Induction and Deduction.

Natural Sciences and Social Sciences

The natural sciences examine the natural phenomena. They study the structure and properties of non-living matter, from tiny atoms to vast galaxies. The natural sciences include physics, chemistry, astronomy, geology and meteorology etc. The social sciences, on the other hand, deal with the individuals, groups and institutions that make up human society. They focus on human relationships, interactions between individuals and their families, religious or ethnic communities, cities, governments, and other social groups. The main branches of the social sciences include anthropology, economics, political science, psychology, sociology etc. Social scientists attempt to develop general laws of human behaviour, but their task is difficult because it is hard to design controlled experiments involving human beings. Social scientists, therefore, rely heavily on careful observations and the

systematic collections of data to arrive at their conclusions. The use of statistics and mathematical models is important in analysing information and developing theories in the social sciences.

Difference between Methods of Social Sciences and Natural Sciences

S. No.	Social Science	S. No.	Natural Science
1.	Social sciences investigate laws related to man or man's social behavior.	1.	Natural sciences search for laws in natural phenomena.
2.	Social sciences proceed on the assumption that man is the central figure of inquiry.	2.	There is no equivalent assumption in natural sciences
3.	The fundamental elements of social sciences are psychologically related.	3.	The fundamental elements of natural sciences have a physical relation.
4.	The basic elements of social sciences are man, his mental states and behavior.	4.	The basic elements of the natural sciences are the physical elements like hydrogen, oxygen, energy particles etc.
5.	The basic elements of the social sciences cannot be separated analytically.	5.	The basic elements of the natural sciences can be separated by analysis.
6.	Being related to the study of society the social sciences have comparatively less exactness.	6.	Because they study natural elements, the natural sciences possess greater exactness.
7.	Because of their lesser exactness social sciences can make comparatively fewer predictions.	7.	The natural sciences can make more prediction due to a higher degree of exactness.
8.	For this reason objectivity is achieved with difficulty in social sciences.	8.	Objectivity or objective truth can be attained easily in natural sciences.
9.	Social sciences provide comparatively lesser scope for measurement of subject matter.	9.	There is greater possibility of measurement in the study of natural phenomena
10.	It is difficult to construct laboratories for social sciences. Society is their laboratory. However, data can be collected from case study, observation and questionnaire.	10.	Natural sciences have their own laboratories to study natural objects.

Note : Phenomenon (singular) = A thing which is perceptible, that is, which can be seen, heard, touched, smelt or tasted

Phenomena (Plural of phenomenon)

Questions

1. What are the main features of science? Discuss both practical and theoretical values of studying science.
2. Explain and illustrate the different steps involved in the inductive process.
3. Inductive reasoning assumes that reality (nature) is uniform. Examine this statement.
4. Explain the Law of Causation. Examine its utility in establishing the scientific theories.
5. Point out the main characteristics of Scientific Induction
6. Induction by Simple Enumeration fall short of Scientific Induction. Examine this statement. Are we justified in saying that Induction by Enumeration is stepping stone for Scientific Induction?
7. Discuss with the help of suitable examples Analogy as a form of Induction.
8. In Perfect Induction there is no 'Inductive leap', hence there is no real Induction. Discuss.
9. What is meant by 'material' and 'formal' grounds of Induction? Distinguish between them very briefly.
10. The methods of natural sciences are different from the methods of social sciences. Discuss.

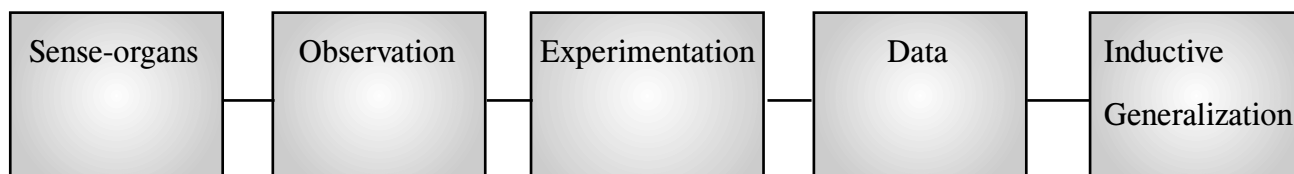
Unit 2

Observation and Experiment

Observation :

An Introduction

Science is primarily based on observation and experiment, guided by reason. Observation and experiment, thus, are two indispensable stages in the formation of any scientific theory. Observation is a procedure whereby senses generate information about an object. It is a process of filtering sensory information. Hearing, sight, smell, taste and touch are the sources of observation and experimentation. It is through these sensory inputs that an inductive generalization is eventually established. Diagrammatically, it can be represented in the following manner:



Meaning of the term 'observation'

The term 'observation' is derived from 'ob' meaning before, and the term 'servare' meaning 'to keep'. Literally speaking, the term means "keeping something before the mind". Thus, the first process in Scientific Method involves the observation of a phenomenon, event or 'problem'. However, it does not mean perceiving things in a careless or casual manner as we do sometimes in our day today life. Observation leads to a question that needs to be answered to satisfy human curiosity about the observation, such as why or how this event happened or what it is like. For example, when I see a shadow passing through my room while I am taking class, I conclude that it must be our watchful school principal who is taking round to see whether classes are being held or not. Later, after the class on examination I find that it was the college electrician who had come to fix fans in the room, seeing room occupied he left in hurry. Thus, careless or casual perception cannot make up for the observation in the strict logical sense of the term.

There is another possibility of error against which we must guard ourselves. Though observation plays a vital role in the formation of scientific laws but all kinds of observation is not our concern. Only those observations excite us intellectually which are worthy of some purpose. My seeing a tall building, hearing an auto sound and other endless observations which I perceive ever since I start my day, do not

serve any purpose as they are routine happenings. In Induction we are concerned with an observation which has a definite purpose, aim or objective. As we have a purpose in those observations, our scientific inquiries proceed without much ado. Such purposive observations involve witnessing both regularities and irregularities and when examined seriously, they lead to successful results. For example, if we wish to ascertain the cause of dengue fever, we observe and examine various cases, separate the common factors from the uncommon ones. In the course of observation we neglect the uncommon factors and concentrate on those common factors and make the generalization that lowering down significantly of platelets in blood due to mosquito bite, is the cause of dengue fever.

Observation must be distinguished from hasty generalization. A single case of observation cannot lead to any generalization. If I see a single case of my friend who dies after taking disprin with soft drink, then I arrive at a generalization that 'disprin when taken with soft drink leads to death', such is an instance of hasty generalization. In hasty generalization we make some observation in haste and draw wrong results; whereas in observation we are very attentive and cautious. Observation necessarily assumes familiarity with lots of empirical data required to form a generalization. Paucity of empirical data makes the observation ineffective and the generalization fallacious. For example, in a dark room I see a shadow of a statue from which I conclude that there is a man in my room. In this case, I do not see a man but someone like a man, someone who shares some of the characteristics of a man. From this seeming similarity I make a generalization and pass a wrong judgement that there is a man in my room. We do the same in the example of mistaking a rope as a snake.

General Principles of Observation

Observation is a mean of discovering underlying assumptions, rules and principles which are important for the process of Induction. Though there is no clear and precise set of rules to be followed in every act of observation, yet some general principles can be stated. These general principles can broadly be classified under three headings:

(i) Intellectual

(ii) Physical

(iii) Moral

- (i) This condition requires that the observer must be keen to know the cause of things and its explanation. Just as an appetite for food is natural to the body in the same manner curiosity to know is natural to a healthy sound mind. This desire to know is essential for observation.
- (ii) This principle requires that to begin with an observation, the observer must be in possession of normal senses. That is to say, any deficiency in senses hinders observation and makes all explanations incomplete. For example, a blind person cannot make observation about colors or a deaf person cannot make any observation about sounds. This is also true that a

person who is normal can also make errors. Anybody can fall victim to optical illusions. It is a common sight that while sitting in a train which is parked parallel to another train, one sees that this train is moving and the other is still stationary whereas the truth is just the opposite. As normal senses too have limited powers various aids are developed to enhance human powers of observation, such as weighing scales, telescopes, microscopes, X-ray machines etc. The list of accompanying aids is endless and they are still getting added to the existing list.

- (iii) This condition is defined as the condition of 'impartiality'. It is difficult to find a perfect person who can make observations, register facts and yet remain unaffected by his own whims and caprices. This moral condition is just an implicit warning to guard against one's own conscious or unconscious beliefs which may not support a theory. Thus, while impartially recording facts we must be careful to avoid the following biases.
 - (a) Observational bias - It occurs when an observer or researcher looks only in those areas where he finds positive results matching his beliefs. Here it becomes all the more easier to record observations and take investigation in the desired direction. It is also called 'streetlight effect'.
 - (b) Confirmation bias - It occurs when the observer is biased towards confirming his conscious or unconscious expectations regarding the observations he is making about some phenomenon. In such biases 'we see whatever we expect to see'. Psychologically, it is called confirmation bias.

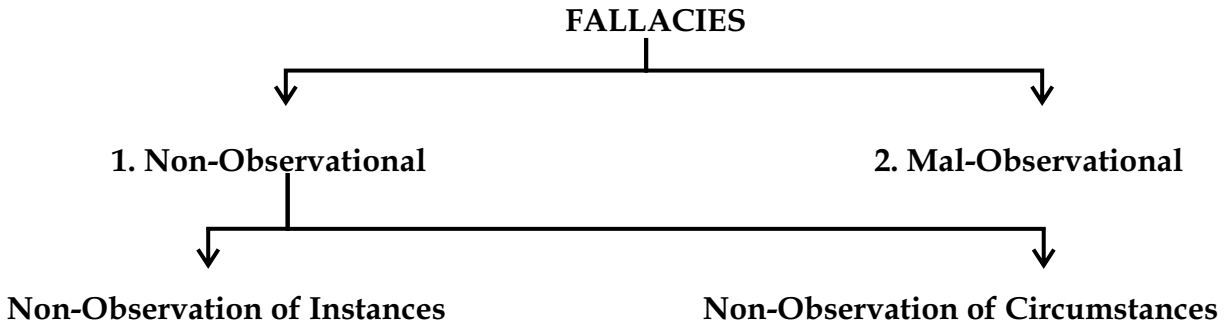
Besides these two major biases there are others also, viz., pathological and processing biases which are concerned with tempering of facts at the observational level and diluting the output. These biases are rampant in pseudo sciences where the correct techniques of science are not followed.

Apart from what has been said so far there are other problems which are encountered so frequently in scientific field. Sometimes observation affects the process being observed so much that it results in a different outcome altogether. For example, it is not possible to check air pressure in an automobile tyre without letting out some of the air, thereby changing the pressure. Further, it is not possible to reduce the importance of observation in favour of some better instrument.

Fallacies of Observation

Scientific theories are primarily tested against observation. Theories are accepted, rejected or modified mainly because of observational data. It is the observational data which provides objectivity to sciences. Its importance can further be gauged when we find that both stability and change in any scientific theory happens because of observation. As we put too much reliance on sensory inputs in observation, we are likely to commit errors. Whenever we commit any error in observation either

because of our over-looking of circumstances or because of some preconceived notions or having some incorrect interpretation, it adversely affects our collection and recording of observational data. Since such errors do affect our observations, they are called observational fallacies. These fallacies are classified as follows:



In the fallacies of non-observation we overlook something which must have been observed. Non-observation can be with regard to particular instances or with regard to particular circumstances.

As far as the non-observation of instances is concerned, we overlook instances which are relevant to the inquiry. This may also happen due to our biases or preconceived notions. For example, in a biased society like ours women are considered to be less superior to man, any inquiry regarding the achievements of women one may overlook several areas where women have made excellent progress. Of recent there was a news item wherein it was told that a man refused to board the aeroplane as it was flown by a woman pilot. This speaks volumes about the deep rooted biases and preconceived notions the community may have towards certain phenomenon.

We also have a natural tendency to overlook those instances which do not support our theory. Sometimes we are attracted towards those impressive reasons other than relevant which suit our theory. Sometimes we look only for positive instances and totally overlook negative instances. At other times weird beliefs and superstitions too play havoc with the outcome of observational data. It is a common sight to find when students do lots of prayers before taking up any examination. It would be nonsensical on the part of any observer who takes this alone to be the criterion for achieving success in examinations.

With regard to non-observation of essential circumstances in our inductive inquiries, we overlook essential conditions which play a vital role. We are not supposed to overlook the circumstances under which the observational study is conducted. It may be the social, political, religious, economical and other reasons which could have made a significant impact on the outcome of the study. The circumstances into which an inquiry is conducted cannot be separated from the observed data. As a

matter of fact, the circumstances and the empirical data are complimentary to each other. No one can be separated or studied in isolation without the other.

To conclude, we may say that observation is an activity of living human beings consisting of receiving knowledge of the outside world through the senses, or the recording of empirical data using scientific instruments.

Experiment

Observation and experiment are two intertwined processes which make inductive generalization possible. In fact, they supply the material ground to induction. An experiment is an observation made under prepared and thus controlled conditions; and when obtainable, it is preferred and finally acquires the honour of a generalization. Formally speaking, an experiment is a methodical procedure carried out with the goal of verifying, falsifying, or establishing the accuracy of a hypothesis. Experiment may vary from an informal to highly formal or controlled conditions. For example, when I lit the match stick by striking on the matchbox, a simple observation shows that the two phenomena are related; it does not show that lightening of the matchstick is dependent on air (oxygen and nitrogen). When the same task is performed under controlled conditions where there is no air, no matter how hard we try there would not be any flame whatsoever. Thus, experiments produce the best results if prepared and conducted carefully. Moreover, conducting of any experiment is possible only when some knowledge is gained through observation. In other words, observation is always prior to conducting of experiments.

An experiment is a controlled manipulation of events, designed to produce observations that confirm or disconfirm one or more rival theories or hypotheses. It is a method of testing - with the goal of explaining- the phenomenon in question. It is also a deciding procedure between two or more competing hypotheses.

Difference between Observation and Experiment

Though both observation and experiment are complementary to each other, yet there are some noticeable distinctions between the two. They (differences) are given below :

1. The first and foremost obvious distinction between the observation and experiment is that the latter is an extension of the former. Experiment not only enables us to produce a much greater number of variations in the circumstances but also produces the sort of variation which is essential for the discovery of some law of the phenomenon. That is why experiment goes much beyond the observable data.
2. In experiment the phenomenon is produced artificially by the researcher whereas in observation phenomenon occurs as an event in the ordinary course of Nature. Through observation we find a fact but through experiment we create a fact. In the case of observation we are at the mercy of

occurrences of phenomena, which are beyond our control. But in the case of experiment we ourselves produce the phenomena and can control the circumstances of their happening.

3. It is also said that observation is natural while the experiment is artificial. This is misleading. In observation, though we depend on Nature for the occurrence of the event but we do sometimes make use of artificial scientific instruments to enlarge and enhance the scope of sense-organs. Similarly experiments are also not totally artificial as we do make use of our natural powers in observing the events produced through experiments.
4. Some people believe that observation is a passive experience while experiment is an active experience. In observation, we watch the event along with its changes which occur in Nature but we cannot make any effort to control them. It is only at level of experiment that we ourselves prepare the conditions under which we control both the event as well as the changes. But it is wrong to suppose that an observer is totally passive while he is observing the event. In fact, an observer has to be very alert while observing the event, its changes and should be able to reject those circumstances which are irrelevant to the phenomenon under investigation. It is equally true that there is greater degree of activity involved in experiments, yet the importance of observation cannot be minimized or underestimated. As a matter of fact, both are corollaries to each other. In the absence of one, the other is futile.

Merits of Experiment over Observation

Direct experiment definitely has advantages over unaided or bare observation. These advantages are as follows :

- (a) In experiment there is a possibility of multiplication of instances. This means that if one instance is not sufficient and does not yield the desired results, the scientist can try as many number of times as he wants. While in simple observation we do not have this advantage because we are dependent on Nature, we wait for opportunities. In experiments we create opportunities.
- (b) Secondly, in experiments there is a possibility of isolating phenomenon. The observed phenomenon can be isolated in experiments to eliminate or mitigate the influence of those agents which need to be observed again. In observation Nature presents phenomenon in complex surroundings which we cannot ignore or isolate anymore. For example, a candle burns in open air but when put in a closed box, its flame is extinguished. As far as observation goes, it is difficult to find answers. It is only through experiment one finds that flame of the candle lit only when there is air which has nitrogen and oxygen along with many other gases.
- (c) Thirdly, experiments are generally created in a comfortable and congenial atmosphere. In observation we are often taken by surprises. For example, when we are to study the causes and

behaviors of earthquakes, we are dependent of Nature. But when we try to study the same phenomenon in a laboratory, we can create conditions and can easily study the phenomenon.

Experimentation is an indispensable step in the Scientific Method that helps us decide two or more competing explanations or hypotheses achieved or arrived at by observation. The two appear different theoretically but practically they are two sides of the same coin. Scientific explanations can be inferred from confirmable data only, and experiments are reproducible and verifiable by other individuals. Together they give rise to good science that is based on information which can be measured or seen and verified by other scientists also.

Questions

1. What is scientific observation? Explain its utility in scientific knowledge.
2. State the general principles (conditions) of good observation.
3. Does observation imply selection and elimination of events? Examine.
4. Discuss the fallacies of observations.
5. Explain the nature and utility of experiments in science.
6. The distinction between experiment and observation is never absolute. Explain.
7. Discuss the advantages of experiments over observations.

Unit 3

Science and Hypothesis

Why Hypothesis?

All men, unlike animals, are born with a capacity "to reflect". This intellectual curiosity amongst others, takes a standard form such as "Why so-and-so is such-and-such?". While answering such queries men proceed from ignorance to the path of knowledge, from incomplete to complete knowledge. In the course of this journey 'to know', various hypotheses are formulated or rejected depending upon the accompanying circumstances. A hypothesis is a form of development of knowledge. Hypotheses are advanced to substantiate various assumptions to explain some phenomenon and its connection with other phenomena. Their importance in the growth and development of natural sciences can by no means be underestimated. Nature is a big mystery governed by its own rules but it is man who discovers these rules and formulates laws and theories. Apple always falls on the ground but it was Newton who found the rationale in the form of Gravitational power of earth.

What is a Hypothesis?

A hypothesis is a tentative statement that proposes a possible explanation for some phenomenon or event. Hypothesis is an educated guess. The term educated is highlighted because no good hypothesis can be developed without research into the problem. The need for a hypothesis arises when some novelty or abnormality is observed in some phenomenon which can neither be understood nor explained through prior established laws. To understand such inconsistencies, some tentative statements are formed on the basis of observation and put to exhaustive scientific investigations. These investigations are necessary in order to assess the testability and accuracy of hypothesis. Since a hypothesis is a possible solution, initially its truth is as questionable as its falsity. It may turn out to be true or it may turn out to be false. For example, when I reach home, see the main door opened ajar and the door lock broken, all household things scattered all over the place, seeing this and other accompanying circumstances, I start making conjectures leading to the conclusion that a burglary is the most possible happening. These conjectures are called hypotheses, and the reasoning used to produce them is called hypothetical reasoning. The hypotheses make up for the lack of direct observation in producing the needed explanation. A useful hypothesis is a testable statement which may include a prediction. A hypothesis is not identical with a theory. A theory is a general explanation based on a large amount of data and underlying assumptions. In contrast, a hypothesis is more specific than a theory.

Types of Hypotheses

Depending upon the level of generality, scientific hypotheses may be divided into general, particular and individual.

A general hypothesis is a scientifically substantiated assumption about the causes, laws and rules governing natural phenomena. For example, there is 'Democritus hypothesis' about the atomic structure of substance which subsequently became a scientific theory.

A particular hypothesis is a scientifically substantiated assumption about the causes, origin, regularities and irregularities of a part of objects singled out from a class of objects belonging to Nature. In other words, they are devised to reveal the reasons for the emergence of irregularities in a subset of the given set. For example, while trying to find some remedy for cancer, several particular hypotheses are advanced about the causes of viruses of malignant tumours.

An individual hypothesis is a scientifically substantiated assumption about the causes, origins, regularities and irregularities of individual facts, concrete events or phenomena. For example, a doctor while diagnosing constructs individual hypotheses in the course of treating an individual patient. After detecting the ailment, he not only selects drugs but also their dosage individually.

Stages of constructing a Hypothesis

- S1. Identification of some unexpected novel happening in a group of facts which is not covered by prior established laws, and thus is required to be explained by observation, collection, and relevant classification of empirical data by forming a new hypothesis.
- S2. Formation of the hypothesis (or hypotheses), i.e., assumptions which would explain the regularities or irregularities in question.
- S3. Derivations of all relevant consequences from the hypothesis in question which will further qualify it for verification.
- S4. Comparison of all the logical consequences drawn from the hypothesis with the existing observations and established laws of science is a step ahead in its acceptance.
- S5. Transformation of the hypothesis as a part of scientific theory if all consequences of the hypothesis are corroborated without any inconsistency.

Conditions of a Good Hypothesis

Every hypothesis is either good or a false one. A hypothesis is good if it finds a secure place in science. In order to be a good or sound hypothesis it must satisfy the following five conditions. These five conditions commonly set the criterion for judging the worth or acceptability of any hypothesis.

1. Relevance

Every hypothesis is an intentional demand for a possible explanation of some fact or the other. Hypothesis is neither proposed for its own sake nor does it come out of nothing. As a matter of fact, it must be relevant to the fact it is trying to explain. The fact demanding explanation must be deducible from the proposed hypothesis, together with certain assumptions about particular initial conditions. A hypothesis which is not relevant to the fact it is intended to explain will not be good. It is regarded as having failed in fulfilling its intended function. Thus, a good hypothesis must be relevant. A relevant hypothesis must be based on observed data. Agreement with facts is the sole and sufficient test of a relevant hypothesis. A hypothesis which fails to distinguish relevant from the irrelevant data while ordering facts, is far from satisfactory.

2. Testability

One of the most distinguishing features of a hypothesis is its testability. That is to say, it must be able to withstand all the possibilities of making observations which can confirm or disapprove any scientific hypothesis. A scientific hypothesis has not only been testable for its truth but also for its falsifiability. There must be a way to try to make the hypothesis fail. Science is often more about providing a scientific statement wrong rather than right. If it does fail, another hypothesis is tested usually one that has taken into account the fact that the last hypothesis failed. One more thing which is very clear about the testability of hypothesis is that it excludes all supernatural explanations. By supernatural we understand 'all the events and phenomena which cannot be perceived by empirical senses or which do not follow any natural rules or regularities.' Thus, all supernatural explanations cannot find any place in science as they cannot be scientifically tested. That is to say, they must be verifiable. They must be such that we can deduce consequences from them in order to compare them with the actual facts. A hypothesis from which nothing can be deduced is of no value whatever. It may be tested directly or indirectly. As in the case of earlier scientifically established hypotheses, it must also be connected in some way with empirical data or facts of experience.

3. Compatibility

This is yet another simple requirement of the acceptability of any hypothesis. It must be compatible or consistent with other hypotheses which have already been well confirmed or have gained reasonable acceptability. Ideally when scientists hope to make progress by gradually expanding the scope of their hypotheses, they comprehend more and more facts and a scientific system is built. This way scientific progress of any system is possible. For such progress can be made only if the new hypothesis is consistent with those already confirmed. The occurrence of an incompatible hypothesis shows that a given region of fact has not yet been sufficiently organized.

4. Predictive Power

Any sound hypothesis should contain a prediction about its verifiability. The predictive or explanatory power of a hypothesis amounts to the range of observable facts which can be deduced from it. Often this condition is related to another condition, viz., testability. A hypothesis is testable if some observable fact is deducible from it. When we confront two testable hypotheses [H1 and H2] of which [H2] has a greater number of observable facts deducible from it than from [H1], then [H2] is said to have greater predictive or explanatory power. The greater the predictive power of a hypothesis the more it explains, and the better it contributes to human understanding of the phenomenon under examination.

5. Simplicity

Though this condition is difficult to define, yet it is invoked intuitively. It is very natural that one is inclined towards the sheer simplicity and elegance of a hypothesis. Suppose there are two competing hypotheses trying to explain some phenomenon, the chosen hypothesis will automatically be the one which explain facts in the simplest terms. Historically, the most famous pair of such hypotheses is (a) Heliocentric (Copernicus) and (b) Geocentric (Ptolemy), both were interested in explaining the centre of the universe so that the movement of other heavenly bodies around it could be understood. According to Ptolemy, the earth is the centre of the universe and the heavenly bodies move about it in paths that require a very complicated geometry to describe it. On the contrary, Copernicus described sun as the centre of the universe. Though both systems require some complicated accounts of epicycles for some observed positions of various heavenly bodies, yet Copernican system was much simpler. This simplicity made Copernicus' theory more acceptable than the other advanced by Ptolemy.

Hypothesis and Crucial Experiments

A scientific inquiry attempts to provide proper justification for accepting or rejecting a hypothesis as true or false. Sometimes it also happens that two different hypotheses fully explain some set of facts and both are testable, both are compatible with the whole body of already established scientific theory. In such situations, it may be possible to choose between them by deducing from the incompatible propositions which may be tested directly. Thus, to deal with such a situation, we set up a crucial experiment to decide between the competing hypotheses. It may not be easy to carry out the task as the accompanying circumstances of these hypotheses may be difficult or impossible to obtain now.

Questions

1. Define hypothesis. What is the utility of hypothesis in science? Explain
2. Give a brief account of different types of hypothesis?
3. Discuss various stages of constructing a hypothesis.
4. What are the conditions of a good hypothesis? Give a brief account.
5. When is the need for crucial experiments arise in scientific inquiry? Is it always possible to have crucial experiment? Discuss

Unit 4

Mill's Methods of Experimental Inquiry

Need for establishing causal relations

To establish the causal relationship is the distinguishing mark of Scientific Induction. Inductive reasoning is based on the assumption that there is a Universal Principle of Causation according to which things are connected in a systematic way. Nothing occurs accidentally. Everything that happens must have a cause. The natural and social sciences describe and explain the phenomena and events in terms of cause and effect. From the view point of practical experiences also we are constantly looking for the causes of the events happening around us. All phenomena without any exception are causally related; everything that happens has a cause, and which in turn is followed by an effect.

Nature and Definition of Cause

It is not difficult to know what cause is ? The real problem before human beings is to establish that A is the cause of B. To know that particular phenomenon, say x, is the cause of another phenomenon y is to establish a universal law. The moment Newton had discovered that the gravitational power of earth is the cause of apple falling down, he established a causal relationship and thus had given an extremely important law of gravitation. There are certain things and events whose causes are known to us, yet there are several other things whose causes are not known to us. For example, in spite of the best efforts of the scientists and doctors the exact causes of a deadly disease like cancer is not known.

Causal connection is a relation of invariable succession and hence is a stronger connection than merely a correlation. Causal relationship implies succession in time. Cause is antecedent and hence precedes the effect. Effect is consequent and hence follows the cause. The time interval between cause and effect may be very less but nonetheless gap is there. In simple terms cause is defined as invariable, unconditional, immediate antecedent of an effect.

Scientists define cause in terms of necessary and sufficient conditions. Necessary conditions are those in the absence of which the effect does not occur. For example, in the absence of oxygen, fire will not occur. But the presence of oxygen does not guarantee the fire to be there because oxygen is merely a necessary condition of fire and not the sufficient conditions of fire. The sufficient conditions are actually sum total number of necessary conditions. These total number of necessary conditions of fire are ignition, fuel and oxygen. If we wish to produce anything desirable then we must look for sufficient conditions. But if we want something not to happen, then we must remove any one of the necessary conditions.

Mill's Experimental Methods

John Stuart Mill in his famous logic book named *System of Logic* gave five Experimental Methods by which causal connections can be identified between events. Through these methods causes can be determined approximately.

Mill's five Experimental Methods :

1. Method of Agreement.
2. Method of Difference
3. Joint Method of Agreement & Difference.
4. Method of Concomitant Variation.
5. Method of Residues

All the methods are derived from the nature of causality. They are indeed a detailed statement of what scientific causality is. The nature of causality is such that,

- (a) Wherever the cause is present, the effect follows
- (b) Wherever the cause is absent, the effect is absent
- (c) Wherever the cause varies, the effect varies and their variations are proportional.
- (d) What is the cause of one thing is not the cause of a different thing.

The four factors, i.e., a,b,c,d are called the 'canons of elimination'.

These relations between cause and effect are reciprocal. It is on these canons Inductive Methods are based. They establish causal connections indirectly by rejecting causes which fail to satisfy some one of these conditions. Thus the principle on which the Experimental Methods proceed is the elimination of the irrelevant conditions which fail to fulfill the requirements of causality. Hence, the true function of the Experimental Methods is the discovery and proof of a causal connection by elimination. Induction, however, does not seek the elimination of a non-cause but the establishment of a cause. The Experimental Methods are rules of applying observation and experience in order to eliminate the accidental factors and thereby to select one phenomenon, and to prove that phenomenon to be the cause or effect of another phenomenon.

1. Method of Agreement

Mill states the canon of the Method of Agreement as follows:

"If two or more instances of the phenomenon under investigation have only one circumstance in common, the circumstance in which alone all the instances agree, is the cause (or effect) of the given phenomenon."

Mill points out that this method of discovering and proving a causal connection is based on the following principle of elimination :

Note : J.S. Mill used circumstance for cause and phenomenon for effect.

"Whatever circumstance can be excluded without prejudice to the phenomenon is not connected with it in the way of causation."

In other words, if some circumstances are left out, and the given phenomenon is present, there cannot be any causal connection between them. Accordingly, it follows that if some circumstances are always present, when the given phenomenon is present, there is a causal connection between them.

In the Method of Agreement we try to discover causal connection from agreement among instances, which are called positive instances, instances in which the suggested cause and effect are both present. This method is a development over the methods of enumeration and analogy. It makes a thorough analysis of the antecedent conditions. It proceeds on the principle that: -

- (1) There is a causal relation between the antecedents as a whole and the consequent as a whole.
- (2) Whatever is not present on any occasion in which a particular consequent follows can be eliminated as not its cause.

Symbolically, the Method of Agreement may be represented as follows, where capital letters represent circumstances (causes) and small letters denote phenomena (effects) :

A B C D occur together with w x y z

A E F G occur together with w t n v

Therefore, A is the cause (or part of a cause) of w.

Concrete example :

If a number of cases of typhoid fever were to appear at about the same time in a community, one would try to discover some circumstance which was common antecedent of all the cases. Cause to be sought for, is among a limited number of circumstances. One would select the various instances with the purpose of testing the different possibilities. The water supply might first be examined. But if it were found that this was derived from entirely different sources in the different cases, we should probably conclude that the explanation must be sought elsewhere. Suppose we find that all the patients of typhoid had eaten oysters bought at the same market. If this were the only common circumstance discoverable after careful investigation we should conclude probably that the oysters were the cause of the fever. The process of analysis could be pushed still further in order to determine more exactly the precise source of infection, i.e., it might be found, that the water in which the oysters were kept was vitiated by sewer.

It is important to note that the conclusion reached by this method is greatly strengthened by micro observations and by taking as many instances as possible which are dissimilar in character. But, howsoever many and varied the instances in which A and w are found together, causal connection between them can never be proved. The whole of A may not be required to produce w. Our analysis may be incomplete, and so we may not have isolated the cause which is in A, as when we say impure water is

the cause of typhoid, when impure milk/oysters would do equally well. The real cause is something in water/milk/oysters in contaminated water.

In this method a systematic effort is made to find a single factor which is common to several occurrences for the purpose of identifying that one factor which is the cause of a phenomenon present in the occurrences. This method identifies the cause in the sense of a necessary condition.

2. Method of Difference

The canon of the Method of Difference is expressed by Mill as follows:

"If an instance in which the phenomenon under investigation occurs, and an instance in which it does not occur, have every circumstances in common save one, that one occurring only in the former; the circumstance in which alone the two instances differ, is the effect, or the cause, or an indispensable part of the cause, of the phenomenon".

The Method of Difference is based on the principle that "whatever cannot be eliminated without interfering with the phenomenon under investigation must be causally connected with the latter". In other words, that which is present in a case when a phenomenon occurs, and absent in another case when that phenomenon does not occur, all other circumstances remaining the same in the two cases, is casually connected with that phenomenon.

In this method we take two instances only. Each instance is a group of antecedent followed by a group of consequent. The two instances differ only in the circumstances (antecedent or consequent as the case may be) which is present in one and absent in the other. In all other respects, the instances are exactly the same. From this we conclude that the circumstances in which the two groups differ is the cause of those circumstances in which alone the two groups of consequents differ.

The Method of Difference may assume two forms : we may add something to the antecedents and the result is that something new happens in the consequents. Or, we may subtract something from the antecedents and something disappears from the consequents. This method is called the Method of Difference because it is the singleness of the difference that constitutes the ground of proof.

Symbolically,

(i) A B C is cause of a b c

B C is cause of b c

∴ A is cause of a

- (ii) B C is cause of b c
 A B C is cause of a b c

 ∴ A is the cause of a

In the first example, A is subtracted from the antecedents and the result is that a disappears from the consequents. In the second example A is added to the antecedents and the result is that a appears in the consequents. Hence we conclude that A is the cause of a.

Concrete example :

If a bell is rung in a jar containing air the sound will be heard at any ordinary distance. But after having removed the air by means of an air-pump let the bell be struck again. It will now be found that the sound is no longer heard. When the two cases are compared it is at once evident that the only difference in the antecedents is the presence of air in the one case and its absence in the other. Other circumstances remain the same; we conclude that the perception of the sound is causally connected with the presence of atmospheric air.

The Method of Difference plays a great part in our everyday inferences. For example, we strike a match stick against the side of the match box and there is light and fire. But a careless use of this method leads to the fallacy of *post hoc ergo propter hoc*. For example, the appearance of a comet in the sky may be followed by the death of a king, but it is wrong to conclude that the appearance of a comet is the cause of the death of the King. In practical life we depend on simple observation for the supply of instances. But in such cases the Method of Difference does not yield conclusive results because in order to comply with the special requirements of this method the instances must be supplied by experiment.

The Method of Difference is essentially a method of experiment because only experiment and not observation, can furnish instances of the special kind required for this method. In experiment we have control over the conditions and are able to vary them at will and as such we may be careful in introducing or removing only one circumstance at a time. The Method of Difference proves causation conclusively when strictly applied. It supplies tests to confirm the conclusion arrived at by an application of the Method of Agreement.

The Method of Difference is subject to following limitations: -

- (a) The Method of Difference being a method of experiment is subject to limitation to which experiment is. In experiment we can proceed from cause to effect but cannot go backwards from effect to cause. The effects are not within our control. We cannot add or subtract from them in the same way as we can add to or subtract from groups of causes.

- (b) The Method of Difference does not enable us to deal completely with the plurality of causes. The Method of Difference only proves that certain circumstance is the cause of a phenomenon in a given case, but it cannot prove that it is the only cause and that there cannot be other causes on other occasions.
- (c) The Method of Difference does not enable us to distinguish a cause from a condition. For example, granting that BC produces bc, will the introduction of A compel us to regard it as the sole cause of the new consequent a? Not necessarily, for a may be due to A combining with B and C. Thus, we cannot say that introducing of a new element is necessarily the sole cause of any change which may happen. It may be one of the conditions merely. If a dish of food be unpalatable, the addition of salt may render it palatable. But it does not follow that the agreeable taste is due to salt alone. The salt is only one condition but there are other conditions which must be taken into account in order that the entire cause may be ascertained.

3. Joint Method of Agreement and Difference.

Mill states the canon of the Joint Method thus, "If two or more instances in which the phenomenon occurs have only one circumstance in common, while two or more instances in which it does not occur have nothing in common save the absence of that circumstance, the circumstance in which alone the two sets of instances differ is the effect, or the cause, or an indispensable part of the cause, of the phenomenon".

The requirements of the Joint Method are: -

- (a) A set of positive and a set of negative instances.
- (b) That both sets be drawn from the same field of investigation.
- (c) That the instances making up each set be as diverse as possible.

The joint method of Agreement and Difference has advantages over each of these methods separately.

- (1) It supplements the positive instances of Agreement by negative instances.
- (2) It applies in many cases where the Method of Difference cannot be realized, i.e., where experiment is impossible because we cannot control the conditions or produce the event at will.

Symbolically it can be expressed as :

Agreement in Presence :

(1) (Set of positive instances)

A B C is cause of a b c

A C D is cause of a c d

A D E. is cause of a d e.

∴ A is cause of a

(2) Agreement in Absence :

(Set of negative instances)

B C D is cause of b c d

D E F is cause of d e f

E F G is cause of e f g

∴ A is the cause of a

In the set of positive instances A is uniformly present in the antecedents and a is uniformly present in the consequents.

In the set of negative instances A is uniformly absent in the antecedents and a is uniformly absent in the consequents.

Concrete example :

A man observes several instances in which he eats a particular article of food and suffers from indigestion. From this set of positive instances, according to the Method of Agreement, he infers that the eating of that article of food is the cause of indigestion. He then takes a set of negative circumstances and finds that when he does not take that article of food he does not get indigestion. In this way, his original conclusion is confirmed.

Mill's example :

We observe that dew is formed on objects which radiate heat rapidly. We also observe that dew is not formed (the phenomenon does not occur) on objects which agree only in the absence of rapid radiation of heat. From this we conclude that the rapid radiation of heat is the cause of the formation of dew.

The Joint Method is also called the Indirect Method of Difference, the Double Method of Agreement or the Method of Double Agreement. It is so called because there is double agreement, agreement in presence and then agreement in absence.

Like the Method of Agreement, the Joint Method is essentially a method of observation and as such possesses all the advantages and disadvantages of observation. The advantages are that both these methods have a wide range of application and can be employed in cases where the phenomenon under investigation is beyond our control. The disadvantages are that neither of them can conclusively prove a causal connection though the conclusion of Joint Method is more probable than that of Method of Agreement because it takes note of both positive and negative instances. The Method of Agreement is frustrated by the possibility of plurality of causes, by the possibility of there being hidden and unknown circumstances which escape our observation. Further, it is unable to distinguish between causation and co-existence. But the Joint Method is more or less free from the difficulty arising out of the possibility of the plurality of causes. If the negative instances are fully exhaustive and contain all the circumstances other than what is uniformly present in the positive set, there cannot be plurality of causes.

4. Method of Concomitant Variations

Mill states the canon of the Method of Concomitant Variation as follows :

"Whatever phenomenon varies in any manner whenever another phenomenon varies in some particular manner is either a cause or an effect of that phenomenon, or is connected with it through some fact of causation".

The Method of Concomitant Variations is based on the principle that "an antecedent and a consequent rising and falling together in numerical concomitance are to be held as cause and effect". In other words, the cause and the effect being quantitatively equal in energy increase or decrease in the one must be followed by a proportionate change in the other. Thus, if two phenomena always vary together, they are casually connected. When it is observed that certain events continue to show correspondence throughout a series of variation it is inferred that the conjunction is not accidental but indicates the existence of a causal connection.

This correlation of events may be discovered through correspondences in temporal or spatial arrangement of phenomena, in their progression, or in changes of quality and quantity. The discovery of Concomitant Variation is of importance in science, not merely because it assists us in determining what events are related as cause and effect but also because the exact form of the causal relation can thereby be rendered more defiant and satisfactory.

Concomitant Variation may be of two types.

- (1) Direct variation, in which the antecedent and the consequent vary in the same direction, that is, they rise and fall together.
- (2) Inverse variation, in which the antecedent and the consequent vary in the opposite direction, that is, the increase in the one is followed by the decrease in the other and vice versa.

1st Symbolic Example

A1 B C cause of a1 b c

A2 B C cause of a2 b c

A3 B C cause of a3 b c

∴ probably A is the cause of a

2nd Symbolic Example

A1 B C cause of a1 b c

A2 D E cause of a2 d e

A3 E F cause of a3 e f

∴ probably A is the cause of a

Concrete example :

1. A farmer establishes that there is a causal connection between the application of fertilizer to the soil and the size of the crop by applying different amounts to different parts of a field, and then noting the concomitant variation between the amounts of the additive fertilizer and the yield.
2. We observe that as heat increases, the mercury in the thermometer expands in the volume. From this we conclude that heat is the cause of expansion of mercury.
3. It is a common experience that the lower the price of a thing, the larger is the quantity bought by the consumers. In other words, if supply of a commodity increases then the prices decreases provided demand remains same.

This method has three main uses.

- (1) Where the variations are not quantitatively measurable or at any rate have not been measured, it can be used exactly in the same way as the other Methods. It can be used either along with the Method of Agreement or the Method of Difference or alone. The variations may suggest causes or eliminate causes which have been otherwise suggested. The Method of Concomitant Variation can be used in those cases where experiment is not possible.
- (2) This method can also be used in cases where the Method of Difference cannot be applied, because the phenomenon in question cannot be eliminated or removed, though it can be varied. We cannot eliminate the atmospheric pressure, temperature, but we can vary them or put

ourselves into positions where we can perceive their variations, as when we climb a mountain and find the atmospheric pressure less.

- (3) In cases where the variations are exactly measurable, the Method of Concomitant Variation gives very much more precise results than the other methods. In such cases it not only supports the other methods but it gives something which they cannot give. It establishes causal relation as well as determines the precise quantitative relation between them. The natural sciences always try to reduce qualitative relations to quantitative ones and in this the Method of Concomitant Variation helps them. For example, when the physicist says that heat is the cause of motion, he means that the amount of energy that we get in the form of heat is identical with the amount that we get in the resulting motion form, so that the relation between them is one of quantitative equivalence in the amount of energy together with a difference in its form. Any variation in the amount of energy form results in a similar variation in the motion form. To establish causal relations in this sense we have to prove not only invariable sequence but quantitative equivalence. When we arrive at such a degree of precision and exactness we can express the causal relation in the form of a mathematical formula.

5. Method of Residues

In general, this method calls attention to any remainder or residues which is left over after other portions of a complex phenomenon have been explained. This is Mill's last method and is applicable only after the work of establishing causal relations has made considerable progress.

Mill expresses its canon as follows :

"Subduct from any phenomenon such part as is known by previous inductions to be the effect of certain antecedents, and the residue of the phenomenon is the effect of the remaining antecedents."

If we are dealing with a complex set of phenomenon and we already know the cause of some of them, we conclude that the cause of the remainder is to be found among the antecedents whose effects we do not know yet. Here the procedure of analysis is followed by elimination; and the elimination is based on negation. The principle is: that which is the cause of one thing cannot be the cause of a different thing.

When the greater part of a phenomenon has been scientifically investigated and its cause is known, and there is very little other than the known cause and effect in the antecedents and consequents, this method establishes relation between the remaining antecedents and remaining consequents. But in such cases also it is desirable to test the suggested relationship by one or more of the other methods.

Symbolic Example :

A B C is cause of a b c

B C is cause of b c

It is already known that the B is the cause of b and C is the cause of c,

Therefore, A is the cause of a.

Concrete examples :

- (1) We weigh a cart with load and note the weight. We already know the weight of the cart alone. By subtracting the weight of the cart from the total weight of the cart with load, we conclude that the difference is the weight of the load.
- (2) Astronomers John C Adams and J. J. Leverrier discovered the planet Neptune by the application of this method in 1846. It was observed that the Planet Uranus presented certain anomalies in its motion - that there was a slight deviation from the path, which according to calculators would have been its orbit. The influence of the Sun and the other known planets on Uranus was calculated but it was found that as a matter of fact, Uranus did not follow the calculated path. This led to a search for the cause of deviations and they were found to be due to the influence of another unknown planet, viz., Neptune.
- (3) Pierre curie and his wife Marie Curie had discovered two chemical elements, radium and polonium by applying this method, They found that uranium ore contained much more radioactivity than could be accounted for by the uranium itself. The Curies then began to search for the source of the radioactivity. They separated minute amounts of two new highly radioactive chemical elements from tons of uranium ore which they called radium and polonium. In 1911, Marie Curie won the Nobel Prize for chemistry for her discovery of the new elements and for her work in isolating radium and studying its chemical properties.

As a general rule, the Method of Residues sets a problem rather than solves it. In certain cases the effects of all the apparent antecedents are known but they do not suffice to explain the facts before us. Hence, we assume that there is some unsuspected cause which accounts for the residual phenomenon, as the unexplained remainder is called. The more exact our observations and analyses are, the more likely we are to notice such residual phenomenon and the more loudly they call for explanation. Thus, the Method of Residues suggests the need for investigation to discover a cause rather than it suggests

what the cause is. To suggest the need for a search for hitherto unsuspected causes has been its main function in the history of science.

The special feature of the Method of Residues is that it can be applied only when we have made some progress in our knowledge of causation. This method contains an element of deduction, nevertheless, it is an inductive method because it yields conclusions that are only probable and cannot be validly deduced from their premises. The Method of Residues may be regarded as a special modification of Method of Difference because the principle underlining both the methods is the same.

We can sum up our considerations of the Inductive Methods as :

- (1) They apply only after a great deal of preliminary work in the form of observation and analysis has been performed. The conclusion at which they arrive are not more general than the premises from which they start. They eliminate or disprove part of the premises and leave the rest standing.
- (2) They give, not certainty, but varying degrees of probability.
- (3) They apply only where we can observe the cause or the effect, or where we can experimentally analyse the effect into its causal conditions.
- (4) They apply to the scientific, not to the non-reciprocating causes. As applied to such causes the methods give invalid results.
- (5) They deal with phenomenon in comparative isolation, with particular recurring connections. They do not unify or organize phenomena into system. Hence the connections which they force upon us are often comparatively unintelligible and call for further explanation.

Limitations of Mill's Methods :

J.S. Mill believed that his Experimental Methods were tools with which causal relations may be discovered and canons with which causal connections may be proved. But he was wrong on both counts. The Methods are indeed of the greatest importance, but their role in sciences is not so majestic as he used to think.

The Experimental Methods are important for the establishment of causal relations but such claims on their behalf are no more than exaggerations. The Methods alone can neither discover nor can prove, causal relations between two facts. The Methods essentially make use of observations and experiments so they cannot prove causal relations. Proof is possible only in the field of mathematics. Sciences (natural or social) do not prove, they only establish the laws. Since mathematics deal with the relation of

ideas, proof is possible there, but sciences deal with facts which are observed to collect data and establish natural laws.

Moreover, even when this preliminary work of collecting data and then analyzing and synthesizing them has been completed, the Methods do not prove causal connections. They can only give further confirmation or added probability to the connections already suggested. They narrow down the field of possible causes. And in some cases their main value is to suggest causes which can be further tested by other methods. Elsewhere Mill himself grants and says that "the four methods have little more in their power than to supply premises for, and a verification of, our deductions." Therefore Mill's claim that his canons are "methods of proof" must be rejected, along with his claim that they are ' the methods of discovery"

Questions

1. Explain and illustrate the Method of Agreement. Discuss its merits and demerits.
2. The Method of Difference is essentially a method of experiment. Explain
3. The Joint Method of Agreement and Difference has advantages over the Method of Agreement alone or the Method of Difference alone. Explain
4. The Method of Concomitant Variation differs from the other Methods of Experimental Inquiry. Discuss.
5. Explain the Method of Residues. How is it different from the Method of Difference?
6. Discuss critically whether Mill's Inductive Methods are methods of proof or methods of discovery or both.
7. Discuss briefly the limitations of Mill's Methods of Experimental Inquiry.

Unit 5

Nyāya Theory of Knowledge

Need for Theory of Knowledge

Every school of philosophy (*Darśana*) in India has attempted a theory of knowledge (*pramāṇasāstra*) on which its metaphysical structure is based. The ultimate goal of all philosophizing, and for that matter of all human enterprises, has been to realize perfection (*mokṣa*) or fullest all round efflorescence of one's potentialities as the *summum bonum* of life and existence. For this realization knowledge of reality (*tattvajñāna*) is an essential and necessary prerequisite. But it is believed that a theory of knowledge is propaedeutic to a theory of reality because before knowing the reality one has to know the nature of knowledge and modes of knowing. This belief is grounded in the fact that to philosophize is to reflect on the nature of reality given in experience. Every experience is caused by, and pertains to, an object which is a part of reality. Every experience has a built-in self-transcendence, an intentionality, pointing to an object. This reference to an object may be cognitive (awareness of) or non-cognitive (desire for etc.) A cognitive reference consists in revelation of an object (*artha prakāśa*) or in the making of a cognisor aware of it. Though every cognitive reference reveals an object, there is always a possibility of going astray in this reference and there is no guarantee that it would adequately and faithfully reveal its object. This possibility of error in cognitive reference necessitates an inquiry into its veracity. The entire epistemological pursuit begins with and centres around this task.

Nature of Cognition and Knowledge

A cognitive reference is a cognition (*jñāna*) of an object (*artha*) in terms of awareness of its existence, nature, relations and functions. A cognition reveals its object. It may reveal its object *as it is* (*yathārtha*) or *different from what it is* (*ayathārtha*). That cognition is knowledge (*pramā/pramāṇa*) which reveals its object *as it is*, i.e., which is non-discordant (*avisamvādaka*) with its object. Non-discordance is known as truth (*prāmāṇya*). All other varieties of cognition (e.g., error, doubt, indecisiveness etc.) are not knowledge (*apramā*). Only that cognition can claim the status of knowledge whose non-discordance or truth is well-evidenced. There has to be indubitability (*asamdigdhatva*) with regard to the truth of that cognition. Only true cognition is knowledge and truth of knowledge needs to be well-evidenced on the basis of cogent and convincing evidence known as *pramāṇa*. Thus, in a knowledge-situation there are three elements, viz., *pramā* (true cognition), *prāmāṇya* (truth) and *pramāṇa* (evidencing condition which is also originating condition). On the basis of cognitivity-claim knowledge is distinguished from volition, feeling etc. Within cognitive domain, again, knowledge is differentiated from memory, doubt, error, conjectures etc.

Knowledge not Justified True Belief only

Instead of understanding knowledge in terms of 'justified true belief', contrasting it with opinion as is done in the western tradition, Indian thinkers point out three essential components of knowledge. They are (i) cognitive reference to an object (*artha viṣayakatva*), (ii) exactitude of reference (*yathārthatva*) and (iii) indubitability or certitude about exactness (*asamdigdhatva*). This means knowledge-content must be caused and determined by object-content. This is necessary condition and sufficient condition is indubitability. The object must be real and not imaginary or fictitious. This is very important and basic condition and this distinguishes Indian epistemology and logic from its western counterpart. To be real means to exist or to be capable of being existent. Only when an object is existent (*astitva*) there can be decision about exactitude or true apprehension of the object. Then only there can be indubitability by adducing conclusive or sufficient evidence (s) for its truth.

Thus, the Indian thinkers out-step subject-centricity of belief and bring in primacy of object reference. So, in a knowledge-game there are four players, viz., knower (*pramātā*), known object (*prameya*), knowledge and truth (*pramā and prāmānya*) and mode of knowing and evidencing (*pramāṇa*).

The Problem of *Pramāṇa*

The problem of *pramāṇa* or evidencing the truth of knowledge has received serious and foremost attention of epistemological thinkers. This problem has given rise to much stimulating debate in the philosophical treatises. As stated earlier, the question of evidencing the truth of knowledge arises because all cognitions are not at par or equal in their epistemic status. Some appear to be true and may reveal their objects as they are whereas others seem to be erroneous and may misrepresent their objects. Had all cognitions been true, there would have been no need of evidencing them and the entire epistemological inquiry would not have arisen. The very possibility of error or doubt etc. in cognition necessitates its subjection to a critical examination with a view to establish its truth or falsity. If the truth or falsity of cognition needs to be established, the question arises what sort of criterion is to be adopted. The problem of *pramāṇa* has been raised and discussed precisely against this background.

Causal Approach to Knowledge

The epistemological thinkers generally adopt a causal approach to knowledge. Knowledge is taken to be an outcome of a particular causal complex (*kāraṇa-sāmagrī*) in which the most efficient instrumental factor is known as *karaṇa*. The other factors are called *kāraṇa*. In a causal complex all factors are causally efficient and contribute to the rise of knowledge, but those factors which are causally sufficient as well, in so far as their introduction alone produces the effect, their totality is known as *karaṇa*. Distinction between *karaṇa* and *kāraṇa* is very important in the Nyāya tradition. Every *karaṇa* is a *kāraṇa* but every *kāraṇa* is not a *karaṇa*. A *karaṇa* of *pramā* is known as *pramāṇa*.

Dual Role of *Pramāṇa*

According to the Nyāya School *pramāṇa* has a dual role to play. Along with other causal factors it gives rise to *pramā* but in addition it adduces evidence for its *prāmāṇya* (truth). The Nyāya thinkers draw a distinction between those conditions which give rise to knowledge and those conditions which impart truth to it. According to them awareness of knowledge and awareness of its truth are different phenomena. Thus, the distinction between *karaṇa* and *kāraṇa* is needed.

The Concept of *Prāmāṇya*

The concept of *prāmāṇya* (i.e., truth) is one of the most significant and central concepts used in epistemological discussions in Indian philosophical tradition. All schools of epistemology in India are unanimous in holding that *prāmāṇya* should be the differential mark of *pramā* (i.e., true cognition or knowledge), even though they put forth divergent views regarding the precise nature of *pramā* and *prāmāṇya*. Here an attempt is made to present an analysis of the concept of *prāmāṇya* as it is expounded in the Nyāya tradition.

Meaning of the term *Prāmāṇya*

A meaningful consideration of the concept of *prāmāṇya* should begin with the question : with what sense of *prāmāṇya* we are concerned presently? The term *prāmāṇya* can be used in two different senses, namely (a) *pramāṭva* and (b) *pramā karaṇatva*. In the first sense *prāmāṇya* belongs to *pramā* and constitutes its differential character, whereas in the second sense it pertains to *pramāṇa* as its property of being instrumental in bringing about *pramā*. In the present chapter we are concerned with the analysis of the concept of *prāmāṇya* understood in its first sense.

Distinction between *Prakāśa* and *Prāmāṇya*

The consideration of the concept of *prāmāṇya* should be distinguished from the consideration of the concept of *prakāśa* because the phenomenon of *prāmāṇya* though connected with the phenomenon of *prakāśa* is quite different from it. The theory of *prakāśa* is concerned with our awareness of knowledge whereas the theory of *prāmāṇya* is concerned with the truth of knowledge. The *prāmāṇya* theory deals with the question, how does a knowledge become true and how is its truth ascertained? The theory of *prakāśa*, on the other hand, pertains to the question, how is the knowledge itself known? The theory of *prakāśa* is of course logically prior to the theory of *prāmāṇya*, for unless the knowledge itself is known no question can be raised about its truth. The theory of *prakāśa* is also wider in scope because it pertains to all states of consciousness and not merely to knowledge. However, it is the theory of *prāmāṇya* which is logically more significant because it is *prāmāṇya* which alone is the differential factor between *pramā* and *apramā*.

Prāmāṇya as property of *Pramā*

In the Nyāya tradition *prāmāṇya* is a property of that *jñāna* which is of the type of *pramā*. Here *jñāna* is used as a generic term which stands for all kinds of cognition of which *pramā* is just a species. *Pramā* designates a true cognition which is attended with a belief in its truthfulness. If a cognition turns out to be false, belief in it is immediately withdrawn and as such it ceases to be regarded as *pramā*.

The English word 'knowledge', in its strict sense, stands for a cognition which is true and unfalsified. The ordinary usages of this word with the adjectives 'true' and 'false' should therefore be considered as cases of loose thinking. The word 'true' as applied to 'knowledge' would then be tautologous and the word 'false' positively contradictory. If this strict meaning of the word 'knowledge' is adhered to it will exactly correspond to *pramā*.

The concept of *pramā* thus stands for a cognition which is necessarily true and assured. Its opposite is *apramā* which stands for all that is 'other than *pramā*'. It is noteworthy that cognitions which do not agree with the real nature of their objects are not always false and erroneous (*viparyaya*) and there may be cognitions which fail to give us a correct presentation of objects and so are not true, but at the same time they may not make any claim to truth, nor lead to any definite assertion. Such is the case with doubt (*samśaya*) and indecisiveness (*anadhyavasāya*). They are not true indeed, but they are not false either. However, they are all different varieties of *apramā* to be differentiated from *pramā*.

Epistemic attitudes in *Pramā*

In the Nyāya tradition *pramā* is regarded as a complex epistemic entity involving several epistemic attitudes, epistemic content and epistemic elements. As regards epistemic attitudes, the first stage of *pramā* consists in a *nirvikalpaka jñāna*, which is bare awareness of an object. Subsequent to this comes the second stage of *savikalpaka jñāna*. The *nirvikalpaka* is the most primitive epistemic datum whose postulation as the ultimate, unanalysable epistemic entity is a matter of logical necessity. Upon this alone the *savikalpaka* which is propositional and judgemental (*vyavasāyātmaka*) is grounded. Implicit in the *savikalpaka* are two *anuvyavasāyas* (post reflections) in the form of *jñāna prakāśa* and *jñāna prāmāṇya*. That is to say, in *pramā* besides a judgemental awareness of an object there is also an awareness with regard to that awareness and further with regard to the truthfulness of that awareness. So, when I say "This pen is brown" it implies (i) I know the pen as brown, (ii) I know that I know the pen as brown, and (iii) I know that it is true that this pen is brown. In other words, implicit in every *pramā* there is not only a cognitivity-claim but also a truth-claim. (There could have been another epistemic attitude in the form of awareness of *aprāmāṇya* when we realize the falsity of a cognition, but then it will not be a case of different form of *pramā*).

The different stages involved in the noetic process can be represented in a tabular form as under:

- i) *Nirvikalpaka* (Indeterminate)

ii) *Savikalpaka* (Determinate)

- (a) *Vyavasāya* → Kn. of object
- (b) *Prakāśa anuvyavasāya* → Kn. of Knowledge
- (c) *Prāmāṇya anuvyavasāya* → Kn. of truth of knowledge

Epistemic elements of *Pramā*

The epistemic elements of *pramā* are three-fold. The basic element is presentativeness of an object (*artha-prakāśakatva*). Every *pramā* is a 'knowledge of --' and there is a necessary transphenomenality built in every knowledge which provides it an intentional character. But this is not the sufficient condition of *pramā* which in fact lies in *prāmāṇya* (truthfulness). *Prāmāṇya* is the most significant element of *pramā*. It is the logical ground of *pramā* but in its turn it is grounded in *asamdigdhatva* (indubitability or assuredness), which is a psychological ground of *pramā*. There is necessary truth-claim put forth in every *pramā*. Thus, it is a definite and categorical assertion distinct from all indefinite and hypothetical ones. But all assured cognitions are not *pramā*. In illusion what is false is firmly believed to be true. So this assuredness in *pramā* is not a mere subjective certainty but a firm belief well grounded in some *prāmāṇa*.

The assuredness about a *pramā* is possible if there is establishment of *prāmāṇya* on the ground of *prāmāṇa*. To make this point clear a distinction needs to be drawn between knowing truth and being assured of it. Being assured here presupposes knowing. Now what intervenes between knowing attitude and assuredness is convincing evidence (*prāmāṇa*). Assuredness requires some ground which provides confirmation of *prāmāṇya*.

Prāmāṇya is a property of knowledge and not of the object of knowledge but it cannot be taken to be a property of knowledge in isolation from the object. It is thus a property of knowledge in relation to its object.

In the Nyāya system the earliest attempt to define *prāmāṇya* and *pramā* goes back to Vatsyāyana who defines *pramā* as '*yathārtha vijñāna*.' He explicates the term *yathārtha vijñāna* as '*tasmin tat iti pratyayaḥ*', i.e., a determinate cognition of something as that very thing. But from *Vācaspati* onwards the Nyāya thinkers have tried to define *prāmāṇya* in negative terms by using the term '*avyabhicāritatva*' or some similar terms. Though the negative definitions serve the purpose of excluding error, doubt and memory, yet what is called for is a positive definition, which is yet capable of performing this task of exclusion. Though the term *yāthārthya* is positive and potential in meeting this requirement when it is explicated as '*tasmin tat iti pratyayaḥ*', still Gaṅgeśa rejects it on the ground of ambiguity which the word '*yathā*' gives rise to in so far as it could possibly refer to some resemblance between knowledge and its object. But Gaṅgeśa rightly maintains that being entirely

heterogeneous in nature one cannot meaningfully talk of the resemblance of knowledge to its object since knowledge is epistemic and object is ontic. Instead of 'yāthārthya' Gaṅgeśa uses the expression 'tadvati tat prakāratva' as a definition of *prāmāṇya*.

Relation between *Pramā* and *Prāmāṇya*

Having analysed the nature of *pramā* and *prāmāṇya* we may now turn to the analysis of relation between *pramā* and *prāmāṇya*. Since every knowledge has to be true, *pramā* and *prāmāṇya* are inseparably related. But the question is what sort of relationship is there between the two? Is *prāmāṇya* the very essence of *pramā* or is it only a property of *pramā*? On this issue thinkers fall under two sharply distinct camps. Those who maintain that *prāmāṇya* is the very essence of *pramā* and that every *pramā* has *prāmāṇya* intrinsic in it are known as *svataḥprāmāṇyavādins*. On the other hand, those who maintain that *prāmāṇya* is not the essence but only an inseparable property of *pramā* and they have substance-attribute relationship (*dharma-dharmī-bhāva*) and that *prāmāṇya* is extrinsic to *pramā*, are known as *parataḥprāmāṇyavādins*. The Nyāya thinkers adhere to the theory of *parataḥprāmāṇya*.

Theory of *Svataḥprāmāṇya*

The theory of *svataḥprāmāṇya* has been put forth by the thinkers of Advaita Vedānta, the Vijñānavāda school of Buddhism, and the school of Pūrva-Mīmāṃsā. Though there are differences in details in the advocacy of this theory in different schools and thinkers, there is something which is common to all of them. All of them agree that there is no distinction between *Jñāna* and *pramā* and also between *pramā* and *prāmāṇya*. In other words, every cognition is intrinsically true. In a cognition-qua-cognition there is no error.

Theory of *Parataḥ Prāmāṇya*

The theory of *parataḥprāmāṇya*, put forth by the Nyāya School, is based upon three presuppositions, viz. (i) *Jñāna* and *pramā* are not the same (ii) *prāmāṇya* is a property of *pramārūpa jñāna* and not its essence and (iii) both *jñāna* and *prāmāṇya* are produced by distinct causes. On the basis of these three presuppositions the Nyāya school puts forth the theory of *parataḥprāmāṇya*, according to which the conditions which give rise to *prāmāṇya* are different from and additional to the conditions which give rise to *jñāna* and further, the mode of ascertainment (*jñāpti*) of the two is also different.

Comparison of *Svataḥ* and *Parataḥ* Theories

The theories of *svataḥ* and *parataḥ* have been put forth in the history of Indian epistemology in such a setting as if they are contending the same issue and answering exactly the same question. But a closer scrutiny would make it evident that they are not at all debating the same issue or answering the same question. They start with different presuppositions and therefore though they might be using the same language their problems are not the same. The terms *jñāna*, *pramā*, and *prāmāṇya* are used in different senses. That is why their theses are different and so also their conclusions. Therefore, the treatment of

the problem of truth in each of the schools is in a way supplementing each other. The apparent contradiction is due to their using the same expressions while infact giving them different meaning.

To take a few examples to substantiate this point we may take up the concept of *jñāna*. In the theory of *svataḥprāmāṇya* it is used in a very restricted sense such that every *jñāna* is *pramā*. For it *pramā* and *apramā* are not just co-ordinate species of *jñāna* because *apramā* is *jñānābhāsa* and not *jñāna*. But this is not the case in the theory of *parataḥprāmāṇya* where *jñāna* is taken as a generic term having *pramā* and *apramā* as its co-ordinate species. Here *jñāna* is not the same as *pramā* but *yathārtha jñāna* is identical with *pramā*.

In the same way *pramā* and *prāmāṇya* are understood differently in the two theories. In the *svataḥ* theory every *jñāna* which is *pramā* is *prāmāṇyarūpa*. Truth here is infact a matter of analytic consequence of its conception of *jñāna*. But in the *parataḥ* theory there is a radically different approach. Here *prāmāṇya* is not essentially identical with *jñāna* but only an essential property of *pramā* such that the latter is *pramāṇyāvān*. So the acceptance or non-acceptance of the two theories is not a matter of an open choice, because that is determined by the acceptance or non-acceptance of their presuppositions. If one accepts the respective presuppositions, one has also to accept the thesis and the conclusions following therefrom. But if one rejects their presuppositions then certainly one cannot accept their thesis and the conclusions.

Secondly, it must also be made clear that the Nyāya concern is not just with mere truth but also with the substantiation of truth-claim. For it *pramā* is not just a true cognition but such a true cognition which is also believed to be true. Belief in truthfulness has to be grounded and ascertained on the basis of evidences. Therefore, the problem of *jñapti* is basic to it, but such a problem is not at all pertinently faced by the *svataḥprāmāṇyavādins*.

We may, therefore, conclude this treatment by saying that the two theories are infact complimentary rather than contradictory. They are two different ways of understanding the relation between *jñāna* and *prāmāṇya*. If the identity theory is accepted then *svataḥprāmāṇyavāda* follows and if the adjectival theory is accepted its natural consequence would be *parataḥprāmāṇyavāda*. It will perhaps give us some new insights and dispel some of the confusion if the two theories are understood and appreciated in their proper setting.

Pramāṇas (Methods of Knowing)

The role of the methods of knowing (*pramāṇas*) has been given great significance in the Nyāya tradition. Truth or objective validity of knowledge is due to the methods of knowing. The methods of knowing (*pramāṇas*) not only give rise to knowledge but also ensure its truth. They are a *karaṇa*, i.e. most efficient or unique operative cause of knowledge. This uniqueness consists in its evidential role in respect of the truth of knowledge.

According to this tradition there are four methods of knowing (*pramāṇas*), namely, perception (*pratyakṣa*), inference (*anumāna*), verbal testimony (*śabda*) and comparison (*upamāna*). All that is real is knowable, and it can be known by any of the methods of knowing (*pramāṇas*) under different conditions.

Pratyakṣa

Perception (*pratyakṣa*) is the first and the foundational method of knowing. It is the direct and immediate mode of knowing. It gives us knowledge of what is directly present to the sense. It is the basis of the remaining three methods of knowing inasmuch as all three derive their starting points from perceptual cognition. It may also be regarded as the final test of the truth of all knowledge in so far as perceptual verification is the most handy and reliable mode of confirmation.

The word *pratyakṣa* is used for both the method of knowing and the resultant knowledge. It consists of two types, or rather two stages, namely indeterminate (*nirvikalpaka*) and determinate (*savikalpaka*). Indeterminate perception is pure un verbalized experience. It is a conscious but not a self-conscious state in the sense that there can be no direct awareness of it. Its existence is known inferentially. In determinate perception an object is known related to its qualifications. This is possible only if the object and its qualities are first known separately prior to being related. This indeterminate stage is presupposed as the ground of the determinate cognition.

Determined perception is cognition of an object as qualified by certain properties. It is a judgemental cognition in which the object of perception is known as characterized by certain qualities and relations. It consists in apprehending an object along with its differentiating characteristics. It is, therefore, defined as a cognition apprehending the qualifiers of a qualificand or as a cognition apprehending the relation between the qualificand and its qualifiers. The contents of indeterminate and determinate perceptions are the same. The only difference is that in the latter they are judged and verbalized. While in an indeterminate perception the object is apprehended as an undifferentiated whole of universal and particulars, in a determinate perception they are analysed and organized into a substantive-adjective relationship. Thus, they differ not in terms of content but in the way they are ordered. To cognize a thing once again, to know it as that which was known before, is also a part of determinate perception. It is an awareness of a common reference to one and the same object by the previous and the present cognition.

Perceptual knowledge is an outcome of sense-object contact. This contact may be normal or supra-normal depending upon the way in which senses come into contact with their objects. Normal perception is again of two types, namely, external and mental. It is the self which is the knower, and it needs mind to perceive mental facts just as it needs senses to perceive external facts. In mental perception one's feelings, emotions, dreams etc. are known. External perception is five-fold as there are five senses, viz., eyes, ears, nose, tongue and tactual sense.

In supra-normal perception the objects are not actually present to the sense but are conveyed to it through an extra-ordinary medium giving rise to a special kind of sense-object contact. It is of three

types. The first and most significant variety is named *sāmānya lakṣaṇa* which pertains to perception of classes and on the basis of which generalizations are made.

Sāmānya lakṣaṇa is the perception of a whole class of objects through the generic property (*sāmānya*) perceived in any individual member of that class. Thus, when we perceive some thing as a pot we judge it as belonging to the class of pots. But to know that the thing belongs to the class of pot is also to know all other pots belonging to the same class. But the other pots are not present, when this pot is perceived. It is the perception of the universal 'potness' in the present pot that serves the purpose of contact between sense and all other pots. Here only one member is perceived as having both specific and generic properties, while the other members are known as possessing the generic property. Without accepting such a type of perception generalization is not possible.

The second variety, known as *jñāna lakṣaṇa*, is the perception of an object which is in contact with a self. Here past experience serves as a medium of contact between sense and the perceived objects. The visual perception of distance and the cognition of ice looking cold are examples of this type. Illusory experiences can also be explained on this basis. Here there is transgression of the normal function of the cognitive sense. For example, eyes can not see 'coldness' of ice and yet by seeing ice one sees its coldness. In a way it is like an *anumāna* but strictly speaking it is not so as it does have all the steps needed in the process of *anumāna*.

The third kind of supra-normal perception is *yogaja*. It is intuitive perception like that of a mystic, a seer or a saint. It is comparable to omniscience inasmuch as it is instantaneous knowledge of all things - past, present or future - due to supernatural powers.

Anumāna (Inference)

The second method of knowing is *anumāna*, i.e., inference. All Indian systems, except *Cārvāka* and a few individual thinkers, accept it as a valid means of acquiring knowledge. The word *nyāya* stands for a logical theory, and ascription of this name to this school indicates that the classical Indian intellectuals looked to the school as the authority pertaining to matters of detail connected with logic.

The theory of inference here is not a system of formal logic in the strict sense, and constants like *pakṣa*, *hetu* and *sādhya* employed in it are not concepts but things or properties. Yet it is formal in the sense that its central concern is 'what follows from what'. It takes both truth and validity into account and its format is a combination of deductive and inductive elements. Inference (*anumāna*) is resorted to for acquisition of knowledge, as also for demonstration of a known truth.

Etymologically, *anumāna* means knowledge which is based on or which follows previous knowledge. It is knowledge of an object on the basis of the knowledge of its mark, which is invariably associated with it. Inference (*anumāna*) as a method of knowing, therefore, stands for knowing an object on the basis of the knowledge of the mark which is known to be invariably associated with it. Thus, in inference (*anumāna*) an object is known through the medium of two sorts of knowledge which may be taken to be the premises.

Among the constituents of inference (*anumāna*) three terms and two relations are basic. The object of inferential inquiry, that which is to be inferred or proved, is known as *sādhya* (major term). The reason or the ground of inference is called *hetu*, *liṅga* or *sādhana* (middle term). That in respect of which the major term (*sādhya*) is inferred on the basis of the middle term (*hetu*) and which is a common locus of the two is called *pakṣa* (minor term). The relation between middle term (*hetu*) and major term (*sādhya*) is that of invariable concomitance, and it is known as *vyāpti* (pervasion). It is the logical ground and the very nerve of the process of inference (*anumāna*). The relation between middle term (*hetu*) and minor term (*pakṣa*) is known as *pakṣadharmatā*, which is the starting point of this process. Both *pakṣadharmatā*, i.e., the relation between middle and minor terms, and *vyāpti*, i.e., the relation between middle and major terms, may be said to be the premises. When the knowledge of *pakṣadharmatā* is characterized by the knowledge of *vyāpti*, the synthetic product, known as *parāmarśa*, becomes the actual complex of premises which alone entails the inferential conclusion. *Parāmarśa* is knowledge of the relation of middle and minor terms along with the knowledge of that middle term with the major term. There are two more complex terms which play a vital role in the inferential process. They are homologues (*sapakṣa*) and heterologues (*vipakṣa*), which stand for positive and negative trilateral relations involving minor term (*pakṣa*), middle term (*hetu*) and major term (*sādhya*). Homologue (*sapakṣa*) stands for a positive instance in which the major term (*sādhya*) is decisively proved to be present. The implicit idea here is that the major term (*sādhya*) is present along with the middle term (*hetu*) in a locus which is similar to the instance where the presence of the major term is intended to be proved on the basis of the presence of the middle term. Heterologue (*vipakṣa*) is that locus which is definitely known to be characterized by the absence of the major term (*sādhya*) and hence by implication that of the middle term (*hetu*) as well. In the process of inference (*anumāna*) the transition from the knowledge of the middle term (*liṅga* or *hetu*) to that of the major term (*sādhya*) is made possible on the ground of a universal relation of concomitance known as *vyāpti*. The Naiyāyikas have done a good deal of hairsplitting in discussing the nature of *vyāpti*. The relation between middle term (*hetu*) and major term (*sādhya*) is an invariable and unconditional one. In the language of Nyāya it is such a relation of coexistence of the middle term (*hetu*) and the major term (*sādhya*) that the major term (*sādhya*) is not a counter-entity to any absence abiding in the middle term (*hetu*). In other words, the middle term (*hetu*) can be present only in the presence of the major term (*sādhya*) and if the major term (*sādhya*) is absent, the middle term (*hetu*) must also be absent. Thus, the invariable relation (*vyāpti*) can be of two types - affirmative (*anvaya*) and negative (*vyatireka*). The invariable relation (*vyāpti*) can also be understood as a relation of pervasion, i.e., correlation between two terms/facts of which one is the pervader and the other the pervaded. A term or fact is said to pervade another when it always accompanies the other. In this extensional sense invariable relation (*vyāpti*) can be of equal or unequal extension, known as *samavyāpti* and *viśamavyāpti* respectively.

As regards the method of apprehending the invariable relations, the Naiyāyikas resort to uncontradicted uniform experience of concomitance. On the basis of observation, single or repeated, of uncontradicted agreement in presence and/or absence and by further verification of this uniformity by

an indirect method of *tarka*, i.e., *reductio ad absurdum*, invariable relation (*vyāpti*) is established.

Another important ground of inference (*anumāna*) is *pakṣatā*, which is the relation between middle and minor terms. It regulates the occurrence of the minor term (*pakṣa*). The minor term (*pakṣa*) is that about which something is inferred. Validity of inference (*anumāna*) depends on invariable relation (*vyāpti*), and its possibility depends on the relation between middle and minor terms (*pakṣatā*). The process of inference (*anumāna*) takes place when (1) there is absence of certainty and (2) there is a will to infer. The Naiyāyikās point out three possibilities which are conducive to inference (*anumāna*) and are known as *pakṣatā*. They are:

- (1) Absence of certainty and presence of will to infer. (This is the most conducive condition.)
- (2) Absence of both certainty and will to infer. (Some times one undertakes inference per force)
- (3) Presence of both certainty and will to infer. (This is for reconfirmations.)

One possibility prevents inference: presence of certainty and absence of will to infer. If there is certainty and there is no will to inference, the process of inference does not start.

The logical form of the process of inference (*anumāna*) consists of five steps, all of which are constituents of the same process. They are named as statement of thesis (*pratijñā*), reason (*hetu*), example (*udāharaṇa*), application (*upanaya*) and conclusion (*nigamana*). This can be illustrated as follows:

There is fire on the hill.

Because there is smoke there.

And because wherever there is smoke there is fire, as in a kitchen.

The hill is an example of this type.

Therefore, there is fire on the hill.

The entire process of inference (*anumāna*) centres around the middle term (*hetu*) on which depends its validity or invalidity. A proper or legitimate middle term (*hetu*) has to fulfil five conditions, the violation of which leads to fallacy. The five conditions are:

The middle term (*hetu*) must be present in the minor term (*pakṣa*) as its property.

The middle term (*hetu*) must be distributively related to the major term (*sādhya*).

The middle term (*hetu*) must be absent in all those cases where the major term (*sādhya*) is absent.

The middle term (*hetu*) must not be contradictory of the major term (*sādhya*).

The middle term (*hetu*) must not be contradicted by some other middle term (*hetu*).

Upamāna (Comparison)

The third method of knowing is named comparison (*upamāna*). It is knowledge through description based on knowing the relation between a word and its meaning coupled with actual observation of the referent. The process of comparison (*upamāna*) consists of four stages as follows:

Receiving of reliable information or description.

Observation of an object agreeing with the description.

Recollection of description.

Identification of the object as the one agreeing with the description.

Since the knowledge here is mainly based on comparison, the Naiyāyikas insist that one has to be very careful in the observation of similarity and dissimilarity because sometimes comparison may be misleading however accredited it may be. With the help of an example it can be illustrated as follow:

A child has not seen an elephant but has learnt about it through a description in a text book. When he visits a zoo he sees an elephant. Immediately he recalls the description he has in his mind. He compares the description with the elephant being seen by him in the zoo. At once he identifies the animal as elephant. This is knowledge by *upamāna*.

Śabda (Verbal Testimony)

The fourth and final mode of knowing is verbal testimony (*śabda*), which stands for language-generated knowledge. More particularly it is knowledge based on understanding the meaning of the statement or assertion of a trustworthy person. Language is a significant means of communication, but it is also a generator and repository of knowledge. The heritage of knowledge is handed down to posterity only through language.

In a sense all determinate and judgemental knowledge is language-embedded. The validity of language-generated knowledge depends upon the trustworthiness of the person or source from where communication is received. Its possibility depends on the rapport between speaker and hearer or writer and reader on the basis of a common linguistic framework. Exact communication, proper apprehension and correct interpretation are its presuppositions.

According to the Nyāya-Vaiśeṣika tradition word and not a sentence is the lowest unit of language. The essential nature of a word lies in its meaning, and its meaningfulness consists in its referential capacity. The meaning of a word is sometimes directly given and sometimes by implication. The relation between a word and its meaning is conventional and not natural. This accounts for varied usages of one word. As regards import, a word refers to an individual through a universal or as characterized by a universal.

In language-composition, which is basically sentence-formation, the sentential meaning is secondary and construed. There are four syntactical, semantic and pragmatic rules of sentence-formation and interpretation of its meaning. Though word is a basic unit of language, a word by itself cannot convey a complete meaning and must be brought into relation with other words in a sentence. Thus, words in a sentence should 'expect' or imply one another. This is technically known as expectancy (*ākāmkṣā*). Any incompatibility between the meanings of different words renders the whole sentence meaningless. So, mutual compatibility and meaning-yielding support is another condition, known as *yogyatā*. Proximity between different words of a sentence is the third condition, known as *sannidhi*. The last condition is due consideration of the meaning intended to be conveyed by a sentence, known as *tātparya*.

The other modes of knowing accepted in the schools of Vedānta and Pūrva Mīmāṃsā have been reduced to these four by the Naiyāyikas.

Note : For details please refer:

Nyaya theory of knowledge, S.C. Chatterjee, Calcutta University, 1965

Questions

1. Explain the nature of a cognition (*jñāna*) and knowledge (*pramā*).
Differentiate between the two according to the Nyāya school.
2. Point out the distinction between *karaṇa* and *kāraṇa*.
3. Discuss the role of *pramāṇa* in producing *Pramā*.
4. Explain the nature and significance of *prāmāṇya*.
5. Discuss the relation between *pramā* and *prāmāṇya*.
6. What is the nature and significance of *pratyakṣa*?
7. Explain the three terms and two relations involved in the process of *anumāna*.
8. Write short notes on *śabda* and *upamāna* as modes of knowing.

Unit 6

The Nature and Subject Matter of Logic

LOGIC: An Introduction

Logic essentially has to do with reasoning of a particular sort, viz., inference. It is, in general, concerned with reflective thinking that is a thinking process which consists of going from one or more stated reasons, evidences or premises to a stated conclusion. Since every rational inquiry depends on logic, so it is very important that we know what follows from what. The gamut of reasoning is very big which attracts both psychologists and logicians alike; while the former is interested in the actual reasoning processes the latter is only interested in the correctness of the completed processes. Thus, the aim of logic is to make explicit rules and methods by which correct inferences or good thinking be distinguished from the incorrect ones rather than to study actual reasoning processes.

Logic provides meaning to any intelligible human linguistic discourse. It imparts and assesses the element of rationality in any completed reasoning process. While imparting rationality it enhances our stock of knowledge whereas in assessing rationality in its own technical way, it shows the utility or futility of any discourse. It is the backbone of any scientific literature. It is both a science and an art. It is science in so far as it provides consistency to what one believes. If there is no consistency in what one believes, then the entire talk of logic falls flat and the basic purpose of language, viz., communication is defeated. Further, it shares two prominent features with science which are as follows:

- (i). It is an organized and systematic knowledge,
- (ii). Its laws are universally applicable.

It is an art because its worth lies in winning strategies in the game of arguments. Awareness of logical principles and techniques leads to good thinking which helps us to distinguish fact from fancy. Either way logic is much more than a learning experience. Thus, logic can decidedly be defined as 'the science of inference'.

Inference is a psychological process that goes on in mind. It consists of going from one or more stated reasons or premises (sensory-evidence) to a stated conclusion of some kind. The linguistic counterpart of any inferential process is called an argument. This shift from a mental process to a linguistic counterpart is essential because most of what we believe, we have inferred. We express our beliefs through statements which are the building blocks of arguments. Thus, every argument reflects the underlying inferential process. When the passage from premises to conclusion is justified, the argument is called valid. When the passage is not justified, the argument is called invalid or fallacious.

From the above it is clear that the logician's primary interest is with arguments. His task is twofold:

- (i) Finding criteria for distinguishing good from bad arguments, and
- (ii) Discovering techniques for constructing good arguments.

Types of Logic

An argument is a set of propositions out of which one is the conclusion which is inferred and the rest are premises. In other words, an argument is a set of propositions barring one which is regarded as its conclusion. The following are examples of arguments:

- (i) All birds are mammals and all sparrows are birds. So, all sparrows are mammals.
- (ii) All communists are opposed to private property. All socialists are opposed to private property. Therefore, all socialists are communists.

A question arises as to what is the connexion between the premises and the conclusion. The reply to this question is that there is an evidential connexion between the two. The premises provide evidential support or justification for the conclusion. It is for the logician to evaluate whether the given evidence supports the conclusion or not. It is on the basis of this intended evidential relationship that we divide logic into two types, viz., deductive and inductive.

Every argument necessarily has two features. It has (i) a structure and (ii) a content. These two features can be best understood from the following figures.

P1 Evidence
P2 Evidence
Pn Evidence

C: X is or is not the case.

(Fig - 1)

P1 Evidence
P2 Evidence
Pn - 1 Evidence

C: X may be or may not be the case.

(Fig - 2)

Figure 1 presents premises (P1 to Pn) as evidences leading to the conclusion as X is or X is not the case. Here, the evidential connection between premises and conclusion is based on necessity; thus the argument is deductive. In deductive argument the premises imply the conclusion. The deductive argument can be termed as valid or invalid when tested by various logical methods. Since deductive arguments are not concerned with the subject matter of the propositions which occur in it, they are not content-sensitive. They are actually those general moulds of thinking that are capable of generating infinite number of likewise arguments. That is to say, one valid argument-form is capable of generating innumerable likewise arguments. Validity as a logical virtue is preserved in all the subsequent

Note : P = Premise C = Conclusion

arguments. A valid deductive argument can never have true premises and a false conclusion; so it is truth preserving.

Figure 2 presents premises (P1 to Pn - 1) as evidences but leaving one instance out irrespective of the total evidential instances. Subtracting this single instance from the total number of instances makes the argument-form probable. Here, the evidential connexion between the premise and conclusion is based on probability; so the argument is inductive. It also shows the limitations of scientific laws which are widely confirmed workable hypotheses. These hypotheses, though open to revision, are always relative to the evidence. That is why scientific laws can never be absolute.

Finally, for our limited purposes we may say that in a deductive argument the premises are supposed to provide absolute guarantee for the conclusion, while in an inductive argument the premises are supposed to provide some degree of support for the conclusion. In deduction we ask for validity or invalidity of an argument whereas in induction 'probability' is all we can ask for. In deductive argument, the true premises lead to validity out of necessity. In inductive argument, there is always a 'logical gap' between the premises and the conclusion, making it probable even if all its premises are true. The use of both deduction and induction in science and ordinary life is essential and can by no means be underrated.

Sentence and Proposition :

A proposition is a sentence because like a sentence it is a meaningful arrangement of words. Every sentence, however, is not a proposition though every proposition is necessarily a sentence. A sentence is unit of language whereas a proposition is unit of logic. The sentence "Water is essential for living beings" is a proposition but the sentence "Get me a glass of water" is not a proposition. Sentences do not always carry truth values. There are sentences which are neither true nor false. For instance, "Close the door" is neither true nor false; it is because there is no belief or assertion in it. It is merely a request or an order to be obeyed. Similarly "What's the time?" is a request for the reply. Sentences such as interrogative, exclamatory, imperative, emotive are not propositions for we do not express judgments in them. Logic deals exclusively with propositions, and sciences both natural and social, also deal with propositions because they (sciences) deal with facts. Human knowledge is mainly constitutive of propositions.

Factual or informative sentences alone are propositions. Other types of sentences such as emotive, directive, interrogative, exclamatory and sentences giving commands and making requests are merely sentences; they are not propositions. A proposition carries truth value. It is believed to be true or false, and it is a description or assertion about facts. A proposition is true when it describes facts correctly and false when it states facts wrongly. The facts simply are, they cannot be said to be true or false. It is our belief in them which makes them true or false. We judge facts and give judgments. Proposition is an expression of these judgments.

In all arguments we make use of propositions which are said to be the building blocks of any argument. In logic 'proposition' and 'statement' are two terms which are used interchangeably. Proposition and statement are both sentences but all sentences are not propositions. A proposition alone is a unit of logical evaluation and not every sentence. In ordinary natural language we use sentences such as (i) Interrogatives- to ask questions, (ii) Imperatives- order someone to get things done, (iii) Exclamatory- to express feelings of wonder, fear etc. (iv) Declaratives- we assert or deny some particular state of affairs. It is only declarative sentences in the indicative mood which are called propositions or statements. For example, we have the following propositions:

- (i) Taj Mahal is made up of white marble. (Affirmative)
- (ii) Taj Mahal is not made up of white marble. (Negative)

Proposition has two prominent features which separate it from other sentences of language. They are as follows:

- (i) A sentence is always language-specific whereas a proposition is not. A sentence could be a sentence from Bengali, Hindi or English but what it expresses is not language-specific. A proposition transcends the linguistic boundary in which it is framed. A proposition belongs to all languages.
- (ii) A proposition alone is capable of assuming truth values. It can either be true or false. It cannot be both true and false at the same time otherwise it will lead to contradiction.

Truth and Validity :

The distinction between a sentence and a proposition is key to advance further in logic. Since propositions occur in arguments, does their truth or falsity make any difference to the validity or invalidity of the argument? While answering this question we must distinguish truth and validity.

The distinction between truth and validity is the fundamental distinction of formal logic. Truth is an empirical relation between the statement and what it asserts or denies about reality. Validity, on the other hand, is a logical relation between premises and conclusion. Some deductive arguments have a distinctive character which indicates that the premises are supposed to provide absolute guarantee for the conclusion. Such arguments are as follows:

1. A *syllogism*, in general, is an argument having exactly two premises and one conclusion. A *categorical syllogism* is a syllogism which makes use of propositions beginning with 'all', 'no', or 'some'.

For example :

Premise₁: All monarchs are dictators.

Premise₂: Some monarchs are great scholars.

Conclusion: Therefore, some great scholars are dictators.

2. *Hypothetical syllogism* is a syllogism having a conditional statement as one or both the premises.

For example:

Premise₁: If surplus food grain is not distributed in time, it will be destroyed.

Premise₂: Surplus food grain is not distributed in time.

Conclusion: Therefore, food grain will be destroyed.

3. *Disjunctive Syllogism* is a syllogism having a disjunctive statement as one of its premises.

For example:

Premise₁: Either John is going to the party or Mary is going to the party.

Premise₂: John is not going to the party.

Conclusion: Therefore, Mary is going to the party.

Besides these the connexion between the truth and validity is by no means a simple one. There are some generic rules through which this relationship can be best understood along with examples. It will also help us to ward off some likely misconceptions about these notions.

1. *True premises do not guarantee validity.*

Example 1: Cows are mammals.

Dogs are mammals.

Therefore, dogs are cows.

2. *A true conclusion does not guarantee validity.*

Example 2: Cars are mammals.

Tigers are mammals.

Therefore, tigers are cats.

3. *True premises and a true conclusion together do not guarantee validity.*

See Example 2.

4. *False premises do not guarantee invalidity.*

Example 3 : Birds are mammals.

Cats are birds.

Therefore, cats are mammals.

5. *A false conclusion does not guarantee invalidity.*

Example 4: Cats are birds.

 Dogs are cats,

 Therefore, dogs are birds.

6. *False premises and a false conclusion together do not guarantee invalidity.*

See example 4.

Thus, while the truth of proposition and the validity of reasoning are distinct, the relationship between them is not entirely straight forward. When an argument has true premises and a false conclusion, it must be invalid. This is how we define invalidity. Although we can speak of valid and invalid arguments and argument-forms, it makes no sense to speak of valid or invalid statements. Nor does it make sense to call an argument as true or false. Validity and invalidity are properties of arguments; truth and falsity are properties of statements. Again, we should not be misled by true premises or true conclusion to suppose that that an argument is valid. Nor should we be misled by false premises or false conclusion to suppose that it is invalid. As a matter of fact, truth and validity are combined in the concept of soundness. An argument is sound if all its premises and conclusion are true, and its reasoning is valid; all others are unsound.

Logical Form

A question arises as to how we can be sure that in valid argument there could be no possible way for premises to be true and conclusion to be false. How can we possibly prove such a thing?

The answer to this question lies in the concept of form, pattern, or structure. To say that an argument could not possibly have true premises and a false conclusion is simply to say that it has a certain kind of form which does not admit of instances of such kind. It is the form of an argument, then, which determines its logical validity. Whether an argument is valid or invalid is determined entirely by its form. Let us examine the following example:

P1. All men are mortal.

P2. Socrates is man.

C: Therefore, Socrates is mortal.

What makes the above argument a valid argument has nothing to do with, Socrates, men or mortality. Rather each sentence in the argument exhibits a pattern , a logical form, which guarantees the truth of the conclusion given the truth of premises. More generally, the logical form of a sentence of natural language is what determines both its logical properties and its logical relations to other sentences. The logical form of a sentence of natural language is typically represented in a theory of logical form by well

formed formula in a logically pure language. In this language all meaningful symbols are expressions with fixed and distinct logical meaning. The arguments' validity is explained by the fact that premises formally entail (implies) the logical form of conclusion. Thus, the primary function of a theory of logical form is to explain a broad range of logical phenomena in terms of logical forms which it essentially assigns to sentences of natural language.

Use and application of Logic

Logic lies at the foundations of our life and is the foundation to every educational curriculum. But unfortunately its study is not included in most of the modern curricula. Money making skills and social skills have taken precedence over right thinking skills. This deviation in thinking has reached at such a sad state of affairs where the new generation refuses to think about others plight. They have become self-centred and insensitive towards the environment in which they live. Avoidance of logic has led to tragic consequences. Wrong political decisions are taken which affect millions of people. A criminal procedure system, which favours criminals rather than victims, has come up. This is the price society is paying for promoting the wrong notion that logic has something to do with mathematics and rest of us can reason in any way we like.

Logic, as we have learned, is the study of methods and principles used to distinguish correct from incorrect reasoning, so that we can refrain from making incorrect inferences. This, however, does not mean that those who have never studied logic cannot make correct inferences and arguments. Men had thought and argued generations before logic was discovered as a science and even today those who are ignorant of the rules of logic also reason and at times reason well. The only advantage of studying logic is that it makes somewhat easier to draw correct conclusions and avoid those linguistic traps which are pits of errors and bad reasoning. Just as a trained tennis player is better than an untrained one and is less likely to make mistakes, similarly, a good familiarity with logic helps us see the goodness or the badness in an argument. Lastly, its practical value cannot be overlooked. The study of logic provides certain techniques for putting to test the correctness or validity of all arguments. This is valuable because once errors are detected, they can easily be avoided.

Logic is one of the pillar stones on which mathematics rests, the other two being the set theory and the number theory. Mathematics deduces conclusions from self-evident truths or axioms and deduces further other conclusions from these. This brings order to the complicated abstractions of mathematics. Quantifiable sciences like physics, chemistry and engineering use deductive methods to draw definite conclusions from their axioms. Qualitative sciences like biology, physiology, medicine and also the social sciences like economics, sociology and psychology use logic by observing particular facts, comparing and classifying them and then seek to explain them by general laws. They adopt the inductive methods and their conclusions are more or less probable. Thus, all the sciences apply logic to their methods of investigations.

The enormous success of computers in recent times owes a lot to logic. The growth and development of computers is largely due to logic. The complex electronic circuits are designed to work primarily on binary (two-valued) logic. The relationship between computer architecture and logic is best seen in a new branch of logic called 'computational logic'. Further, a new three valued logic, viz., Fuzzy logic has given a new direction to the present technology regarding controls. It is used for developing sophisticated control systems. Fuzzy logic addresses control applications perfectly as it resembles human decisions with an ability to generate precise solutions from certain or approximate information. For example, let's take a fuzzy washing machine. A load of cloths in it and we press start button; now the machine churns automatically choosing the best cycle for washing. There are other kinds of logic which are very popular such as (i) Modal logic which is designed to express the logical structure of statements that contain modal terms like 'possible', 'necessary' and their variants. (ii) Temporal logic connected with the notions of time, (iii) Deontic logic is an attempt made to extend the arena of logic to certain kinds of reasoning in ethics. It deals with the ethical notions of permission, obligation and the like. Several deontic systems were developed but Nicholas Rescher's system is the most popular amongst all. (iv) Epistemic logic is an attempt to extend resonating to discourses which are connected with the notions of 'knowledge' and 'belief'. These are all specialized branches analysing different types of discourses which are beyond the scope of this book. Today logic is sited at the intersection of philosophy, mathematics, linguistics and computer science as it deals with the structure of reasoning and the formal features of information. Regardless of advances in its allied areas, logic thrives. Its techniques are applied to many different domains of reasoning, and its connections with linguistics and computer science have strengthened the discipline and brought it new applications.

Questions

1. Differentiate proposition from sentence. Give suitable examples in support of your answer.
2. Highlight the importance of logical form in evaluating arguments in logic.
3. Explain the difference between truth and validity.
4. Can a valid argument have false conclusion? If yes, how? Give reasons.
5. All true premises and a false conclusion always make a deductive argument invalid, Discuss.
6. Explain the relation between logic and mathematics.
7. Write a note on the advantages of studying logic.
8. What do you understand by inference? Differentiate deductive inference from inductive inference.
9. Name different types of logic besides the traditional Aristotelian logic.
10. Can the study of logic help in improving human society? Discuss.

Unit 7.1

Terms and Propositions

Nature of propositions

A proposition is a unit of reasoning or logical thinking. Both premises and conclusion of reasoning are propositions. Since propositions are so important, we must know what a proposition is? A proposition is that which is believed to be true or false or doubtful. It is a unit of logical thinking in the sense that it is asserted and expressed in the form of proposition. For example "All men are mortal", "No child is a voter", "Some cats are black", "Ram is a student of this school" etc.

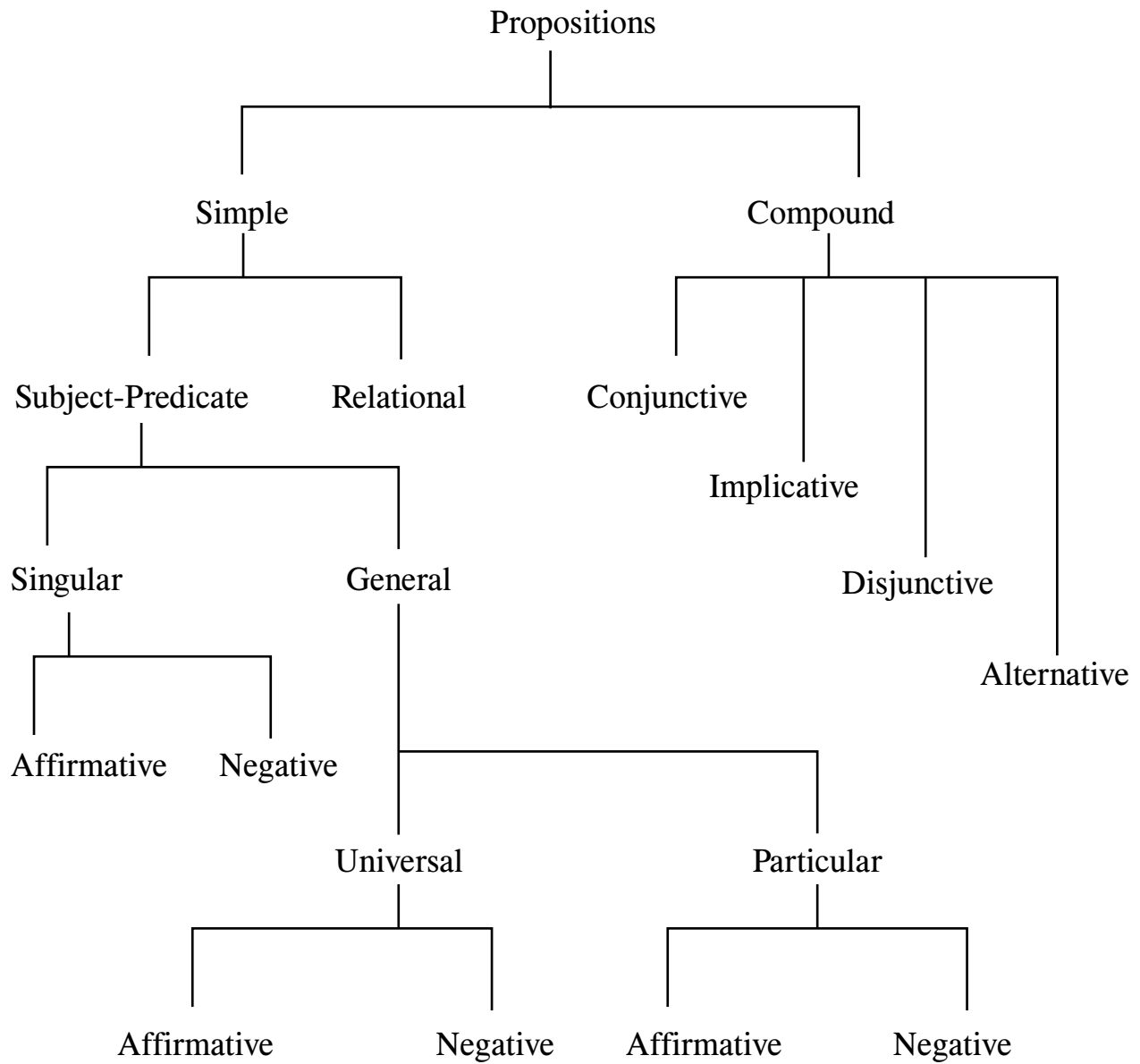
Types of proposition

From the view point of composition and construction propositions are either simple or compound. A simple proposition is a simple sentence having one verb whereas a compound proposition is a combination of two individual propositions. "New Delhi is the capital of India", "Two plus two make four", "Mrs. Indira Gandhi was mother of Rajiv Gandhi", "All voters are citizens" are simple propositions. Compound propositions have at least two simple propositions as components. "Mohan is a student and he is intelligent", "Either it rains, or we shall go for picnic", "If I get ticket, then I will go to see the match".

Classification of propositions

Propositions are classified in many ways. Let us take three classifications. The first classification is general classification of propositions which is based on the composition of propositions. The second classification is the traditional classification of propositions. The third classification is the one accepted by modern logicians.

I. General classification of propositions



(Table - 1)

Types of simple proposition

(i) Subject-Predicate Form:

There are three constituents in subject-predicate form of propositions, viz., subject term, predicate term and a copula. Subject of a proposition is that about which something is said. Predicate of a proposition states something about the subject. Between the subject term and the predicate term of every simple proposition occurs some form of the verb 'to be'. The verb 'to be' serves to connect the subject and the predicate term and is called 'copula'.

Copula is an essential part of every simple proposition. It is the joining link between the subject and the predicate. A proposition is the result of the combination of the subject term with the predicate term. If there is no copula, there is no connecting link between these two terms and consequently there is no proposition. Copula, however, is not a term. In the well-formed proposition copula is put in present tense.

(ii) Singular propositions:

Singular proposition has one definite person or thing or object as a subject. For instance, "Ram is a student of this school", "New Delhi is the capital of India", etc. A singular proposition is affirmative when predicate is assigned to subject. For instance, "Manmohan Singh is the Prime Minister of India". A singular proposition is negative when predicate is denied to subject. For instance, "Bombay is not the capital of India".

(iii) General (class membership) propositions:

The subject of a general proposition indicates a class of objects, persons or events. The terms like 'all' and 'some' designate quantity of subject term and thus are called quantifiers. Quantifiers indicate as to how the subject term is wholly or partially connected to the predicate. For instance, "Some cats are black" indicates that some members of a class 'cat' are 'black.' Whereas in the proposition "All cats are mammals" the quantifier refers to all the members of the subject class 'cat'. The former proposition is particular the latter is universal. Particular proposition is of two types, affirmative and negative. Similarly, universal proposition is of two types, affirmative and negative.

Relational propositions :

Relational propositions, though may be simple, yet there are different from subject - predicate form of propositions. Relational propositions highlight relation between two or among more objects, things, or persons. For instance, "Mrs Indira Gandhi was mother of Rajiv Gandhi". Here relation of mother and son is stated. "Ram told about Sohan to his teacher", highlights relationship among three persons. Relations that hold between two individuals are called 'binary' or 'dyadic' relations. Relations that hold

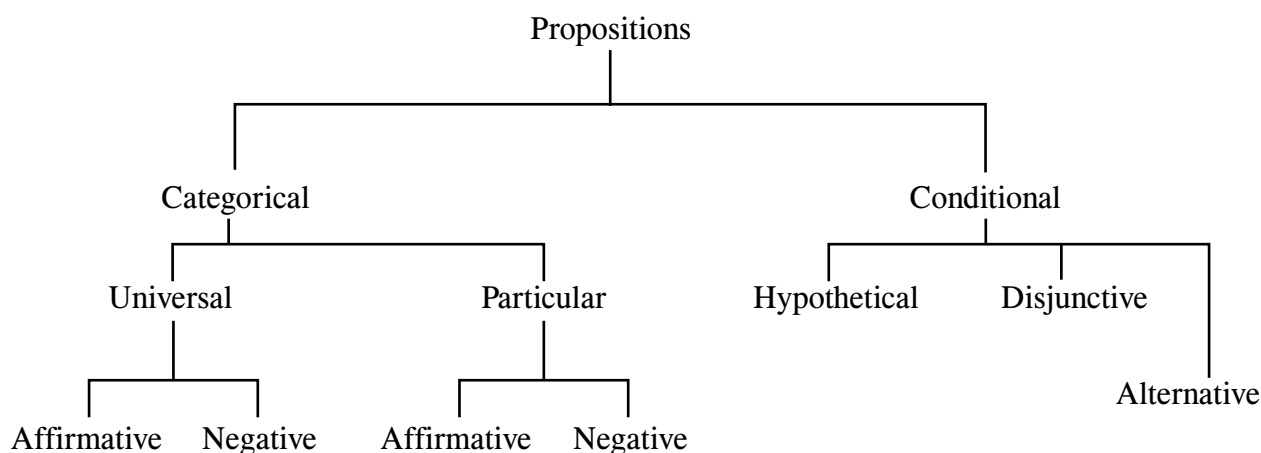
among three individuals or things are called 'triadic relations'. Tetradic relations are expressed by the four elements or things. For instance, "Ram sold his cow to Sohan for a handful of rupees".

Compound propositions:

A compound proposition is constituted of at least two simple propositions. When two simple propositions are joined by 'and', it is called a conjunctive proposition. For instance, "Ram is a student and Mohan is a player." In implicative proposition two simple propositions are joined by 'if, then' relation. For example, "If I get ticket, then I will go to see movie". In disjunctive proposition two simple propositions are joined by 'either, or' relation. For instance, "Either I will take ice cream or I will take chocolate". The alternative compound propositions are also joined by 'either, or' relation. For instance, "Either I will drink tea or I will take coffee". There is, however, difference between disjunctive and alternative propositions. A disjunctive proposition is 'inclusive' sense of 'either, or'. This sense of 'either, or' includes the possibility of both the options such as one may take both ice cream and chocolate at the same time. The 'exclusive' sense of 'either, or' suggests a meaning according to which it is simply 'not both'. Alternative proposition is the exclusive sense of 'either, or'. The example cited above states that either a person will take tea or he will take coffee but not both at the same time. Alternative sense of 'either, or' thus excludes the possibility of both.

II. Traditional Classification of propositions

Aristotle (who had given logic a status of science) and other traditional logicians classified propositions as categorical and conditional. A categorical proposition is stated or asserted unconditionally and a conditional proposition is stated or asserted on certain conditions.



(Table-2)

Categorical propositions:

Categorical propositions are stated without any condition. Here, the predicate is either asserted or denied to the subject without any condition. For instance, "All voters are citizens", "This table is round", "Some students of this college are not Indians" are categorical propositions. For the traditional logicians all simple, singular and unconditional propositions are categorical propositions. They have only one form that is subject - predicate form. A subject-predicate form of a categorical proposition has three constituents, subject term, predicate term and a copula. Besides, the categorical propositions in the traditional classification of propositions have two important elements also, quantity and quality.

Quantity

Quantity refers to the number of members in the class represented by the subject term of a proposition. It may refer to all the members of a class or to some of the members of a class. There are two types of quantities, universal and particular. Subject of a universal proposition indicates unrestricted generalization, and subject of a particular proposition indicates only restricted generalization. For instance, in the proposition, "All men are mortal", the subject term 'men' denotes the entire class of 'man' and the quantity of the proposition is universal. In the proposition "No egg is red", again, the quantity is universal. Here the entire class of eggs is excluded from the entire class of red things. However, when the subject of a proposition indicates only part of a class, the quantity of the proposition is particular. For instance, in the proposition "Some cats are black", the quantity is particular and similarly, in the proposition, "Some roses are not red things", the quantity is particular.

Quality

Quality of a proposition indicates whether a proposition is affirmative or negative. There are two qualities which a proposition can have; affirmative or negative. If a predicate is assigned to subject then quality of the proposition is affirmative. For instance, in the proposition, "All roses are beautiful", the predicate 'beautiful' is assigned to the subject 'roses'. If a predicate is denied to the subject then quality of the proposition is negative. For instance, in the proposition "Some students are not voters" predicate being 'voter' is denied to the subject 'students'. However, a negative term like 'immortal', 'unwise' etc. does not make a proposition negative. It is negative copula which makes a proposition negative. For example, "Some men are illiterate", is an affirmative proposition with a negative predicate whereas "Some men are not literate", is a negative proposition.

Quantity and Quality together give four types of categorical proposition :

1. Universal affirmative----- A
2. Universal negative----- E

3. Particular affirmative----- I

4. Particular negative----- O

In A proposition, "All voters are citizens", quantity is universal and quality is affirmative. In E proposition, "No lion is black", quantity is universal and quality is negative. In I proposition, "Some students are Indian", quantity is particular and quality is affirmative. And in O proposition, "Some Indians are not vegetarians", quantity is particular while the quality is negative.

In the traditional classification of propositions singular propositions are included under universal propositions. In a singular proposition subject is either a proper noun or refers to specific person or object. For example, "Sachin Tendulkar is a good cricketer", "This is a girl's college", "New Delhi is the capital of India" are few instances of singular propositions. No independent status is given to such propositions by the traditional logicians. They are bracketed with universal propositions. "Sachin Tendulkar is a good cricketer" is universal affirmative proposition whereas "Sachin Tendulkar is not a mathematician" is universal negative proposition. This was, however, challenged and criticized by the modern logicians. For them propositions are divided into three categories, singular, categorical and conditional. Why were the singular propositions treated as universal proposition by the classical thinkers? It is because in spite of the fact that the subject term of the singular proposition is a 'specific individual or object', it represents a class, a unit class (one member class). There is only one member in the class referred by the subject 'Sachin' in the proposition "Sachin is a good cricketer". Since the predicate in this proposition is assigned to that very one member of the class, it becomes A proposition. "Sachin Tendulkar is not a mathematician" is E proposition for the similar reason.

The logical form of a categorical proposition in the traditional logic is as follows:

1. Universal affirmative - All S is P - "All cats are mammals", A type proposition.
2. Universal negative - No S is P "No child is a voter", E type proposition.
3. Particular affirmative - Some S is P - "Some students are voters", I type proposition.
4. Particular negative - Some S is not P - "Some roses are not red", O type proposition.

In our day to day life, however, our arguments do not always contain propositions which are in clear and neat logical form. In sciences also universal or particular statements are not in the logical form. But for the logicians the validity of arguments needs the premises and the conclusion (which are also propositions) to be in the standard logical form.

This aim, nevertheless, can be achieved by reducing the non-standard form sentences into logical form of A, E, I, O. In this process the meaning of the propositions should not be lost. In fact the meaning of the proposition is the guide to tell us which type of proposition it is. For instance "Every voter is

citizen" means "All voters are citizens". Similarly, the sentence "Many students of this class are bright children" is "Some students of this class are bright children". "A few politicians are statesmen" is "Some politicians are statesmen" and it is I proposition.

Conditional propositions

A conditional proposition is that in which a predicate is assigned or denied to the subject on certain conditions. For instance, "If it rains in time, then crops will be good", "Sita will not go unless she is invited", "Either I will go to see the match or sit in the coffee house", "If Sohan is graduate, then he is eligible for this post." etc.

Questions

1. Which of the following sentences are propositions?
 - a. God bless us all.
 - b. A mango is fruit.
 - c. It is very hot today.
 - d. Oh! What a beautiful rainbow.
 - e. You should respect your parents.
 - f. No men are perfect.
 - g. Tell me who is the father of nation (India).
 - h. Some students are both intelligent and hardworking.
 - i. Please pass me a spoon.
 - j. Sit down.
2. State in each case the logical form (A, E, I, O) of the propositions:
 - a. All students of this class are healthy children.
 - b. Some roses are red things.
 - c. No fish is mammal.
 - d. Some writers are not scholars.
 - e. All men are mortal.

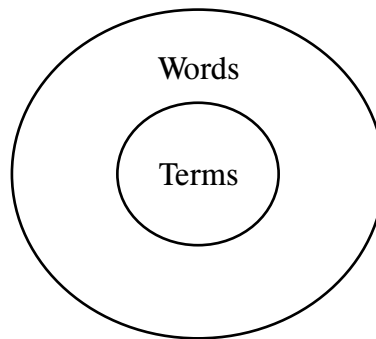
- f. Some women are literate.
 - g. No circle is square.
 - h. Some men are six feet tall.
 - i. Some fruits are not sweet.
 - j. All snakes are reptiles.
-
- 3. Explain traditional classification of propositions.
 - 4. Give an account of quantity and quality of categorical propositions.
 - 5. From the viewpoint of composition and construction categorical propositions are either simple or compound. Illustrate and explain.
 - 6. Explain the nature of singular propositions.
 - 7. Explain with examples relational propositions.
 - 8. Give a brief account of general classification of propositions.
 - 9. Discuss nature and types of conditional propositions with the help of examples.
 - 10. Differentiate General and Traditional classification of propositions.

Unit 7.2

Terms

What is a Term?

A term is a word or group of words which is either a subject or a predicate of a proposition. If a word or a group of words is neither a subject nor a predicate of a proposition, then it is not a term. In the proposition, "All logicians are mathematicians", 'logicians' and 'mathematicians' are terms but 'all' and 'are' are not terms. For they can neither be subject nor predicate of the proposition. Thus, whereas all terms are words, all words are not terms. This is because all terms are classes for the traditional thinkers.



(Table - 1)

A term is a word or group of words which has the following characteristics:

- i. it is either a subject or a predicate of a proposition, and
- ii. it must have a definite meaning of its own.

The word 'term' comes from the Latin word terminus, a limit or boundary. Terms limit the movement of the thought. Proposition is a unit of reasoning and terms are its constituents. In each categorical proposition (A, E, I, O) there are two terms, a subject and a predicate.

Two important aspects of a term are:

1. Denotation and Connotation
2. Distribution

Denotation and Connotation

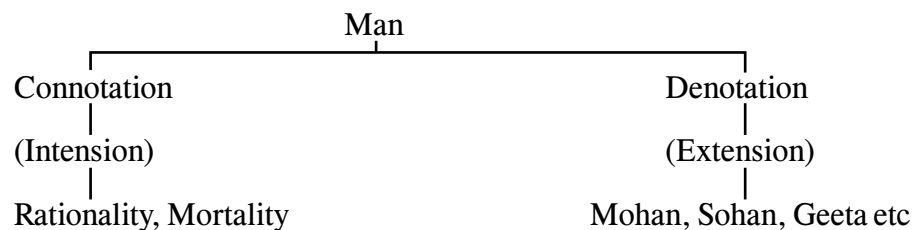
The aim of logicians is to differentiate good reasoning from bad, and since arguments are expressed through language, our use of language should be correct. The wrong use of language while making

reasoning will make it only fallacious. In order that our reasoning remains straight and correct the meaning of the terms used in the reasoning should also be absolutely clear. The terms whose meaning is not clear or is partially known must not be used in the arguments. The logicians have suggested two different techniques, viz., denotation and connotation for knowing the meanings of terms.

Denotation of a term consists of the thing or object to which it applies and its connotation consists of the attributes which it implies. So a term denotes class membership and it connotes essential attributes. The term 'man' denotes all human beings to which it is applicable, that is, Ram, Sohan, Sita, Meera and in fact all of us. Rationality and mortality are essential attributes possessed by all men. Nothing can be called a man, if it does not possess these two characteristics and anything possessing these two characteristics must be called a man.

A term in a categorical proposition represents a class. A class is a collection of all objects that have some specified characteristics in common. The meaning of a class (i.e., a term) can be known in two ways. Firstly, by the members belonging to that particular class; and secondly, by knowing all the essential qualities possessed by the members of that class. For example, in the class of 'man' we refer to all 'human beings' as members, and 'rationality' and 'mortality' as the essential characteristics possessed by them.

The connotation of a term is the characteristic or set of characteristics which are such that these characteristics determine the object(s) to which the term intends and which are therefore sufficient to distinguish that object(s) from other objects. The denotation of a term refers to the extension to which it can be referred. The connotation, on the other hand, refers to the intension which a term intends. The extension of a term is given by specifying the class members what the term denotes (the objects, the things, it refers to). The intension of a term is specified by listing the characteristics, properties, that the term connotes. For example, to specify the extension and intension of the term 'man' you might provide the following illustration:



(Table - 2)

The characteristics or qualities referred by the term do not always refer to all qualities, essential or accidental. Connotation indicates only essential qualities. For example, the essential characteristics of term 'man' are only 'rationality' and 'mortality'. Essential characteristics are those bare minimum qualities without which the existence of a thing, person or an object is not possible. The accidental characteristics of 'man' are many like a man has two hands, two legs, two ears etc. There are men who do not have hand or leg. Man can exist without these accidental characteristics. But we will not call living being a man if he is immortal or if he is irrational. Rationality differentiates a man from 'animals', 'mortality' differentiates a 'man' from 'super human beings'.

Not all terms, however, have both denotation and connotation. Only the general terms (which are classes) have both connotation and denotation. The proper names like Ram, Sita, Mohan etc. do not have proper connotation. 'Ram' for example can refer to the student of standard X in the Y school or it can refer to a boy working in a factory or to a mythical character of Ramayana. The imaginary objects also do not have proper denotation. For example, 'centaur' has no reference, and thus has no extension. At the same time there are things which can be only known through extension and not through intension. For example, we can know the colors, red, yellow etc. only by looking at them. A blind man can never know the colours by stating or describing their characteristics. It is also true that children learn meanings of terms quickly and correctly by looking at the objects and things. From the view point of logicians, however, connotation of a term is more basic and fundamental than denotation. There are classes which are empty like class of the 'square round objects'. Neither any example of this class is there nor can it be found. Yet the class is meaningful because of its connotation.

Relation between Connotation and Denotation

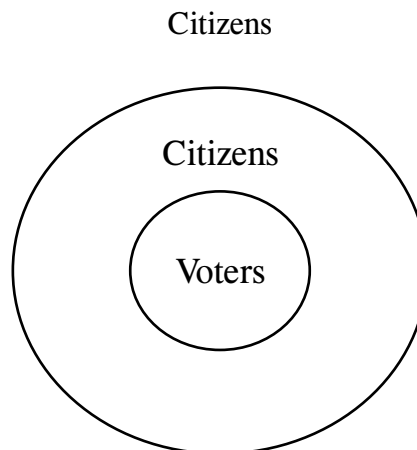
Connotation and denotation are related to each other by inverse variable relation. This means if connotation increases denotation decreases. Similarly, if connotation decreases, then denotation increases. More qualities in a class means less members who possess them. For instance, suppose there is class of 'automobiles', then all the vehicles are its members. The class of 'four wheeler automobiles' has lesser members than the previous class. The class of 'Indian made four wheeler automobiles' will have even lesser members. Further, the class of 'Indian made four wheeler heavy vehicle automobiles' will have still lesser members. This way increase in number of qualities will reduce the number of members.

However, increase and decrease of denotation (members of class) does not guarantee decrease or increase in connotation. For instance, with the increase of human population the connotation of the term 'man' like 'mortality' and 'rationality' does not decrease. But certainly both denotation and connotation do not increase or decrease together. Out of these two it is connotation and not denotation which is more fundamental and it determines the denotation very satisfactorily.

Distribution of terms

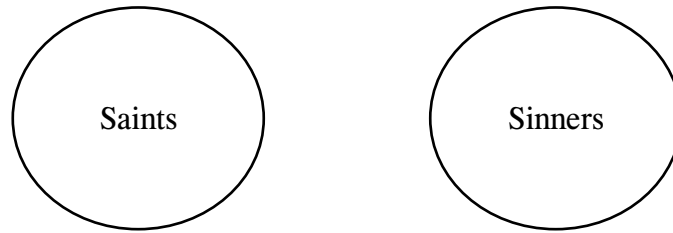
A term is said to be distributed if it refers to all the members of its class. For example, in the proposition, "All men are mortal", the term 'man' is distributed for it refers to all the members of the class man. Likewise, in the proposition, "No men are immortal" the term 'men' is distributed for it excludes 'all men' from the class of 'immortal'. If, on the other hand, a term refers to some or few members of a class, then it is called undistributed term. In the proposition, "Some men are tall", the term 'man' is undistributed for it refers to only some members of the class 'men'. In other words, a term is distributed when it includes or excludes all the members of a class, and if a term includes or excludes only some members of a class, then it is undistributed.

In a universal affirmative A proposition, "All S is P", subject term 'S' is always distributed but predicate term 'P' is undistributed. In the proposition "All voters are citizens", the term 'voters' refers to 'all voters' but the predicate term 'citizens' does not refer to all citizens (it refers to only some citizens, that is, only those citizens who are voters), hence it is undistributed. Look at the following diagram: here a class is represented by a diagram



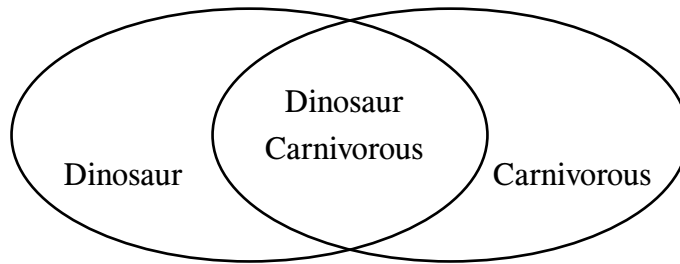
(Table - 3)

In a universal negative E proposition, "No S is P", both subject and predicate terms are distributed. In the proposition, "No saints are sinners", all members of the class 'sinners' are excluded from all members of the class of 'saints'. Hence both subject and predicate terms are distributed in E proposition.



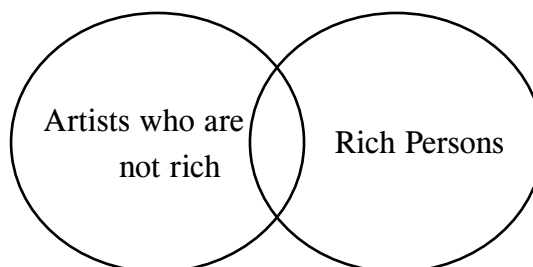
(Table - 4)

In a particular affirmative I proposition, "Some S is P", none of the terms is distributed. In the proposition, "Some dinosaurs are carnivorous", the subject term 'dinosaurs' is undistributed. The predicate term 'carnivorous' also does not refer to all the members of the class of the carnivorous animals (there are carnivorous animals who are not dinosaurs). Thus, both subject and predicate terms are undistributed in I proposition.



(Table - 5)

In a particular negative, O proposition, "Some S is not P", subject term is undistributed but predicate term is distributed. "Some artists are not rich persons" distributes its predicate term 'rich persons' but not the subject term 'artists'. The subject term 'artists' here refers only to some artists, so the subject term in O proposition is undistributed but the predicate term 'rich persons' is distributed. According to this proposition the entire class of 'rich persons' is excluded from the class of some 'artists'. Hence, the predicate term is distributed in the O proposition.



(Table - 6)

The position of terms (as distributed or undistributed) in the four categorical propositions A, E, I, O is as follows:

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

(Table-7)

The quantity of a proposition determines whether a subject term is distributed or not. If quantity of the proposition is universal as in A and E propositions, then subject term is distributed. If quantity of the proposition is particular as in I and O proposition, then the subject term is undistributed.

Quantity of a proposition :

Universal	Subject term distributed
Particular	Subject term undistributed

To determine whether predicate term is distributed or not, one looks to the quality of a proposition. In affirmative propositions A and I predicate term is always undistributed, whereas in negative propositions E and O predicate term is always distributed.

Quality of a proposition :

Affirmative	Predicate term undistributed
Negative	Predicate term distributed

Distribution of terms partially determines validity / invalidity of syllogistic arguments.

Questions

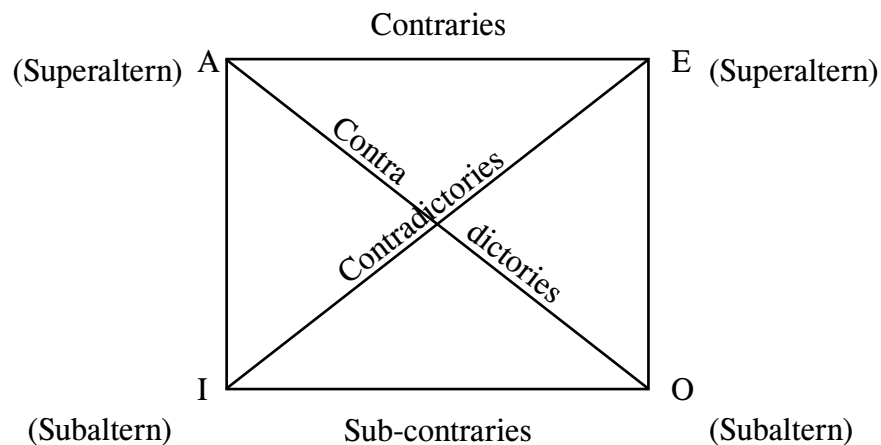
1. Determine distributed and undistributed terms in the following propositions:
 - a. All computers are helpful devices.
 - b. No bats are vegetarians.
 - c. Some movies are comedies.
 - d. Some cars are not expensive things.
 - e. No politicians are honest persons.
 - f. Some auto mechanics are trustworthy people.
 - g. Some football players are not tall persons.
 - h. All cats are mammals.
 - i. Some politicians are not socialists.
 - j. No soldier is coward person.
2. Explain the notion of a term. Is every term a word? Or is every word a term? Support your answer with suitable examples.
3. Explain distribution of terms. Which terms are distributed in four types of categorical propositions? Give examples.
4. Quality of a proposition determines whether the predicate term of the proposition is distributed or not. Do you agree? If yes, explain.
5. Quantity of a proposition determines whether subject term of the proposition is distributed or not. Do you agree? If yes, explain.
6. Explain denotation and connotation of term by giving suitable examples.
7. Explain and illustrate relation between connotation and denotation of terms.
8. Terms which represent proper names do not have proper connotation. Explain citing examples.

Unit 7.3

Square of Opposition

What is opposition of propositions?

Four categorical propositions A, E, I and O are related and at the same time different from each other. The relation among them is explained by a diagram called the "Square of Opposition". A, E, I and O propositions differ from one another to which the traditional logicians have given a name of 'opposition'. The following diagram shows that opposition:



Two categorical propositions are said to be opposite if they differ in:

1. Quantity
2. Quality
3. Both Quantity and Quality

The pair of AI and EO differs in quantity but not in quality. AI has same quality; both are affirmative but A is universal and I is particular. Similarly EO have same quality; both are negative but E is universal and O is particular. AE and IO differ in quality. Both AE are universal in quantity but A is affirmative and E is negative. Similarly both IO are particular; they have same quantity but I is affirmative and O is negative. The pairs AO and EI, however, differ both in quality and quantity.

Contrary propositions :

Universal affirmative A proposition, "All S is P" and universal negative E proposition, "No S is P" are related to each other by the contrary relation. The proposition "All basket ball players are tall" is contrary to "No basket ball players are tall". Similarly, "No lion is black" is contrary to "All lions are black".

Sub-contrary propositions :

Particular affirmative I proposition, "Some politicians are well read scholars" is related to O proposition, "Some politicians are not well read scholars" by sub-contrary relation. Similarly O proposition, "Some animals are not carnivorous" is related to I proposition, "Some animals are carnivorous" by sub-contrary relation.

Subaltern and superaltern propositions :

Universal affirmative A proposition, "All army generals are soldiers" is superaltern to I proposition, "Some army generals are soldiers". Similarly, E proposition, "No fish is mammal" is superaltern to O proposition, "Some fish are not mammals". But I is related to A by subaltern and similarly O is related to E by subaltern. "Some cats are mammals" is subaltern to "All cats are mammals." Similarly, "Some roses are not red things." is subaltern to "No roses are red things."

Contradictory propositions :

The universal affirmative A proposition, "All S is P" is related to particular negative O proposition, "Some S is not P" by contradictory relation. The contradictory of "All men are mortal" is "Some men are not mortal" and vice versa. The contradictory of E proposition, "No egg is red" is I proposition, "Some eggs are red".

1. "All S is P" is contrary to "No S is P" and vice versa.
2. "Some S is P" is sub-contrary to "Some S is not P" and vice versa.
3. (i) "All S is P" is contradictory to "Some S is not P" and vice versa.
(ii) "No S is P" is contradictory to "Some S is P" and vice versa.
4. (i) "Some S is P" is subaltern to "All S is P".
(ii) "Some S is not P" is subaltern to "No S is P".
5. (i) "All S is P" is superaltern to "Some S is P".
(ii) "No S is P" is superaltern to "Some S is not P".

Each opposite relation has certain characteristics

Contrary proposition A and E cannot be both true together though they both can be false at the same time. If one of the contrary propositions is true, then the other contrary proposition is false. But if one of the contrary propositions is false then the other contrary proposition is undetermined (it can be true or it can be false also). If "All politicians are honest" is false, then "No politician is honest" can be false, or, it can be true also.

Sub-contrary propositions I and O cannot both be false together though they both can be true together. If I is true, O is undetermined; whereas if I proposition is false, O is necessarily true. Similarly, if O is true, I is undetermined but if O is false, I is definitely true.

Subaltern relationship shows if A is true, then I is necessarily true, but if I is true, A remains undetermined. Same is the case with E and O. If E proposition "No S is P" is true, then O proposition "Some S is not P" is also true but not the other way round.

Contradictory relation between A and O, and also between E and I is of strict opposition. If A is true, O is false; if O is true, A is false. Similarly, if E is true, I is false and if I is true, E is false.

(i) If A proposition is given as true, then it implies :

E proposition is false

I proposition is true

O proposition is false

(ii) If A proposition is given as false, then it implies:

E proposition is undetermined (can be true or can be false also)

I proposition is undetermined (can be true or can be false also)

O proposition is true

(iii) If E proposition is given as true, then it implies:

A proposition is false

I proposition is false

O proposition is true

(iv) If E proposition is given as false, then it implies:

A proposition is undetermined (can be true or can be false also)

I proposition is true

O proposition is undetermined (can be true or can be false also)

(v) If I proposition is given as true, then it implies:

A proposition is undetermined (can be true or can be false also)

E proposition is false

O proposition is undetermined (can be true or can be false also)

(vi) If I proposition is given as false, then it implies :

A proposition is false

E proposition is true

O proposition is true

(vii) If O proposition is given as true, then it implies:

A proposition is false

E proposition is undetermined (can be true or can be false also)

I proposition is undetermined (can be true or can be false also)

(viii) If O proposition is given as false, then it implies:

A proposition is true

E proposition is false

I proposition is true

In "Square of Opposition", one important point should be noticed, that is, in order to find out the opposite relations from a given proposition, the subject and the predicate of both the given and the inferred propositions should remain the same, as shown in the following examples:

Example 1: Contrary, contradictory and subaltern of A proposition: "All children are innocent beings" are as follows :

Contrary "No child is innocent being" (E)

Contradictory "Some children are not innocent beings" (O)

Subaltern "Some children are innocent beings" (I)

Example 2: If "Some athletes are healthy persons" (I) is true, then it can be inferred about its opposites as follows :

Sub-contrary "Some athletes are not healthy persons" (O) is undetermined.

Contradictory "No athletes are healthy persons" (E) is false.

Superaltern "All athletes are healthy persons" (A) is undetermined.

Questions

1. Find contrary / sub-contrary, contradictory and subaltern / superaltern of the following propositions:
 - a. All old men are wise.
 - b. Some physicians are humanitarians.
 - c. Some rich persons are not happy persons.
 - d. No military men are expert in social legislation.
2. If "No lion is black" is true, then what can be said about the truth/falsity of its opposite propositions?
3. If "All scientists are women" is false, then what can be said about the truth/falsity of its opposite propositions?
4. If "Some students are voters" is true, then what can be said about the truth/falsity of its opposite propositions?
5. If "Some women are soldiers" is false, then what can be said about the truth/falsity of its opposites?
6. Both the contrary propositions (A,E) can be false together but they cannot be true together, Explain with the help of examples.
7. Both the sub-contrary propositions (I,O) cannot be false together though both can be true together. Discuss with the help of examples.
8. Can the pair of contradictory propositions be false together or true together? Examine.
9. Four types of categorical propositions (A,E,I,O) are related to each other through the relation of opposition, Explain.
10. Draw square of opposition showing all the opposite relations.

Other forms of Immediate Inferences

What is an Inference?

Inference is a network of propositions in which the preceding proposition(s) known as premise implies the conclusion. It is a necessary connection between premise and conclusion. The truth or falsity of the former implies the truth and falsity of the latter. An inference may have one premise or more than one premise. If an inference has just one premise and the conclusion is drawn from that very premise, it is called immediate inference and where there are more than one premise, it is called mediate inference.

Immediate inference

These are two types of immediate inference:

- i. Square of opposition
- ii. Education

Education

In 'Square of Opposition' the premise and the conclusion differ in quantity or in quality or both quantity and quality. But in education the meaning of the premise and meaning of the conclusion may remain the same. In that case they are called equivalent propositions. The premise and the conclusion differ only in form. This chapter deals with different types of education. Education is of four types:

1. Conversion
2. Obversion
3. Contraposition
4. Inversion

Conversion

Conversion is a form of immediate deductive inference (i) where the subject of the conclusion is predicate of the premise and the predicate of the conclusion is the subject of the premise (ii) the qualities of the premise and the conclusion remain the same (iii) The quantities of the premise and the conclusion should be same as far as possible (iv) the term which is distributed in the conclusion should be distributed in the premise. This we call law of distribution.

Application of these rules leads to the following:

	Premise		Conclusion
A	All S is P	I	Some P is S (by limitation)
E	No S is P	E	No P is S
I	Some S is P	I	Some P is S
O	Some S is not P		Not valid

- (A) The converse of A is I. It could not be A, because in that case 'P' which is distributed in the conclusion cannot be distributed in the premise. This breaks the law of distribution. A then is converted to I. Thus converse of A is not its equivalent but its complement. This form of conversion is called conversion by limitation. The conversion of "All men are mortal" is "Some mortals are men".
- (E) The conversion of "No beasts are rational beings" is
"No rational beings are beasts".
- (I) The conversion of "Some cats are black" is
"Some black beings are cats".
- (O) cannot be converted. 'Some S is not P' if converted will be like "Some P is not S". But this is invalid because 'S' which is distributed in the conclusion is not distributed in the premise. This violates the law of distribution. Hence there is no valid conversion for O

Obversion

Obversion is a form of immediate deductive inference where (i) the predicate of the conclusion is the contradictory of the predicate of the premise. The subject of the premise and of the conclusion is same (ii) In this form of inference the quality of conclusion is opposite to the quality of premise. (iii) The quantity of premise and conclusion is same. (iv) The law of distribution should be obeyed.

Application of these rules leads to the following:

	Premise		Conclusion
A	All S is P	E	No S is non- P
E	No S is P	A	All S is non- P
I	Some S is P	O	Some S is not non- P
O	Some S is not P	I	Some S is non -P

Contraposition and Inversion

Conversion and obversion are the two original forms of eduction. Other forms of eduction like contraposition and inversion may be obtained by successively converting and obverting in either order.

Contraposition

Contraposition is that form of immediate inference where the contradictory of the original predicate is the subject of the conclusion and the contradictory of the original subject is the predicate of the conclusion. Contraposition of A, E and O proposition is given below:

- | | | | |
|---|---|-------------------------|--|
| (i) | A | All S is P | Given proposition |
| | E | No S is non P | by obversion |
| | E | No non P is S | by conversion (this is partial contraposition) |
| | A | All non P is non S | by obversion (this is complete contraposition) |
| | | | |
| (ii) | E | No S is P | Given proposition |
| | A | All S is non P | by obversion |
| | I | Some non P is S | by conversion (This is partial contraposition) |
| | O | Some non P is not non S | by obversion (this is complete contraposition) (But it is called contraposition by limitation) |
| | | | |
| (iii) | I | Some S is P | Given proposition |
| | | Some S is not non P | by obversion |
| | | | |
| Since O proposition can not be converted, so contraposition of I proposition is not possible. | | | |
| | | | |
| (iv) | O | Some S is not P | Given proposition |
| | | Some S is non -P | by obversion |
| | | Some non P is S | by conversion (partial contraposition) |
| | | Some non P is not non S | by obversion (complete contraposition) |

Inversion :

Inversion is yet another form of eduction. This again is combination of conversion and obversion. In inversion subject of the conclusion is contradictory of original subject and predicate of the conclusion is contradictory of the original predicate. Inversion of A, E, I and O propositions is given below:

A	All S is P	Given proposition
	No S is non - P	obversion
	No non - P is S	conversion
	All non - P is non - S	obversion
	Some non - S is non - P	conversion
	The inversion of A into I is called inversion by limitation.	
E	No S is P	Given proposition
	No P is S	by conversion
	All P is non S	by obversion
	Some non S is P	by conversion (This is partial inversion)
	Some non S is not non P	by obversion (This is complete inversion)
E is inverted in O. This is inversion by limitation.		
I	Some S is P	Given proposition
	Some P is S	By conversion
	Some P is not non S	by obversion

Since O proposition cannot be converted, so there is no inversion for I proposition. Even if we start with obversion, then also we are stuck as we have seen in the case of contraposition.

O Some S is not P

Since O proposition cannot be converted hence there is no inversion of O proposition also. Alternatively even if we start with obversion, then also we are stuck as we have seen in the case of the contraposition of O proposition.

Questions

1. Give converse, obverse, contrapositives (partial and complete) and inverse of the following propositions:
 - a. Some roses not red things.
 - b. All cats are mammals.
 - c. No lion is black creature.
 - d. Every voter is a citizen.
 - e. Some educated persons are sinners.
 - f. All successful people are hard working persons.
 - g. Some scientists are women.
 - h. All logicians are mathematicians.
 - i. Some women are not literate.
 - j. No fish is mammal.
 - k. All students of this class are healthy children.
 - l. Some boys are good football players.
 - m. No saint is a cheater.
 - n. Some writers are not scholars.
 - o. All men are mortal.
 - p. Some women are doctors.
 - q. No circle is square.
 - r. Some men are six feet tall.
 - s. Some fruits are not sweet.
 - t. All snakes are reptiles.
2. Explain the notion of an inference in logic. Discuss different types of inferences.
3. Point out the differences between immediate inferences and mediate inference.
4. Explain different types of immediate inferences.
5. Discuss rules of conversion as a form of immediate inference. Also examine conversion of E and I propositions.
6. Why O proposition cannot be converted? Give precise reason.
7. Why A proposition cannot be converted into A itself? Give an exact answer.
8. Contraposition is not independent form of inference. Explain citing examples.
9. Inversion of I and O propositions are not possible. Give reasons.
10. Briefly discuss the difference between Square of Opposition and Eduction.

Unit 8

Categorical Syllogism

What is a syllogism?

Inference or reasoning is the process of passing from one or more propositions to another with some justification. This inference when expressed in language is called an argument. An argument consists of more than one proposition (premise and conclusion). The conclusion of an argument is the proposition that is affirmed on the basis of the other propositions of the argument. These other propositions which provide support or ground for the conclusion are called premises of the argument.

Inferences have been broadly divided as deductive and inductive. A deductive argument makes the claim that its conclusion is supported by its premises conclusively. An inductive argument, in contrast, does not make such a claim. It claims to support its conclusion only with some degrees of probability.

Deductive inferences are again divided into Immediate and Mediate.

Immediate inference is a kind of deductive inference in which the conclusion follows from one premise only. In mediate inference, on the other hand, the conclusion follows from more than one premise. Where there are only two premises, and the conclusion follows from them jointly, it is called syllogism.

A syllogism is a deductive argument in which a conclusion is inferred from two premises. The syllogisms with which we are concerned here are called categorical because they are arguments based on the categorical relations of classes or categories. Such relations are of three kinds.

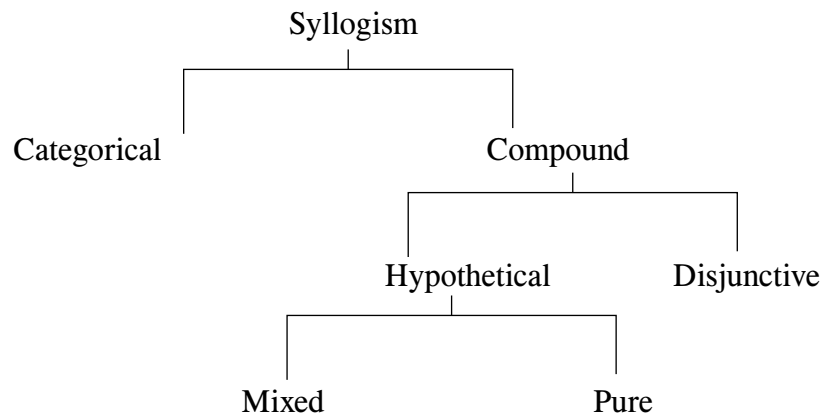
1. The whole of one class may be included in the other class such as
All dogs are mammals.
2. Some members of one class may be included in the other such as
Some chess players are females.
3. Two classes may not have anything in common such as
No man is perfect.

A categorical syllogism, thus, can be defined as a deductive argument consisting of three categorical propositions that together contain exactly three terms each of which occurs twice only.

Types of Syllogism

Before discussing the structure and rules of a valid syllogism, it is necessary to distinguish categorical

sylllogism from various other kinds of sylllogism. These different kinds of sylllogism can be shown by the following table:-



(Table - 1)

In a categorical sylllogism all propositions (both the premises and conclusion) are categorical propositions that is A, E, I and O. For example :

All men are mortal

All players are men

Therefore, all players are mortal

In a compound sylllogism one premise or both the premises and conclusion are compound propositions.

If it rains in time, then the crops will be good.

If crops is good, inflation will be controlled.

Therefore, if it rains in time, then inflation will be controlled.

(i) In mixed hypothetical sylllogism, the major premise is hypothetical, the minor premise is categorical and the conclusion is also categorical. We have two forms of this kind of sylllogism known as Modus Ponens and Modus Tollens. These two kinds can be understood by the following examples:

(i) If you work hard then you will pass.

You are working hard.

Therefore, you will pass.

This is an example of Modus Ponens where by affirming the antecedent we can affirm the consequent.

Symbolically, we can express it as:-

$$p \supset q$$

$$p$$

$$\therefore q$$

(ii) If the car runs, then there is fuel in its tank.

There is no fuel in its tank

Therefore, the car does not run.

The above is an example of Modus Tollens in which by denying the consequent, the antecedent is denied. Symbolically, we can express it as:-

$$p \supset q$$

$$\sim q$$

$$\therefore \sim p$$

In pure hypothetical syllogism all the premises and conclusion are hypothetical propositions. For example :

If there is scandal, then CM will resign

If CM resigns, then there will be mid-term election

Therefore, if there is scandal, then there will be mid-term election.

The other kind of compound syllogism is called disjunctive categorical. In this kind of syllogism the major premise is disjunctive, the minor is categorical and the conclusion is also categorical.

The simple rule for disjunction is that by denying one of the disjuncts, we can affirm the other one. It is based on the fact that both the disjuncts cannot be false together. So, if we deny one disjunct, we can thereby affirm the other one but not the other way round. Symbolically, one can express it as :

$$\text{Either } p \text{ or } q \quad p \vee q$$

$$\text{not } p \quad \sim p$$

$$\therefore q$$

After discussing the various kinds of syllogism, now we can turn to the structure of categorical syllogism.

Structure of Syllogism

A syllogism consists of three propositions of which two given propositions are called premises and the third proposition (which is inferred from the given propositions) is called conclusion. Each proposition consists of two terms. Therefore, a syllogism must consist of three terms and each one occurs twice. For example:

All self- confident persons are mentally strong.

No coward is mentally strong.

Therefore, no coward is self- confident person

The three categorical propositions in the above example contain exactly three terms that is 'self-confident person' 'mentally strong' and 'coward'. To identify the terms by name we look at the conclusion. The predicate of the conclusion is called the major term. The subject of the conclusion is called the minor term. The term which occurs in both the premises but not in the conclusion is called the middle term. In the above example, the term 'self-confident' person is the major term 'coward' is the minor term and 'mentally strong' is the middle term.

The premises of a syllogism also have names. Each premise is named after the term that appears in it. The premise that contains the major term is called the major premise. In the example 'self-confident person' is the major term, so the premise "All self-confident persons are mentally strong" is the major premise.

The premise containing the minor term is called the minor premise. In the example, 'coward' is the minor term so "No coward is mentally strong" is the minor premise. It is the minor premise not because of its position but because it is the premise that contains the minor term.

A syllogism is said to be in standard form when its premises are arranged in a specified standard order. In a standard form of syllogism, the major premise is always stated first, the minor premise is second and the conclusion is last. It may be noted that in the accepted usage the symbol M stands for the middle term, S stands for the minor term and P stands for the major term. Now, we can discuss the mood and the figure of a syllogism.

Mood of Syllogism

The mood of a syllogism is determined by the quantity and the quality of its constituent propositions or by the types of (A,E,I,O) standard form categorical propositions it contains. The mood of the syllogism is represented by three letters given in standard form order. The first letter represents the type of major premise, the second letter is for the minor premise and the last letter is for the conclusion.

- A All artists are egoists. (Major premise)
 I Some artists are pampers. (Minor premise)
 I Therefore, some pampers are egoists. (Conclusion)

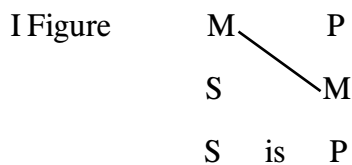
Figure of Syllogism

The mood of a standard form syllogism is not enough by itself to characterize its logical form. The syllogisms having the same mood may differ significantly in their forms depending on the relative positions of their middle terms. To know the form of a syllogism, we must state its mood and its figure.

The figure of a syllogism is determined by the position of the middle term in its premises. The middle term occurs in both the major and the minor premises but the position of the middle term is not the same in all syllogisms. There are four possible arrangements of the middle term in the two premises and, thus, there are four figures of a syllogism:-

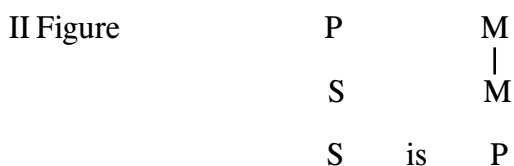
First Figure

In the first figure, the middle term is the subject of the major premise and predicate of the minor premise. Thus,



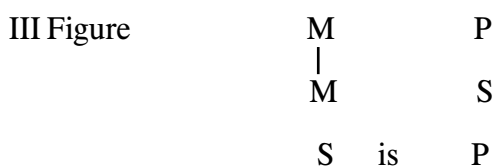
Second Figure

In the second Figure, the middle term is the predicate in both the premises. Thus,



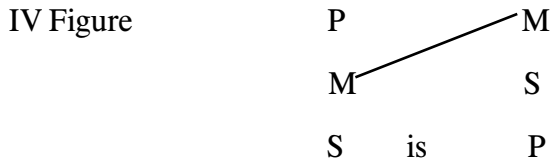
Third Figure

In the third figure, the middle term is the subject in both the premises. Thus,



Fourth Figure

In the fourth figure, the middle term is the predicate in the major premise and subject in the minor premise. It is exactly the opposite of the first figure. Thus,



Any standard form categorical syllogism is described completely when we specify its mood and its figure. If we take an example, we can understand it better. For example, in the following syllogism:-

- E No heroes are cowards.
- I Some soldiers are cowards.
- O Therefore, some soldiers are not heroes.

This syllogism is in the second figure where 'cowards', the middle term, is the predicate in both the premises. Its mood is EIO. It is completely described as a syllogism of the form EIO-2

Now we have to determine the conditions under which an argument is valid. To avoid common errors, the logicians have set forth certain rules. By observing these rules we can avoid the errors commonly made in such arguments. These rules also help in evaluating standard form syllogisms by observing whether any one of these rules has been violated.

We commit a mistake if we violate any one of these rules. Such mistakes are called fallacies. Since these mistakes are there in the form of the arguments, we call them formal fallacies. Now we shall understand the five rules to test the validity of syllogistic arguments.

Rules and Fallacies of Syllogism

- 1 Every syllogism must contain three and only three terms, each of which is used in the same sense throughout the arguments. Any violation of this rule leads to the fallacy of four terms.

For example

No man is made of paper

All pages are men

Therefore, no pages are made of paper.

The above argument commits the fallacy of four terms by using one term (minor term) in two different senses. The term 'page' means 'boy servant' in the minor premise while in the conclusions it means 'pages of a book'. In fact, the definition of categorical syllogism, by itself, indicates that by its nature every syllogism must have three and exactly three terms only.

- 2 According to this rule, the middle term must be distributed at least once in the premises. Otherwise, the connection required by the conclusion cannot be made. For example as in AAA - 2:

All virtuous persons are happy.

All rich men are happy.

Therefore, all rich men are virtuous.

The above arguments violate rule no.2 because the middle term 'happy' is not distributed even once in the premises. Hence, it commits the fallacy of undistributed middle. There is a need to link the minor and the major terms. If they are to be linked by the middle term, either the major or the minor term must be related to the whole class designated by the middle term. If it is not so then both the major and minor terms in the conclusion may be connected to different parts of middle term and thus will not be necessarily connected with each other.

- 3 The third rule again deals with the distribution of terms. According to this rule, no term can be distributed in the conclusion unless it is also distributed in the premise. This rule is based on the fundamental rule of deduction that the conclusion cannot be more general than the premises. It cannot say more than what is said in the premises. We know that a term is distributed when it is taken in its entire denotation. Hence, if a term is distributed in the conclusion without being distributed in the premises, it will say more than what is said in the premises. The premises, thus, will not entail the conclusion or the conclusion will go beyond its premises. The violation of this rule leads to the fallacy of illicit process. There are two different forms of illicit process. If the major term is distributed in the conclusion without being distributed in its premise, the fallacy committed is called the fallacy of illicit major.

For example in the following syllogism AEE-1:

All rational agents are accountable.

No animals are rational agents.

Therefore, no animals are accountable.

Here, in this argument, the major term 'accountable' is distributed in the conclusion without being distributed in the premise. This leads to the fallacy of 'illicit major.' Similarly, if the minor

term is distributed in the conclusion without being distributed in its premise, we commit the fallacy of 'illicit minor' as is apparent in the following AAA-3:

All men are mortal.

All men are rational.

Therefore, all rational beings are mortal.

Here, in this argument, the minor term 'rational being' is distributed in the conclusion without being distributed in the premise. This leads to the fallacy of illicit minor.

Hence we can say that in both kinds of such fallacies, the conclusion goes illicitly beyond what the premises say.

- 4 The fourth rule says that from two negative premises no conclusion follows. A negative proposition states that the predicate is denied of the subject. If both premises are negative that means there is exclusion of both extremes from the middle term, no connection between the extremes would be established. This rule follows from the same consideration as rule 2 about distribution of the middle term. Both the premises should refer to the same part of the middle term, either by inclusion in both cases or by inclusion in one case and exclusion in the other. Then only middle term can connect major term with minor term. A violation of this rule leads to the fallacy of exclusive premises. For example OEO in any figure, commits this fallacy.
- 5 The fifth rule states that if one premise is negative, the conclusion must be negative. It also states that if the conclusion is negative one premise must be negative.

A violation of this rule leads to the fallacy of drawing an affirmative conclusion from a negative premise. For example, AEA in any figure has this fallacy.

The above five rules are supposed to apply to all the standard form categorical syllogisms. They are adequately sufficient to test the validity of any argument. If an argument conforms to all these five rules, it is valid, otherwise invalid. These rules are based on quantity of propositions, distribution of terms (Rule No. 2 and 3) and quality of propositions. (Rule No. 4 and 5). In addition to these general rules there are certain corollaries which are applicable to all categorical syllogisms irrespective of their figures.

Corollaries

- 1 From two particular premises no conclusion follows:

This rule may be explained as:

If both the premises are particular then the possible combinations are II, IO, OI and OO. Now we can examine them one by one.

- II - If both the premises are II then no terms will be distributed then the result will be violation of rule no. 2 because the middle term will remain undistributed. This will lead to the fallacy of undistributed middle.
- OO - If both the premises are OO then both the premises will be negative. This will be violation of rule no. 4 according to which both the premises cannot be negative. It will lead to the fallacy of exclusive premises.
- OI&IO - In these two combinations, only one term will be distributed, the predicate of O proposition. Since one premises is negative the conclusion will also be negative. Being a negative conclusion it must distribute its predicate, i.e., the major term. According to rule no. 3 this major term should also be distributed in its premise to avoid the fallacy of illicit major. In the two premises, only one term is distributed. Hence, in attempting to draw a conclusion, we either commit the fallacy of illicit major or the fallacy of undistributed middle.

Thus, two particular premises yield no valid conclusion.

2. If one premise is particular the conclusion must be particular

This corollary can be understood by taking into consideration the wider rule of deduction which says that the conclusion must be implied by the premises. In other words the conclusion cannot be more general than the premises. Hence, if one premise is particular the conclusion has to be particular or violation of some rules of syllogism will make the argument fallacious.

3. If both premises are affirmative, the conclusion must be affirmative and vice-versa, if the conclusion be affirmative, both the premises must be affirmative

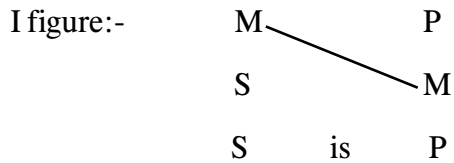
If both the premises be affirmative it means that the middle term has a connection with both the major and the minor term. From this, if we have to have a valid syllogism then in the conclusion the major term and the minor term must have some connection with each other i.e., the conclusion must be affirmative.

4. From a particular major and a negative minor no conclusion follows:

If the minor premise be negative, the major premise must be affirmative and the conclusion must be negative as per rules. The conclusion being negative, it will distribute its predicate i.e. the major term but the major premises being a particular affirmative does not distribute any term. Hence, all this will lead to the violation of rule no. 3 which clearly states that no term can be distributed in the conclusion unless it is also distributed in the premises. The result will be that we shall commit the fallacy of illicit major in our attempt to draw conclusion.

Special Rules of the first figure

1. The major premise must be universal :



If the major premise is not universal, it must be particular. If it is particular then the middle term is not distributed there because the middle term is the subject of the major premise. According to rules, the middle term must be distributed at least once in the premises. So, if not in the major premise, the middle term must be distributed in the minor premise. In the first figure the middle term is the predicate in the minor premise. To distribute the middle term the minor premise must be negative because only negative propositions distribute their predicate. Now, if the minor premise is negative the major must be affirmative and the conclusion negative.

We assumed in the beginning that the major premise is particular and now we know that it is affirmative. The major term which is distributed in the conclusion (which is negative) will not be distributed in the major premise which is particular affirmative, i.e., I proposition. Thus, our assumption that the major premise is particular leads to the fallacy of 'illicit major'. Thus, we prove that the major premise cannot be particular, it must be universal

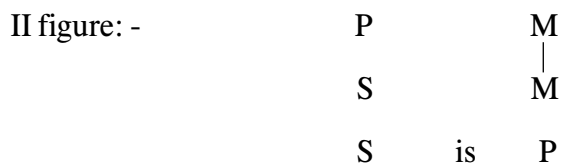
2. The minor premise must be affirmative:

If the minor premise is not affirmative then it must be negative. If the minor premise is negative, the major must be affirmative and the conclusion negative. The conclusion being negative will distribute its predicate, i.e., the major term. The major term in the major premise is the predicate which being affirmative will not distribute its major term.

Thus, if we assume the minor premise as negative we commit the fallacy of illicit major. The minor premise, therefore, must be affirmative.

Special Rules of the second figure

1. The major premise must be universal :



If the major premise is not universal, it must be particular and being particular, it will not distribute its subject which is the major term in the second figure. Since the major term is

undistributed in the major premise, it should not be distributed in the conclusion to avoid the fallacy of illicit major. In that case, the conclusion must be affirmative because only affirmative propositions do not distribute their predicate. Now, if the conclusion is affirmative, both the premises should also be affirmative. If it is so, the middle term will remain undistributed in both the premises because in the second figure, the middle term is the predicate in both the premises and affirmative propositions do not distribute their predicate. This will lead to the fallacy of undistributed middle. Hence, the major premise must be universal, it cannot be particular.

2. One of the premises must be negative :

In the second figure, the middle term is the predicate in both the premises. It is only negative propositions which distribute their predicate. Since the middle term must be distributed at least once in the premises, one of the premises must be negative to avoid the fallacy of undistributed middle.

Special Rules of the third figure

1. The minor premise must be affirmative :

III figure:-

M	P
M	S
S	P

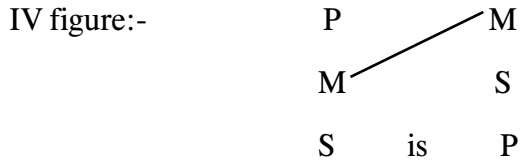
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If the minor premise is not affirmative, it must be negative and then the major premise must be affirmative and the conclusion negative. The conclusion being negative it will distribute its predicate, i.e., the major term. This major term should also be distributed in the major premise to avoid the fallacy of illicit major. The major term in the major premise is its predicate which being affirmative does not distribute its predicate, i.e., the major term. This is violation of rule no. 3 leading to the fallacy of illicit major. Hence, the minor premise must be affirmative in the third figure.

2. The conclusion must be particular:

In the third figure, the minor term is the predicate in the minor premise. As proved in the last special rule, this minor premise must be affirmative. If the minor premise is affirmative, it will not distribute its predicate, i.e., the minor term. This minor term should also be undistributed in the conclusion to avoid the fallacy of illicit minor. The minor term is the subject of the conclusion and will remain undistributed only if the conclusion is particular because universal propositions distribute their subject. The conclusion, thus, must be particular, or, we commit the fallacy of illicit minor.

Special Rules of the fourth figure



1. If the major premise be affirmative, the minor premise must be universal.

In the fourth figure, the middle term is the predicate in the major premise and if this premise is affirmative, the middle term will remain undistributed in the major premise. In the minor premise, the middle term is its subject and since only universal propositions distribute their subject so the minor premise must be universal to get the middle term distributed and thus avoid the fallacy of undistributed middle.

2. If the minor premise be affirmative the conclusion must be particular.

In the fourth figure, the minor term is the predicate in the minor premise. If the minor premise be affirmative, the minor term being its predicate will remain undistributed in the premise and therefore cannot be distributed in the conclusion. The minor term being the subject of the conclusion will be undistributed only if the conclusion is particular because universal propositions must distribute their subject. Therefore, if the minor premise is affirmative, the conclusion must be particular, or, we commit the fallacy of illicit minor.

3. If either premise be negative, the major premise must be universal.

If either premise be negative, the conclusion will also be negative; distributing at least its predicate i.e. the major term this major term should also be distributed in the major premise to avoid the fallacy of illicit major. In the fourth figure, the major term is the subject in the major premise and can be distributed only if the major premise is universal. Hence, if either premise is negative in the fourth figure, the major premise must be universal.

Questions

1. Test the validity/ invalidity of the following syllogistic forms with the help five rules:
 - a. IAA - 3
 - b. IEO - 1
 - c. AAA- 2
 - d. OEO - 4
 - e. AAE - 1
 - f. EAA - 2
 - g. EEE - 3
 - h. IAO - 2
 - i. AEE -2
 - j. OAI - 3

Solution: - Example:

AAA-2

PM	All P is M
SM	All S is M
∴ SP	∴ All S is P

In the second figure the middle term is the predicate in both the premises. Affirmative propositions do not distribute their predicate. So the middle term remains undistributed in both the premises. This is violation of Rule no. 2 according to which the middle term must be distributed at least once in the premises. This leads to the fallacy of undistributed middle.

2. Arrange the following syllogisms into standard form and name figures and moods.
 - a. All musicians are talented people and no musicians are cruel, obviously no talented people are cruel.
 - b. Some philosophers are mathematicians; hence some scientists are philosophers, since all scientists are mathematicians.
 - c. Some mammals are not horses, for no horses are centaurs, and all centaurs are mammals.
 - d. No criminals are pioneers, for criminals are unsavory person and no pioneers are unsavory persons.
 - e. Some women are not strong persons, because all mothers are strong persons but some women are not mothers.

Example :

All supporters of popular government are democrats, so all supporters of popular government are opponents of the Republican party, since all democrats are opponents of the Republican party.

To arrange this syllogism in standard form, we must first recognize the conclusion which will give us the major and the minor terms. This will help us in identifying the major premise and the minor premise. When all this is arranged, we shall know the mood and the figure of this syllogism.

All democrats are opponents of the Republican Party. (Major premise)

All supporters of popular government are democrats. (Major premise)

Therefore, all supporters of popular government are opponents of the Republican Party. (Conclusion)

Now, it is clear that the above argument is in Ist figure with AAA mood, i.e., AAA-I.

3. Determine the validity/invalidity of the following arguments by using the rules of syllogism:
 - a. Some cobras are not dangerous animals, but all cobras are snakes, therefore, some dangerous animals are not snakes.
 - b. Some writers are artists because all artists are sensitive people and some writers are sensitive people.

- c. Some successful men are not Americans, because all Americans are rich, and some rich man are not successful.
- d. Some philosophers are reformers, so some idealists are reformers since all philosophers are idealists.
- e. All proteins are organic compounds; hence all enzymes are proteins, as all enzymes are organic compounds.

Example :

No coal-tar derivatives are nourishing foods, because all artificial dyes are coal-tar derivatives, and no artificial dyes are nourishing foods.

When we arrange this argument in standard form, we get the following:

No artificial dyes are nourishing foods.

All artificial dyes are coal-tar derivatives.

Therefore, no coal-tar derivatives are nourishing foods.

This argument is in the form of EAE-3. When we look at the conclusion, the minor term is distributed there but the same term is not distributed in the minor premise, being the predicate of A proposition. This is in violation of Rule no. 3 according to which no term can be distributed in the conclusion unless it is also distributed in the premise. Hence, this argument is invalid committing the fallacy of illicit minor.

Note : There are certain words which are conclusion indicators such as therefore, hence, so, it follows, consequently, thus, it is implied by etc. There are certain words which are premise indicators like, since, for, because etc.

4. Define syllogism as a form of an argument. Explain different types of syllogism.
5. Write a note on the structure of categorical syllogism. Define and illustrate mood and figure of categorical syllogism.
6. Explain with examples the fallacies of undistributed middle, illicit major and illicit minor.
7. Explain fallacy of four terms.
8. Prove why:
 - a. A valid categorical syllogism cannot have two particular premises.
 - b. From a particular major premise and a negative minor premise no conclusion follows in a valid categorical syllogism.
10. Prove special rules of 1st and 2nd figures.

Unit 9

Elements of Symbolic Logic

Origin of symbolic logic:

In the history of western logic, symbolic logic is a relatively recent development. What sets symbolic logic apart from traditional logic is its leaning towards mathematics. Aristotle, the Greek thinker, in the fourth century BC, laid the foundation of logic as a science of sciences. Logic for him is a science which can serve as the backbone of all other scientific queries. He was the first to propose that logic is the indispensable tool which can provide a set of correct rules for correct reasoning, and that these rules will be applicable in all scientific studies and discussions. Aristotle's conception of logic as a formal study of valid inferences was accepted by all logicians for nearly 2000 years.

In the seventeenth century G. W. Von Leibniz, a mathematician turned philosopher, however, could see that Aristotle and his followers' style of reasoning needs modification. But he merely suggested, and never worked or showed the direction which logic possibly could take. It is only in the nineteenth century that the thinkers started actualizing the ideas conceived by Leibniz. For nearly two thousand years since its inception, logic did not progress so much as it had done in last one hundred and fifty years. This is mostly because of rapid development in mathematics and its use in logic. Since Leibniz's discovery of Differential Calculus, mathematics developed rapidly. Soon, it became the 'key-science'.

With the ascending of the mathematical method, George Boole (1815-1864), an English mathematician, rediscovered logic and its potential. He mathematized logic by highlighting the resemblances between disjunction and conjunction of concepts and addition and multiplication operations of mathematics. Through his efforts Class Calculus emerged in logic. While Boole and others like De Morgan (1806-1871), Charles Sanders Pierce (1839-1914) were mathematizing logic, Gottlob Frege (1824-1925), a German mathematician, attempted something revolutionary. He tried to reduce all mathematics into logic by analyzing the concept of number. This is known as the thesis of logicism. In order to achieve this aim he invented a language; a Begriffsschrift (language of thought) to free logical thinking from the dominion of ordinary language and its grammar. The new language which is also called artificial language makes use of logical notations. These notations can express much larger complex sentences than Aristotle's logic could do. This achievement of Frege ushered in the age of symbolic or mathematical logic for which he is rightly called the father of modern symbolic logic.

Arguments presented in natural language whether in English or in any other language are sometimes difficult to evaluate because of the ambiguous, vague and equivocal nature of words and idioms in which they are expressed. To avoid these impurities of ordinary language the logicians as well as some of the mathematicians have developed specialized technical language and vocabulary which is called artificial language or symbolic language.

Nature of symbolic language

Ideograms and Phonograms:

In sharing the same platform with mathematics, modern logicians made extensive use of symbols. Symbols are ideograms, written words are phonograms. Ideograms stand directly for ideas whereas phonograms stand for sounds that we make while speaking words. Every word of a language is a phonogram. For example, the written words 'question mark' are phonograms because they are the written characters of the sounds we make while uttering these words. But '?' is an ideogram. This does not represent written characters of the sounds, but stands for the idea directly. Similarly, 'minus' is a phonogram, but '-' is an ideogram; 'Square root of 10' is phonogram, but $\sqrt{10}$ is an ideogram. Symbolic logic makes use of ideograms instead of phonograms.

There is no doubt the classical logic used symbols like S, P, M which represent minor term, major term and middle term in a categorical syllogism respectively. A, E, I, O symbols were also used to denote categorical propositions by the traditional thinkers. But the use of symbols was very little and it was restricted to a few symbols only. Modern symbolic logic made extensive use of symbols both as variables and constants.

Types of symbol

Variables:

Two types of symbol are used in logic - variables and constants. A variable symbol keeps on changing its value from argument to argument. These symbols are 'dummies'. They do not have fixed values. For example, 'P' in one argument may stand "It is very pleasant today", 'P' may stand for 'She is Priya' in another argument. Similarly 'P' may represent 'We will go to Palampur' in yet another argument. Here symbol 'P' is variable. Many more types of variables are used in modern logic such as propositional variables (which represent propositions), predicate variables (which represent predicates of proposition), class variables (which represent classes) and many more types. In the traditional logic variables were used for the three terms of categorical syllogism, S, P, M only. This shows that the use of symbols and variables, was known to Aristotle though it was restricted only to a few symbols.

Constants:

A constant symbol should be distinguished from a variable symbol. Constant symbols do not change their values in the domain of logic whereas variables do not have fixed values. Aristotle and other traditional logicians never used symbols for constants. The use of symbols for constants was done for the first time in the modern logic. Some important constant symbols used in elementary symbolic logic are as follows:

1. '~' for negation; called (curl or tilde)

2. ' $\vee$ ' for the relation of 'either, or' in inclusive sense ; called wedge. (disjunction)
3. ' $\wedge$ ' for the relation of 'either, or' in exclusive sense called alternation.
4. ' $\bullet$ ' for the relation of 'and'; called dot.
5. ' $\supset$ ' for the relation of 'if, then' and is called horse shoe.
6. ' $\equiv$ ' for the relation of 'if and only if' and is called equivalent.

Uses of Symbols:

A question many arise why the modern logicians make extensive use of symbols? What are the advantages of using symbols in logic? There are at least two major advantages of using symbols in logic: First, the logical form of an argument becomes explicit by using symbols. The complexity of language may hide the structure of an argument, and thus can conceal its logical form. Earlier in this chapter it has been emphasized that ordinary language which makes use of phonograms is not fit for evaluating arguments in logic. Symbolic language is better than the ordinary language for the logicians.

The use of language in logic has to be very clear as the slightest variation in the interpretation of the meanings of terms or propositions can change the logical form of the reasoning. By replacing language by symbols, the logical form of an argument becomes explicit. Once right logical form of an argument is captured, its validity can be decided quickly and accurately. A question may arise why are the logicians interested in the logical form an of argument? This is because the validity of an argument is decided by the logical form of the argument.

Second, the use of symbols in logic is seen as an economical device. The long and big arguments become small and handy expressions after symbolization. They can be operated quickly and easily. The chances of committing errors in deciding their validity are thus reduced.

Symbolization

One of the important tasks in modern logic is to to express propositions and arguments in symbols. This process is called symbolization. One letter from alphabet represents one simple proposition. For Example:

1. "Sita is a student" is symbolized as S.
2. "Mohan is citizen of India" is symbolized as C.
3. "Qutab Minar is in Delhi" is symbolized as Q.
4. "Sita is a good student and she is hardworking" is symbolized as: S and H.
5. "If it rains, then we shall go for picnic" is symbolized as :

If R, then G.

6. "Either it rains or it will be very humid" is symbolized as Either R or H.

Negative proposition such as:

"Sachin is not a mathematician" is symbolized as $\sim S$

Symbolization of Compound Propositions

Conjunctive: When two simple propositions are in conjoined by 'and' then the conjoined form is called conjunctive proposition.

For example :

"Sita is intelligent and she is hardworking student" is symbolized as:

$I.H$

I, H are called conjuncts

"Sita is intelligent" - I

"Sita is hardworking" - H.

Besides 'and', there are many words such as yet, but, both, although, however, moreover, neither nor, as well as, while etc. for which '·' is used.

For example:

1. "She is poor yet she is honest".

$P.H$

2. "He is intelligent but could not clear this test."

$I. \sim T$

3. "Both Sita and Gita are students."

$S.G$

4. "Not both Sita and Gita are Students."

$\sim (S.G)$

5. "Sita and Gita both are not students".

$\sim S. \sim G$

6. "Neither Sita nor Gita are students."

$\sim S. \sim G$

Disjunctive : (inclusive sense) :

When two simple propositions are combined by 'either, or' then the compound form is called disjunctive proposition. For example :

1. "Either I write to him or I will talk to him on telephone" is symbolized as :

$W \vee T$.

W, T are called disjuncts.

2. "Either the government will reduce the price of oil or it will have to increase the salary".

$R \vee I$

3. "Either it rains in time or the crops will not be good".

$R \vee \sim G$

4. "Either S is not guilty or M is not telling truth".

$\sim S \vee \sim M$

If 'unless' occurs between two components of a sentence, then they can be symbolically joined by the disjunctive sign. For example:

"I do not drive in night unless it is very necessary. "

$\sim D \vee N$.

$\sim D$ - "I do not drive in night".

N - "It is very necessary. "

'Neither, nor' relationship between two propositions can also be symbolized by using wedge ($\vee$) sign. For example:

"Neither the teachers nor the students are the members of this library. "

$\sim (T \vee S)$

'neither, nor' relationship can be symbolized in two ways. The above example can be symbolized in an other way also such as:

$\sim T. \sim S$

Thus $\sim (T \vee S) = (\sim T. \sim S)$

Alternative: (Exclusive sense)

Two simple propositions are joined by 'either, or' in exclusive sense also.

"Either I go to library or I will stay in the hostel."

$L \Delta H$. (L, H are alternates)

Implicative :

Simple propositions when combined by 'If, then' relation are called implicative, hypothetical or conditional propositions. Such propositions are symbolized by using ' $\supset$ ' sign and the sign is read as 'horse-shoe' for it looks like shoe of a horse.

Example :

1. "If I get ticket of plane, then I will attend board meeting in Bombay", is symbolized as :

$T \supset A$.

2. "If you are not regular visitor to library, then you are not a serious student."

$\sim L \supset \sim S$

In $p \supset q$ proposition 'p' is antecedent, 'q' is consequent. Sometimes instead of 'if, then' some other words or phrases are used in implicative propositions.

For instance: the following propositions are implicative propositions and they all are symbolized as ' $p \supset q$ '.

- | | |
|--------------------------|---------------|
| 1. p, only if q | $p \supset q$ |
| 2. q if p | $p \supset q$ |
| 3. q provided that p | $p \supset q$ |
| 4. q on condition that p | $p \supset q$ |
| 5. q in case p | $p \supset q$ |
| 6. p hence q | $p \supset q$ |
| 7. p implies q | $p \supset q$ |

- | | | |
|-----|-----------------------------------|---------------|
| 8. | Since p, so q | $p \supset q$ |
| 9. | "q is necessary condition for p" | $p \supset q$ |
| 10. | "p is sufficient condition for q" | $p \supset q$ |
| 11. | "Only if q, p" | $p \supset q$ |

Equivalent propositions:

When two propositions have same values then they are called equivalent propositions; and this is symbolized as ' $\equiv$ '

For example:

"You will catch the train if and only if you reach in time" is symbolized as $C \equiv R$

' $\equiv$ ' is symbol use for 'if and only if'.

There are different formulations for three similar looking propositions.

- | | | | |
|------|--------------------|---|---------------|
| i. | p only if q | - | $p \supset q$ |
| ii. | p if q | - | $q \supset p$ |
| iii. | p if and only if q | - | $p \equiv q$ |

Symbolization of arguments

Now we are in a position to symbolize arguments. Each premise of an argument is symbolized separately. For example:

"If the demand stays constant and prices are lowered, then the business will increase. If business increases, then the prices are lowered and we can control the market. Demand will stay constant. Therefore, we can control the market.

The demand stays constant - D

Prices are lowered - L

Business will increase - I

We can control the market - C

1st premise (D.L) $\supset$ I

2nd premise I $\supset$ (L.C)

3rd premise D

Conclusion: C

Truth Table Method

There is two-fold task in elementary symbolic logic: First, to symbolize the propositions and arguments; second, to test the validity / invalidity of arguments and also the logical status of the propositions.

Logicians have provided many methods for this purpose. These methods are called decision procedures. Here we are dealing with the truth table method only. This is the most elementary and popular method to test the validity/invalidity of arguments and also to test the logical status of the propositions. By the logical status of the propositions we mean whether a proposition is tautology, contingent or contradictory (self-contradictory). A proposition is called tautology when it is always true. For example, "The sum of all the angles in a triangle is equivalent to 180° ". A proposition is contingent when sometimes it is true and some other time it is false. For example, "It is very pleasant today." It is true now but it may not be true some other time. A proposition is contradictory when it is always false. For instance, "Two plus two is five."

Truth Table Method is a decision procedure because it helps us to take a decision whether an argument is valid/invalid and also whether a proposition is tautological or not, and also whether propositions are logically equivalent or not.

Let us see how the method is applied.

Number of propositional variables:

First of all the number of simple propositions in the argument are counted. If a simple proposition is repeated in the argument or in the expression, then it is counted only once. In the expression $p \supset (q \vee p)$, the number of propositional variables are 2, since p occurs twice, it will be considered only once. In the expression $\{p \vee [(q \cdot r) \supset \sim r]\}$ the propositional variables are three, p , q and r . In the expression $(p \cdot q) \supset (r \vee s)$ propositional variables are four.

Number of rows

After knowing the number of propositional variables, the number of rows are decided. This depends on the number of propositional variables. If the numbers of propositional variables are three, the numbers of rows are $2^3 = 8$; and if the propositional variables are four, then the number of rows are $2^4 = 16$.

The base is always two, because we are dealing with two-valued logic only. A proposition has two values, true or false. The power of '2' or the exponent of '2' is according to the number of propositional variables an argument or an expression has. In the expression $\{\sim p \supset [q \vee (r \cdot s)]\}$ since the number of propositional variables are four, the number of rows are $2^4 = 16$. After counting the variables and deciding the number of rows, the truth table is constructed. Before that we must know the characteristics of various logical constants such as :

., V, $\wedge$, $\supset$, $\equiv$, $\sim$

$p \cdot q$ is true when both or all the conjuncts (p, q etc.) are true.

$p \vee q$ is true when at least one of the disjuncts (p, q etc.) is true,

$p \wedge q$ is true when one alternate is true and the other is false.

$p \supset q$ is true in all cases except when antecedent (p) is true and consequent (q) is false.

$p \equiv q$ is true when either both p, q are true or both p, q are false.

$\sim p$ is true when p is false.

Let us work them out in detail :

T = True

F = False.

$p \cdot q$	$p \vee q$	$p \wedge q$	$p \supset q$
TTT	TTT	TFT	TTT
TFF	TTF	TTF	TFF
FFT	FTT	FTT	FTT
FFF	FFF	FFF	FTF

$P \equiv Q$ $\sim P$

TTT FT

TFF TF

FFT

FTF

In a conjunctive proposition p. q; p is one conjunct and q is another conjunct. There are two variables p, q. So the number of rows are $2^2 = 4$. Under the first variable (p) we assign 2 Ts and 2Fs, (half of total number of rows are Ts and half of total number of rows Fs). Under the second variable (q). we keep one T and one F (total number of rows are 4)

For instance in the conjunctive proposition p. q we work out like this:

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

F	T	F
F	F	F

In the 1st row since both p, q are true p . q is also true. In the 2nd row though p is true but q is false so p . q is also false. In the 3rd row p is false though q is T hence p.q is false. In the 4th row p is false and q is also false, hence p .q is false.

Disjunctive proposition: $p \vee q$: p, q are two disjuncts.

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

In the 1st row both p, q are true hence $p \vee q$ is true; in the 2nd row p is T though q is F, $p \vee q$ is true. In the 3rd row p is false but q is T therefore $p \vee q$ is T. But in the 4th row p is false, q is also false, therefore $p \vee q$ is false.

Alternative proposition: $p \wedge q$ (p, q are two alternates)

p	q	$p \wedge q$
T	T	F
T	F	T
F	T	T
F	F	F

In the 1st row p is T and q is also T, therefore $p \wedge q$ is F. In the 2nd row p is T but q is F therefore $p \wedge q$ is T. In the 3rd row p is F, q is T hence $p \wedge q$ is T. But in 4th row p is F and q is also F, therefore $p \wedge q$ is F.

Implicative proposition: $p \supset q$

p	q	$p \supset q$	(p is antecedent q is consequent)
T	T	T	
T	F	F	
F	T	T	
F	F	T	

Implicative proposition is false only when antecedent (p) is true and consequent (q) is false. (This incidentally is the main characteristic of deductive logic) . In other combinations $p \supset q$ is true.

Equivalent proposition: $p \equiv q$

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

In the 1st row both p and q are T therefore $p \equiv q$ is T also, In 2nd row p is T but q is F $p \equiv q$ is F. In 3rd row p is F, q is T hence $p \equiv q$ is F. In 4th row p is F, q is also F hence $p \equiv q$ is T.

Negative proposition: $\sim p$

p	$\sim p$
T	F
F	T

In the first row p is T hence $\sim p$ is F and in the second row p is F hence $\sim p$ is T.

Logical status of propositions

Let us see some questions and their solutions for a better understanding. Determine the logical status of the following propositions with the help of truth table method.

Q1. $p \supset (q \vee r)$

Since there are 3 propositional variables we will make $2^3 = 8$ rows like this.

Solution:

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

F	F	F	F
1	2	3	4

$p \supset (q \vee r)$

T

T

T

F

T

T

T

T

5

Since in the main column (No. 5) there are both Ts and Fs therefore the logical status of the above expression is contingent.

Q.2 $\sim(\sim p \supset q) \vee q$

Solution: Since there are two propositional variables, p, q, we have $2^2 = 4$ rows.

p	q	$\sim p$	$\sim p \supset q$	$\sim (\sim p \supset q)$
T	T	F	T	F
T	F	F	T	F
F	T	T	T	F
F	F	T	F	T
1	2	3	4	5

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

T

F

T

T

6

Since in the column No. 6 there are both Ts and Fs, it is contingent.

Q3. $(p \supset q) \vee p$

Solution:

p	q	$p \supset q$	$(p \supset q) \vee p$
T	T	T	T
T	F	F	T
F	T	T	T
F	F	T	T
1	2	3	4

Since there are all Ts in the main column No. 4, therefore the logical status is tautology.

Q4. $(p \supset q) \supset \sim (\sim q \supset \sim p)$

Solution:

p	q	$\sim p$	$\sim q$	$p \supset q$
T	T	F	F	T
T	F	F	T	F
F	T	T	F	T
F	F	T	T	T
1	2	3	4	5

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

T F

F T

T F

T F

6 7

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

F

T

F

F

It is contingent

8

Q5. $[(p \cdot q) \supset r] \supset \sim [p \supset (q \supset r)]$

Solution:

p	q	r	$p \cdot q$	$(p \cdot q) \supset r$
T	T	T	T	T
T	T	F	T	F
T	F	T	F	T
T	F	F	F	T
F	T	T	F	T
F	T	F	F	T
F	F	T	F	T
F	F	F	F	T
1	2	3	4	5
$(q \supset r)$	$p \supset (q \supset r)$		$\sim [p \supset (q \supset r)]$	
T	T		F	
F	F		T	
T	T		F	
T	T		F	
T	T		F	
F	T		F	
T	T		F	
T	T		F	
6	7		8	

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

F

T

F

F

F

F

F

F

Since there are T and Fs in the main column

9

It is contingent.

Questions

1. Symbolize the following propositions using given notations:
 - a. I sit on the chair but my cat sits on the floor. (C, F)
 - b. We will miss bus unless we run. (B, R)
 - c. Two triangles are formed if a square is divided diagonally. (T, S)
 - d. He is both fool and knave. (F, K)
 - e. A man is both rationalist as well as hedonist. (R, H)
 - f. Either the taxes rise or the inflation continues. (T, I)
 - g. A doctor can diagnose this disease if and only if he has experience in the tropics. (D, T)
 - h. If the market drops, Simon will borrow more money. (M, B)
 - i. A will dance only if B sings. (A, B)
 - j. Mr X can secure majority of votes if Mr X cares for the people. (S, C)
 - k. She prepares to earn a good living only if her school days are well spent. (P, S)
 - l. Neither the cost of living will rise nor will the public agitate. (C, A)
 - m. We will go if it does not rain. (G, R)

- n. Be neither a borrower nor a lender. (B, L)
 - o. Vinod failed though he tried. (F, T)
 - p. A implies B, and C implies D. (A, B, C, D)
 - q. If mathematics is difficult, then you will pass only if you work hard.
(M, P, Q)
 - r. Either she is too good and innocent, or she is pretending to be so. (G, I, P)
 - s. Ram will go provided he is invited. (G, I)
 - t. Geeta is intelligent as well as hard working (I, H)
2. Make the truth tables of the following and determine their logical status as tautology, contingent or contradictory
- a. $p \supset \sim q$
 - b. $\sim p \vee q$
 - c. $\sim (p \cdot q)$
 - d. $(p \vee q) \supset r$
 - e. $p \supset (p \vee q)$
 - f. $(p \cdot \sim p) \supset q$
 - g. $(p \vee q) \supset \sim p$
 - h. $(p \cdot q) \equiv \sim p$
 - i. $p \supset (q \cdot \sim q)$
 - j. $p \vee (\sim p \supset p)$
 - k. $p \supset (\sim p \supset \sim q)$
 - l. $\sim (p \supset q) \vee \sim r$
 - m. $p \supset \sim (q \vee r)$
 - n. $(p \cdot q) \supset (r \vee p)$
 - o. $(\sim p \cdot \sim q) \cdot \vee r$

- p. $p \supset \sim (q \supset \sim r)$
- q. $(p \vee q) \bullet (\sim p \bullet \sim q)$
- r. $\sim (p \bullet q) \bullet (q \supset p)$
- s. $(p \supset q) \supset \sim (\sim q \supset \sim p)$
- t. $(\sim p \vee \sim q) \equiv (p \equiv q)$
- u. $\sim (p \bullet \sim q) \supset (q \bullet \sim p)$
- v. $(p \equiv q) \equiv [(p \supset q) \bullet (q \supset p)]$
- w. $(p \supset q) \supset [(\sim p \vee q) \vee r]$
- x. $[(p \bullet q) \supset \sim r] \supset (p \supset r)$
- y. $[(p \supset q) \bullet (q \supset r)] \supset (p \supset r)$

3. Give a brief history of symbolic logic.
4. Explain and illustrate the notions of ideograms and phonograms.
5. What are the various uses of symbols in logic? Explain.
6. Explain various types of symbols used in symbolic logic.
7. Point out difference between disjunction and alternation.
8. Explain Truth Table Method as a decision procedure.
9. What is the main characteristic of constant symbol? Explain with the help of examples.

Unit 10

Buddhist Formal Logic

The Buddhist Theory of *ANUMĀNA* (Inference)

Anumāna as *Pramāṇa*

In Indian context logic, used for the theory of *anumāna*, has been a part of epistemology as it is one of the modes of knowing. The epistemological thinkers in India have generally adopted a casual approach to knowledge. Knowledge is taken to be an occurrence, an outcome of a particular causal complex (*kāraṇa sāmagrī*) in which the casual condition acting as an instrumental cause (*kāraṇa*) is known as *Pramāṇa*. *Pramāṇa* is the mode of knowing. In Indian epistemology there are two broad traditions, viz., Nyāya and Buddhist. Unlike the Nyāya thinkers the Buddhist thinkers do not entertain demarcation between *pramāṇa* and its outcome (*pramāṇa phala* = *pramā*) mainly because this demarcation is not needed in their epistemological set up. Moreover, they maintain that no rigid separation is possible between the act of cognizing and the cognition of an object. Only rough distinction can be drawn.

Anumāna as Mode of Knowing and Reasoning

In the Buddhist epistemology there are two modes of knowing, viz., *pratyakṣa* (perception) and *anumāna* (inference). The theory of *anumāna* can be regarded as logic, as a science of reasoning. It is logic in Indian context. *Anumāna* is at once a mode of knowing and a way of reasoning. Thus, it has an epistemic as well as a logical aspect both of which are inseparably coalesced into one. Study of *anumāna* is therefore called as *Pramāṇa/Nyāya śāstra* as well as *Hetu vidyā*.

Nature and Structure of *Anumāna*

The word *anumāna* (*anu*+*māna*) literally means 'a knowledge which follows'. This means that inferential knowledge is necessarily a knowledge which is to be preceded by some other knowledge. In other words, *anumāna* consists of two stages, one pertaining to the preceding which constitutes the causal complex and the other to the particular type of relationship known as *liṅga-liṅgī-bhāva* which implies that the succeeding one should necessarily come from the preceding. The preceding knowledge has to be in the form of *liṅga*. A *liṅga* is defined as that which is a necessary mark of something other than itself. '*Liṅgin*' stands for that which is necessarily marked by *liṅga*. Between *liṅga* and the *liṅgin* there is always a *gamaka-gamya-bhāva* which can roughly be regarded as the relation of entailment such that every case of the presence of *liṅga* is necessarily a case of the presence of *liṅgin* and every case of absence of *liṅgin* is the case of the absence of *liṅga*. This entailment relation is the basis of inference. Between any two concepts there will be *gamaka-gamya-bhāva* if and only if they have

avinābhāva/svabhāva pratibandha, i.e., necessary connection or existential tie. It is the presence of the necessary connection which is the basis for the passage from the one to the other. This relationship of *avinābhāva* is also known as *vyāpti*. *Vyāpti*, therefore, constitutes the very basis of the inferential process. It will be discussed in detail later on. The term '*hetu*' is used for *līṅga* and the term '*sādhya*' is used for *liṅgin*. Either of these terms can be used as they are synonyms. Since they are synonyms meaning remains the same. But they are to be used in pairs of *hetu-sādhya* or *līṅga-liṅgin* depending upon requirements of the situation. To avoid confusion they are used here in togetherness using a stroke. There is no definite convention for their usage but generally for *vāda* (debate) *hetu-sādhya* pair is used.

In the Buddhist tradition *hetu/liṅga* and *sādhya/liṅgin* are in the form of concepts (*vikalpas*). They are not objects or events or meta-physical reals as they are taken in the Nyāya tradition. This makes the Buddhist theory formal. Here entire thought process operates at the conceptual level only and therefore the Buddhist logicians could conceive of one concept being subsumed under or necessarily connected with another concept by the relation of analyticity. In this way they could develop a formal system of logic, of course, keeping ontology at the back. For them *anumāna* is a sort of analytical entailment.

Nyāya analysis of *Anumāna*

In order to have a better understanding of the Buddhist analysis of '*anumāna*' it will be worthwhile if we discuss in brief the Nyāya analysis of '*anumāna*'. According to Nyāya *anumāna* is the knowledge of an object on the basis of the cognition of its mark along with a remembrance of a previous knowledge concerning an invariable and unconditional relation between the object and its mark. In other words, in every case of *anumāna* in the preceding cognition, which can be treated as a premise, there are two elements, viz., (i) perceptual cognition of the *hetu/liṅga* (*pakṣadharmatā*) and (ii) the remembrance of unconditional and invariable relation (*vyāpti*) between the *hetu/liṅga* and the *sādhya/liṅgin*. The perceptual cognition of the mark leads to the remembrance of its unconditional and invariable relationship with the *liṅgin* resulting in a synthesized knowledge. The synthesis of both these stages is named as *parāmarśa*, which is therefore defined as '*vyāpti viśiṣṭa pakṣadharmatājñānam*'. The act of *parāmarśa* can thus be said to consist of three elements, viz., the knowledge of *vyāpti*, the knowledge of *pakṣadharmatā* and the knowledge of the *vyāpti* qualifying *pakṣadharmatā*. Thus, though *vyāpti* is one of the causal conditions, and a necessary causal condition (*karaṇa*), yet it is not the sufficient condition of inference. The sufficient condition (*vyāpāra*) is *parāmarśa* only.

Buddhist rejection of *Parāmarśa*

The Buddhist logicians do not make separation between *pakṣadharmatā* and *vyāpti* in the way in which the Nyāya logicians do. According to them, *pakṣadharmatā* and *vyāpti* are both comprehended under the concept of *trairūpya līṅga* and therefore there is no point in talking of *vyāpti* qualifying *pakṣadharmatā*. Thus, the Nyāya notion of *parāmarśa* is not needed by the Buddhists.

Classification of *Anumāna*

In the Buddhist framework *anumāna* consists of a thought process which may or may not be verbalized. If it is linguistically not expressed and is purely cognitive (*jñānātmaka*) it is called *svārthānumāna*. When it is expressed in language (*ākhyāna*) it is called *parārthānumāna*. This two-fold classification was already prevalent in the Nyāya tradition but it was used in a slightly different sense as 'inference for one's own sake' and 'inference for the sake of others' respectively. Of course, generally we resort to sentential expression to communicate with others but this is not a necessary condition for using language. Moreover, according to the Buddhist viewpoint there can be non-verbalized conceptual cognition. This is in sharp contrast with the Nyāya view that no conceptual cognition can be non-verbal.

Constituents of *Anumāna*

According to the Buddhist analysis, like the analysis of other Indian systems, the process of inference involves three basic terms and their interrelations. We may first discuss the terms and thereafter their interrelations. The three terms are *pakṣa* (*anumeya*) the logical subject, *hetu/liṅga* the reason, and *sādhya/liṅgin* the logical predicate. They roughly correspond to the minor, middle and major terms of the traditional western logic.

We may take this example of *anumāna* as given under to know these terms.

"There is fire on the hill because there is smoke there". Here 'hill' is *pakṣa* because in respect of it 'fire' is inferred from presence of 'smoke' on it. 'Smoke' is *hetu/liṅga* because this provides the ground/reason for inferring 'fire on the hill'. 'Fire' is the *sādhya/liṅgin* because it is inferred on the hill on the basis of presence of 'smoke' there.

Pakṣa :

Pakṣa is the subject under consideration in the inferential reasoning. Every inference pertains to some individual or class of individuals about which we want to prove something. Hence *pakṣa* is that individual or class of individuals about which we want to establish something. It is also named as *anumeya* because it is the object about which something is to be inferred. In a special sense it also means the underlying substratum (*dharmin*) to which *sādhya/liṅgin* is to be inferred/ascribed as a property on the ground of *hetu/liṅga* being its property.

Pakṣa can be regarded as the starting point of inferential inquiry. There is perceptual cognition of *pakṣa*. Though it is a concept it has some empirical reality at its back. For example, 'hill' is the *pakṣa* here. Hill is empirically real. It is not an empty or barren concept having no reality to fall back upon. Likewise 'smoke' and 'fire' are also not empty concepts. Thus, Buddhist logic is formal but not in the western sense. Not only *pakṣa* should not be an empty or barren concept, it should not be incompatible with *hetu/liṅga* and *sādhya/liṅgin*. Thus, for example, lake can not be a *pakṣa* in that case where 'smoke' is *hetu/liṅga* and 'fire' is *sādhya/liṅgin*.

Hetu/Liṅga :

The other term involved in the process of inference is *hetu/liṅga*. In fact it is the pivotal element in the process of *anumāna*. It is the necessary mark which leads to the inference of its marked object which is not directly given or perceived. Like *pakṣa*, *hetu/liṅga* is also perceptually cognized. It is also known as *sādhana* because it is a means to know its *sādhya*. In the above stated example 'smoke' is *hetu/liṅga*.

Hetu/liṅga has three formal characteristics the satisfaction of which alone enables it to act as a sufficient reason for the inference of its marked object. A *hetu/liṅga* which possesses these three characteristics is known as *sadhetu* or *trairūpya liṅga*. We shall later on discuss in details these three marks.

Sādhya/Liṅgin :

The third entity involved in the inferential process is *sādhya/liṅgin*. It is necessarily marked by *hetu/liṅga*. The two have necessary connection. It is *sādhya/liṅgin* which constitutes the property (*dharma*) which is to be inferred in relation to the *pakṣa* on the basis of another property of *pakṣa* which is *hetu/liṅga*. *Hetu/liṅga* is the perceived property of *pakṣa* and *sādhya/liṅgin* is the inferred property. In the above stated example 'fire' is *sādhya/liṅgin*.

Sapakṣa :

Another significant concept which is given in the analysis of the inferential process is *sapakṣa* (homologue/similar instances). *Sapakṣa* means an object similar to *pakṣa*. In other words, all those objects which possess the property which is to be inferred are known as *sapakṣa*; for example, if 'fire' is the predicate which is to be inferred in relation to a 'hill' then all those instances like 'kitchen' etc., where fire is known to be a predicate, constitute *sapakṣa*. A *sapakṣa* is similar to *pakṣa* in this sense only that both of them comprehend a common property. *Sapakṣa* is metaphorically called copartner of *pakṣa*. *Pakṣa* is something which is perceptually given but *sapakṣa* is something which is to be remembered on the basis of past indubitable experience.

Asapakṣa :

A case which is not similar to *pakṣa* is regarded as *asapakṣa* or *vipakṣa* (heterologue, dissimilar instances). In other words, *asapakṣa* is dissimilar to *sapakṣa* in that it is never a possessor of the property commonly possessed by *pakṣa* and *sapakṣa*. *Asapakṣa* can be of three types:

- (a) Different from it (*anya*)
- (b) Contrary to it (*viruddha*)
- (c) Absence of it (*abhāva*)

Of these *abhāva* is most fundamental.

Subsequently the roles of *sapakṣa* and *asapakṣa* will be discussed.

Vyāpti :

The entire inferential process, as stated above, is based upon the relation between *hetu/liṅga* and *sādhya/liṅgin*, which can be understood in terms of necessary dependence (*avinābhāvānīyama* = *a + vinā + bhāva*) and which is technically known as *vyāpti*. It implies absence of *hetu/liṅga* in the absence of *sādhya/liṅgin*. In other words, *hetu/liṅga* can not be present in the absence of *sādhya/liṅgin*. The Buddhist conception of *vyāpti* stands for an invariable necessary connection. *Vyāpti* is a necessary bond because of the fact that it is rooted in what is technically known as *svabhāva pratibandha*, existential dependence or existential tie. Existential dependence means dependent existence. Existential tie means the existence of one thing is tied to the other. It may be in the form of a casual relation or an analytical entailment. For example, the dependence of effect on its cause enables us to infer the cause the moment the effect is known to us. Similarly, an analytically deduced fact by its very essence depends upon the fact from which it is deduced. Thus, there is *svabhāva pratibandha* between cause and effect and between the deduced object and that from which there is deduction. The example of the former type is relation between smoke and fire and of the latter type is the relation between rose and flower. We can deduce one fact from another only if there is existential dependence. It may be asked why is it that we can deduce one fact from another only if there is existential dependence. The answer given by the Buddhist logicians is that this is so because an effect which is not dependent upon another object cannot be invariably and necessarily concomitant with the latter. In other words, if effect is not tied up by its existence to another object, it can not be necessarily concomitant with the latter. There will be no invariability (*avyabhicāra*). Thus, the possibility of deducing one fact from the other depends upon an invariable and necessary connection which precludes the existence of the one without the existence of the other. Therefore, if two facts are existentially connected we can assert that one of them can not exist independently of the other and therefore from the presence of the one follows the presence of the other.

Existential tie (or dependence) is always that of the *hetu/liṅga* with *sādhya/liṅgin*. *Hetu/liṅga* is always dependent on *sādhya/liṅgin*, whereas the *sādhya/liṅgin* is independent of *hetu/liṅga*. That is why *hetu/liṅga* is said to be 'tied to' and the *sādhya/liṅgin* is said to be 'not-tied'. That which is tied is the *gamaka* and that to which it is tied is *gamyā*. In the above example 'smoke' is tied to 'fire' and there can be no smoke without 'fire', but 'fire' can be without 'smoke'. So, 'smoke' is the *hetu/liṅga* and 'fire' is the *sādhya/liṅgin*. There is necessary connection between 'smoke' and 'fire' but not between 'fire' and 'smoke'.

Hetu/liṅga is also known as *vyāpya* and *sādhya/liṅgin* is known as *vyāpaka*. Accordingly, it is said that the presence of *vyāpaka* is necessary for the presence of *vyāpya*, and *vyāpya* can exist only when *vyāpaka* exists. These two conditions are, respectively, known as *anvaya* and *vyatireka*. These two conditions are necessary for *vyāpti* relation. Thus, in short, the *vyāpti* relation stands for the regulation that *hetu/liṅga* can be present only in the presence of *sādhya/liṅgin* and that absence of *sādhya/liṅgin* implies necessary absence of *hetu/liṅga*.

According to the Buddhist logicians the positive relation of *vyāpti* is of two types, namely, *tādātmya* (analytical entailment) and *tadutpatti* (causal). There can be analytical entailment relation between two concepts such that one of them can not be conceived without the other and has necessary dependence on the other. For example, 'rose' and 'flower' are two such concepts such that 'rose' can not be conceived without its being a 'flower'. So there is analytical entailment relation between 'rose' and 'flower'. The concept of 'rose' entails the concept of 'flower'. The other type of *vyāpti* is causal. The effect necessarily presupposes its cause. Here it must be noted that whenever there is an effect there must be its cause, but it is not necessary that whenever there is a cause there must be its effect. The analytical relation is a relation of simultaneity or coexistence whereas the causal relation is a relation of succession. It must be noted here that according to the Buddhist logicians *vyāpti* relation is mental construction though stimulated by perceptual cognition.

Kinds of *Liṅga*

There are three varieties of *hetu/liṅga*, viz., *anupalabdhi*, *svabhāva* and *kārya*. The *sādhya/liṅgin* is a sort of predicate and a predicate is either denied or affirmed. When it is denied, this is done on the basis of the non-existence of its mark. Such a mark is known as *anupalabdhi hetu* or *anupalabdhi liṅga*. When it is affirmed, its mark is either existentially identical with it or if different, it is its effect. In the former case its *hetu/liṅga* is known as *svabhāva hetu* or *svabhāva liṅga* and in the latter case it is known as *kārya hetu* or *kārya liṅga*.

Anupalabdhi:

Anupalabdhi has been defined as non-cognition of such an object which otherwise fulfils the conditions of cognizability. For example, a 'jar' is an object which fulfils the condition of cognizability. If at a particular place there is non-cognition of a 'jar', this enables us to infer its non-existence. So here non-cognition of the 'jar' is the *hetu/liṅga* and non-existence of the 'jar' is the *sādhya/liṅgin*. The non-cognition (of a thing) is to be regarded as *hetu/liṅga* for the non-existence (of that thing) which is its *sādhya/liṅgin* on the ground that if the 'jar' were present, it would have necessarily been perceived when all other conditions of perceptibility are fulfilled. In spite of all the conditions of perceptibility being present, if the 'jar' is not perceived, we can legitimately infer its non-existence.

Svabhāva hetu or *Svabhāva Liṅga*:

The second type of *hetu/liṅga* is known as *svabhāva hetu* or *svabhāva liṅga*. It is defined as that whose mere existence is sufficient for the deduction of *sādhya/liṅgin*. For example, in the judgment, "It is a flower because it is a rose" the reason, namely, 'rose' is sufficient for the deduction of 'flower'. As stated earlier, the terms 'rose' and 'flower' have one and the same object for their reference though they may have different meanings. It is this sameness of reference known as *tādātmya* which is responsible for the existential tie between rose and flower.

Kārya hetu or Kārya Liṅga:

The third type of *hetu/liṅga* is *kārya hetu* or *kārya liṅga* which is in the form of an effect. It necessarily presupposes its cause like smoke necessarily implies the existence of fire. The causal connection is given to us in our experience of both *anvaya* and *vyatireka* types, i.e., on the basis of agreement in presence and agreement in absense between two phenomena.

Three types of *Anumāna*

Since there are three types of *hetu/liṅga*, there are three types of *anumāna*, viz., *Anupalabdhi*, *Svabhāva* and *Kārya*. *Kārya* is also known as *Tadutpatti*.

There are five types of propositions which may be involved in an inference. They are as follows:

1. That which is to be proved is stated as *Pratijñā*.
2. That on the basis of which something is proved is stated as *Hetu*.
3. The supporting examples, positive and negative, are stated as *Udāharaṇa*,
4. Subsuming the case to be proved under a general principle is stated as *Upanaya*
5. The conclusion deduced after proof is stated as *Nigamana*.

In Buddhist system of logic it is not necessary to employ all the five types in an inference or argument. First three or last three can be used depending upon the logical requirements. Sometimes an abbreviated form consisting of two propositions is used.

The examples of the three types of *anumāna* can be as under:

Anupalabdhi:

Whatsoever is present and is perceptible is necessarily perceived, like a jar.

But there is no such a jar being perceived here.

Therefore, a jar is not present here.

Svabhāva:

All roses are flowers.

This is a rose.

Therefore, this is a flower.

Kārya:

Wherever there is smoke there is fire.

There is smoke here in the next room.

Therefore, there is fire here in the next room.

Doctrine of Trairūpya:

Though a *hetu/liṅga* may be either in the form of *anupalabdhi* or *svabhāva* or *kārya*, every *hetu/liṅga* necessarily possesses three marks. The doctrine of three marks of a *hetu/liṅga*, technically known as *trairūpyavāda*, is of great logical significance in the Buddhist theory of inference.

According to Buddhist logic the *hetu/liṅga* is characterized by three essential characteristics. In fact in the history of Indian Logic we find different views with regard to the essential characteristics of *hetu/liṅga*. Whereas the Nyāya tradition insists on five characteristics and the Jaina tradition regards only one characteristic, the Buddhist tradition maintains that there are three and only three essential characteristics of a *hetu/liṅga*. Every *hetu/liṅga* must possess all the three characteristics simultaneously (*trilakṣaṇa hetu*). Then and then only it can be regarded as a *hetu/liṅga*, and be made use of in the process of inference.

The three characteristics (*rūpas*) are as under:

1. Pervasive presence of *hetu/liṅga* in the *pakṣa* in its totality. Symbolically it can be expressed as "hetu is present in every *pakṣa*"
" 'h' is present in every 'p' "
"every 'p' is 'h' ".
2. Necessary presence (never absence) of *hetu/liṅga* in *sapakṣa* although not in their totality.
"*Hetu* has to be present in at least one *sapakṣa* and at most in all *sapakṣas*. Symbolically it can be expressed as "at least one 's' and at most every 's' is 'h' ".
3. Pervasive absence (never presence) of *hetu/liṅga* in all *asapakṣas*. *Hetu/liṅga* must be absent in every *asapakṣa*. Symbolically it can be expressed as "No 'a' is 'h' ".

Here *Hetu* = h

Sapakṣa = s

Asapakṣa = a

This is distribution of quantification of *hetu* in its extension with regard to *pakṣa*, *sapakṣa* and *asapakṣa*

In short it can be stated as under :

1. In *pakṣa* wholly
2. In *sapakṣa* only
3. In *asapakṣa* never

Laws of Extension :

1. If a term is related to another term by its presence in its extension, then it is known as *vyṛtti*. If it is absent in the extension of another term, then it is known as *avṛtti*.
2. If the extension of one term is pervading the entire extension of another term, then it is known as *vyāpaka/sakaladeśavṛtti* (*sakala* + *deśa* + *vyṛtti*). If the extension of one term is only a part of the extension of another term, then it is known as *ekadeśavṛtti* (*eka* + *deśa* + *vyṛtti*)

There are corollaries of these two laws but we need not discuss them here.

'Hetu Cakra Ḍamaru' of Diñnāga

The doctrine of *trairūpya* has been explicated by *Diñnāga* in his work '*Hetu Cakra Ḍamaru*', a primer of Buddhist formal logic. In this work nine different conceivable relations of *hetu* with *pakṣa*, *sapakṣa*, and *asapakṣa* are presented. This presentation of the doctrine of *trairūpya* in a wider context was named by him as the doctrine of *hetucakra*. Both these doctrines refer to the extension of *hetu*. This doctrine of *trairūpya* represents only three valid relations of *hetu* with *pakṣa*, *sapakṣa*, and *asapakṣa*, whereas the doctrine of *hetucakra* takes for granted the presence of *hetu* in *pakṣa*, and its relations with *sapakṣa* and *asapakṣa* are alone taken into consideration. Here three possible ways of the relation between *hetu* and *sapakṣa* and *hetu* and *asapakṣa* are conceived and analyzed, namely, *vyāpaka* (pervasive presence), *avṛtti* (pervasive absence), and *ekadeśavṛtti* (partial presence). He gives a formal schema of nine valid and invalid types of *anumāna* based on three possible relations of *hetu* with *sapakṣa* and *asapakṣa*. Since the text is very short we can have the advantage of giving it here in full, for those who take interest in it. Since in the text *Diñnāga* uses the word *hetu* and not *liṅga* and likewise *sādhya* and not *liṅgin*, we follow him here.

Here '*hetu*' is translated as 'reason'

'*Sādhya*' is translated as 'probandum'

Sapakṣa is translated as 'similar instance'

Asapakṣa is translated as 'dissimilar instance'.

Hetu Cakra Damaru (The Wheel of Reasons)

Homage to *Mañjuśrīkumārabhūta*.

Homage to the Omniscient One, who is

The destroyer of the snare of ignorance.

I am expounding the determination of

The reason with three-fold characteristics

Among the three possible, cases of “presence,” “absence” and “both”

Of the reason in the probandum,

Only the case of its “presence” is valid.

While its “absence” is not.

The case of “both presence and absence” is inconclusive,

It is therefore not valid either.

The “presence,” “absence” and “both.”

Of the reason in similar instances,

Combined with those, in dissimilar instances,

There are three combinations in each of three,

The top and the bottom are valid,

The two sides are contradictory.

The four corners are inconclusive because they are “too broad.”

The centre is inconclusive because it is “too narrow”.

Knowable, produced, non-eternal,

Produced, audible, effort-made,

Eternal, effort-made and incorporeal,

Are used to prove the properties of being:

Eternal, non-eternal, effort-made,

Eternal, eternal, eternal,
Non-effort-made, non-eternal and eternal.

When two tops or two bottoms meet,
The reason is valid.
When two corresponding sides meet,
It is inconclusive because it is “too narrow.”

Since there are nine classes of reason,
Accordingly we have nine sets of example:

Space-pot, pot-space,
Pot-lightning-space
Space-pot-lightning,
Lightning-space-pot,
Pot-lightning-space,
Space-action-pot.

The above concerns the “determined reason” only;
A regards the “doubtful” ones,
There are also nine combinations of
“Presence,” “absence” and “both.”

Here the presence of *hetu* in *pakṣa* is taken for granted and it is combined with different types of relations that a *hetu* may possess with *sapakṣa* and *asapakṣa*. The combination of these possibilities gives rise to nine types. Among these nine possible relations between *hetu* and *sādhya*, only two are valid, and these constitute the II and III *rūpas* of the doctrine of *trairūpya*, and the remaining seven are graded as invalid as they are at variance with the doctrine of *trairūpya*. The nine possible relations are as follows:

I. *Sapakṣāsapakṣavyāpaka*: Pervasive presence in similar and dissimilar instances.

- II. *Sapakṣavyāpaka asapakṣāvr̥tti*: Pervasive presence in similar instances and necessary absence in dissimilar instances.
- III. *Sapakṣavyāpaka asapakṣaikadeśāvr̥tti*: Pervasive presence in similar instances and partial presence in dissimilar instances.
- IV. *Sapakṣāvr̥tti asapakṣavyāpaka*: Necessary absence in similar instances and pervasive presence in dissimilar instances.
- V. *Sapakṣāsapakṣāvr̥tti* : Necessary absence in similar and dissimilar instances.
- VI. *Sapakṣāvr̥tti asapakṣaikadeśāvr̥tti*: Necessary absence in similar instances and partial presence in dissimilar instances.
- VII. *Sapakṣaikadeśāvr̥tti asapakṣavyāpaka*: Partial presence in similar instances and pervasive presence in dissimilar instances.
- VIII. *Sapakṣaikadeśāvr̥tti asapakṣāvr̥tti*: Partial presence in similar instances and necessary absence in dissimilar instances.
- IX. *Sapakṣāsapakṣaikadeśāvr̥tti* : Partial presence in similar and dissimilar instances.

Hetu may be present in all, some or none of the *sapakṣa* and *asapakṣa*. Accordingly the above stated nine possibilities are conceived. They may be put in the form of a chart as under:

No.	Relation of <i>hetu</i> with <i>sapakṣa</i>	Relation of <i>hetu</i> with <i>asapakṣa</i>	Logical status of <i>hetu</i>
1.	Wholly Present	Wholly present	Invalid (inconclusive)
2.	Wholly present	Wholly absent	Valid
3.	Wholly present	partly present	Invalid (contradictory.)
4.	Wholly absent	Wholly present	invalid (inconclusive)
5.	Wholly absent	Wholly absent	invalid (contradictory.)
6.	Wholly absent	partly present	invalid (inconclusive)
7.	Partly present	Wholly present	Invalid(inconclusive)
8.	Partly present	Wholly absent	Valid
9.	Partly present	Partly present	invalid (inconclusive)

In short this implies that:

- (i) If *hetu* is wholly or partly present in *sapakṣa* but wholly absent from *asapakṣa*, then it is valid.

- (ii) Their opposites are contradictory.
- (iii) Rest are inconclusive.

These nine *rūpas* of the *hetucakra* have been represented by *Diñnāga* in the form of this diagram:

I	II	III
IV	V	VI
VII	VIII	IX

Referring to this diagram, he writes:

The top and the bottom are valid,

The two sides are contradictory,

The four corners are inconclusive because they are “too narrow”

The center is inconclusive because it is “too narrow”

Keeping this in view, we can explicate the diagram as follows:

I (corner)	II (top)	III (corner)
IV (side)	V (center)	VI (side)
VII (corner)	VIII (bottom)	IX (corner)

After stating the *hetucakra*, *Diñnāga* proceeds to illustrate the different *rūpas* with the help of the following example:

Nine *hetus*:

Knowable	Produced	Non-eternal
Produced	Audible	Effort-made
Eternal	Effort-made	Incorporeal

Nine *Sādhya* :

Eternal	Non-eternal	Effort-made
Eternal	Eternal	Eternal
Non-effort-made	Non-eternal	Eternal

With the help of these examples we can explain the earlier mentioned verse like this:

Two Tops Meet:

Whatever is produced is non-eternal: **Valid.**

Two Bottoms Meet:

Whatever is effort-made is non-eternal: **Valid.**

Two Corresponding Sides Meet:

Whatever is produced is eternal: **Contradictory.**

Whatever is effort-made is eternal: **Contradictory.**

Corresponding Corners Meet:

Whatever is knowable is eternal: **Inconclusive, “too broad.”**

Whatever is eternal is non-effort-made: **Inconclusive, “too broad.”**

Whatever is non-eternal is effort-made: **Inconclusive, “too broad.”**

Whatever is incorporeal is eternal: **Inconclusive, “too broad.”**

Two Centers Meet:

Whatever is audible is eternal: **Inconclusive, “too broad.”**

The statement of the *hetucakra*, because of its cryptic wording, is unintelligible by itself, but with the help of examples given by *Diñnāga* it can be better understood. Here we take an example of *anumāna* consisting of three steps because Buddhists accept only three steps. The three steps are *pratijñā*, *hetu*, and *udāharaṇa* of *sapakṣa* and *asapakṣa*. The three terms of *anumāna* are *pakṣa*, *hetu*, and *sādhya*. It is presumed that *hetu* is present in *pakṣa* (i.e., *pakṣadharma*). The relation of *hetu* with *sapakṣa* is conceived to be of three possible types, namely, *vyāpaka*, *avṛtti*, and *ekadeśavṛtti*. Similarly, the relation of *hetu* with *asapakṣa* can also be conceived of in the preceding manner. On the basis of the preceding stipulations the *hetu cakra* can be exemplified in the following way:

Statement of the example of First Form:

Pratijñā : Sound is eternal.

Hetu : because it is knowable.

Udāharaṇa of *sapakṣa* and *asapakṣa* : like space and unlike pot.

The three terms are:

Pakṣa : sound

Hetu : knowable

Sādhya : eternal.

In this example the *hetu*, apart from being present in *pakṣa*, is also present in both *sapakṣa* and *asapakṣa*. It renders this argument invalid. Here there is a fallacy of *sādhāraṇa anekāntika* (inconclusive, too broad), because the *hetu* is present in all three, whereas as per rule it should be present only in the first two.

Statement of the example of Second Form :

Pratijñā : sound is non-eternal.

Hetu : because it is produced

Udāharaṇa of *sapakṣa* and *asapakṣa* : like a pot and unlike space.

The three terms are :

Pakṣa : sound.

Hetu : produced.

Sādhya : non-eternal.

In this example the *hetu* is present in *pakṣa*, is also present in *sapakṣa*, and is absent in *asapakṣa*. Thus, it satisfies all the three requirements of *trairūpya*. So it is valid.

Satatement of the example of Third Form :

Pratijñā : Sound is effort-made.

Hetu : because it is non-eternal.

Udāharaṇa of *sapakṣa* and *asapakṣa* : like pot and unlike lightning and space.

The three terms are :

Pakṣa : sound.

Hetu : Non-eternal.

Sādhya : effort-made.

In this example, the *hetu* is no doubt *present* in *pakṣa* and *sapakṣa* but is absent in some instances of *asapakṣa* and is present in others. The *hetu* has *asapakṣaikaadesavṛtti* because (1) some non-effort-made things are non-eternal like lightening whereas (2) some non-effort-made thing are eternal like ether. Thus, the presence of *hetu* in some *asapakṣas* renders this argument invalid. Here there is a fallacy of *sādhāraṇa anekāntika* (inconclusive, too broad).

Statement of the example of Fourth Form :

<i>Pratijñā</i>	: sound is eternal.
<i>Hetu</i>	: because it is produced.
<i>Udāharaṇa</i> of <i>sapakṣa</i> and <i>asapakṣa</i>	: like ether and unlike pot.

The three terms are :

<i>Pakṣa</i>	: sound.
<i>Hetu</i>	: produced.
<i>Sādhya</i>	: eternal.

In this example, the *hetu* is present *pakṣa*, is absent in *sapakṣa* and present is *asapakṣa*. Thus, *hetu* is contradictory of *sādhya*. This renders it invalid. Here there is a fallacy of *viruddha* (contradictory).

Statement of the example of Fifth Form :

<i>Pratijñā</i>	: sound is eternal.
<i>Hetu</i>	: because it is audible.
<i>Udāharaṇa</i> of <i>sapakṣa</i> and <i>asapakṣa</i>	: Like space and unlike pot.

The three terms are :

<i>Pakṣa</i>	: sound.
<i>Hetu</i>	: audible.
<i>Sādhya</i>	: eternal.

Here the *hetu* is present only in *pakṣa* and is absent not only in *asapakṣa* but also in *sapakṣa*. Here there is a fallacy of *asādhāraṇa anekāntika* (inconclusive, too narrow).

Statement of the example of Sixth Form :

<i>Pratijñā</i>	: sound is eternal.
<i>Hetu</i>	: because it is effort made.
<i>Udāharaṇa</i> of <i>sapakṣa</i> and <i>asapakṣa</i>	: like space and unlike pot and lightning.

The three terms are :

<i>Pakṣa</i>	: sound
<i>hetu</i>	: effort made

Sādhya : eternal

Here the *hetu* is present only in *pakṣa*, absent in *sapakṣa*, but present in some instances of *asapakṣa* and absent in others. Here there is a fallacy of *viruddha* (contradictory).

Statement of the example of Seventh Form :

Pratijñā : Sound is non-effort made.

Hetu : because it is non-eternal.

Udāharaṇa of *sapakṣa* and *asapakṣa* : Like lightning and space and unlike pot.

The three terms are :

Pakṣa : sound

Hetu : non-eternal

Sādhya : non-effort-made.

Here the *hetu* apart from its presence in *pakṣa* is present in some instances of *sapakṣa* and absent in others, whereas it is present in *asapakṣa*. Here there is a fallacy of *sādhāraṇa anekāntika* (inconclusive, too broad).

Statement of the example of Eighth Form :

Pratijñā : sound is non-eternal.

Hetu : because it is effort made.

Udāharaṇa of *sapakṣa* and *asapakṣa* : Like pot and lightning and unlike space.

The three terms are :

Pakṣa : sound

Hetu : effort made

Sādhya : non-eternal.

Here the *hetu* is present in *pakṣa*, present in some instances of *sapakṣa* and absent in others, whereas it is absent in all the cases of *asapakṣa*. Thus, the argument satisfies all the three requirements of the *trairūpya*. So it is valid.

Statement of the example of Ninth Form :

Pratijñā : Sound is eternal.

Hetu : because it is incorporeal.

Udāharaṇa of *sapakṣa* and *asapakṣa* : like space and infinitesimal particles and unlike action and pot.

The three terms are :

Pakṣa : sound.

Hetu : incorporeal

Sādhya : eternal

Here, no doubt, *hetu* is present in *pakṣa* and in some instances of *sapakṣa* but is also present in some instances of *asapakṣa*. This renders it inconclusive (too broad). Here there is a fallacy of *sādhāraṇa anekāntika*.

Because of lack of interest in later times the Buddhist formal logic did not develop further. But there are immense possibilities of development and refinement. Here it must be clarified that Buddhist Logic has ontological commitment in the sense that it has been formulated to substantiate the basic tenets and key doctrines of Buddhist philosophy propounded by Gautama, the Buddha. So even though it is formal it takes into account the nature of empirical reality which has to be known correctly to realize wisdom, the liberating knowledge. Therefore, it has a necessary practical orientation and applied dimension.

Questions

1. Point out the nature of *anumāna*.
2. How many terms are involved in the process of *anumāna* ? Explain each of them.
3. What is the relation of *pakṣa* with *sapakṣa* and *asapakṣa*?
4. Discuss the nature and role of *vyāpti* in the process of *anumāna*.
5. Discuss the types of *hetu/liṅga* and types of *anumāna*.
6. Explain the theory of *trairūpya liṅga (trilakṣaṇa hetu)*.
7. In the following example point out which are *hetu/liṅga*, *sādhya/liṅgin* and *pakṣa*.
"Pot is non-eternal because it is produced".
8. Point out the *vyāpti* relation in the following argument :
" The cloth is perishable because it is a product".



CENTRAL BOARD OF SECONDARY EDUCATION

Shiksha Kendra, 2, Community Centre, Preet Vihar, Delhi - 110092, India

Tel.: 91-11-22509252-59 Fax : 91-11-22515826

E-mail : cbse1@nda.vsnl.net.in website : www.cbse.nic.in