G.C.E (Advanced Level)

Logic & Scientific Method

Teacher's Guide
Grade 12
(To be implemented from 2017)

Department of Social Sciences

Faculty of Languages, Humanities and Social Sciences

National Institute of Education

Maharagama

Sri Lanka

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Message from the Director General

The first phase of the new competency based curriculum, with 8 years curriculum cycle was introduced to secondary education in Sri Lanka in 2007 replacing the existed content based education system with basic objective of developing the national level competencies recommended by the National Education Commission.

The second phase of the curriculum cycle to be introduced to grades 7 and 11 starts from 2016. For this purpose, National Institute of Education has introduced a rationalization process and developed rationalized syllabi for these grades using research based outcomes and various suggestions made by different stakeholders.

In the rationalization process, vertical integration has been used to systematically develop the competency levels in all subjects from fundamentals to advanced levels using the bottom up approach. Horizontal integration is used to minimize the overlapping in the subject content and to reduce the content over loading in the subjects to produce more students friendly and implementable curricular.

A new format has been introduced to the teachers' guide with the aim of providing the teachers with the required guidance in the areas of lesson planning, teaching, carrying out activities and measurement and evaluation. These guidelines will help the teachers to be more productive and effective in the classroom.

The new teachers' guides provide freedom to the teachers in selecting quality inputs and additional activities to develop the competencies of the students. The new teachers' guides are not loaded with subject content that is covered in the recommended textbooks. Therefore, it is essential for the teacher to use the new teachers' guides simultaneously with the relevant textbooks prepared by
Education Publication Department as reference guides to be more aware of the syllabi.

The basic objectives of the rationalized syllabi and the new format of teachers' guide and newly developed textbooks are to bring a shift from the teacher centered education system into a student centered and more activity based education system in order to develop the competencies and skills of the school leavers and to enable the system to produce suitable human resource to the world of work.

I would like to take this opportunity to thank the members of Academic Affairs Board and Council of National Institute of Education and all the resource persons who have immensely contributed in developing these new teacher guides.

Director General
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Message from Ven. Deputy Director General

Learning expands into a wider scope. It makes life enormous and extremely simple. The human being is naturally excellent in the skill of learning. A country when human development is considered the main focus uses learning as a tool to do away with malpractices identified with intellect and to create a better world through good practices.

It is essential to create valuable things for learning and learning methods and facilities within the adhere of education. That is how the curriculum, syllabi, teachers' guides and facilitatiors join the learning system. Modern Sri Lanka has possessed a self – directed education system which is a blend of global trends as well as ancient heritage.

It is necessary to maintain the consistency of the objectives of the subject at the national level. However, facilitators are free to modify or adapt learning teaching strategies creatively to achieve the learning outcomes, competency and competency level via the subject content prescribed in the Syllabus. Therefore, this Teachers' Guide has been prepared to promote the teachers' role and to support the students as well as the parents.

Furthermore, at the end of a lesson, the facilitators of the learning- teaching process along with the students should come to a verification of the achievement level on par with ones expected exam by a national level examiner, who evaluates the achievement levels of subjects expected. I sincerely wish to create such a self-progressive, motivational culture in the learning- teaching process. Blended with that verification, this Teachers' Guide would definitely be a canoe or a raft in this endeavor.

Ven. Dr. MabulgodaSumanarathanaThero
Deputy Director General
Faculty of Languages, Humanities and Social Sciences

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Contents

Preface

This syllabus had been prepared for the G.C.E Advanced Level Examination subject stream. This syllabus will be executed from 2017 related to new educational refurbishments. This curriculum is scheduled for three dimensional representatives who inculcate Advanced Level Logic and Scientific method as well as students by analytically acquiring ideas, attitudes and suggestions of them.

The subject content will be developed within 18 competencies and competency levels. Specific Teacher Guides for grade 12 and 13 including expected learning and learning outcomes will be introduced in near future. (theoretical and practical aspects of logical thinking and scientific thinking)

We constrain to contribute for generating good citizens with logical knowledge and prospering their lives by demystifying this particular syllabus.

Introduction

The new syllabus of Logic and Scientific Method will be started from grade 12 in 2017. This syllabus is convincingly prepared relevant to national procedures and encountered potentials.

The logic is depicted as a subfield of eastern and western philosophy and also appeared as an important component for facilitating knowledge in many civilizations. Incomparable and uncountable results could be obtained by elucidating this subject accordingly. The ability for generating accurate, systematic and logical conclusions is one of the unique practises could be reached among this subject. The person, who is involved in reasoning, diligently contemplates errors which had occurred in logical thinking rather than the others. Therefore the utility of logic is incomparable for any knowledge based subject.

Obviously reasoning is not extraneous of human thoughts. Therefore nothing could exist without reasoning or inference. The truth and accuracy will have escaped whether it is unsystematic. The logic becomes prominent of applied knowledge experimentations until recently it was concentrated on inculcating veritable of nature. This subject was rapidly developed in the following nineteenth century. It has recently popularised as a technological subject stream. It is also manifested in computer schools by constructing technology and artificial intelligence. The logic is the centre in all sciences because an intimate relationship was constructed with subjects which are sophistically contributed for academic development.

The reason which had intertwined with regular usage is one of our inheritances. An academic exposure would emphasise when it inculcates formally and systematically. The scientific method is enunciated as the science of logic and it correlates with logical reasoning. The knowledge of logic is helpful for determining scientific knowledge through deductive and inductive basements and to question the redefined knowledge through logical thinking patterns. It is conspicuous that the previous syllabus had also accomplished for determining above circumstances. The new syllabus is a proper integration of all components. The ultimate objective of this syllabus is to provide an accurate knowledge in fundamental and specific utility of logic and scientific method.

The first approach of this syllabus is to demystify the formal accuracy of reasoning and term calculus, proposition calculus and predicate calculus. Truth tree method, logic gates and Indian logic were also explicated in this curriculum. "Karnaugh Map" will be introduced as a neo approach for this process. The new syllabus is also consisted with fallacies, logical formats of law related to critical thinking and logical features of evaluative sciences. The second approach of this syllabus is on scientific method. The components based on modern science will be experimented and elaborated in this aspect. Apart from that, this curriculum aims to generate an academic discipline for referencing the correlation between science and society, the socio ethical and environmental crisis faced by modern globalised society in a particular scientific basement.

This syllabus will be an appropriate element for empowering student centred learning process by the original features derived from this subject field. And also the edification will have provided to become a knowledge originator.

National Goals

(i) Nation building and the establishment of a Sri Lankan identity through the promotion of national cohesion, national integrity, national unity, harmony, and peace, and recognizing cultural diversity in Sri Lanka's plural society within a concept of respect for human dignity.

(ii) Recognizing and conserving the best elements of the nation's heritage while responding to the challenges of a changing world.

(iii) Creating and supporting an environment imbued with the norms of social justice and a democratic way of life that promotes respect for human rights, awareness of duties and obligations, and a deep and abiding concern for one another.

(iv) Promoting the mental and physical well- being of individuals and a sustainable life style based on respect for human values.

(v) Developing creativity, initiative, critical thinking, responsibility, accountability and other positive elements of a well- integrated and balanced personality.

(vi) Human resource development by educating for productive work that enhances the quality of life of the individual and the nation and contributes to the economic development of Sri Lanka.

(vii) Preparing individuals to adapt to and manage change, and to develop capacity to cope with complex and unforeseen situations in a rapidly changing world.

(viii) Fostering attitudes and skills that will contribute to securing an honorable place in the international community, based on justice, equality and mutual respect. (Adapted from National Education Commission Report -2003)

Basic Competencies

The following basic competencies developed through education will contribute to achieve the above national goals.

(i) Competencies in communication

Competencies in communication are based on four subsets: Literacy, Numeracy, Graphics and IT proficiency.

Literacy	:	Listen attentively, speak clearly, read for meaning, write accurately and lucidly and communicate ideas effectively.
Numeracy	:	Use numbers for goods/items, space and time, use of. numerals sysrtematically to count & measure.
Graphics	:	Make sense of line and form, express and record details, instructions and ideas with line, form and colour.
IT proficiency	:	Computer literacy and the use of information and communication technologies (ICT) in learning, in the work environment and in personal life.

(ii) Competencies relating to personality development

- Generic skills such as creativity, divergent thinking, initiative, decision making, problem solving, critical and analytical thinking, team work, inter – personal relations, discovering and exploring ;
- Values such as integrity, tolerance and respect for human dignity;
- Emotional intelligence.

(iii) Competencies relating to the environment

These competencies relate to the social, biological and physical environment.

Social Environment	-	Awareness of the national heritage, sensitivity and skills linked to being members of a plural society, concern for distributive justice, social relationships, personal conduct, general and legal conventions, rights, responsibilities, duties and obligations.
Biological Environment	-	Awareness, sensitivity and skills linked to the living world, people and the ecosystem, the trees, forests, seas, water, air and life – plant, animal and human life.

Physical Environment - Awareness, sensitivity and skills linked to space, energy, fuels, matter, materials and their links with human life, food, clothing, shelter, health, comfort, respiration, sleep, relaxation, rest, wastes and excretion.

Included here are skills in using tools and technologies for learning, working and living.

(iv) Competencies relating to preparation for the World of Work

Employment related skills to maximize their potential and to enhance their capacity.

- To contribute to economic development.
- To discover their vocational interests and aptitudes,
- To choose a job that suits their abilities, and
- To engage in a rewarding and sustainable occupation.

(v) Competencies relating to religion and ethics

Assimilating and internalizing values, so that individuals may function in a manner consistent with the ethical, moral and religious modes of conduct in everyday life, selecting that which is most appropriate values.

(vi) Competencies in play and the use of leisure

Pleasure, joy, emotions and such human experiences as expressed through aesthetics, literature, play, sports and athletics, leisure pursuits and other creative modes of living.

(vii) Competencies relating to ' learning to learn'

Empowering individuals to learn independently and to be sensitive and successful in responding and managing change through a transformative process, in a rapidly changing, complex and interdependent world.
(Adopted from National Education Commission Report - 2003)

Aims of teaching Logic and Scientific method

Students will acquire following capabilities after completing this curriculum successfully. They are;

- To work towards for perfecting intelligent abilities.
- Contemplation of fallacies occurred in logical thinking.
- Taking accurate approaches for logical judgements.
- Understand laws of the nature
- Comprehend "how to think?" and avoid "what to think?"
- Generate logical thinking for investigating, analysing, criticising and creating a perfect thing.
- Obtain the edification for revealing points and to refer them.
- Facilitate to clear, unique mind and thinking for empowering comprehensive capability to infer unknown things from well-known things.
- Understand that the logical rules are also entitled as well as grammatical rules for determining meaningful statements.
- Guide for creating and solving problems relevant to a logical approach.
- Determine that the scientific and technological knowledge is based on a specific logical foundation.
- Assign a logical foundation for legal and ethical judgements in a realistic approach.

Grade	Term	Competency Level	Periods
12	I	1.1 , 1.2 , 1.3, 2.1 , 2.2 , 2.3 , 3.1 , 3.2 , 10.1	100
	II	4.1, 4.2, 5.1 , 10.2 , 11.1, 11.2, 11.3	100
	III	5.2 , 5.3, 5.4, 5.5 , 5.6, 12.1	100
13	I	6.1 , 6.2 , 6.3, 6.4, 7.1, 7.2, 12.2	100
	II	13.1, 13.2, 13.3, 14.1, 15.1, 15.2, 15.3, 15.4, 15.5, 15.6, 17.1, 17.2, 17.3	100
	III	8.1 , 8.2 , 8.3, 9.1, 9.2, 9.3, 16.1, 16.2, 18.1, 18.2	100

Competency	Competency Level	Subject Content	Learning Outcomes	No. of Periods

1. Exhibits the ability of reaching a conclusion, of the un known with the help of known facts.	1.1 Explains the different definitions of Logic	• The nature and subject matter of Logic
		• Difinitions of Logic
		• History of Logic
		  • Western
		  • Eastern
			• States the nature of Subject matter by means of logical definitions.
			• Describes the historical devel opment of Logic through the ages.
			• Compares the manner in which the development of Western and Eastern Logic took place
				10

	1.2 Explains the relation between Logic and other sciences	• Logic - Philosophy • Logic - Language • Logic - Pure Mathematics • Logic - Psychology • Logic - Law	• Analyses the relation between Logic and other Sciences • Evaluates the practical application of Logic to other Sciences	06
	1.3 Analyses the Practical value of Logic	• It as the basis of systematizing Knowledge. • logical thinking as a component of problemsolving • logic as a personality measurement • logic as a specific basement / foundation for the modern technology.	• Assess how Logic is useful in daily life • Analyses how logical thinking could be applied in research • Evaluates computer activities on logical thinking	04

Competency	Competency Level	Subject Content	Learning Outcomes	No. of Periods
2. Indicates by means of different method of analysis, correct logi cal meaning	2.1 Analyses the ways of building logical connections of terms.	• The features of systematic Language - Charactertics of logic Language - Truth and validity - Introduces in a simple manner, terms and propositions. • Classification of terms. • Based on connotation and denotation • Concrete and Abstract terms • Singular terms, General terms, Collective terms and theirdivisions • Positive terms and Negative terms • Contradictory and contrary terms • Absolute terms and Relative terms • Privative terms • Logical relations of relative terms • Symmetrical Relations • Asymmetrical Relations • Transitive Relations • Non -Transitive Relations	• States the correct use of language • Distinguishes truth and validity • Analyses the Logical meanings of terms. • Categorises the logical relation between terms • Assesses the importance of use of terms in arguments.	10

Competency	Competency Level	Subject Content	Learning Outcomes	No. of Periods
	2.2 Application of Laws of Thought	• Laws of Thought • The general features of laws - The Law of Identitiy - The Law of Non - Contradiction - The Law of Excluded Middle - The Law of Double Negation - The Law of Sufficient Reason	• Lists the different laws of thought • Identifies the difference be tween laws of thought and Sci entific laws • Differentiates between the law of sufficient reason and traditional • Determines the importance of these fundamental laws in rela tion to valid thinking	05
	2.3 Uses propositions, identifying their different categories.	• Propositions • Sentence and Propsition (Features of a declarative statement) • Different Propositions • Simple - Complex • Analytic - Synthetic Propositions • Categorrical, Hypothetical, Disjunctive Propositions • On the basis of quantity and quality (A,E,I,O) propositions and their distribution of terms • Singular, Particular,Universal, Propositions	• Identifies the difference between a sentence and proposition • Exhibits the ability of categorizing propositions. • Applies the distribution of terms in categorical propositions • Recasts sentences into categorical form • Evaluates the logical nature of different statements.	15

Competency	Competency Level	Subject Content	Learning Outcomes	No. of Periods
3.Inference of conclusions in traditional logic by means of immediate and mediate inferences	3.1Illustrates how immediate inferences could be practically applied in daily life	• Inferences in Traditional Logic • Immediate inference • opposition of Propositions (Contrary ,sub - Contrary, sub - altern, contradictory) • The validity of inference based on the square of opposition of propositions - Eduction - Conversion - Obversion - Contrapositive - Obverted Converse - Obverted Contrapositive - Inversion - Obverted Inversion	• List the main forms of inference • Identifies a pair of propositions to be, true, false or indeterminable • Distinguishes between opposition of propositions and eduction • Analayses the fallacies that occur in general discourse in relation to the rules of eduction. • Evaluates how diferent inferences help to construct valid arguments	25
	3.2 Constructs figures for arguments in traditional Logic.	• Mediate Inference (syllogism) • Features of syllogisms • Arrives at conclusions by means of premises • Derives a knowlesge of the three types of terms in syllogisms • Pure syllogisms (Categorical, Hypothetical, Disjunctive) • Mixed syllogisms (Hypothetical, Disjunctive, Dilemma) • Main rules of syllogism and validity	• Understands the knowledge derived from logical inference • Describes different forms of inferences • States the difference between form and content of an argument. • Recasts verbal statements into strict syllogistic form	10

Competency	Competency Level	Subject Content	Learning Outcomes	No. of Periods
		• Sub - rules of syllogisms • The relation between main rules and sub - rules of syllogisms • figures of syllogisms and valid moods • Enthymeme and sorites • Limitations and weaknesses of syllogistic reasoning • comparative study on Aristotelean Logic and Indian Logic (based on Indian logic)	• Determines the validity of arguments by means of rules of syllogism • Determines by means of syllogistic rules the ommitted proposition of an enthymeme.	

Competency	Competency Level	Subject Content	Learning Outcomes	No. of Periods
4. Studies class Logic and attaining into logical implications	4.1 Basic concepts explicated in class logic (set theory)	• Introduction to set theory • Euler's diagrams and Venn's diagrams with a modern analysis. • Introdues the main concepts of set theory(Universal set, set, set complement, Null set, sub sets, infinite set, equal set, Union, Intersetction)	• Understands the nature of set theory • Explains the concepts of set theory in relation to mathematical concepts	10
	4.2 Demonstrate propositions and arguments by Venn Diagrams.	• Different types of propositions - Universal propositions - Particular propositions - Singular propositions - Exclusive, Exceptive, Existential propositions • To symbolize verbal arguments in terms of classes and represent them by means of Venn's diagrams. • To determine the validity of arguments by means of symbolizations with Venn's diagrams.	• To represent different propositions by Venn's diagrams. • Translate symbolic formulae into verbal statements. • Determines the validity of arguments in terms of venn's diagrammes (sets)	15

Competency	Competency Level	Subject Content	Learning Outcomes	No. of Periods
5. Determines the validity of arguments by identi fying the formal aspect of deductive systems	5.1 Translates verbal sentences into symbolic statements and symbolic formulae into language.	• Nature and objective of Modern Logic • Introduces Propositional calculus • Deductive systems • Simple sentences. • Well formed formulae • Translate linguistic statements (sentences into symbolic formulae.	• Obtains the correct knowledge of the basic concepts of Propositional Calculus. • Identifies the logical nature of simple and complex sentences. • Constructs well - formed formulae •Translates verbal statements into symbolic formulae. • Exercises to translate symbolic formulae into vebal sentences	20
	5.2 Determines the validity of ar guments by means of direct amd indirect truth tables.	• Introduce truth table method in Propositional Calculus • Providing truth values for variables. • The basis of truth values (Negation, Implication, Conjunction, Disjunction, strong Disjunction, Biconditional) • Determine tautologies, contra dictory and contingency. • To determine that a pair of symbolic formulae is logically equal, contradictory, or neither equal nor contradictory	• Understands the truth values in relation to the meanings of constants • Compares the nature of different symbolic formulae • Determines by means of truth tables, tautology, equal and contradictory symbolic • Determines the validity of arguments by the direct and indirect methods of truth tables • Constructs symboilc formulae that are equal or contradictory to given symbolic formulae	20

Competency	Competency Level	Subject Content	Learning Outcomes	No. of Periods
		• Constructs equal/ contradictory for mulae • Determines the truth value of a given symbolic formulae without the use of truth tables	• Predicate the verification of symbolic statement by the veri fication of a formulae/ character.	
	5.3 Enunciate the validity of an argument by truth tables.	•Determine the validity of an argument - Direct truth tables - indirect truth tables	•Recognise various practises •Establish the validity of an argument through direct and indirect truth tables.	15
	5.4 Applies the truth tree method to determine the validity of arguments	• Introduction to truth tree method • The general rules of truth truth tree method. • Indicates by the truth tree method the structure of symbolic formulae. • Close and open trees. • Consistency and inconsistency of a system.	• Determines the consistency - inconsistency within a system. • Identifies the contribution of the truth three method to deterrmine the validity of arguments. • Discusses the rules of truth tree method. • Apply the rules of truth tree	10

Competency	Competency Level	Subject Content	Learning Outcomes	No. of Periods

Competency	Competency Level	Subject Content	Learning Outcomes	No. of Periods
		• Determines by the truth tree method whether a symbolic formulae are a tautology, contradictory or contingency • Determines by truth tree method whether the conclusions of pairs of symbolic formulae are equal, contradictory or neither equal or contradictory	method to determine the validity of arguments. • Analyses different logical formulae by the truth tree method. • Evaluates the use of truth tree method in propsitional calcilus	
	5.5 Proves the validity of an argument by means of truth tree method	• Determine the validity of an argument by the truth tree method • proving theoroms by truth tree method	• Insert rules of truth tree method for determining the validity of an argument • Prove theoroms by truth tree method • evaluate the truth tree method with in proposition calculus.	10
	5.6 Proves the validity of arguments and theorems by means of approved rules of derivational methods.	• Derivational method in Propositional calculus. • Approved rules. • Derivational methods. (Direct Indirect, Conditional) • Application of sub - derivations. • Introdues theorems and their proof	• Identdenifies the approved rules of derivation • Derives the conclusions of an argument by means of its premises and ten approved rules of derivation. • Identifies theorems and proves them • Evaluate the usage of theoroms	25

Competency	Competency Level	Subject Content	Learning Outcomes	No. of Periods
10. Formulates scientifi c methods in terms of critcal thinking in relation to the History of science	10.1 Defines the concept of "science"	• Introduces science. • The difference between Science and non - Science in relation to Popper's demarcation principle	• States the historical development of science in relation to different periods. • Gathers information regarding different analyses of science.	10
	10.2 Applies the nature of science and its divisions in formulating scientific methodology	• Science, is knowledge based on reason or/and sense perception. • Divisions of science - Non - Empirical Sciences - Empirical Sciences. - Natural Sciences - Social Sciences - Pure Sciences - Applied Science. - Descriptive Sciences - Evaluative Sciences. - Sciences, non-sciences (Problems that emerged in relation to these divisions)	• Categorizes sciences • Describes the basic features of different sciences • Describes the mutual relation between sciences • Evaluate the integration of sciences.	10

Competency	Competency Level	Subject Content	Learning Outcomes	No. of Periods
11. Application of different scientific methods in practical situation	11.1 Analyses the difference between the function of the scentist and methodologist.	• The basic features of scientific methodology • The difference between the function of the scientist and methodologist	• Understands the basic features of Scientific methodology • Demonstartes scientific methodology in relation research.	05
	11.2 The difference between Inductive and Deductive methodologies.	• The schools of scientific methodology • Inductive Methodology • Deductive verficational Method ology • Deductive falsificational Method ology	• Identifies traditional methodologies and describes contemporary criticisms leveled agaisnt them. • Examines deductive and inductive methodology. • Examines the difference between deductive and inductive methodologies.	20
	11.3 Analyses critically the views of Relative Methodology and Scientific Research Programme.	• The view of Relative Methodology. (Thomas Kuhn's and Paul Feyerabend's) • Features of a paradigm and the inconsistency and incommensurability in successive theories. • Scientific Research Programme (Imre Lakatos) • A descriptive introduction and criticisms levelled against the above mentioned methodologis	• Examines different views of Relative methodology • Concludes that there is no definite methodology in scientific discovery. • Describes the features of Lakatos' scientific research programme in relation to a scientific theory.	20

Competency	Competency Level	Subject Content	Learning Outcomes	No. of Periods
12. Applies methods to test scientific hypotheses	12.1 Describes the nature of scientific generalizations.	• Scientific hypotheses • Formation and development of a hypothesis • Problem and construction of hypotheses. • Language and models. • Characteristics of a scientific hypothesis • Questions the acceptibility of a hypothesis • Features of a Scientific hypothesis • The difference between laws and theories • Universal and Statistical generalizations • Scientific explanation • Nature of scientific explanations • Deductive nomological model • Covering law model of explanation	• States the importance of hypothesis in scientific research • Explains the stages of verification of a hypothesis in relation to scientific reserearch • Evaluates the importance of different hypotheses and explanations in establishing scientific knowledge. • Explans the difference between scientific law and theroy with re lated exmaples • Explan a natural relavent through the covering law model	20

Competency	Competency Level	Subject Content	Learning Outcomes	No. of Periods
6. Studies Predicate Calculus	6.1 Symbolizes universal, Particular and Singular sentences by means of symbols such as Name letters, Predicate letters, variables etc in terms of Predicate Calculus	• Differentiates symbols related to Names, Variables and Predicates. • Symbolic formulae with quantifiers and variables. • Well formed formulae • Symbolizing and translation of sentences. • Equal and contradictory formulae	• Understands the nature and objectives of Predicate Logic • Constructs well formed formulae • Symbolization of verbal sentences.	05
	6.2 Identifies the bound and free variables and applies propper substitutions	• Bound and free (independent) vari ables • Proper substitution	• Identifies free and bound variables. • Applies propper substitution to a free variable.	10
	6.3 Derivation of arguments and proof of theorems.	• Approved rules. • Derivation of arguments. • Proof of theorems.	• Proving arguments and theroems in terms of rules of predicate calculus • Evaluates the manner in which traditional Logic is combined with modern Logic.	20
	6.4 Tree method in Propositional Calculus.	• Rules of truth tree method open/ close trees. • Determines the validity of arguments by the truth tree method.	• Understands the rules relevant to truth tree of Propositional calculus. • Test the validity of arguments by means of the rules of truth tree method. • Evaluates the relation of the truth	10

Competency	Competency Level	Subject Content	Learning Outcomes	No. of Periods
			tree method used in Propositional Calculus and Predicate Calculus.	
7.Application of logical principles in relation to the function of electronic circuits.	7.1 Constructs Logic Gates for symbolic formiulae.	• The relation between Logic and Computer Science. • The relation between Boolean and Logical expression. • Truth tables for bacic and secondary Logic Gates. • Constructs circuits for symbolic formulae. • Constructs simple clrcuits for complex ones	• Understands the function of electronic circuits. • Identfies the inputs and output of different Gates. • Constructs simple Logic Gates for complex symbolic formulea. • Assesses the importance of Logic Gates in the construction of electronic circuits.	15
	7.2 Uses carno maps to make complex circuits simple.	• Introdues the method of Carno maps. • Boolean expressions and Carno maps. • The rules for the construction of Carno maps for not more than three varlables. • Constructs simplified logic gates for complex symbolic formulae in terms of Carno maps.	• Carno maps constructed upto three variables • Identifies rules related to carno maps •Transfer complex symbolic formulae int simple symbolic formulae.	15

Competency	Competency Level	Subject Content	Learning Outcomes	No. of Periods
8. Demarcates the nature of logical fallacies while studying critical thinking.	8.1 Fallacies in formal arguments.	• Logical thinking based on reason. • The nature of Logical fallacies • Formal fallacies in relation to terms and propositions	• Lists the formal and non - formal fallacies • Distinguishes between formal and non - formal fallacies.	05
	8.2 Tests the nature of non-formal fallacies in arguments.	• Non - formal fallacies. • Fallacies of Irrelevance. • Weak Induction. • Fallacies of Presumption • Fallacies of Ambiguty. • Fallacies of Grammatical Analogy. • Non - formal fallacies belonging to the above mentioned categories of fallacies.	• Classifies non - formal fallacies • Indicates the differences in non - formal fallacies. • Identifies logical fallacies committed in the use of language. • Shows the differnce between non-formal fallacies comparatively.	15
	8.3 Explains the difference between factual statements and evaluative statements.	• Language and theory • Descriptice Statement • Evaluation Statement • The Function of the legal field and the nature of evidences. • The ethical views related to crime and punishment	• Discusses the validity of ethical statements.	05

Competency	Competency Level	Subject Content	Learning Outcomes	No. of Periods
9. Sudies the nature of Law and legal determinations.	9.1 Nature of Various fields in Law.	• The relation between Law and Logic. • Fields of Law	• Describes with understanding the importance of the practical use of Logic in the field of Law. • Studies the different fields of law.	05
	9.2 Analyses the nature of evidence in legal field.	• The Function of the legal field and the nature of evidences. • The ethical views related to crime and punishment	• Demonstartes the relevance of nature of evidence in legal determination. • Analyses ethical views in relation to crime and punishment.	10
	9.3 Deductive and Inductive process of reasonning in the field of Law	• Study of cases in the field of law.	• Involves in case studies of criminal law. • Evaluates the nature of ethical approach in legal determination	05

Competency	Competency Level	Subject Content	Learning Outcomes	No. of Periods
12. Applies methods to test scientific hypotheses	12.2 Analyses the features of different scientific tests.	• Methods of Scientific tests • Observation • Experiment • Control Group method • Case study Method • Crucial test • Thought Experinent • Mill's Methods • Features of tests • Errors in tests	• Lists the different types of Scientific tests. • Describes the special features of various scientific tests. • Explains how these tests are used in scientific discoveries. • Compares the differences of various tests. • Evaluates the contribution made by there scientific tests in making scientific discoveries.	15

Competency	Competency Level	Subject Content	Learning Outcomes	No. of Periods
13. Uses the concept of probability in practical situations.	13.1 Defines events of a probable pre-test.	• Features of scientific • Concepts of Probaility and their importance • Describe probabe pretests. • Representation of sets and its elements. • Explication of events and the concept of events. - authentic events - probable events - simple events complicate events • Permutation and combination • Intersection, union and complement of sets. • Independent, dependent, mutually exclusive and non - mutually exclusive complementary events.	• Understands the practical application of probability in varions situations • Select probable event out of all events • Utilizes Permutation and com bination for solving problems. • Identifies events & their relations.	10
	13.2 Explicate probability in different approaches.	• Doctrines of probability and its importance. • Historical concept(conservative). • Statistical approach(relative frequency) • Psychological approach(personal analysis) •Mathematical interpretation.	• Explains various definitions of probability. • Shows limitations of various interpre tations. • Facilitate mathematical foundation for predicting events. • Take a mathematical approach to explicate events and their	10

Competency	Competency Level	Subject Content	Learning Outcomes	No. of Periods
	13.3 Utilize structures of probability for solving problems.	• Law of integration • Law of multiplication • Conitional Probability	interrelations • Arriving to conclusions by probability concepts. • Determine the importance of probability for scientific investigations. • Develop the relation between mathematics and probability.	10
14. Application of basic features of measurement in scientific research	14.1 Applies measurement in science meaningfully.	• Introduction to measurement its features and function. • Instruments of measurements and benefits of analysis. • Benefits of numbers. • Different types of scales. • Errors of measurement.	• Understands quantification techiniques in scientific tests • Describes the importance of the use of measuring instruments • Explains various scales in data analysis. • Selects ways of minimizing errors of measurement. • Evaluates the importantance of measurement & quantitative data in scientific experiments/ research.	20

Competency	Competency Level	Subject Content	Learning Outcomes	No. of Periods

15. Utilizes statistical methods for increasing desicion making skills	15.1 Introduces the nature of statistics.	• Introduction to Statistics
		• The nature of statistics
		  • Descriptive Statistics
		  • General statistics
		• The advantages of statistics.
			• Apply satistics for desicion making.
			• Evaluates the importance of statistics for constructing scientific generalizations.
				05

	15.2 Monitoring samples for collecting data and information.	• Experiments and data
		• Objectives and foundations of data classification.
		• Samples
		  • Probablesamples
		  • Non probable samples
			• Understands the importance of collection of data in scientific tests.
			• Select most suitable sampling method for scientific experiments.
			• Explains characteristics of fair sampling.
				05

	15.3 Utilizes the eligible central tendencies for arriving accurate desicion of a statistical distribution.	• Central tendencies
		  • Mode
		  • Median
		  • Arithmetic mean
		  • Weighted mean
			• Identify methodologies of data analyzing and monitoring.
			• Arriving conclusions through the central tendencies.
				05

Competency	Competency Level	Subject Content	Learning Outcomes	No. of Periods
	15.4 Enunciate the expansion of a statistical distribution by the means of dispersion measures.	•Dispersion measures •Variance •deviation •standard deviation •variability •Relative dispersion	• Utilize statistical methods for numeric data analysis • Generating conclusions of phe nomenon by dispersions.	05
	15.5 Correlational measures	• Correlation methods • Possitive correlations in scatter plot • Negative correlations in scatter plot • No correlation	• Apply statistical methods for the quantification of attitudinal events. • Develop scatter plot/line graph connections through data.	03
	15.6 Explain the errors of statistical usage.	•Statistical errors •sample errors •non-sample errors	• Select samples to aviod statistical fallacies. • Evaluate the protection of objectivity of social sciences by statistical methods.	02

Competency	Competency Level	Subject Content	Learning Outcomes	No. of Periods
16. Faces future challenges by means of scientific concept which were nutured before and after the renaissance	16.1 Exhibits past knowledge in modern science	• Historical Scientific concepts • Science before Renaissonce (Indian, Chinese Babylonian, Egyptian,Greek, Arabic and Sri Lankan Civilizations) • Renaissance and Copernican Revolution. • Knowledge of research done by Copernicus, Tycho De Brahi, Galileo, Kepler, Newton and how they arrived at conclusions. • How science relates itself to society during different historical periods. • How the facts arising from the above topics are relevant to scientific methodology. • The theoretical development of Natural and Social Sciences.	• Understands how the knowledge of technical skills were converted to scientific knowledge. • Analyses how both western and Eastern views contibuted to the development of science • Gathers information regarding the views of scientists that contributed to renaissance of science • Evaluates the contribution of scientists to the development of science	10

Competency	Competency Level	Subject Content	Learning Outcomes	No. of Periods
	16.2 Analyses modern science and contemporary views and theories.	• Modern and contemporary views of science. • Views rearding the origin and nature of the Universe. • Views related to origin and evolution of life. • Theory of gravitation and laws related to motion of physical phenomena. • Kinetic theory of gases and laws gases. • Views related to light (Corpuscular • Models and views related to atom. • The Phlogiston theory and chemical revolution. • Blood circulation (Gallen, Harvey) • Mendel and the views of Genetics • Einsteins theory of Relativity • Quantum theory • Psychology and its schools • Theories in Politcal science • Main aspects of Maxism • Keynesian Economic theory.	• Lists the events of nature scientifically • Explains the scientific philosophy that formed the background to scientific views • Evaluation the various views that contributed to the origin of science evolution of life.	15

Competency	Competency Level	Subject Content	Learning Outcomes	No. of Periods
17 Participates in scientific tests maintaining its authenticity and validity.	17.1 Analyse the difference between social science and Natural science	• The subject matter of Social Science • Differences between Natural Science and Social Science	• Understands the nature and subject matter of Social science • Explains how Social Sciences differ from Natural sciences.	05
	17.2 Applies social scientific research methods.	• Methods of tests in Social Science • Direct observation and partcipatory observation • Control group method • Case study method • Questionnaire method • Interview method • Excavations and the study of documents. • Introspection. • Living in research • Sociometric test.	• Analyzes the differant methods of tests in Social Science. • Constructs a balance analysis of social surveys.	10
	17.3 The substaintiality of the social sciences	• The authenticity and validity of data obtained by the method of tests used in Social Science. • The scientific exposure of social sciences. • Foundational arguments and problems related to it.	• Analyses the challenges for the protection of susbstantiality of social sciences. • Estimate the activites relevant to social sciences.	10

Competency	Competency Level	Subject Content	Learning Outcomes	No. of Periods
18. Faces successfully the challenges posed to society by modern science and technology.	18.1 Observes the relation between science and technology	• Science and Society • How science and technological development • How the development & science impact on person and society. • The Arts and Science • Engineering Technology in SriLanka.	• Understands the challenges posed to social ethics due to the advancement of science and technology. • Ethical problems derived from scientific and technological methods. • Discusses how to work out strategies to minimize ethical problems caused by Scientific research.	15
	18.2 Identifies that the development of science and technology could be used for the advantage and disadvantage of individual and society.	• A comparative view of the aims and function of Arts and Science • Religion and Science • A comparative view of the aims and functions of Religion and Science • Modern Science and related problems. • Professional problems. • Ethical Problems related to medicine and other professions • Problems related to Science, tchnology, Law and Ethics • Science, technology and environmentar problems.	• Opens a discussion to the effect that Arts and Science should be interrelated. • Analyses the problems posed by modern science and technology. • Uses technology to over-come challenges. • Exploring strategies to over come interrogations occured due to social scientific and technological development.	15

Competency	Competency Level	Subject Content	Learning Outcomes	No. of Periods
		• Ethical problems related to Genetic Engineering. • Use of Nano technology • Spatial technology.		

The Nature and Scope of Logic

Competency	-	Exhibits the ability of reaching a conclusion of the unknown with the help of the known facts.
Competency Level	-	Explains the different definitions of logic Explains the relation between logic and other sciences Analyses the practical value of Logic
Number of Periods	-	20

Learning Outcomes

- States the nature of Subject matter by means of logical definitions.
- Describes the historical development of Logic through the ages.
- Compares the manner in which the development of Western and Eastern Logic took place
- Analyses the relation between Logic and other Sciences
- Evaluates the practical application of Logic to other Sciences
- Assess how Logic is useful in daily life
- Analyses how logical thinking could be applied in research
- Evaluates computer activities on logical thinking

Introduction -

Logic is the field of study that enables man to develop his manner of reasoning by adopting a correct and perfect form of thinking. It is essential to provoke valid thinking to reach accurate thinking. The person who thinksperspicuously he would attain to logical thinking. Therefore logic is to be concerned as a norm psychic of humans. It does not determine how wethink; urge to demystify how we ought to think.

Like every other science, Logic too was grown in the accompaniment of Philosophy. The philosophy denotes the origination as well as the end of each discipline. Therefore philosophy becomes a universal science. It is intertwined with the wisdom. It simply depicts the idea of “vision”. Philosophers are attempting to develop their notions on a logical

foundation for acquiring an exquisite vision. If not the philosopher would not be able to construct their ideologies perfectly to cope with challenges which might come from outside world. Therefore philosophers were attentive to utilise their logic as a formally and systematically equipped component.

Logic was derived its meaning from the Greek word *"logike*", it means thought, word and discourse. The validity of thinking is examined by this. The Greece is the place of origination in western logic. Aristotle(Greece 384 BC-322BC) empowered this discipline as a formal science which was early depicted as an art of arguing and formed it by Parmenides, Zeno and Protagoras. He had also evaluated this subject as knowledge of valid thinking by demonstrating deductive and inductive features accordingly. The shape of logic had been changed to reach mathematical formation by George Boole (England/Ireland 1815-1864) with his works to convert algebraic concepts to deductive systems of traditional logic. Gottfried Wilhelm Leibniz(Germany 1646-1716), Ernst Schroder (Germany, 1841-1902), GottlobFrege(Germany 1848-1925), Bertrand Russell (UK 1872-1970) and Alfred North Whitehead (UK 1861-1947) had generate this discipline as a perfect formal science. Nowadays this subject has become one of the broadestsubjects related to mathematics, computer science, artificial intelligence and etc.

According to the evolution, western method and Indian theory (nyaya) seem equal relevant to their originations. It has been developed in the Vedic and Upanishad philosophies. The Indian logic depicted as "PramanaShastra" is based on perception and inference. It is also introduced as Anvikshiki. The indian logic can be recognised as philosophical, psychological and epistemological discipline which had been developed through Ajivaka, Jiansm, Buddhist and Hindu (six types of philosophies).

A guideline to explain the subject matter through definitions

- Logic is knowledge about valid thinking (Aristotle)
- Logic is apure formal science (Susan Stebbin)
- Logic is the study of methods and principles used to distinguish good (correct) from bad (incorrect) reasoning Irvin M Copi)
- Logic is the science that investigate into common truths (Fredrick Ludwig Frege)
- Logic is a tautological science (Wittgenstein)

History of logic

Eastern- NasadhiyaSutta in Regveda and the Anvikshiki school of MedhathithiGauthama's arguments contain the features of logic.

Logic is knowledge(Pramana) a study that contains many valued determinations

Logic has developed through the traditions of thinking of the Agivakas, Jainas, Buddhists and Hindus

Western

The tradition of western logic which had been developed within the trend of Greek Philosophy was regulated

Today logic is used in the fields of computer technology, information technology, artificial intelligence and etc.

The development on western logic was not only in the form of thinking but also in the form of science and technology.

Logic and its relation to other fields of study

Philosophy - philosophy is a study that investigates into the ultimate reality of things. This philosophical knowledge is beneficial to the educated as well as to the uneducated. Logic is employed in every form of philosophical analysis. If not for the use of logic philosophical studies would become vague and not clear.

Science - science is a study that establishes systematic and objective knowledge about the phenomenal world. It makes scientific investigations and knowledge meaningful. Its knowledge is mainly founded on a scientific methodology. Both deductive and inductive methodologies are used in establishing scientific knowledge.

Psychology - psychology studies the nature and function of man's mind and behaviours. Its investigations are conducted between thought and feelings, thought and perception. In all these investigations psychology makes use of logic to arrive at rational conclusions. Logic is interested

in establishing valid thinking. Therefore it is mainly interested in discovering how we ought to think rather than how we think.

Mathematics - logic can be considered as a continuation of mathematics. They are mainly deductive formal systems. It derives knowledge by abstract justifications.

Law - it is evident when taking into consideration the different sources of law, nature of law(Jurisprudence) and the different branches of law that legal arguments are founded on logical reasoning. In the field of law logical inferences are derived through evidence.

Computer science - Computer soft wares and hard wares are basically functioning on logical concepts. The structure of integrated circuits of computer hardware technology is based on logic gates. And also the flow chart of software had been designed with logical patterns.

Laws of thought -Laws of thoughts could be defined as the guidance provided towards accurate logical thinking process through a basic and determined principles accordingly. There are three dominant traditional laws presented by Aristotle.

- Law of identity
- Law of non-contradiction
- Law of excluded middle
- Principle of sufficient reason
- Law of double negation

The practical value of logic

- Helps to reach conclusions of the unknown with the helpof known facts
- Contributes to find solutions to problems and t arrive at rational decisions.
- Contributes to establish knowledge in relation to technical and artificial intelligence.
- Helps to derive scientific predictions and to build knowledge in relation to them

Teaching Learning Activities

- ❖ Motivate students to conduct research in relation to history of logic, utility value of logic and how it is related to other fields of study.
- ❖ Divide students into groups and get each group to conduct a research on a topic related to the subject and makea presentation to the class.
- ❖ Prescribe each student an assessment in relation to the above mentioned topics.

A Common Explanation to the Basic Concepts of Logic

Competency - Indicates by means of different method of analysis, correct logical meaning

Competency Level - Analyses the ways of building logical connections of terms.
Application of Laws of Thought
Uses propositions, identifying their different categories.

Number of periods - 30

Learning outcomes -

- States the correct use of language
- Distinguishes truth and validity
- Analyses the Logical meanings of terms.
- Categorises the logical relation between terms
- Assesses the importance of use of terms in arguments.
- Lists the different laws of thought
- Identifies the difference between laws of thought and Scientific laws
- Differentiates between the lawof sufficient reason and traditional
- Determines the importance of these fundamental laws in relation to valid thinking
- Identifies the difference between a sentence and proposition
- Exhibits the ability of categorizing propositions.
- Applies the distribution of terms in categorical propositions
- Recasts sentences into categorical form
- Evaluates the logical nature of different statements.

Introduction

It aims to develop a logical thinking by eradicating ambiguity and amorphous terms as well as compromising with accurate terms and propositions. It develops the foundation for constructions deductive and inductive arguments with evidence of correct language and factual statements.

Guidance to explain the subject matter

Laws of thought

Laws of thought are the principles which essential for developing a valid thinking in a broad perspective

1. The law of identity
2. Law of non-contradiction
3. The law of excluded middle
4. The law of sufficient reason
5. The law of double negation

Characteristics of a systematic language

- ❖ Logic needs a systematic and logical language perpetually
- ❖ Letters are the symbols of language depicts, the correct usage of these symbols
- ❖ Propositions are called the linguistic statements which utilize for reasoning. These sentences would state truth or false.
- ❖ Errors and ambiguities can be avoided of practical language if the arguments will be given in symbolic language.

Truth and validity

Descriptive sentences become truth and only arguments and inferences are attaining valid.

Example to a proposition;

1. All men are dying. Pidurutalagala is the highest mountain in Sri Lanka.

Argument;

1. All me are dying

   Aristotle is a man

   Therefore Aristotle is dying
2. All philosophers are intelligent therefore no non-intelligent persons are philosophers.

Valid arguments with truth premises and conclusion are called sound (strong)arguments, others to be considered as unsound(week)arguments.

2.3 Introduce terms and propositions simply

Only the descriptive sentences are propositions. Therefore two types in descriptive sentences,

1. Consisted components (subject and predicate)
2. Conjunctive (quantity and annexe)

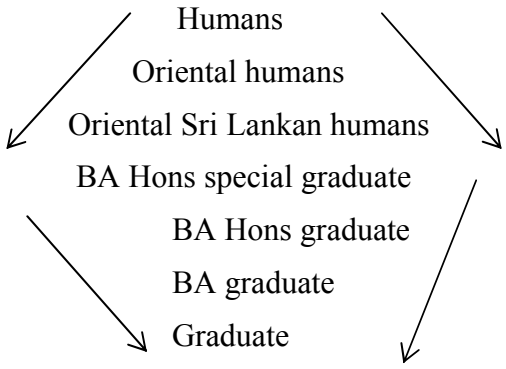
There are some special featured sentences indicated without quantifier.

Terms are defined as the components located in conjunctive consisted aspect as words or set of words.

2.3.1 Denotations and connotations of a term

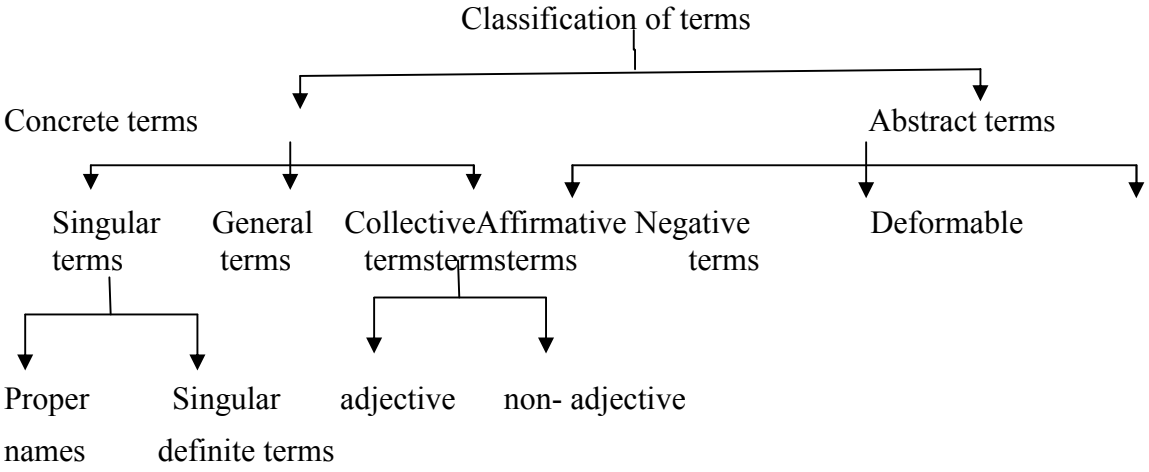
Connotation is described as a specific insisted quality and numbers of representatives were indicated in denotation. There is an inverse interrelated between denotation and connotation.

Ex 01;



Above mentioned inversion does not exist on all terms provided.

Classification of terms



In addition to this

- ❖ Contrary and contradictory terms
- ❖ Absolute and relative terms

Important

It should be exemplified above mentioned formations of terms accordingly.

2.4 logical interrelation of relative terms

1. symmetrical
2. asymmetrical
3. transitive
4. non transitive

Symmetrical relation exists of only the relation in between A,B remains on B,A

Ex; spouse

Asymmetrical relation occurs if there is an in equal interrelation between A,B and B,A

Ex; elder, younger north

Transitive relation exists between three components, if this connection is equal it describes as a transitive relation

Ex; A equal B
B equal C
Therefore A equal C

A elder than C
B elder than C
Therefore A elder than C Non transitive relation

If there is an unequal interrelation between three components, occurs non transitive relation.

A,B and C located in a line

10KM from A to B
10KM from B to C
20 KM from A to C

A's father is B
B's father is C
Therefore A's grandfather is C

2.5 The different between sentences and propositions

All propositions are sentences but all sentences are not propositions

ex; iron material is expanded if it burns or warm up. (proposition as well as sentences)

Non propositional sentences

Sentences without proper meaning

- mathematical formula went to the city
- Questionable sentence- what is your name?
- Paradoxes- A Sri Lankan Sunil says that all Sri Lankans are lying.

Explain there are several other sentences exist in the category of no propositional sentences.

2.5.1 Various proposition types

- ❖ Based on truth- analytic and synthetic propositions
- ❖ Based on calculus – simple and concrete propositions

- ❖ Based on logical relation- categorical, hypothetical, disjunctive and conjunctive propositions
- ❖ Based on quality and quantity- universal and particular propositions

  A- Universal Affirmative

  E- Universal Negative

  I- Particular Affirmative

  O- Particular Negative
- ❖ Based on modern logic method
  - Singular affirmative
  - Singular negative

2.5.2 Distribution of terms on categorical propositions

	Subject	Predicate
A	Distribute	Undistributed
E	Distribute	Distribute
I	Undistributed	Undistributed
O	Undistributed	Distribute

2.5.3 Translate propositions into categorical form

Construct propositions explicating quantity and quality clearly.

Learning and teaching activities

Teaching Learning Activities

Group activity

1. Terms

   Explain there is a different between terms and logical terms utilised in the language. Then explore the classification of terms and develop the logical relation of the terms.

2. Propositions

   Enunciate the difference between sentences and propositions through definitions then demonstrate the classification of propositions and introduce various types of propositions.

Categorize students in the classroom into two groups of A and B appoint two leaders from each group. Give them topics of propositions randomly. According to the topic received of the group.

1. Explain the difference between terms of language and logical terms/ differentiate between sentences and propositions.
2. Various types of terms/ list various types of propositions
3. Classify them accordingly.

The Inference of Traditional Logic

Competency - Inference of conclusions in traditional logic by means of immediate and mediate inferences

Competency Level - Illustrates how immediate inferences could be practically applied in daily life
Constructs figures for arguments in traditional Logic.

Number of periods - 15

Learning outcomes -

- List the main forms of inference
- Identifies a pair of propositions to be, true, false or indeterminable
- Distinguishes between opposition of propositions and education
- Analyses the fallacies that occur in general discourse in relation to the rules of education.
- Evaluates how different inferences help to construct valid arguments
- Understands the knowledge derived from logical inference
- Describes different forms of inferences
- States the difference between form and content of an argument.
- Recasts verbal statements into strict syllogistic form.
- Examine the validity of an argument by the means of logical reasoning.
- Determine the elided proposition of an enthymeme relevant to logical theories.

Introduction

This allows recognising the logical nature of consisted in immediate and mediate inferences. It would explain the opposition of propositions under the immediate inference and syllogisms are discussed in mediate inference. It describes differentiations and limitations betweeninferences and finally considers the nature of oriental and western inference.

The guidance for demystifying related subject components.

3. Inference

There are two different types of inferences afforded in Aristotelian logic.

3.1 Immediate inference

3.2 Mediate inference

3.1 Immediate inference, there are two types of inferences given,

3.1.1 Opposition of Propositions

3.1.2 Importation/Education

3.1.1 Opposition of Propositions

Corresponding propositions (same subject & predicate)

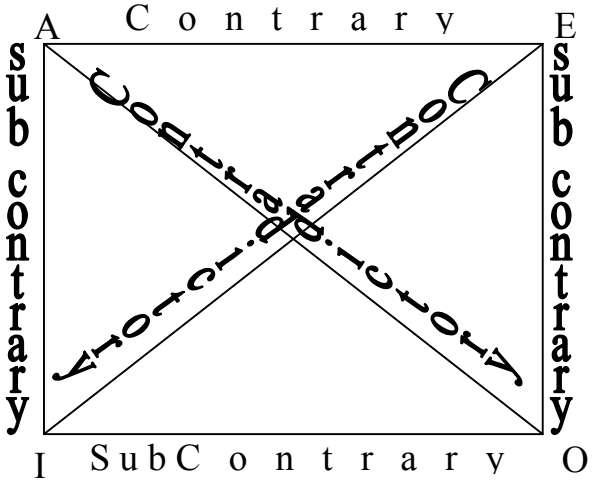
Related to difference between …… quantity or quality or neither quantity nor quality opposition of propositions given in two different ways.

3.1.1.1- contrary

3.1.1.2- sub contrary

3.1.1.3- sub alternate

3.1.1.4- contradictory



Given proposition	A	E	I	O
If A is truth	-	F	T	F
If A is false	-	D	D	T
If E is truth	F	-	F	T
If E is false	D	-	T	D
If I is truth	D	F	-	D
If I is false	F	T	-	T
If O is truth	F	D	D	-
If O is false	T	F	T	-

Importation/ Education

Education is defined as the process of obtaining approved propositions which is corresponding the basic proposition by changing/modifying/amending the either subject or predicate and subject as well as predicate accordingly.

Education is fourfold

- Obversion
- Conversion
- Contrapositive
- Inversion

Obverted Eduction/importation

- Obverted conversion
- Obverted Contrapositive
- Obverted inversion

The chart indicating valid Educations

Proposition given	SP	A	E	I	O
Obversion	$S\overline{P}$	E	A	O	I
Conversion	PS	I	E	I	-
Obverted conversion	$P\overline{S}$	O	A	O	-
Contrapositive	$\overline{P}S$	E	I	-	I
Obverted contrapositive	$\overline{P}\,\overline{S}$	A	O	-	O
Inversion	$\overline{S}P$	O	I	-	-
Obverted inversion	$\overline{S}\overline{P}$	I	O	-	-

The Buliean explanation of Opposition of proposition is limited to contradictory.

The chart of truth & false of traditional opposition of proposition

Mediate inference

The mediate inference is depicted as obtaining an approved proposition as a conclusion by two premises propositions consisted a common middle term

This syllogism basically divided in to two

3.2

1. Pure syllogisms

3.2 1.1 categorical syllogisms

Pure hypothetical

Pure disjunctive

3.2 Mixed/assorted/combined/complex

3.2 Complex hypothetical

Complex disjunctive

Complex Dilemma

Categorical syllogisms

It is defined as; obtaining a third proposition from two categorical syllogisms consisting common middle term at least one out of two propositions is formed as a general proposition.

Ex; All philosophers are sophisticated

Some Grecians are philosophers

Therefore some Grecians are sophisticated

There are six rules impact on the validity of a categorical syllogism.

1. Rules related to the structure
    1) Twice indicated amounts of terms of two distinct terms
    2) There should be three propositions
2. Rules related to distribution of terms
    1) The middle term must be distributed in atleast one premise
    2) Any term distributed in the conclusion must not be distributed in its premise
3. Rules related to quality
    5) Atleast on premise must be affirmative
    6) If either or premise is negative, the conclusion must also be negative.

There are three subrules of syllogisms derived from major rules of syllogisms.

Cannot assume a conclusion whether the two premises are particular

If a premise is particular the conclusion becomes particulars

Cannot assume a conclusionwhether the subject term is particular & predicate term is negative form.

Pure hypothetical syllogism

"if thebaby was taken to Kandy, procession could be shown to him/her

If the procession could be shown to baby, baby would see elephants.

Therefore if the baby was taken to Kandy baby would see the elephants.

3.2 Pure disjunctive syllogisms

This is the syllogisms format which had denoted all three syllogisms in disjunctivepropositions.

Ex; I went to Colombo or Kandy

I went to Kandy or Galle

Therefore I went to Colombo or Kandy or Galle.

Hypothetical Syllogisms

The premise term is hypothetical, synonym, term & conclusion are categorical, and these kinds of syllogisms depicted as mixed hypotheses.

Ex; if she studies then she'd pass the exam, she studies therefore she passes the exam.

Rules related to the validity of complex hypothetical syllogisms

1. Modus ponens
2. Tonendo ponens

3.2 complex disjunctive syllogisms

The premise term is disjunctive, synonym term & conclusions are categorical syllogisms denoted as complex disjunctive syllogisms.

Ex; she studies logic or maths

She doesn't study logic

Therefore she doesn't study maths

Dilemma Syllogisms

The dilemma syllogisms are consisted with a complex hypothetical predicate term &disjunctivesynonym term, the conclusion is remaining as a categorical proposition. There are four major types of dilemma syllogisms as given below.

1. Simple affirmative dilemma
2. Simple negative dilemma
3. Complicate/compound affirmative dilemma
4. Complicate/compound negative dilemma

The figures are dominated according to the position of middle term of syllogisms. There are four major figures of syllogisms

1st mode	2nd mode	3rd mode	4th mode
MP	PM	MP	PM
SM	SM	MS	MS
∴ SP	∴ SP	∴ SP	∴ SP

If it is a particular proposition it should be the synonym term

If it is a negative proposition it should be the premise term

2nd figure & related valid modes

BARBARA

CELARENT

DARII

FERIO

BARBARI

CELARONT

MP	A	E	A	E	A	E
SM	A	A	I	I	A	A
∴SP	A	E	I	O	I	O

CESARE
CAMESTRES
FESTINO
BAROCO
CESARO
CAMESTROS

PM	E	A	E	A	E	A
SM	A	E	I	O	A	E
∴SP	E	E	O	O	O	O

DARAPTHI
DISAMIS
DATISI
FELAPTON
ᵖBOCADO
ᵖFERISON

MP	A	I	A	E	O	E
MS	A	A	I	A	A	I
∴SP	I	I	I	O	O	O

BRAMANTIP
CAMENES
DIMARIS
FESAPO
ᵖ FRESISON
CAMENOS

PM	**A**	**A**	**I**	**E**	**E**	**A**
MS	A	E	A	A	I	E
∴SP	I	E	I	O	O	O

Enthymeme

Enthymemes are the varieties of syllogisms which afforded with elisions of syllogisms in brief. There are three major steps of Enthymemes

1. Prime category
2. Secondary
3. Tertiary

Prime category enthymemes

The enthymemes are which contain the subject terms of conclusions in premises of enthymeme. The elision was the premise term

Ex; Aristotle is judicious for as much as Aristotle is a philosopher

Secondary enthymeme

The predicate term of conclusion proposition was indicated in premises, these types of enthymeme belong t secondary type.

Ex; Aristotle is judicious for as much as All philosophers are Judicious.

Tertiary enthymeme

These kinds of enthymemes had been elided the conclusion proposition.

Ex; All philosophers are judicious & Aristotle is a philosopher.

Sorites3.2.5

This is a set of progressive reasoning which had elided the previous conclusion of each syllogism. It is a grade series of enthymeme, there are two types of sorites

1. Aristotelian Sorites

   The elided conclusion become the synonym term of subsequent syllogism

   Rules- if there is a particular term, it should be the first component

2. GocklieanSorites

   The elided conclusion becomes the subject term of subsequent syllogism.

Indian logic

The Indian logic is depicted in various perspectives such as nyaya, hethu and conceived facets of nasadiyasutta of Vedic philosophy as well as Anvikshikisuttaof Gautama. This is concerned as a quantitative study therefore the importance is highly verified. Multi evaluative, this is also recognised as multi- functional reasoning system.

The Ajivakareasinig system is merely based on a three-fold (trikotika) which is stable for the time of each. It is also consisted with “available” “unavailable “available also unavailable” the Jainism has created in a (anekanthawada) it depicts that no any ideas imply on (ekantha) at all. Jainismclearly proceeds the

"Syadwada"by elaborating the truth which referred to our personal perspective relatively. Therefore they hadn't attempted to take inference quantitatively. The Buddhistlogicians had implemented a logical system of (bavyatha) for obtaining results related to reality by challenging questions arisen upon each phenomenon. The tetra lemma logical figure is a step of it.

	A	`A
Available	truth	false
Unavailable	false	truth
Available also unavailable	truth	truth
Neither available nor unavailable	false	false

Following Buddhisttheorists such as asanga, vasubandu, Dharmakeerthi, deegananga had configured this disciplineexquisitely. The Hindu logical system is basically arranged in perception, inference, (anupalabdi, Karana Bhavyapti and hethwabasa). Gautama Akshpada had sharpened the Hindu logical system, the rehinyaya was a dominated concept presented by him in the history of Indian logic.

The nyaya concept is considered as a prominent concept discussed in the Indian theory. It is depicted as swarthanumana and pararthaanumana. The swarthanaumana is the inference originated in it- self, it is an incapable process as well. As it was dumped aside as a written language it is concerned as parathanaumana. It could be proceed as an argumentcontaining five terms, for an instance

There is fire in the mountains consent/convenient

There is smoke in the mountains reason

If there is smoke, fire will be there, the kitchen evidences example

This mountain is also the same (covered with smoke) premise

Therefore mountain is same (fire) conclusion

This five-fold argument could be substitute to Aristotelian logic by using BARBARA as follows,

Fire is available where the smoke exists

Smoke is there in the mountain

Therefore fire is in the mountain

The Indian logic considers inference, reasoning as well as perception so the content of this argument is truth and the structure is also valid.

Teaching Learning Activities

1. Refer student to involve in comparative studies of contrary, sub-contrary, sub-altern and contradictory
2. Allow each student to develop the chart indicating the valid eductions

3. Refer students to construct sub-figures of dominate figures in syllogisms.(giving middle term, predicate term and synonym term will ease off the evaluation).

The class Logic

Competency - Studies class Logic and attaining into logical implications

Competency Level -

1. Basic concepts explicated in class logic (set theory)

2. Demonstrate propositions and arguments by Venn Diagrams.

Number of periods - 25

Learning outcomes -

- Understands the nature of set theory.
- Introduces the main concepts of set theory by mathematical concepts.
- To symbolize verbal arguments in terms of classes and represent them by means of Venn's diagrams.
- To determine the validity of arguments by means of symbolizations and Venn's diagrams.

Introduction

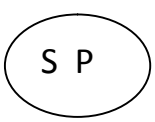
The class logic could be defined as a subject which had been derived from set theory of mathematics an developed independently. The set theory was invented by George Canter in 19th century who was a German mathematician. The logicians had attempted to interpret propositions with the amalgamation of class logic after considering the similarities between characteristics of Aristotle's propositions& mathematical set theory. The Leon hard Euler was alogician who committed in above matter lived in 18th century. John Venn (1834-1923) used the Venn Diagrams which was implemented in mathematics. It is clearly apparent the logical intervention between subject & predicate as well as expansions and limitations.

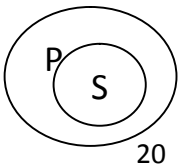
Class logic

The modern class logic is originated as an integration of principles of mathematical set theory and thinking principles of traditional logic. This class logic was extended with the contributions of Euler, John Venn and George Booley.

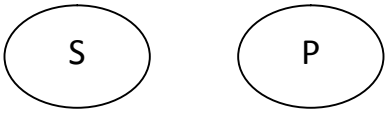
The transfigure of demonstrating the diagrams of traditional propositions

1. All S are P

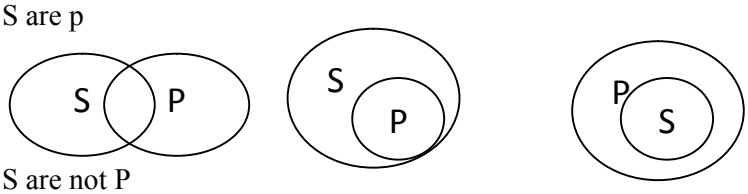




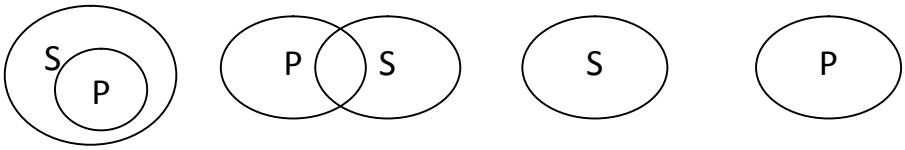
2. No S are P



3. Some S are p



4. Some S are not P



According to the limitations ad errors of Euler's diagrams, they were refused in use.

Basic concepts of Class Logic

Class (set) complement universal set

The class or set is the clear accumulative component. It is based on a certain rule or a tradition. It demonstrates ina closed figure using A,BC capital letters.

Ex; humans, Sri Lankans, birds, mammalians, married persons, prime numbers below 10…

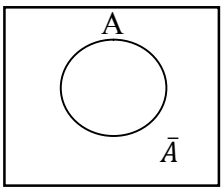
The complement is the set of all components incorporated in the universal set but not indicated I certain classgiven. It is symbolised as ABC.

All the components discussed in relevant incident are considered as universal set. The classes &complements are representing this universal set. "U" is the symbol of it.

Figure

$A \cup \bar{A} = u$

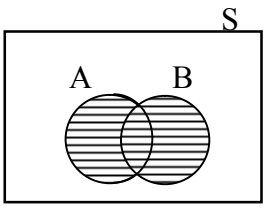
u



The class of parrots, universal set is birds & "A" would be the non-parrot birds

- Class union and intersection

Whether there are two classes given as A& B in universal set, all the components belong to A or B as well as A & B to be considered as the class union.



A - graduates

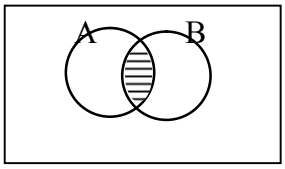
B - teachers

Whether there are A & B in a universal set, the common components related to both sets are to be considered as class intersection.

A- Mammalians

B- Carnivorous/ carnal

S



$(A \cap B)$

- Null set

This not depicted the idea of emptiness. It describes that there are no components indicated in at the certain discussion.

It is a null set whether there is no anyone more than five members

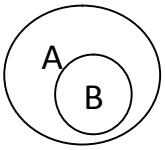
A- People more than 5m

- Sub set/equal sets/ set interval

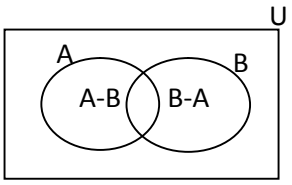
If all the components of the set A belongs to the set B, A is a subset of B,

A = {p, q, r, s }

B = {p, q, r, s, t, u } ,A ⊂ B



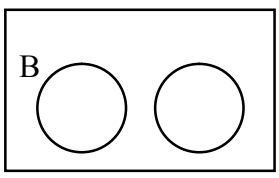
If all the components of set A are belonging to the set B and all the components of set B included in set A, A and B sets are considered as equal sets.



- Disjunctive, abstract sets

If there are interpreted A and B two sets and don't have common components of both , it is subjected to concern them as abstract sets. A & B abstract sets.

A

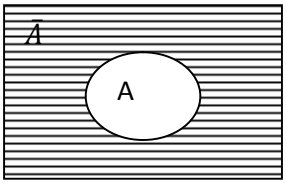


Represent differentpropositions in Venn diagrams

1. Colour shade the class to represent null set

   Ex; everything is glamorous

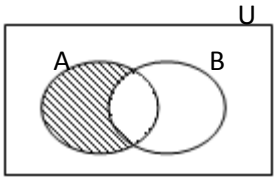
   A- glamorous $\bar{A}=\phi$



2. All reptiles are poisonous

   A- Reptiles

   B- Poisonous

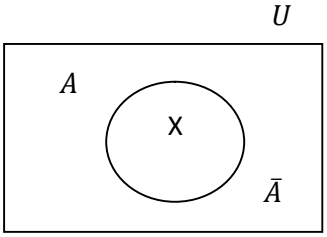


$A \cap \overline{B} = \phi$

The denotation of a component of a proposition should indicate “x” in the class

1. Some of them are students

   A- Students

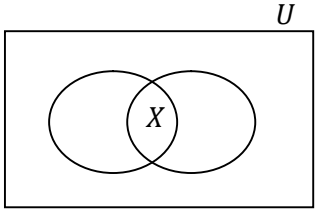


$A \neq \phi$

2. Some flowers are red

   A- Flowers

   B- Red



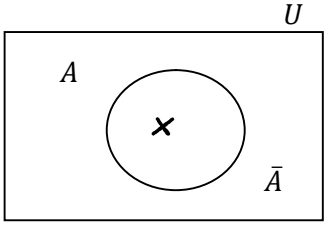
$A \cap B \neq \phi$

While recommending a certain object related to class should be indicated as x,y,z…… ascending letters.

1. Rama is a king

   A- Kings

   x - Rama

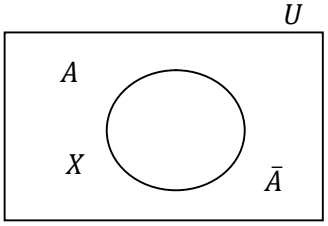


$x \in A$

2. She is not a singer

   A- - Singer

   X - she



$x \notin A$

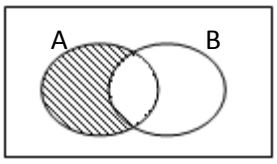
- Universal propositions

If the predicate manifest all the components denoted by the subject, is considered as universal propositions.

1.1 universal affirmative

all swans are white

A :Swan
B :white



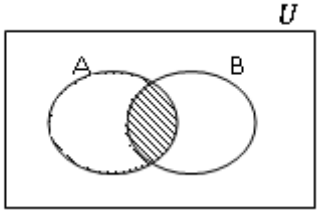
$A \cap \bar{B} = \phi$

1.2 Universal negative

No reptile is a mammalian (reptiles are not mammalians)

A :reptiles
B :mammalians

$A \cap B = \phi$



2. Particular propositions

If the predicate manifestation allowed to a part of predicate objects it denotes as particular proposition

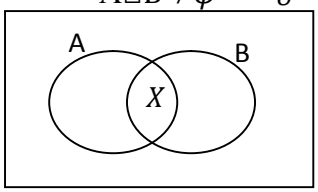
2.1 particular affirmative and negative propositions

e.g. some reptiles are poisonous

A: reptiles

B: poisonous

$A \cap B \neq \phi$ U

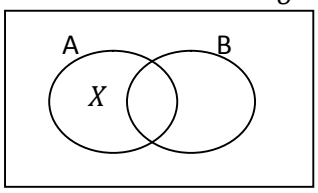


2.2 Some Grecians are not philosophers

A: Grecians

B :Philosophers

U



$A \cap \overline{B} \neq \phi$

3. singular propositions

If the subject does not assert on single object, it is considered as singular propositions.

3.1 Singular affirmative

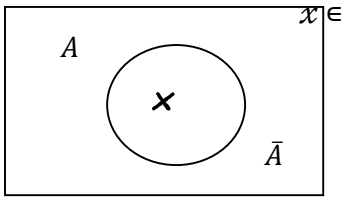
Ex; two is an even number

A: even numbers

:two

U

$x \in A$



3.2 Singular negative;

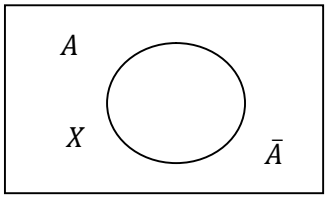
This book is not a novel

A: novels

x :this book

U

$x \notin A$



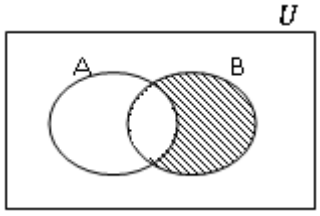
- **Represent Venn's diagrams on residual sentences.**

According to the modern clarifications, various kinds of verbal arguments can be demonstrated in Venn's diagrams.

Ex; only triers will win (there is no one who will win without triers)

A: triers

B: wining class

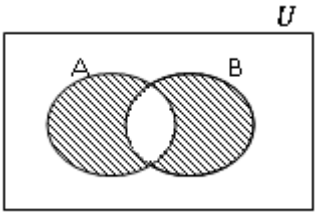


$\bar{A} \cap B = \phi$

Ex:-Lawyers & only lawyers will argue

A: lawyers

B: ~~cl~~ass of arguing

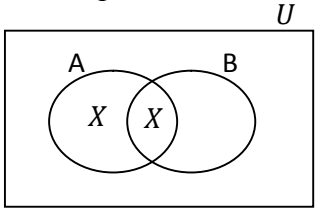


$A \cap \bar{B}$ $\bar{A} \cap B = \phi$

Ex:-Only few of the mangoes are ripen

A: mangoes

B: ripen



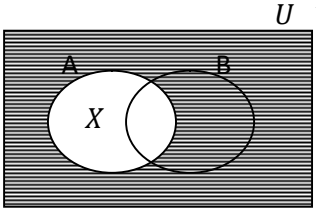
$A \cap B$ $A \cap \bar{B} \neq \phi$

Ex:-Though all things glitter they are not gold.

A: glittering class

B: gold class

$\bar{A} = \phi$ $\bar{B} \neq \phi$

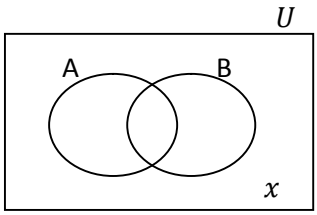


Ex: - She is not pretty or wealthy

A :pretty

B :wealthy

:she



$x \notin A \cup B$

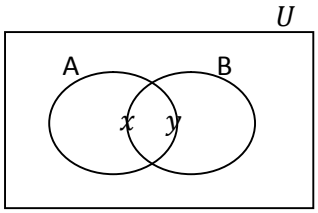
Ex: - Two is an even number and three is a prime number.

A: even numbers

B: prime numbers

x: two

y: three



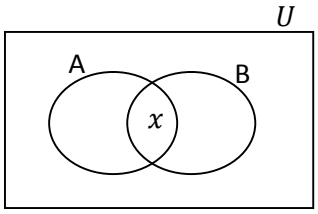
$x \in A \cap y \in B$

Ex: - Two is prime number which is also an even number

A: even numbers

B: prime numbers

x: two



$x \in A \cap B$

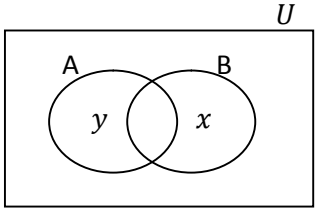
Ex:-Five is a prime number which is not an even number & four is an even number of prime number.

A: even numbers

B: prime numbers

x: five

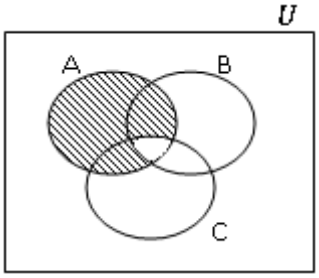
y: four



$x \in \bar{A} \cap B \cap y \in \bar{B} \cap A$

Ex: All politicians are intelligent & educated

A: politicians
B: intelligent
C: educated

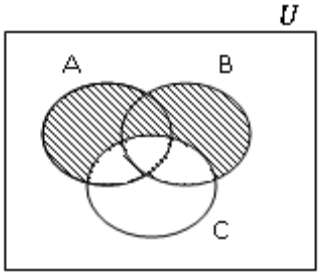


$A \cap (B \cap C)' = \phi$

Ex: Snakes and vipers/pythons are poisonous

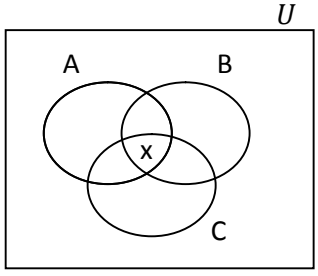
A: snakes
B: vipers
C: poisonous

$(A \cup B) \cap \bar{C} = \phi$



Ex:-Some youngsters are educated & intelligent

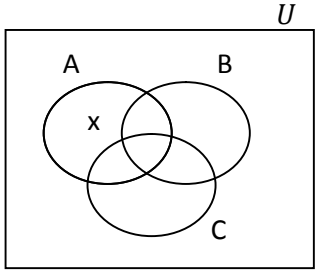
A: youngsters
B: educated
C: intelligent



$A \cap (B \cap C) \neq \phi$

Ex: - Some ladies are neither pretty nor wealthy

A: ladies
B: pretty
C: wealthy



$A \cap (B \cup C)' \neq \phi$

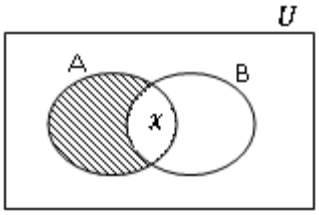
Determine the validity of arguments by the means of symbolizations and Venn's diagrams.

If the conclusion had derived from the Venn's diagram after symbolizing the argument has tobe considered as valid and if the conclusion snot implicated it is concerned as an invalid argument.

Ex1; philosophers are intelligent

A: Socrates is a philosopher

B: Therefore he is sophisticated



$A \cap \bar{B} = \phi$

$x \in A$

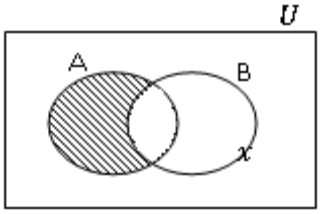
$\therefore \quad x \in B$

Valid

Ex: Lawyers are arguing

A: Sarath is not a lawyer

B: Therefore Sarath is not arguing



$A \cap \bar{B} = \phi$

$x \notin A$

$\therefore \quad x \notin B$

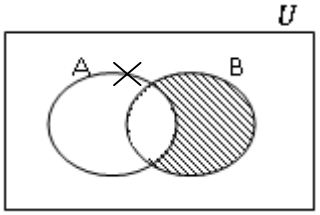
Invalid

Ex3 : Only triers would win

A: trier

B: wins

X: Piyal



$\bar{A} \cap B = \phi$

$x \in A$

$\therefore \quad x \in B$

invalid

Cities are not clean

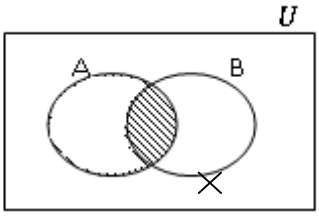
Peradeniya is clean

Therefore Peradeniya is not a city

A : City

B: Clean

X :Peradeniya



$A \cap B = \phi$

$x \in B$

$\therefore \quad x \notin A$

Valid

Some novels are fictions

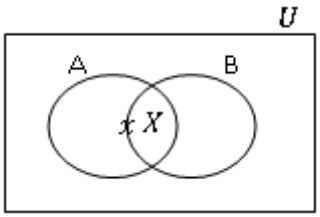
Gamperaliya is a novel

Therefore Gamperaliya is a fiction

A: Novels

B: Fiction

X: Gamperaliya



$A \cap B \neq \phi$

$x \in A$

$\therefore \quad x \in B$

Invalid

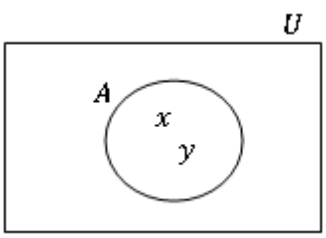
Piyal is a student Kamal is a student

Therefore everybody is a student

A: Students

X: Piyal

Y: Kamal



$x \in A$

$y \in A$

$\therefore \quad \bar{A} = \phi$

Invalid

Two is an even number, three is a non-evennumber

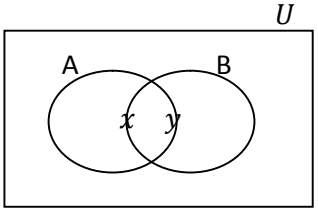
Therefore some even numbers not non even numbers

A: even numbers

B: non – even numbers

X: two

Y: three



$x \in A$

$y \in B$

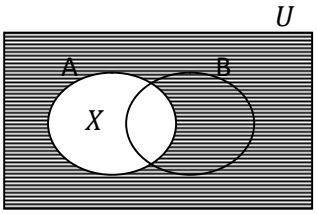
$\therefore \quad A \cap B \neq \phi$

Invalid

All are lawyers, not all are arguing therefore all lawyers are not arguing

A: Lawyers

B :Argue



$\bar{A} = \phi$

$\overline{B} \neq \phi$

$\therefore \quad A \cap \overline{B} \neq \phi$

Valid

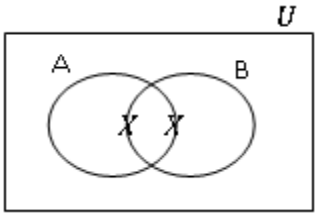
Some of them are educated

Some of them are intelligent

Therefore some educated persons are intelligent

A: Educated

B: Intelligent



$A \neq \phi$

$B \neq \phi$

$\therefore \quad A \cap B \neq \phi$

Invalid

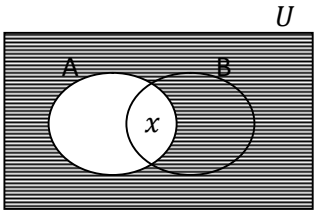
Everyone is beyond 18 years of age. Piyal is a voter

Therefore everybody who is beyond 18 years are voters

A: Everybody beyond 18 years

B: Voter

X :Piyal



$\bar{A}=\phi$

$x \in B$

$\therefore$ $A \cap \overline{B} = \phi$

Invalid

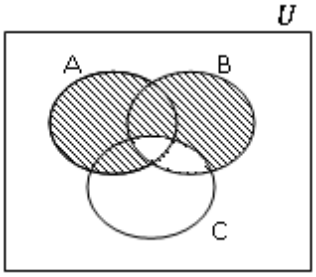
Snakes are not reptiles. Reptiles are poisonous

Therefore snakes are poisonous

A: Snake

B: Reptiles

C: Poisonous



$A \cap \overline{B} = \phi$

$B \cap \overline{C} = \phi$

$\therefore$ $A \cap \overline{C} = \phi$

Valid

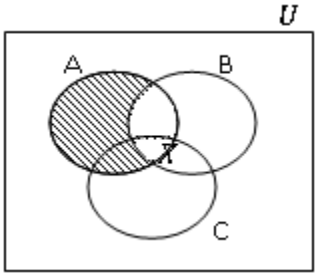
All graduates are educated. Some politicians are educated

Therefore some politicians are graduates

A: Graduates

B: Educated

C: Politicians



$A \cap \overline{B} = \phi$

$C \cap B \neq \phi$

$\therefore$ $C \cap A \neq \phi$

Invalid

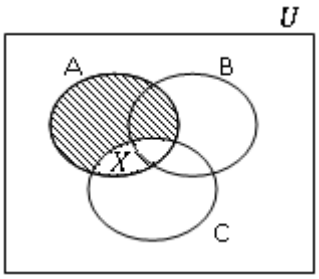
Every Lankan is not wealthy. Every Lankan is interested in hospitality

Therefore every Lankan who interested in hospitality would notwealthy

A: Lankan

B: Wealthy

C: Interested in Hospitality



$A \cap \overline{B} \neq \phi$

$A \cap \overline{C} = \phi$

$\therefore \quad C \cap \overline{B} \neq \phi$

Valid

Philosophers& only philosophers are sophisticated.

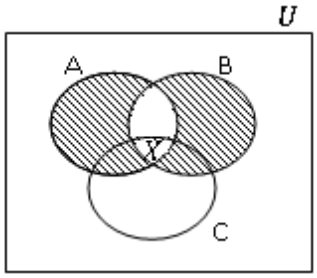
Some people who would see the future are sophisticated.

Therefore some prophets are philosophers

A: Philosophers

B: Sophisticated

C: Prophets



$A \cap \overline{B} \cup \overline{A} \cap B = \phi$

$C \cap B \neq \phi$

$\therefore \quad C \cap A \neq \phi$

Valid

Some justifiable persons are obedient.

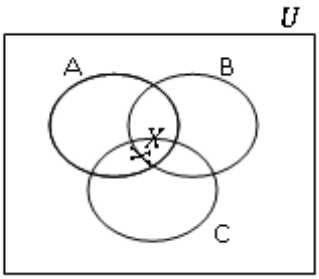
Some disciplinarians are justifiable

Therefore some obedient persons are disciplinarians

A: Justifiable person

B: Obedient

C: Disciplinarians



$A \cap B \neq \phi$

$C \cap A \neq \phi$

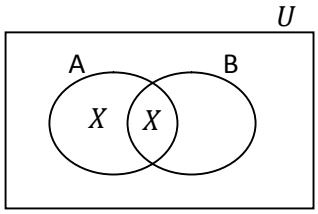
$\therefore \quad B \cap C \neq \phi$

Invalid

Ex; Only few of them are ripen from fruits available.

Demonstrate the above mentioned proposition by attaining "A" as the class of fruits & "B" as the class of ripen accordingly. Then conclude whether following statements are implied duly.

1. There are fruits
2. Some fruits are ripen
3. All ripen things are fruits
4. Only fruits are ripen
5. Some fruits are not ripen
6. No ripen fruits



1. $A \cap \overline{B} = \emptyset$not implied
2. $A \cap B \neq \emptyset$implied
3. $B \cap \overline{A} = \emptyset$not implied
4. $\overline{A} \cap B = \emptyset$not implied
5. $A \cap \overline{B} \neq \emptyset$implied
6. $\overline{B} \cap A \neq \emptyset$implied
7. $A \cap B = \emptyset$not implied

Teaching Learning Activities

A- Amoeba B- single celled C- Paramecium

1. There are amoebas
2. There are no amoebas
3. All amoebas are single celled
4. No amoebas are single celled
5. Some amoebas are single celled
6. Some amoebas are nor single celled
7. Only amoebas are single celled
8. Amoebas and only amoebas are single celled
9. Amoebas and paramecium are single celled
10. Amoebas or paramecium are not single celled

Proposition Calculus

Competency : Concludes validity of arguments having understood the formal features of deductive logical system.

Competency level :

1. Translates linguistic statements into symbolic statements, and vice versa.

a. Determines the validity of arguments through direct truth tables, indirect truth tables and truth trees.

2. Inquires residual proving methods of symbolic sentences.
3. Proves logically the accuracy of valid arguments through methods of derivations, being based on rules of inference.

Number of periods : 100

Learning Outcomes :

1. Defines propositional calculus.
2. Direct truth tables, indirect truth tables and truth trees are used to determine logical validity.
3. Understands residual proving methods in propositional calculus.
4. Understands means

Introduction

The modern symbolic logic can be identified as a gradual extension that awakened through traditional logic. It expresses a more abstract thought with the influence of the mathematical and symbolic language. Words are used in a language to imply concepts of day to day life. In the same manner, mathematics also uses different symbols to imply concepts. The mathematical philosophers of the 19^{th} century were able to introduce a logical system with mathematical model. Sentential patterns, such as conjunction, disjunction, implication and negation were introduced by Megarian and Stoic thinkers, and they were understood to indicate systematically using algebraic models by George Boole. In this purpose, Leibniz's universal logical language was more helpful. Since then, logic also tended to evolve with the influence of formal features of mathematics.

A Supplement to Understand Subject Matters

<u>Features of a Deductive System</u>

For constructing a valid logical system, deductive systems are used. These systems which lead for valid conclusions are defined as axioms. Axioms can be identified in logic and mathematics, geometry, set theory etc, mathematical subject as well.

A deductive system with axioms consist the following elements.

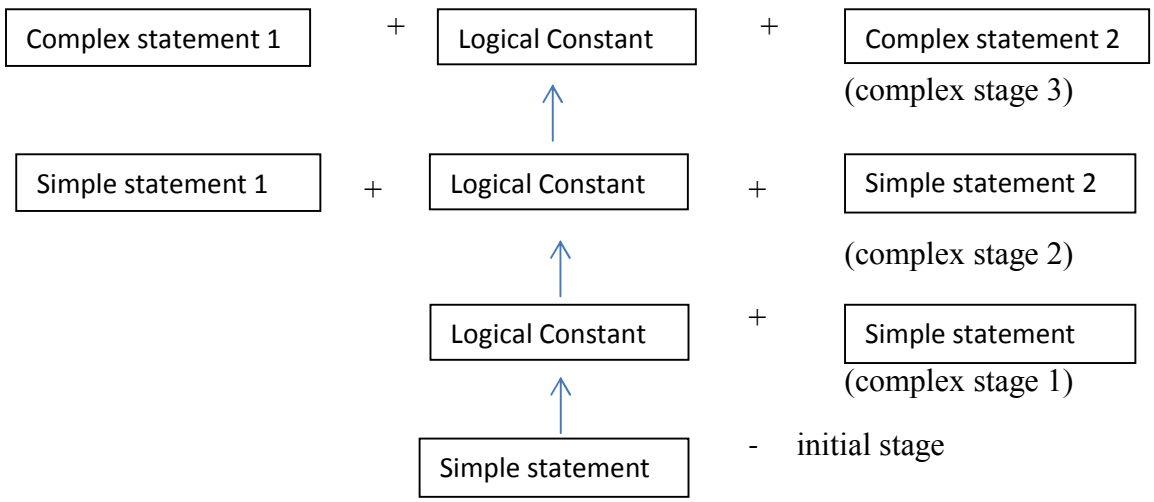
- Elementary terms (Primitive terms / non- interpretative terms)
- Interpretative terms
- Rules of inference
- Axioms
- theorems

Simple Sentences and Complex sentences

Descriptive sentences which cannot be separated further, meaningfully**,** are called simple sentences.

Eg : - He went Colombo

- Light travels in air faster than that of in the water. (Speed of light in air is faster in relation to it in water).
- By combining a simple sentence or a few simple sentences with logical constants, a complex sentence is formed. They can appear in different manner.



<u>Identifying Propositional Calculus</u>

- Sentential variables

The simple sentences are symbolized using P, Q, R, S, T, U …….. Z etc.

P - He went Colombo

Q - Light travels in air faster than that of in the water.

Logical Constants, their Different Sentence Patterns and Symbols

The elements which indicate the patterns of combination of sentences are called logical constants. These imply their definite meanings without any variations. The conventional logical constants and the complex sentences related to them are indicated are indicated symbolically.

- **Negation - ~**

  Negation is used to indicate negativity.

  P - Wind blows.

  ~P - Wind does 'not blow.

- **Conjunction - ∧**

  Conjunction is used to indicate factors inseparably connected within time and space.

  When wind blows, trees fall down.

  P - Wind blows.

  Q - Trees fall down.

  (P∧Q)

- **Implication - →**

  The sentences which indicate Consequent as a necessary result of Antecedent are considered to be hypothetical sentence. The prepositions such as *if...then.... , if, because*etc, are used to imply this logical sense.

  Eg:- If he goes up, then he comes down.

  Scheme of Abbreviations

  P – He goes up

  Q – He comes down

  Symbolization (P →Q)

- **Weak Disjunction - V**

  The statementswhich indicate that at least one alternative is true are considered here. The prepositions, *or , either or*are used.

  Eg:- She studies logic or mathematics.

  Scheme of Abbreviations

  P – She studies logic.

  Q – She studies mathematics.

  Symbolization (P **V**Q)

- **Strong Disjunction** **V**

The strong disjunction implies that out of the alternatives one and only one is true.

Eg: - Out of captain and the vice-captain, one and only one will bat first.

P - Captain bat first.

Q - Vice captain bat first.

(P **V**Q)

Here, instead of the following various complex formulas, the strong disjunction is introduced.

- [(PVQ) ∧~ (P∧Q)]
- [(P∧~Q) V (~P∧Q)]
- [(PVQ) ∧ (~PV~Q)]
- ~[(P∧ Q) V (~P∧~Q)]

Accordingly, the above sentences can be symbolized as (P **V**Q).

Eg:- She will register at one and only one of Universities of Peradeniya, Kelaniya or Ruhuna.

P - She will register at University of Peradeniya.
Q - She will register at University of Kelaniya.
R - She will register at University of Ruhuna.

[PV(QVR)] or [(PVQ) V R]

- **Bi-conditional** - ↔

This is used to indicate the simultaneity of two statements, thatthe Consequent is implied from the Antecedent, and vice versa. The preposition *if and only if* is used here.

Eg:- If and only if it rains, the river stream.

Scheme of Abbreviations

P – It rains.

Q – The river stream.

Symbolization (P↔Q)

Use of Brackets

Brackets have to be used properly in the symbolic sentencesto avoid vagueness. If not, they become Ill Formed Formulae. Yet, logicians, Henry Maurice **Sheffer** (1882 – 1964)andLukasiewiczstate that the Well Formed Formulae can be constructed even without the use of brackets. However, to indicate the scope of symbolic sentences there are some

basic kinds of brackets. The purpose of these is different from one another. Therefore, it is very important to use them in due position.

- Round Brackets (P→ Q)
- Square Brackets [(P→Q) ∧ (RV∼P)]
- Curly Brackets {[(P∧Q) ∧(RVQ)] → (QVP)}

In most of the foreign texts, only the round brackets can be seen to indicate the limitations of the symbolic statement.

((((P∧ Q) ∧ (R∧Q)) ∧(QVP)) →(P→T)

Further, in some cases, brackets can be omitted when it does not matter.

- P→ (Q∧R)
- PV∼Q

Well Formed Formulae and non-Well Formed Formulae

A symbolic formula which is formed using sentential variables, constants, brackets in proper manner is called a Well Formed Formulae – (WFF). They can be translated again into the language meaningfully. In other words, symbolic statements which are in accordance with the rules of the system are called WFFs. And the statements which are not in accordance with the rules of the system are called non- Well Formed Formulae. When the sentential variables, constants and brackets are not accurately used according to the system, they are called the non- Well Formed Formulae.

Rule 1

All the sentential variables are WFFs. Accordingly, the following are WFFs.
P
Q
R
S

Rule 2

If is a variable is a WFF ∼ is also a WFF. Therefor the following are WFFs.
Eg:- ∼ P
∼Q
∼R

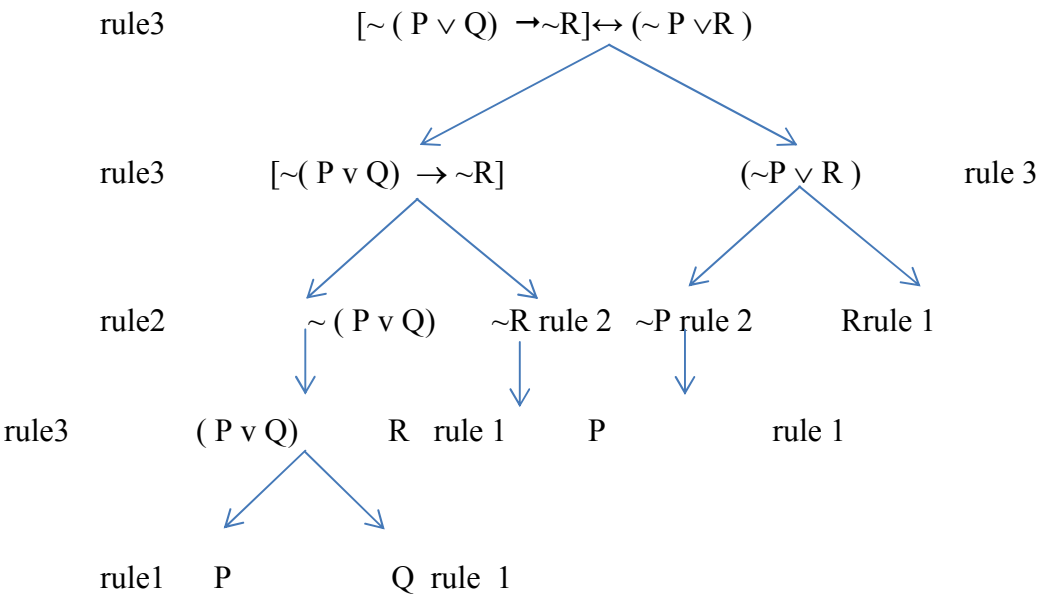
Rule 3

A combination of two WFFs by a logical constant is also WFF. If and ψ are symbolic statements, then the following are symbolic statements.

(∧ψ) (P∧Q)
(V ψ) (PVQ)
(→ψ) (P→Q)
(↔ ψ) (P↔ Q)
($\underline{V}$ ψ) (P$\underline{V}$Q)

According to the above rules, a formula can be tested, whether it is a WFF using a grammatical tree.

Eg:- {[~ (P v Q) →~R]↔ (~ P v R)}



- ~ (P∧Q)→(R∨S)
  This is not a WFF ; brackets have not been used accurately.

- [(P + Q)→R]
  This is not a WFF; logical constants are not accurate.

- [(A ∧ B) →C]
  This is not a WFF; sentential variables are not accurate.

- [(P ∧ Q) → ~R]
  This is a WFF.

Translation

Linguistic (colloquial) Statements are Translated into symbolic language, and vice versa.

- Linguistic Statement

If it is given that it has rained causing the river flood, the paddy will be flooded.

Scheme of abbreviations

P - It rains.
Q - The river floods.
R - The paddy will be flooded.

Symbolization [(P∧ Q) → R].

- Symbolization $[(P \vee Q) \rightarrow R]$

  Scheme of abbreviations

  P - Wind blows.
  Q - Trees move.
  R - It rains.

  Linguistic Statement

  If it is given that either wind blows or trees move, then it will rain.

Propositional Calculus and Use of Truth Tables

To conclude the validity or invalidity of a given argument, the Direct or Indirect method of truth tablesis used.

In the Direct method, all the values of the formula are tested gradually. Finally, if all the values of the main logical constant (the nucleus) are found to be true, then the argument is concluded to be valid. If at least only one value of the nucleus is found to be false, the argument is concluded to be invalid.

In the Indirect method, having assumed the conclusion to be invalid, if any controversy is arisen the argument is considered valid, and if there is no controversy, it is considered invalid.

When the argument is valid with assumptions, it would be more logicaltodraw the conclusions being based on minimum variables.

- Truth Table Method

After symbolizing a linguistic statement, a truth value can be drawn for that. A truth table is needed there. A truth table is constructed based on the truth / falsity of each variable of the given complex symbolic sentence.

Based on the number of variables, the number of values is 2^n. A truth table can be constructed based on it.

P	Q	(P∧Q)	(P∨Q)	(P$\underline{\vee}$Q)	(P→Q)	(P↔Q)
T	T	T	T	F	T	T
T	F	F	T	T	F	F
F	T	F	T	T	T	F
F	F	F	F	F	T	T

- **Direct Method of Truth Tables and Testing Validity**

  Argument 1

  Step 1 $(P \rightarrow Q) \cdot P \therefore Q$
  Step 2 $\{[(P \rightarrow Q) \wedge P]\} \rightarrow Q$

P	Q	{[	(P	→	Q)	∧	P]}	→	Q
T	T		T	T	T	T	T	*T*	T
T	F		T	F	F	F	T	*T*	F
F	T		F	T	T	F	F	*T*	T
F	F		F	T	F	F	F	*T*	F
			1	3	2	5	4	7	6

Argument is valid.

Argument 2

Step 1 $(P \rightarrow Q) \cdot Q \therefore P$
Step 2 $\{[(P \rightarrow Q) \wedge Q]\} \rightarrow P$

P	Q	{[	(P	→	Q)	∧	Q]}	→	P
T	T		T	T	T	T	T	T	T
T	F		T	F	F	F	F	T	T
F	T		F	T	T	F	T	*F*	F
F	F		F	T	F	F	F	T	F
			1	3	2	5	4	7	6

Argument is invalid.

- **Indirect Method of Truth Tables and Testing Validity**

Argument 1

Step 1 $(P \rightarrow Q) \cdot P \therefore Q$
Step 2 $\{[(P \rightarrow Q) \wedge P]\} \rightarrow Q$

{[	(P	→	Q)	∧	P]}	→	Q
	T	*T*	F	T	T	F	F
	7	4	6	2	5	1	3
		*					

Argument is valid.

Argument 2

Step 1 $(P \rightarrow Q) \cdot Q \therefore P$
Step 2 $\{[(P \rightarrow Q) \wedge Q]\} \rightarrow P$

{[	(P	→	Q)	∧	Q]}	→	P
	F	T	T	T	T	F	F
	6	4	7	2	5	1	3

Argument is invalid.

Eg:- Argument in language 1

Either Piyadasa or Martin has taken part in the theft, but they both have not. Therefore, if and only if Piyadasa has taken part in the theft, Matin has not taken part.

Scheme of abbreviations

P - Piyadasa has taken part in the theft.
Q - Martin has taken part in the theft.

Symbolization

Step 1 $[(P \vee Q) \wedge \sim (P \wedge Q)] \therefore (P \leftrightarrow \sim Q)$
Step 2 $\{[(P \vee Q) \wedge \sim (P \wedge Q)]\} \rightarrow (P \leftrightarrow \sim Q)$

Testing Validity

{	[	(	P	∨	Q	)	∧	~	(	P	∧	Q	)	]	}	→	(	P	↔	~	Q	)	
			F	***T***	F		T	T		T	***F***	T				F		T	F	F			(i)
				(ii)							(i)							F	F	T			(ii)

Argument is valid.

Argument in language 2

If the law is reasonable then both defendant and the witness are convicts. Although the law is reasonable, if the complainant lies, then neither defendant nor witness is a convict. Therefore, if the complainant lies then law is neither reasonable nor unreasonable.

Scheme of Abbreviations

P - Law is reasonable
Q - Defendant is the convict.
R - Witness is the convict.
S - Complainant lies.

Symbolization

Step 1 $P \rightarrow (Q \wedge R) \,.\, (P \wedge S) \rightarrow (\sim Q \wedge \sim R) \therefore S \rightarrow (\sim P \wedge \sim \sim P)$
Step 2 $\{[P \rightarrow (Q \wedge R)] \wedge [(P \wedge S) \rightarrow (\sim Q \wedge \sim R)]\} \rightarrow [S \rightarrow (\sim P \wedge \sim \sim P)]$

Testing Validity

{	[	P	→	(	Q	∧	R)	]	∧	[	(	P	∧	S)	→	(	~	Q	∧	~R)	]	}	→	[	S	→	(	~P	∧	~	~P)	]
		F	T		T	T	T		T		F	F	T	T	F		F	F			F	T	F	T	F	F						

Argument is Invalid.

Argument in Language 3

One and only one of the captain and the vice-captain, bats fist. Therefore, if the captain bats first the vice -captain bats last.

Scheme of Abbreviations

P - The captain bats first.
Q - The vice-captain bats first.
R - The vice-captain bats last.

Symbolization

Step 1 $(P \underline{\vee} Q) \therefore (P \rightarrow R)$
Step 2 $(P \underline{\vee} Q) \rightarrow (P \rightarrow R)$

Testing Validity

{	(P	$\underline{\vee}$	Q)}	$\rightarrow$	(P	$\rightarrow$	R)
	T	T	F	F	T	F	F

Argument is Invalid

- Symbolic Sentences and the Residual Methods

  - Concluding Equality, Contradictoriness or Neither Equal nor Contradictoriness of couple of sentences.

    (Indirect method of truth tables can also be used for proving two equal formulas. Bi-condition is replaced instead of the semicolon (;) between the two symbolic statements. Then based on the values of it, the conclusion is drawn.

    - $\sim(P \wedge Q)$;$(\sim P \vee \sim Q)$
    - $(P \vee Q)$;$(\sim P \wedge \sim Q)$
    - $(P \rightarrow \sim Q)$;$(\sim P \rightarrow Q)$
    - $(P \underline{\vee} Q)$; $[(P \wedge \sim Q) \vee (Q \wedge \sim P)]$

    Concluding tautological, contradictory or contingent formulas (The judgment is based on the values of the nucleus)

    - $[Q \rightarrow (P \rightarrow Q)]$
    - $[(P \wedge Q) \wedge (\sim P \vee \sim Q)]$
    - $[(P \rightarrow Q) \rightarrow (Q \rightarrow R)]$

  This can be applied for conjunction, disjunction, strong disjunction, implication and bi-condition sentences.

- Determining the Truth Value (true, false or indeterminate) without the Use of Truth Tables

  When 'P' is given false,

  $[(P \wedge Q) \rightarrow (R \rightarrow S)]$

  When 'P' is given false, the value of theantecedent($P \wedge Q$) is false, and as a result he main constant, implication becomes true.

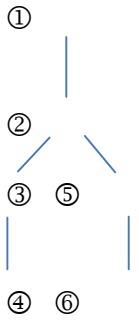
  Here, to gain the value of the nucleus, only the essential steps are indicated.

  $[P \rightarrow (Q \wedge R)] \rightarrow (\sim P \vee \sim R)$

  When 'P' is given false, ~P becomes true. As a result the consequent becomes true. Therefore the main constant of the statement becomes true.

Truth Tree Method

The truth tree method which is based on the truth table itself, is also used to judge the symbolic formula and the arguments. The Dutch logician E.W. Beth (1908-64), introduced this system. It was introduced as *method of analytic tableaux*. Instead of the truth values used in the truth table method, the occurrence of the truth values when a formula is true is indicated here in a truth tree.



There are two types of rule applied in this methodology.

- Stacking rules
- Branching rules

- If a statement becomes true only in one option, without having alternatives, it is positioned in stacking rules. There are four options that stacking rules are used.

  - Double Negation

    $\sim \sim \phi$

    ϕ
  - When conjunction is true

    $(\phi \wedge \psi)$

    ϕ

    ψ

- When thenegation of implication is true

  $\sim(\phi \rightarrow \psi)$

  ϕ

  $\sim\psi$

- When the negation of disjunction is true

  $\sim(\phi \vee \psi)$

  $\sim\phi$

  $\sim\psi$

If there are alternatives for a statement to be true, it is indicated in branching rules. There are seven options for the branching rules.

- When disjunction is true

  $(\phi \vee \psi)$

  $\phi \quad \psi$

- When implication is true

  $(\phi \rightarrow \psi)$

$\sim\phi\psi$

- When the negation of conjunction is true

  $\sim(\phi \wedge \psi)$

  $\sim\phi\sim\psi$

- When bi-condition is true

  $(\phi \leftrightarrow \psi)$

  $\phi \qquad \sim\phi$

  $\psi \quad \sim\psi$

- When the negation of bi-condition is true

  $\sim(\phi \leftrightarrow \psi)$

  $\phi \qquad \sim\phi$

  $\sim\psi\psi$

- When the strong disjunction is true

  $(\phi \veebar \psi)$

  $\phi \quad \sim\phi$

  $\sim\psi\psi$

- When the negation of strong disjunction is true

  $\sim(\phi \veebar \psi)$

  $\phi \qquad \sim\phi$

  $\psi \quad \sim\psi$

- **Open and Closed Truth Trees**

A tree consists of the trunk or the trunk and branches. If there is a contradiction in the trunk of a tree or within tree and branches in collinear manner,it is closed. To close the tree, all the branches are to be closed. If there is a contradiction within the trunk, even then it is closed. The symbol (x) is used to indicate that the tree is closed. If there is at least one branch is open, then it is an open tree.

Open Tree

1. $[(P\rightarrow Q) \vee (Q\rightarrow P)]$

$(P\vee Q)$

$(P\rightarrow Q)$ $(Q\rightarrow P)$

$\sim P$ Q $\sim Q$ P

2. $[(P\vee Q) \wedge \sim(P\wedge Q)]$

$\sim(P\wedge Q)$

P Q

$\sim P$ $\sim Q$ $\sim P$ $\sim Q$

× ×

Closed Tree

1. $\sim[(P\rightarrow Q) \vee (Q\rightarrow R)]$

$\sim(P\rightarrow Q)$

$\sim(Q\rightarrow R)$

P

$\sim Q$

Q ×

2. $[(P\rightarrow Q) \leftrightarrow(P\wedge\sim Q)]$

$(P\rightarrow Q)$ $\sim(P\rightarrow Q)$

$(P\wedge\sim Q)$ $\sim(P\wedge\sim Q)$

P P

$\sim Q$ $\sim Q$

$\sim P$ Q $\sim P$ Q

× ×× ×

- *Consistent and Inconsistent Tree*

When a set of formulae is indicated in a tree, if and only if the tree is closed, the set of formulae is considered 'Inconsistent'. If the tree is open (at least one branch is open) it is 'Consistent'.

$[(P\vee Q) \wedge \sim (P\wedge Q)] \cdot (P\leftrightarrow Q)$

$[(P\vee Q) \wedge \sim (P\wedge Q)]$

$(P\leftrightarrow Q)$

$(P\vee Q)$

$\sim (P\wedge Q)$

$(P\vee Q)$

P $\sim P$

Q $\sim Q$

P Q P Q

× ×

inconsistent

$[(P\vee Q)\wedge(R\vee S)] \cdot (P\wedge R)$

$[(P\vee Q)\wedge(R\vee S)]$

$(P\wedge R)$

P

R

$(R\vee S)$

P Q

R S R S

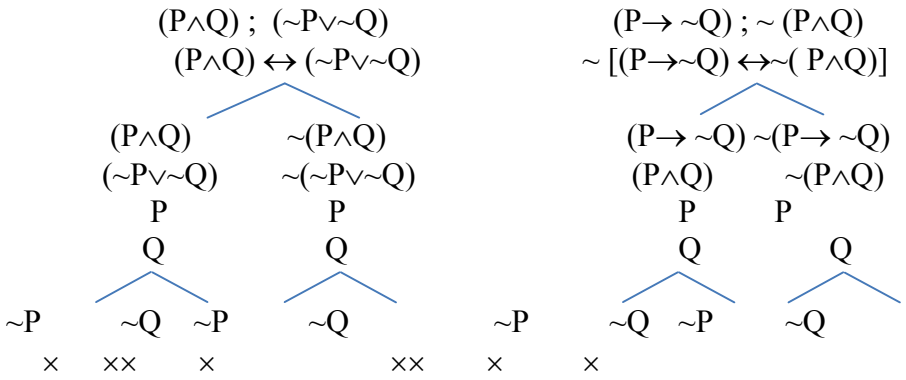
$\sim P$ $\sim Q$ $\sim P$ $\sim Q$

× ×××

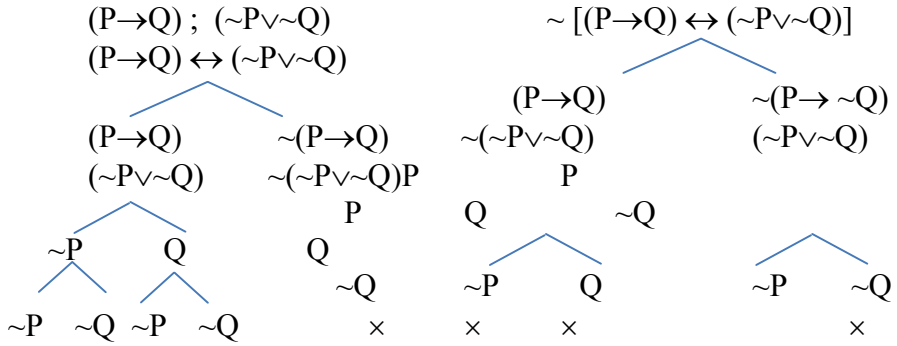
consistent

Truth trees can be used to determine equal, contradictory and neither equal nor contradictoriness of couples of formulas. There, the truth tree is created having coupled the formulas using the bi-condition.

- If and only if the tree is closed, the couple of formulas are contradictory.
- If and only if the negation of the statement (once it is combined with negation) is closed, it is equal.
- If the tree is open when both the formulas are combined with bi-condition and it is negated as well (the above two options), the couple of formulae are considered neither equal nor contradictory.



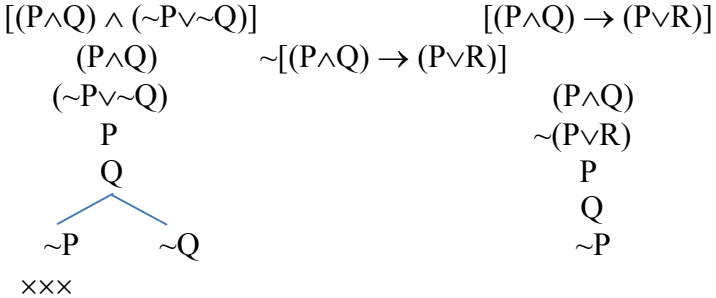
The couple of formulae are contradictory. The couple of formulae are equal.



The couple of formulae are neither equal nor contradictory

The truth trees can also be used to determine tautological, contradictory and contingent formulas.

- If and only if the truth tree of a negated formula is closed, it is called tautological.
- If and only if the truth tree of a formula is closed, it is called a contradictory.
- If the truth trees of both a formula and its negation are open, it is called contingent.



Contradictory Tautological

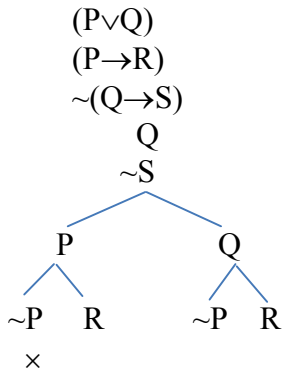
- To determine validity or invalidity of arguments, truth tree method is used.
  - The argument is symbolized following the relevant scheme of abbreviations. Then, the premises and the negation of the conclusion are listed one by one vertically.
  - If the argument is closed following the rules, it is concluded to be valid. If the tree is open the argument is invalid.

Argument
Canada or Sri Lanka qualifies for the final match. If Canada qualifies for the final match, they will be given the cup. Therefore, if Sri Lanka qualifies for the final match, they will be given the cup.

Scheme of Abbreviations

P	- Canada qualifies for the final match.
Q	- Sri Lanka qualifies for the final match.
R	- Cup will be given to Canada.
S	- Cup will be given to Sri Lanka.

Symbolizing $(P \vee Q) \cdot (P \rightarrow R) \therefore (Q \rightarrow S)$



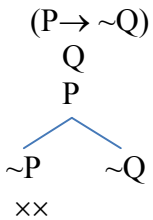
argument is invalid

Argument

She selects logic only if she does not select mathematics. She has selected mathematics. Therefore, it is false that she selects logic.

P - She selects logic.
Q - She selects mathematics.

Symbolizing $(P \rightarrow \sim Q) \cdot Q \therefore \sim P$



argument is valid

Argument

One and only one of captain and vice - captain bat first. The captain has batted first. Therefore, the vice captain does not bat first.

Symbolizing $(P \veebar Q) \cdot P \therefore \sim Q$

$(P \veebar Q)$

P

Q

P ~P

~Q Q

×× Argument is valid.

- ***Derivation Method***

Derivation means analyzing validity of a valid argument is with the aid of rules of inference. It is proof of the conclusion with the aid of premises. Validity of the argument is indicated here step by step in a way that geometric theorems are proved. Rules which applied in the derivations are called rules of inference.

1. *Repetition* *(REP)*

   A proved statement in a line of a derivation can be repeated in the same derivation.

   $\phi \therefore \phi$

   $\sim\phi \therefore \sim\phi$

2. *Double Negation* *(DN)*

   A statement in a line of a derivation can be re-written in the same derivation making double negated.

   $\phi \therefore \sim\sim\phi$

   $\sim\sim\phi \therefore \phi$

3. *Modus Ponens* *(MP)*

   In a derivation, if an implication occurs in a line and its antecedent occur in another line, the consequent of the (above mentioned) implication can be implicated.

   $(\phi \rightarrow \psi)$

   $\phi \therefore \psi$

4. *Modus Tollens* *(MT)*

   In a derivation, if an implication occurs in a line and the negation of its consequent occurs in another line, the negation of the antecedent of the (here mentioned) implication can be implicated.

   $(\phi \rightarrow \psi)$

   $\sim\psi \therefore \sim\phi$

5. *Simplification* *(SIMPLI)*
   When a conjunctive statement is in a line of a derivation, its components can be implicated separately where necessary.
   $(\phi \wedge \psi) \therefore \phi$

6. *Adjunction* *(ADJ)*
   Two proved statements of a derivation which appear separately in two lines, can be combined and written as a line with conjunction.
   ϕ
   $\psi \therefore (\phi \wedge \psi)$

7. *Addition* *(ADD)*
   Any symbolic statementcan be connected with another proved statement in a lineusing disjunction.
   $\phi \therefore (\phi \vee \psi)$

8. *Modus Tollendo Ponens* *(MTP)*
   In a derivation, if a disjunction occurs in a line and negation of one of its components occur in another line, the other component can be written as line. This is relevant for the strong disjunction as well.
   Eg:- $(P \square Q)$
   $\sim Q$
   $\therefore P$

9. *Modus PonendoTollens* *(MPT)*
   If one component of strong disjunction is affirmed in a line, the other component can be negated in a line (Sheffer stroke).
   $(\phi \vee \psi)$ or $(\phi \veebar \psi)$
   $\sim\phi \therefore \psi$ $\sim\psi \therefore \phi$

10. *Conditional Bi-conditional*
    If antecedent and the consequent are mutually implied in two different lines (as implications) in a derivation, they can be combined as a bi-conditional statement.
    $(\phi \rightarrow \psi)$
    $(\psi \rightarrow \phi) \therefore (\phi \leftrightarrow \psi)$

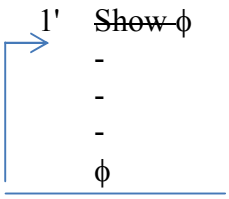
11. *Bi-conditional Conditional*
    If a bi-conditional statement occurs in a derivation as a line, the relevant component implications of it can be written as lines.
    $(\phi \leftrightarrow \psi) \therefore (\phi \rightarrow \psi), (\psi \rightarrow \phi)$

Methods of Derivations

- Direct Derivations
- Indirect Derivations
- Conditional Derivations

- Direct Derivations

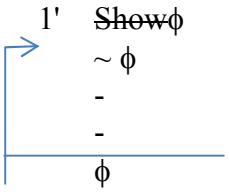
The conclusion of the argument is proved in a line in direct derivations.



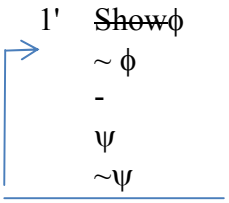
- Indirect Derivations

Proving the conclusion by creating a contradiction in a derivation is called an Indirect Derivation. This can be used for any valid arguments.

The conclusion can be constructed in two ways.

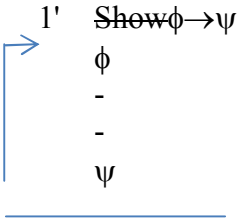


This is reduction ad absurdum



- Conditional Derivations

When the conclusion of the argument is a hypothetical (conditional) statement, the conditional derivation method is used. In this method, the antecedent of the conclusion is assumed in the second line. Then, the consequent of the conclusion is derived.



- Sub Derivation

Sub Derivations are used when a conclusion of derivation cannot be proved with the aid of premises and the assumptions. These are created within the main derivation itself. As a rule, except the proved line, the other grouped lines cannot be adopted for proving the main derivation. The number of sub derivations may vary according to the requirement.

$(P \rightarrow Q)\ .\ (P \rightarrow \sim Q)\ \therefore\ (P \rightarrow R)$

1. ~~Show~~ $(P \rightarrow R)$

2.	P	(ACD)	
3.	$(P \rightarrow Q)$	(premise 1)	
4.	Q	(3,2MP)	it is not wrong indicating as (2,3 MP)
5.	$(P \rightarrow \sim Q)$	(premise 2)	
6.	$\sim Q$	(5,2 MP)	
7.	~~Show~~R		
8.	$\sim R$	(AID)	
9.	Q	(4REP)	
10.	$\sim Q$	(6 REP)	

- *Theorems*
  A theorem is a valid logical conclusion without a set of premises. It is necessarily true in a deductive system.

$[(P \wedge Q) \leftrightarrow (Q \wedge P)]$

1.	~~Show~~ $[(P \wedge Q) \leftrightarrow (Q \wedge P)]$		
2.	~~Show~~	$[(P \wedge Q) \rightarrow (Q \wedge P)]$	(1 BCC)
3.	$(P \wedge Q)$		(ACD)
4.	Q		(3 SIMPLI)
5.	P		(3 SIMPLI)
6.	$(Q \wedge P)$		(4,5 ADJ)
7.	~~Show~~ $[(Q \wedge P) \rightarrow (P \wedge Q)]$		(1 BCC)
8.	$(Q \wedge P)$		(ACD)
9.	Q		(8 SIMPLI)
10.	P		(8 SIMPLI)
11.	$(P \wedge Q)$		(10,9 ADJ)
12'	$[(P \wedge Q) \leftrightarrow (Q \wedge P)]$		(2,7CBC)

$[P \leftrightarrow (P \rightarrow Q)] \rightarrow Q$

1. ~~Show~~ $[P \leftrightarrow (P \rightarrow Q)] \rightarrow Q$
2. $[P \leftrightarrow (P \rightarrow Q)]$ (ACD)
3. ~~Show~~ $(P \rightarrow Q)$
4. ~~P~~ (ACD)
5. $[P \rightarrow (P \rightarrow Q)]$ (2 BCC)
6. $(P \rightarrow Q)$ (5,4MP)
7. Q (6,4MP)
8. $[(P \rightarrow Q) \rightarrow P]$ (2 BCC)
9. P (8,3MP)
10. Q (3,9MP)

Teaching Learning Activities

- *Individual Studies*
  Here it is expected to make the student aware of constructing arguments and evaluating their validity. Advise the students to identify the logical constants separately and construct complex statements and arguments using them.
  Guide the students to use different methods of inference to inquire validity and evaluate them.
  Assign derivations of different methods. Having made the students understoodthat it is more logical to complete derivations using proper steps and limited lines, evaluate the students assigning them activities.

  At the end of the activities, give the students assignments based on the relevant topic
  - Explain features of a Well Formed Formula (WFFs) with examples.
  - Discuss drawbacks and limitations of direct and indirect means of proofs.
  - Construct equal and contradictory statements (two for each) for $[(P \wedge Q) \rightarrow (Q \wedge P)]$, and prove them using truth tables.
  - If the statement $[(P \wedge Q) \rightarrow (R \rightarrow S)]$ is given false, find the validity of the relevant variables using truth tables.
  - If P is given true, what is the truth value of $[(P \vee Q) \wedge R] \rightarrow (P \wedge S)$? Explain how it is concluded in brief, without using truth tables.
  - Inquire the nature of logical validity of different means of proof.
    - $((P \rightarrow Q) \rightarrow (Q \rightarrow))$
    - $((P \rightarrow Q) \rightarrow (\sim P \rightarrow \sim Q))$
    - $(P \rightarrow (Q \rightarrow P)) \leftrightarrow (Q \rightarrow (P \rightarrow Q))$
    - $(P \rightarrow \sim Q) \leftrightarrow \sim (P \rightarrow Q)$
    - $(P \rightarrow \sim Q) \leftrightarrow \sim (P \rightarrow Q)$
    - $(P \rightarrow (Q \rightarrow R)) \leftrightarrow ((P \rightarrow Q) \rightarrow (P \rightarrow R))$
    - $(P \rightarrow (Q \rightarrow R)) \leftrightarrow ((P \rightarrow Q) \rightarrow (P \rightarrow R))$
    - $((P \rightarrow Q) \rightarrow (P \rightarrow \sim Q)) \leftrightarrow P$
    - $((\sim P \rightarrow Q) \rightarrow (\sim P \rightarrow \sim Q)) \leftrightarrow \sim P$

Nature and Varieties of Science

Competency - Formulates scientific methods in terms of critical thinking in relation to the History of science

Competency level - Defines the concept of "science"

Applies the nature of science and its divisions in formulating scientific methodology

Number of periods - 20

Learning outcomes –

- States the historical development of science in relation to different periods.
- Gathers information regarding different analyses of science.
- Categorizes sciences
- Describes the basic features of different sciences
- Describes the mutual relation between sciences
- Evaluate the integration of sciences.

Introduction

Before finding out what scientific methodology is, it is necessary to know what is meant by "science". It is clear that the definition of science stated by Francis Bacon and Galileo have contributed a lot in this regard. According to them integration of the knowledge of the scholars and the knowledge of the craftsmen enabled the development of scientific knowledge.

The main objective of this unit is to explain what science ids by the study if various definition of science and categorizations of science guide lies to explain the subject matter.

The guidance for demystifying subject matter

Historical evolution of science.

By the end of the middle ages there were two traditions of knowledge in Europe

1. Knowledge of scholars
2. Knowledge of craftsmen

He compared scholastic knowledge to a lame person because it was theoretical knowledge based on reasons that do not have any practical utility. The knowledge of the craftsmen was compared to a blind person who based his knowledge on experiences and sense perception which lacked theory but had practises value.

Scientific knowledge could be developed by the creation of a bee, integrating the two traditions of the scholars and craftsmen .as a result this the first to integrate the two traditions is Galileo who is considered to be the father of modern science.

Define the concept of science.

- It is knowledge based on reason and sense perception or reason only.
- It is knowledge based on the methodology introduced by the Francis bacon and Galileo.
- It is knowledge based n following a methodology of science.
- It is knowledge accepted by means of empirical tests. (Carl Hempel)
- Science is knowledge that can be as a principle falsified by empiricaltests.

  (Carl Popper)

The nature of science and its varieties

Science is based on concepts that could be as a principle falsified by empirical tests according to Carl Popper(1902-1994)

Ex; natural sciences and social sciences those that cannot be falsified in that manner are non-sciences.

Ex; formal sciences aesthetic sciences

Features of a scientific concept

1. it should be a concept that is clear and definite
2. It should be a concept that could be empirically tested
3. It could be a concept that as a principle colid e falsified such tests.

Though it is necessary for a science to be empirical that alone is not sufficient. It should be capable of being falsified. What is meant by this is that there has to be observational instances that could contradict a scientific concept.

According to Popper there are theories thatare falsified and falsifiable.

Ex; falsified theory- phlogiston theory

Falsifiable theory- oxidization theory

- Accor dint to Popper, non- sciences are

  Pure mathematics, logic, geometry.

- According to Popper non-scientific subjects are

  Astrology

  Religion

  Devil dancing

  Para Psychology

  Metaphysical concepts

❖ **According to Popper's demarcation principle non- scientific statements are**

- Tautological statements- puppy is a little dog
- Ambiguous statements- the child assimilates from the environment. Evaluative s
- Evaluative statements- that song is very melodious

❖ **According to Popper non- scientific theories are**

- Marxism,
- Freudian Psychoanalysis
- Behaviourism
- Utilitarianism

Sciences are established on the basis of paradigms. Marxism and psycho-analytic theories could be presented as broad theories in social sciences. But it is clear that these theories are not scientific because they don't follow the criteria stipulated by Popper on science, as they are vague concept, cannot be empirically tested and falsified.

There are certain fields of study that pose doubt as to whether they could be called scientific according to poppers law of demarcation

Ex; Para psychology

Categorization of sciences

Empirical sciences and non-empirical sciences

Empirical sciences

Natural sciences and social sciences

❖ Subject matter

Natural sciences are such as physical sciences that study non-living objects and biological sciences that study living objects,

Ex; physics, chemistry, biology

Social sciences are those that study facts related to human society.

Ex; economics, political science

❖ Methods of scientific tests applied.

Natural sciences make use of experiments and social sciences make use of observation.

Causal relationships can be explained in natural sciences but such relations cannot be explained in social sciences.

Capability of making predictions

Predictions can be made in natural sciences but nit un social sciences

❖ Nature of explanation

Though causal explanations are possible in natural sciences such explanations are not possible in social sciences.

❖ Nature of conclusions

The conclusions derived in natural sciences are objective but the conclusions derived in social sciences are subjective.

But this division of natural sciences and social sciences is not always meaning full.

Because

1. Subjects such as psychology and geography have both the features of natural sciences and social sciences.
2. According to the traditional classification of science natural sciences are hard sciences and social sciences are soft sciences.

   Ex; Newton considered time a space as absolute in classical physical science but according to Einstein theory of relativity they were considered relative.
3. According to the view of applied sciences there is not such a division as natural sciences and social sciences.

   b. pure sciences and applied sciences

   the sciences that aim at obtaining a theoretical knowledge of the woridare called pure sciences

   ex; natural sciences and social sciences

   the sciences that make use of the theoretical knowledge f pure sciences of the practical use of man are called applied sciences

   ex; engineering , medicine

   a scientist is in who makes use of theoretical knowledge for inventions. One who invents things without the knowledge of pure sciences but with his experience is a craftsman.

Scientist ex; doctor, engineer

Craftsman ex; carpenter, seamstress

The difference between discovering and invention.

- Discovery is to find out something that has already existed in the world, but invention is what has been made entirely new.

  Ex; Alexander Fleming discovered penicillin

- Fleury and his team produced penicillin
- The advancement of pure sciences, the way the advancement of applied sciences and vice versa

  Ex; advancement of science and advancement of instruments.

- Advancement of applied sciences pose certain problems to science such as

  Ex; test tube babies

  Gene robbery

  Cloning

- Division of sciences as pure sciences and applies sciences are not meaningful today.

  Reason; there are sciences that have both the features of pure sciences and applied sciences.

  - engineering

  There is such a close relation between knowledge and this application in these sciences that one cannot identifying the deference between them.

Non- empirical sciences (formal sciences)

- These are sciences that are fully based on reason ex; pure mathematics, deductive logic
- The main feature of these sciences is to logically derive conclusions based on accepted axioms.
- Though pure mathematics and logic are not empirical sciences they help the progress of empirical sciences.

  ex; the discovery of the elliptical orbit of mars

  the discovery of Neptune

- They are non -sciences according to Popper because they cannot be falsified.

Evaluative sciences (normative sciences)

- Evaluative sciences are those that evaluate traditions, recommendations and standards of a society. Ex; ethics, aesthetics
- Ethics evaluates human behaviour , obligations, responsibilities, rights.
- Aesthetic sciences evaluate beauty, melody tec.
- These sciences are based on subjective concepts,.
- Therefore these sciences are not considered as sciences.

Behavioural sciences

These are sciences that stand in between natural sciences and social sciences.

These study various behavioural patterns of men ad animals.

Ex; psychology, educational psychology

Fake sciences

Though they seem to be like sciences they are non- sciences.

- Astrology
- Palm reading

Teaching Learning Activities
Group activities

The objective of this activity is to assess the ability, the students have in identifying the sciences and their features.

1st group- natural sciences

2nd group- social sciences

3rd group – applied sciences

4th group- non-empirical sciences

5th group- non-sciences

- Exhibits to the class a brief review of all the records of the different groups.
- Submits the following assignments at the end of the activity
- "modern sciences do not highlight the division between pure sciences and applied sciences
- Why is normative sciences not considered as science?
- The function of pure mathematics is to state the necessary truth explain.
- Explain the division of science and non-science, according to Popper's demarcation principle of science.

Methodologies of Science/ Scientific Methods

Competency - Application of different scientific methods in practical situation

Competency level - Analyses the difference between the function of the scientist and methodologist.

States the difference between Inductive and Deductive methodologies.

Analyses critically the views of Relative Methodology and Scientific Research Programme.

Number of periods - 45

Learning outcomes -

- Understands the basic features of scientific methodology
- Demonstrates scientific methodology in relation research.
- Identifies traditional methodologies and describes contemporary criticisms levelled against them.
- Examines the difference between deductive and inductive methodologies.
- Differentiates between, deductive verification and falsification.
- Concludes that there is no definite methodology in scientific discovery.
- Describes the features of Lakatos' scientific research programme in relation to a scientific theory.

Introduction

1. Inductive ideology
2. Deductive verification
3. Deductive falsification

} hypothetical deductive method

4. Relativism
5. Scientific research program

Theory of inductive

New criterions related to valid knowledge of the modern science which was developed in post -revolutionary Europe had been firstly summarised by Francis Beckon who was en English philosopher (1561-1626). He had pioneered the theory of inductive. Beckon denoted that intelligent characteristics of academicians(scholars) and empirical characteristics

of craftsman should be attached for the enhancement of knowledge. He laid the theoretical foundation for the encountered empirical methodology as the scientific method.

The inductive method is the compromising generalization of observed specific conditions or several other situations accordingly.

Specific conditions related to phenomenon

P - Particular situations

P1 - observed crows are black

P2 - observed crows are black

P3 - observed crows are black

\- .....

\- .....

Pn - observed crows are black

Therefore all observed crows are black.

Therefore all observed crows are black.

Ex; $1+3 = 2^2$

$1+3+5 = 3^2$

$1+3+5+7 = 4^2$

$1+3+5+7+9 = 5^2$

Therefore the total of any following number starting form 1 will be similar to quadratic f each number given.

The constant analogy of observed components are generalised by inductive method.

Basic characteristics of Beckonion empiricism

1. The sensory perception is the one and only valid and accurate mode for the meaning of the knowledge.
2. The objective of the scientific experiment is to reveal a scientific law and generalization
3. The capability is given to the scientist predicting the future behaviours of phenomenon by the laws/ generalizations
4. Knowledge which cannot be empirically experienced are not valid.
5. Scientific statements are substantial
6. Assimilating a **phenomenon** means manifesting/showing ot is a certain situation of publishing a scientific law.

Charles Darwin had attained to two different generalizations while constructing the natural selection theories

1. Over production
2. Variation

J.S Mill provides two accepted denotations

1. The uniformity of nature
2. The determinism of causality (casual determinism)

There are several interrogations emphasised by logical positivists and David Hume as a philosopher in empiricism.

1. The problem of the base of induction

   Unsolved problem; the question raised by the David Hume on induction regarding the relevancy of non-observed components or situation of a phenomenon observed by limited components.

2. Does an observation conduct with a tentative hypotheses /
3. The strategy proposed for constructing a broad hypothesis by induction theories is not valid.
4. Perception and observational sentences
5. A common system for scientific experiments had not been given

   Ex; Newton's activities on gravity

Hypothetical deductive method

The deduction provides conclusions not away from evidences. Deductive methodologists say that scientists refer to experiments by dominating a generalization. The deductive methodology attempts to afford a solution for the question raised by Hume.

According to the deductive method, scientists experiments stars from a hypotheses which is knownas generalization. Predictions are the consequences of each hypothesis. The hypothesis will be acceptedas truth whether the experimental data convention/suits with hypothesis to be rejected. It demonstrates as structures

$H \rightarrow P$	$H \rightarrow P$	H: Hypotheses
P	$\sim P$	P: Predictions
$\therefore H$	$\therefore \sim H$	

(S1^S2^S3 and E1,E2,E3) are used while implying /implicating prediction froma hypotheses on above mentioned two approaches

Ex; while theory of gravitation depicts on Mars's axilla, will take scale of the sun, scale of the planet and distance between planet and the sun

There are two structures given for the inquiry of validity of a hypotheses

1. Deductive verification
2. Deductive falsification

Deductive Verification

The verification was a dominant concept of Carl Hempal and Hegel who were logical perception philosophers in Vienna circle

There is no validity of a statement or a opinion, when it can be empirical verified

Here ids the hypotheticals deductive method in scientific method.

If hypothesis is truth predictions will truth $H \longrightarrow P$

The prediction was truth on empirical facts $\underline{\quad P}$

Therefore hypothesis is truth $\therefore H$

Descriptive structure

$H \wedge [(S_1 \wedge S_2 \wedge \ldots\ldots\ldots \wedge S_n) \wedge (E_1 \wedge E_2 \wedge \ldots\ldots\ldots \wedge E_k)] \rightarrow P$

$$\frac{P}{\therefore H}$$

Hypotheses ^ (**El**ementary components ^**S**upportive hypotheses) ⟶ **P**redictions
Predicate is experimentally truth
Therefore hypothesis is valid

Theory of gravity, general theory of relativity theories of light, etc.

Verification process such theories are compatible to above mentioned methodologies.

Popper, Coon and Feyaraband such philosophers are strictly criticising on verification method.

Some criticism had given below.

1. The logical structure presented by verificationsists, is invalid in conclusions.
2. Deductive verification's arguments are not liberated from inductive characteristics.
3. Perception and observational sentences have executed in the basement of invariant.
4. No construction of a new knowledge when hypotheses are constantly manifested ina experimental/ observational status.
5. Scientific knowledge is taken to the progress not by the means of verification process only through let them decline and falsify.
6. Publishingpredictions based on deduction would not be a common idealistic characteristic.

Deductive Falsification Method

Carl Popper(1902-1994) who holds the notions of "nothing can be implied by the means of induction as well as deductive verification. " he had demonstrated a different formation it is called deductive falsification.

Deductive falsification

Deduction is the ideal method for affording inward conclusion of evidences. Also there should be a logical hypothesis before a scientific experiment. Popper suggests the deductive falsification of Deductive verification to keep the empirical method empowered.

There are several reasons for attaining deductive falsification by Karl popper,

- The deductive verification structure does not logically valid.
- It is convenient to develop a breaking process ofa hypothesis rat her than constructing experiments, it cannot be decided that the hypotheses are totally truth.
- Hypothesis can be falsified by a single experiment of false prediction ‘
- The historical pathway of the science is much familiar with conjectures an d process of rejection.
- The allocation to become bad scientists by clinging on bias notions through the verification strategy.
- The experiences gained by Popper at the beginning era regarding Marxist & psycho analytics.
- The scientific method should be executed for denoting the capability of falsification n not for manifesting it as truth. This is the dominant concept presented by carl Popper
- Popper recommends adhoc hypothesis due to avoid falsification of a notional theory because the bad behaviours of scientist in the verification process was persuades to him.
- This is the logical formation of falsification regarding methodology of Popper

$$H \longrightarrow P$$
$$\underline{`P}$$
$$\therefore\ `H$$

This is avalid deductive logical structure according to hypothetical negative rule but while making deductive prediction from a hypothesisshould demonstrate descriptive valid structure

Popper had presented his logical structure in 1935 by his book of “The Logic of Scientific Discovery” which was translated to English in 1959. Special consideration will not be given to the scientific knowledge through the capability of verification. The ability for experimenting a theory is the testability in falsifiability.

The scientific criterion of a theory is the capability to let it to the falsifiability or rejection(Popper 2002, 47,48)

The scientific knowledge arrives in progress through refutations and falsification not by manifestation.

The authenticity and empiricism of a theory is shining toward each & every effort taken to falsify theories by scientists

Popper says that, science need brave conjectures & novel predictions all the time . Popper doesn't accept the manifestation of non-falsified conjecture in experiment.

Empirical content of the science is constructed by the empirical components derived from conjectures.

When taking two hypotheses which had not been falsified yet, hypothesis which has a tendency to the falsification would be better.

While the content is increased it becomes a low probable hypothesis.

Duhem& W.V.O Quine argues that Popper's falsification method does not discordant with complicate activities of science though his method is theoretically valid. They believed that auxiliary hypothesis& initial conditions are supportive while taking a prediction based on theory. Therefore we could not assume that a hypothesiswould be falsified whenever a prediction doesn't agree with experiment results.

Criticism entailed for the Popper's methodology

1. Popper's notion manipulate a process of eliminating a hypothesis but would not encourage to select an accurate hypothesis
2. Does the Popper's methodology totally liberated from inductive characteristics.
3. Constructing a generalization which would entail predicting t totally deductive system is challenged.
4. It is practically (contradictory) on falsification process of hypothesis though his argument is theoretically valid,
5. The difficulty for taking the prediction exposition of hypothesisas acommoncharacteristic.
6. The perception & observational language are activated on invariant basement.
7. Above mentioned criticism had been influenced by the interrogations of Uranus's auxiliary relevant to gravitation, observational sentences are on a certain theory or theories such as Doppler's covering theory.

It has expected t clarify instances such as Darwinism and etc. which elaborate the difficulty of undertaking methodology for developing hypotheses.

Relativism

It is ideal to consider the relativism as a notion derived from compendiums compiled by philosophers rather than realise it as a common notion founded in 1960's.

Pioneers of relativism such as Koon, Feyeraband had strictly challenged the attitudes schools & components of traditional methodologists.

Thomas Koon wrote the structure of scientific revolution in 1962 and studied on Copernicus's revolution & history of Newton's physics, Feyeyrabandstudies on problem of philosophy of science & its history Russel Hansen explicated his idea by analysing observations, components, theories, causalityand etc.

Notions of relativists are considered as negative vision (nihilistic perspective) to the methodology

Relativists challenge that the scientific knowledge produce a knowledgeliberated from independent evaluations of natural world.

Relativists decline the idea of "Science is a knowledge which is derived from logical conclusions based no rational or intelligence.

The idea of science is sensory perception based knowledge developed through certain data.

Relativists against on the notion of the concepts & laws incorporated in priori theories could be substituted to its following representing theories.

Relativists eliminate that the observational languages are stable.

And accepted perceptions of methodologies such kind of observation anyone doesn't interprettheories.

The elimination/deprivation of "there is something could be taken as scientific method significantly"

"The science is a process which will be reaching the data by the means continuous development for reaching the truth" This statement was abolished by the relativists.

Koon's explanation

Carl Popper & Koon (1922-1996) were in the same tradition. Popper came from the scientific philosophies originated in European continents. He was an empiricistseparated from Marxism, Freudianism, Adler's psychology, Wittgenstein linguistic philosophy and logical positivism of ViennaCircle.

Thomas Koon was in America and started his career as a physicist then he attained to the problems of history & the development of Science. One of his books written in 1962 called the structure of scientific revolution" was a revolutionary publication among philosophers & scientists of that era.

Koon explicates the science, paradigm as relative knowledge. The traditional beliefs of scientific rationality(universality of scientific knowledge, objectivity) had been enfeebled due to a Koon;s thesis of scientific revolution.

Scientists seek for the solutions regarding the problems occurred within core theories of paradigms & determined theories. It's a research agreement among scientists.

The "Paradigm Core Theory" is a disciplinary matrix followed by scientific community in the journey of research & determined as the "Paradigm Core Theory" is determined as problems puzzles of related sciences, researchers to be organised regarding these problems.

Paradigm is a holism which was developed by the community of scientists as an authenticity by deploying scientificresearchessolvingpuzzles doing innovation and attaining conventions accordingly. There are two sides of Paradigm Core Theory; it gives a foundation to theories &beliefs of relevantscientific field. It's a pre model persuades hints &components asa guidance to scientists & researchers.

The scientists' knowledge had empowered through a process of being established and then suddenly collapsed asa revolution. This refutation allows a new replacement of knowledge frame by attaining collapsing the previous structure.

According to the Koon's depiction of scientific activities

- Pre ideologist era

- Developing a paradigm
- General scientific era
- Scientific revolution& paradigm shift
- Inconsistency/ discordant &incommensurability of intimate scientific theories are dominated.

Theory of Paradigm

This is a common structureconsisted with theories, research problems, methodologies, scientific languages, criterions &etc. which had been accepted by the scientists in significant ancient era.

Aristotelian paradigm, Newton's Paradigm, Eisenstein Paradigm &etc. they are considered as core theories of Paradigms.

Normal science

Science and its own history flow ina long duration unshakably. According to Koon the sciences happen within this duration are called normal science; the scientists of this era had attempted to manifest the Paradigm Core Theory instead of falsifyingrelevant delays. The scientists who represent this era usually did puzzle solving derived from authoritative (dominant theory.

It has taken Paradigm Core Theory to a progressive level. Some scientists had perceived anomalies which did not suit with existingtheories. Then scientists used to abolish it as fake knowledge occurred irregularly. They remove this knowledge according to the schemes of not following a certain methodology & research procedure or persuading the unmatched of errors occurred in measurements. The paradigm was not questioned or curios in this era. But while it has happened this research & academic process, the failures of predictions derived from experiments based on paradigms; and difficulties to explicate paradigm, gradually increased. The scientists would lose the faith of paradigm while anomalies had been increasing among scientist community.

Scientific revolution

The scientific revolution occurs due to the explosions of interiorresistances in superior paradigm asa far as it was collected for a long time. Copernic's revolution of physics chemical revolution of chemistry was appeared as storms in the scientific flow.

A scientist or group of scientists used to terminate the paradigms from the authenticity by challenging them as very dominant in that era.

The scientificrevolutiondepicted by Koon is not merelyunequal to the revolution presented by Marxists .

According to the Copernick's revolution the heliocentric view Established and geocentric view eliminated. After the revolution of chemistry, theory of atmosphere & phlogiston theory Authenticated, Scientistsembraced in new paradigms always.

But ancient scientists are not yet ready to accept new paradigms totally. One day they will die (scientists would embrace the paradigm as they believe in religion) due to this

situation the paradigmexisted in previous stage would relatively consistent& valid. The new knowledge derived from post relativism period paradigms will be relativity consisted and validated. Therefore we could logically conclude that knowledge of a certain field is related to the paradigm of that era. Therefore the new paradigm& previous Paradigm Core Theory before he revolution are inconsistence and incommensurability.

Inconsistency/ discordant & incommensurability between Paradigm Core Theory

Koon presents another revolutionary idea that there were no any interrelation between previous and prevailing paradigms a paradigm shift. The perception and global perspective will be changed by a paradigm shift. The incommensurability means the disconnection of ideas included ina followingbasedtheory.

There is not a common criterion formatching two incommensurabilityparadigms. The time of Newtonianphysicscan't be matching totime of Einstein's relativism.

Gravitation is a result ofscale occurred ona gravity field. According to the Newton, it's a result of time curving to the element of a paradigm.

The concept of up and down are ideal between geocentric & heliocentric theories are non-ideal, thus a gap will occur between these two theories.

Two paradigms are mutuallyinconsistenttheoreticalframes. Newton's process is valid for the indeterminable frames. It matches macroscopic systems perfectly. But Quantum mechanism isvalid for microscopic systems.

This incommensurability remains between wave theory and particle theory of light Feyeraband described this incommensurabilitythrough Galileo law &theory of gravitation.

The incommensurability occurs due to the ambiguity of ideas in between wave theory and Copernick'stheory.

The Feyeraband'sAttitude/ perspective

- The article "science without experience" written by the Feyeyraband in1969 clearly depicted that the experiences are not principally essential forconstructing understanding & investigating scientific theories.
- Feyeraband refuses concept that the ideas are derived from experiences& observations.
- The anarchism of knowledge experiment arrives through his publication of "Against method in 1974"
- Feyeraband strictly refuses this, it is essential to implement a certain scheme of rules and methodology for compiling scientific knowledge.
- 1978 denoted that science in free society.
- There is not a certain method called scientific method even there is a not a methodological procedure which could be certified and confidential properly.
- Scientists revise the criterions of standards procedures & intelligence while they entering new research field.

- There is not a methodological rule which had been violated by scientists. These rule violations were not unavoidable, unawareness or probable in that manner. While focusing the basement for each incident violating methodological rules had constructively impacted on progression of scientific knowledge,
- "Anything goes" Feyerabanddenotes that methodologically. Anything is valid though not for demonstrating monarchisms confuse of scientific experiments.
- Feyeraband says that scientists should get ready for experimenting the validity of conclusions, ideas &theories though scientistscould follow their preferred methodology.
- Feyerabandmakes monarchism as his perspective by the "against method" book in 1974. Eminent scientific inventions had been done, related to certainmethodology or rules
- The Galileo represents toward Copernic's revolution evidenced above statements.
- The theoretical monarchism encourages the progress if science rather than methodologiesinsisted with certain principles and rules.
- They emphasise that the diversity of knowledge should be protected.
- The scientific knowledge moves forward due to the untraditional inventions which had violated authoritative frame. Feyeraband refuses hegemony& methodological ownership of iconic scientific knowledge system.
- Feyerabandband's basic idea is that the scientific knowledge doesn't have a right for requesting a speciality, superiority than other knowledge categories.

The conditional trait of scientificknowledge is the nature of non-continuity.

Methodology of scientific research program

Imere Lakatos (1922-1974) was a disciple and a friend of a Carl Popper. They taught philosophy of science in London university of Economics. Feyeraband&Lakatos were colleagues. Feyeraband was a rigid criticiser of Popper's ideas. Feyeraband& Lakatos have made arguments with each other but they were good friends ever.

The Lakatos contribution is clearly elaborated in the "falsification&English typed new" in 1970.

Lakatos developed a new theory called "scientific research program" by criticising Koon's scientific revolution based on Popper's falsification theses.

But Popper concentrated ona single theory relevant to a certain problem.

- Lakatos introduce the Popper's falsification method as a Naive methodological falsification. Because it doesn't emphasise in a wide frame of relevant theories.

It clearly depicts that the Lakatos had perceived an importance & relevance of Koon's idea due to the viewed limitations Popper's theory. Koon says that scientifictheories do not exist alone. They are located as historically socially&culturally, Lakatos agreed above statement. Lakatos believed that the conversation science should be guidance for future scientific experiments thus Lakatos developed a sophisticated methodological falsification.

- Lakatos stated while working at Popper's falsification frame, that the development of science should be concerned as development of consistedtruth.
- Lakatos attempted to describe scientific revolution in a rationalistic perspective against Koon's interpretation of irrational activities (processes)
- One of a characteristic of Lakatos doctrine is to considering scientific theory and structural systems.
- The central value of a scientific research program was the hard core. It is the very basic theory of a program. The research should not conduct anything against the hard core. It is a restriction. If he does it , to be considered as left the certain program, it's methodological rule that the hard core should not be violated by the researcher due to any circumstance
- There is protective belt originated around the hard-core in a certain program. The protective belt is consisted with auxiliary hypothesis & additional standards. The scientific falsify or amend the components in protective belt. The characteristic of a program is to protect the central value of it by the means of false or refutations through rigid experiments.
- There are two methodological rules incorporated ina program according to Lakatos. They are introduced as positive heuristic & non Heuristic
- The positiveheuristic protests the hard core by increasing the protective belt of a program a protective wall is being constructed by assimilations.
- Strategies, new auxiliary hypothesis& amending present auxiliaryhypothesis. The scientists had allowed using new mathematical systems, experiments, ushering measures & equipment as well as empowering new interpretations. Positive heuristic is created with disposal & amendable hints of a program.

Negative heuristic should not be activated against the central value of a program. Adhoc hypotheses that have no independent evidences should not be used in a program. They are recognised rules in the negative heuristic.

The research program becomes a progressive one whether it could be able to precede successful prediction now and then. Therefore the programs don't confer successful results had concerned as regressive program. Progressive program should be continued & refutable programs should be relinquished.

Teaching Learning Activities

1 Explain the problem raised by David Hume related to the Beckonion empiricism

2 Discuss,

Similarities

Differences

Common errors of deductive hypothetical method

3 Enquire whether the relativist doctrine of methodology is nihilistic

4 Discussion the similarities and differences between attitudes of methodology provided Popper and Koon

5 Theoretical anarchism " is more entitled for the development of science rather than the significant rules of methodology

6 Explain with examples, how the structural characteristics and methodological rules given in Lakota's scientific research program were facilitated for the success of a research program

Scientific Generalization

Competency - Applies methods to test scientific hypotheses

Competency level - Describes the nature of scientific generalizations.

Differentiate the scientific research methods.

Number of periods - 20

Learning outcomes

- States the importance of hypothesis in scientific research
- Explains the stages of verification of a hypothesis in relation to scientific research
- Evaluates the importance of different hypotheses and explanations in establishing scientific knowledge.
- Explains demonstrating the difference between scientific law and theory.
- Explains a natural event in terms of the covering law model.

Introduction

The science is functioning for examining the validity of a developed hypothesis which had been constructed as a solution regarding an interrogation. These validated hypotheses are considered as laws and theories. Scientific generalizations are developed in form of law-theory as universal or statistical levels.

The origination & evolution of scientific hypothesis

Problem; problems are defined as, incidents or situations which cannot be matched with existing theories& concepts as well as ambiguous.

Construction of a hypothesis

- The hypothesis is the temporary solution towards an investigation experiment on a certain problem.

  e.g. The experiment which was conducted by Simmel regarding mothers' deaths of Vienna hospital.

- The experiments conducted to prove the Pasture's sporogenousgeneration.

- The experiment conduct by Emile Ru on diphtheria

Predictions and empirical investigations

The predictions are supportive for evaluating the validity of a hypothesis whether it would rather difficult to imply predictions directly. Predictions make the connections between observational sentences and hypotheses.

Amendments & evolutions

Explain how the scientific hypotheses are declined, amended & proved /manifested which they were experimental.

Ex; the weight influence on speed

The above hypothesis denoted by Aristotle …….. it was declined by Galileo Galilee and he afforded the law of acceleration

The characteristics of a scientific hypothesis

1. A solution to a problem.
2. Explain phenomenon
3. Could be admitted to empirical investigation
4. Implies predictions
5. Simple
6. Accuracy

The successful hypotheses are the accurate solution given by the scientists on the nature &its functioning or why, what & how such questions raised about humans

Ex; the theory of gravitation

The hypotheses are not rejected as it couldn't become successful. It would be supportive hypothesis to construct an accurate hypothesis in utility level.

Ex; phlogiston theory

Explain the phenomenon

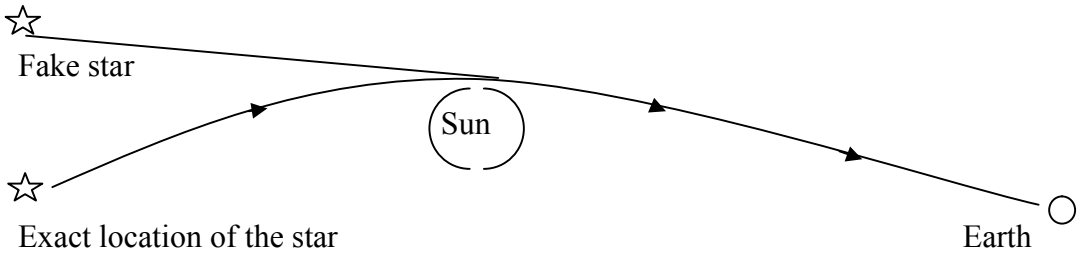
The concepts integrated to hypothesis should be measured in quantitative level & defined actively. It should be also consisted in the capability of commentating or understanding.

Predicting

The consequent implied by a hypothesis is depicted as predictions. The validity of hypothesis should be examined through these predictions.

Ex; Albert Einstein predicted in 1915 that the light rays of a star can be bended in front of a high gravity given from the sun by the means of his general relativism.

Ex; Sir Arthur Edwin observed this from Africa in 1919



Simplicity

It is the congruence of following components, relationship, bounded less of variables ability for publishing more prints & more theories of science would compare with a certain hypothesis & its related information/materials

Ex; theory of gravitation

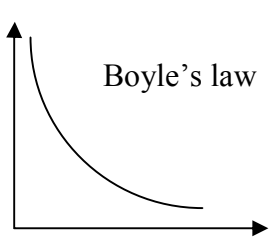
The difference between law and theories

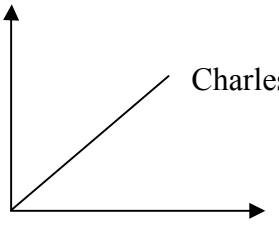
1. Law provides the answer for "what" and theory answers "why" questions.

   e.gwhat is the connection between pressure & the volume of an air; Boil's law answers above question.

   e.g. why a stone comes backward after throwing it to the sky? The gravitation theory answers this question.

2. The law depicts a connection between two variables and theory commentate various incidents, reasons.





3. A law is directly experimented but a theory is not. (indirectly experimented)

   e.g. Horke's law- directly experimented by balance with related scales9 the quantity of spring tension)

   Gravitation theory

   The theory is manifested after determining the comparison of predictions derived from auxiliaries of planets.

4. The field of a theory is extended than a law. The theory is consistedwith broad assumptions/hypotheses.

Ex; explain the law of constant proportions, law of definite proportions and reciprocal proportional law

By the means of atomism

PV=nRT P- Pressure V- Volume T- Temperature N- Numbers of moles

R- Universal gas constant

1)$\bar{n}\bar{T}$→P $\alpha {}^{1}/_{V}$= Boyle's law. (nRT=K)ᵇpv=k

2)$\bar{n}\bar{P}$→ V∝T = Charles Law. 1 (V=nR${}^{T}/_{P}$and${}^{T}/_{V}$ = K)therefore V∝T

3)$\bar{n}\bar{V}$→ P∝T = R Charles Law . 11 (P=nR${}^{T}/_{V}$ and${}^{P}/_{T}$ = K)therefore P∝T

5. The theory is changeable than a law.

   Ex; the heliocentric is established after diminishing egocentrism

<u>Universal & statistical generalization</u>

- The universal generalizations denote a common characteristic for related objects of the field and it is allocated for each person & sub objects of this.

  Ex; all the planets of the solar system move on a elliptic path around the sun.

- All mammalians are dissipate heat survivors
- Even though a statistical generalization is depicted on objects of the field, it would be rather devoid of accuracy.

  Ex; 95% of heart patients had smoked

  The progressive level of G.C.E O/L in 2015 was 55%

The utility of structures and language of hypothecations

If sensory perceptions could conjoin with hypotheses directly or indirectly, information out of the sensory perception will relate to a hypothesis.

Ex; the theories based in idealistic or theoretical concepts such as complete gases, complete resilience objects and anti- collisional black objects.

It would attain to conclusions of clarifying assimilation of structure of previous system by the means of structure.

Perhaps the mathematical structures, formal and physical structureswill have produced by computers as a simulation.

Some structures denoted as physical structures as follows, Watson-Creek structure for explaining the 3D formation of DNA.

Formal or mathematical were frequently practised in the science.

Ex; for explaining force transformations

For explaining the analogy between heat conductivity and electric conductivity

To explain the process of mutual attraction of electric charges and mutual attraction force between two scales

Origination of the universe, species and black hole are the simulation structures of computers.

Supporting the sociology for developing theories of structuring

Examples; complete competitive analysis of economics, autocracy of trade, structures based in international trade, structures related to Weberian theory of sociology.

If the accuracy of inferences will be manifested it would become a law structure of science. If it would not, the science will develop a new structure for it.

Observations, theories and laws will be explicated through the language. Theoretical language and observational language is utilised for this. There are three stages of a language,

1. Language with common matters
2. Symbolic language
3. The language in applied utility level

Common matters are consisted with sentences including terms of related technical terms and concepts of a science.

The physics would afford technical ideas on concepts such as inertia, force, scale and implication.

The statements of logic and mathematics will be presented through logical constancies and variables. Sciences are also referred the symbolic language properly.

Ex; the Newton's second law f=ma, it comprises as follows, F denoted as Force, M given as Mass and A is called acceleration.

The symbolic language is also used in social sciences such as economics.

Ex; MV=PT

The analysis as follows

M- Moneybulk V- velocity of circulation P- common price level T- Transactions

Apart from that the language utilised in subcultures and group people are always relevant.

Ex; "*thelabedanawa, kuppidanawa, Kramadanawa, alawena"*the language used in campuses as a subculture.

The observational language is depicted by foundational-theories. The observational language will also let into some changes while foundational-theories were being changed as an impact of scientific revolutions. New concepts and terms will also be constructed through foundational-theories

Scientific explanation

This is the explanation given by scientifically Carl Hemple clarifies two types of explanation basically.

1. Deductive homological modes (D N)
2. Inductive statistical model (I S)

Covering Law Model

The Covering Law Model is the model which was developed by Carl Hemple on the structure of scientific explanation relevant to deductive structure/model

$C_1 \quad C_2 \quad C_3 \ldots\ldots C_K$

$\underline{L_1 \quad L_2 \quad L_3 \ldots\ldots Lr}$

$\therefore E$

C- Specific Conditions

L- Laws

E- Event

A scientist could use this for exploring a physical incident

Ex; assume a satellite located on a stable axilla/axill

Specific conditions

C1- …….

Laws-

L1- theory of gravity

L2- circular motions

Thus things can be explained such as mirage, get a wicket by a catch, billets ball drops into a pit, incidents according to this clarification.

Ex; explain ona demand of economics

The importance of covering law model as an explanation structure

1. This explains even a law in addition to a specific condition
2. There is not a certainty of covering law model whether it was undertaken to inductive model
3. Covering law model depicts a reasonable explanation.

Types of explanation

1. Causal explanation
2. Teleogicalexplanation
3. Functional explanation
4. Probabilistic explanation
5. Mechanical explanation

- Causal explanation

This is the explanation based on providing relevant reasons

Ex; why a thrown stone has come backward to the ground?
Why the leaves are green?
How the death of this patient happened?

- Teleogicalexplanation/genetic explanation

Explanation based on denoting objectives and final outcome are considered as teleogicalexplanation.

Ex; mother lives for her children

He ordinates for attaining Nibbana.

- Functional explanation

  This is the explanation bounded with a certain functioning of something.

  Ex; craw is for the digestion

- Probabilistic explanation

  It is difficult to perceive compulsory cause & effect interrelations pertain to the contemporary science. Therefore some incidents are explained in probabilistically.

  Ex; C $\longrightarrow$ E

  The explanation of semi due of radioactive elements

- Mechanical explanation

  This explanation is denoted by an incident explained trough a mechanical foundation/basement

  Ex; the pendulum motion

  Even though the same components could combine directly & indirectly as sensory perceptions for developing hypothesis structures&utility, some specific extra sensory materials/information are based on hypotheses

  Use for the structure of original structure of system.

Teaching Learning Activities

1	Categorize students into groups and ask them to clarify the following statement with examples "how the scientists had extended hypotheses within the history of science" evaluate students and their performances.
2	Explains the characteristics of scientific hypotheses.
3	Explains with examples, the importance of structures for developing hypotheses
4	Nominate the types of scientists classifications & provide examples for each category

ග්‍රන්ථ නාමාවලිය

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