CONTENT ENRICHMENT WORKSHOP FOR THE MATHEMATICS TEACHERS OF ANDHRA PRADESH SOCIAL WELFARE RESIDENTIAL SCHOOLS

12th to 17th December 1988

A REPORT

REGIONAL COLLEGE OF EDUCATION, MYSORE 570 006
(National Council of Educational Research & Training, New Delhi 110 016)

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RESOURCE TEAM

Dr.V. Shankaram (Academic Coordinator)

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(All from the Regional College of Education, Mysore)

PREFACE

The educational development of the disadvantaged sections of our population , especially those belonging to the Scheduled Castes and Scheduled Tribes, is one of the priority concerns of national education. The task of fulfilling the constitutional directive of universalisation of elementary education which is yet to be completed is intimately linked up with the enrolment and retention of the disadvantaged groups in the school system. Accordingly, a series of measures have been instituted by the NCERT to contribute towards the educational progress of the SC/ST groups. At the Regional College of Education, Mysore, activities pertaining to training of teachers, research and development have been undertaken with the expectation that these would help the educational personnel in understanding the educational problems that are peculiar to these disadvantaged sections and in dealing with them effectively.

The present programme 'Content Enrichment Workshop for the Mathematics Teachers of Andhra Pradesh Social Welfare Residential Educational Institutions' was conceptualised and conducted in the light of the overall objectives of educational development of SCs and STs. The major purpose of the programme was to update the content knowledge and teaching competencies of mathematics teachers of these schools. These schools cater predominantly to children coming from SCs and STs and it is expected that the competency acquired by the teachers in this programme will lead to the overall progress of mathematics education in these schools. A significant feature of these programmes was the focus laid on developing such interests and competencies in the teachers as would help them to acquire further knowledge and training in topics in mathematics not covered in the programme on their own. It is hoped that the teachers who participated in this programme will continue to interest themselves in the problems and issues raised and will strive to acquire greater competencies and facilities in teaching mathematics through self-directed learning.

I thank Mr.Y.Ravi, Secretary of APSWREIS, Hyderabad, for having come forward to organise such a programme at our request and for offering all cooperation for its successful conduct.

I thank my colleagues Dr.V.Shankaram, Dr.N.B.Badrinarayan and Dr.N.M.Rao, from the Department of Mathematics and Dr.K.Dorasami and Dr.V.Ramachandra Rao, from the Department of Education, for the successful conduct of the programme.

I also thank Dr.A.N.Maheshwari, Principal, Regional College of Education, Mysore, for giving the necessary encouragement and push to the implementation of this project.

The report highlights the major activities of the programme and I hope it will befound useful by all the concerned for carrying out further follow up and evaluation.

- Dr.C.Seshadri
Professor & Head, Dept. of Education &
Dean of Instructions,
Regional College of Education,Mysore-6

Date:

CONTENT ENRICHMENT WORKSHOP FOR THE MATHEMATICS TEACHERS OF ANDHRA PRADESH SOCIAL WELFARE RESIDENTIAL INSTITUTIONS SOCIETY (REGD.), HYDERABAD

A REPORT BY THE ACADEMIC COORDINATOR

Background

At the request of the A.P.S.W.Residential Institutions Society, Hyderabad, to enrich the content competency of the mathematics teachers of these residential schools, a six-day workshop was organised and funded by the Regional College of Education, Mysore (NCERT, New Delhi). The College finalised the workshop to be held from 12.12.88 to 17.12.88 and deputed the Coordinator(Extension), and four members of the Mathematics/Education faculty for the conduct of the workshop. The team of resource persons got the mathematics syllabus of the secondary schools of A.P. and planned the strategy to be used during the workshop.

Objectives of the Workshop

1. To identify the content areas of difficulty experienced by the teachers and give intensive exposure to the relevant content topics.

2. To enrich the content competencies of the teachers.

3. To enlighten the teacher on the pedagogical aspects in a classroom situation.

Planning Educational Inputs and Methodology

The planning for the workshop consisted of designing strategies for different purposes. These were

a) Identification of the entry competencies and abilities of the teachers.

b) Identification of the areas of deficiency and difficulty in the mathematics content.

c) Exposure to the content with a view to enrich the teachers.

d) Clarification on points of doubts and difficulty.

e) Generating problem solving abilities.

f) Measuring the extent of achievement due to participation in the workshop.

Accordingly, on reaching the venue of the workshop, a preliminary meeting was held with the Secretary of the A.P.S.W.R.I. Society to know the areas of difficulty experienced by the teachers. In this meeting, a tentative list of topics in school maths found difficult by the teachers was drawn up.

A pre-test on the topic was designed and administered to all the participants on the first day of the workshop. The primary purpose of the pre-test (Appendix I) was diagnosis of the teachers' deficiencies and difficulties. The responses to the pre-test were scored and evaluated. This analysis and a face-to-face interaction with the participants helped in evolving a basis for the workshop - the basis consisting of the topics which have to be dealt with in detail within permissible limits, during the workshop-.

Difficulty areas Identified On the Basis of Pre-Test and Exploratory Session Findings

1. Logic, Sets, Relations and Functions
2. Equations, Inequations and Linear Programming
3. Statistics
4. Quadratic Polynomials/equations
5. Real Numbers
6. Modular Arithmetic
7. Coordinate geometry - Preliminaries to straight lines
8. Permutations and Combinations
9. Motion geometry

The strategies used to sort out difficulties and correcting misconcepts were through

1. A minimal number of lecture-cum-discussions in which the teachers' difficulties in the particular topic were discussed giving ample scope for their reactions, responses and participation.

2. Problem Solving -sessions each day when the teachers had the experience of problem solving. To facilitate this, work-sheets containing problems on the topics discussed earlier were supplied. While some of the problems were intended to be solved in the sessions themselves, the rest required to be tackled outside the working hours.

3. In order to find out the extent of assimilation of new ideas discussed and acquisition of knowledge and competencies, a post-test (Appendix II) was administered to the teachers. This in turn was analysed to form a basis for our impressions about the participants and the workshop.

4. In order to allow free expression of the teachers' opinions on different aspects of the workshop, a questionnaire (Appendix III) was circulated among the teachers and the feedback so got helped us to estimate the extent to which the objectives of the workshop were achieved.

5. Besides the work sheets, lecture synopses were distributed to the teachers. These synopses highlighted only the main concepts, ideas and results to be focussed while teaching.

Workshop Schedule

The venue of the workshop was the Govt. Comprehensive College of Education, Masab Tank, Hyderabad. The daily schedule of the workshop was :

1.	Working hours	:	9.45 a.m. to 5.00 p.m. (with lunch break from 1.00 p.m. to 2.00 p.m)
2.	Forenoon sessions	:	Three lecture-cum-discussions, each of one hour duration.
3.	Afternoon sessions	:	Group work - A Participatory, ProblemSolving Session for 3 hours duration.

This included three tests -

a) A pre-test - with 30 Multiple Choice items,

b) A test to find out their ability to discriminate between different ingredients of mathematical content and teaching points.

c) A Post-test - with 30 Multiple choice items.

A copy of the daily work-schedule is appended.

Participants' Reaction to the Workshop

A questionnaire was circulated among the participants of the workshop. The questionnaire sought their reactions on the following aspects -

1. The extent to which the objectives of the workshop were achieved.
2. The procedure used for diagnosis.
3. The choice of the topics in relation to the needs of the teacher.
4. The various activities in the workshop.
5. Daily Schedule - duration of the workshop.
6. Instructional materials supplied.
7. Topics to be covered in the future workshops.
8. Any other academic aspects not covered in the questionnaire.

Besides, the faculty used to interact with the participants informally as well as on issues raised in the questionnaire.

The participants' reactions to these are summed up below:

1. The objectives on content enrichment are fulfilled to a satisfactory extent while the ones regarding methodology are partially fulfilled.
2. Generally the tests -both pre test and post test - were welcomed by the participants. They were happy about the procedure used in the workshop in interacting and communicating.
3. The choice of the topics was found to be the ones where they needed help. However, they wanted that in future workshop(s), the following topics must be included - (i) Motion geometry, (ii) Logic, (iii) Calculus - Limits, continuity and Differentiability, (iv) Trigonometry, (v) More aspects of methodology - lesson planning, class room activities and evaluation.
   The topics they felt have to be discussed in greater detail. In order that this is possible, they pleaded for such workshops of longer (say 10 days or 15 days) duration.
4. Since a large number of teachers were teaching in Telugu medium and were more at ease with Telugu than with English, they felt it would be more useful if the workshop is conducted using Telugu language both in communication and in giving equivalent terms to technical terms in mathematics.

5. They welcomed the instructional materials, particularly the work sheets.

6. The working hours of the workshop were found all right.

7. Regarding physical facilities, they suggested that if living accommodation is arranged close to the venue of the workshop, either free of cost or on nominal charges, they would be able to concentrate more on the follow up home assignments and studies every day as otherwise they will be wasting more time on transport and they can ill-afford to reside in lodgings with the daily allowance they get.

Impressions, Suggestions and Reactions from the Faculty

The workshop was for the benefit of those teachers of the Residential Schools of A.P. which have a social commitment to the weaker, deprived and vulnerable sections of the society. The intake for these schools is from these sections and the children coming to these schools are the ones for whom education has never been attractive; consequently the schools had the problem of retaining the children. Retaining the children for whom the entry into other schools was impossible has been a perrenial challenge, not to speak of making education to these children attractive and meaningful. The teachers of these schools have these challenges. This was the point that motivated the faculty to plan for the workshop meticulously. During the workshop, it was found that the teachers had genuine difficulty in the business of teaching and were quite serious minded to sort out their difficulties with our help. They showed generally keen interest in the activities of the workshop and took the assignments in right earnestness and due seriousness. While the general level of performance and grasp was quite satisfactory, some of the participants displayed extraordinary attitudes and abilities.

The faculty endorses some of the suggestions made by the participants (listed earlier) worthy of recommendation. Further it is suggested that

1. the proposal for such workshops in future, must be accompanied by a proper, more specific point-wise apprisal about the areas which need indepth treatment in the workshops. In order that this can be done, a brief survey must be conducted by the proposing agency to find out the weaker aspects of teaching among the teaching community.

2. The proposing agency should arrange accommodation for the participants in a place close to the venue of the workshop. Further, it is desirable if the participants can have access to library for reference work. This will ensure greater involvement of the teachers in the activities of the workshop.

3. Every encouragement may be given to the willing teachers with the right attitude to attend such programmes.

4. Short term orientation programmes on methodology of teaching mathematics with respect to specific topics may be organised as this is one of the felt needs of the participants. For such programmes, the number of participants may be restricted to 25, as these programmes involve development of skills.

5. This workshop has to be looked upon by the participating teachers as an open ended one where the teachers continue the exercise begun in the workshop, rather than feeling that whatever has been done is over. This means that the exercises like (i) problem construction, (ii) problem solving, (iii) content analysis, and (iv) correspondence with the faculty of the Regional College for any possible and reasonable assistance in academic matters must be continued.

   The Society on its part may have a suitable mechanism to find the needs of its teachers and arrange similar orientation/enrichment workshops.

WORKSHOP SCHEDULE

Date	Time	Programme Particulars
12.12.88	10.30 a.m.- 1.00 p.m.	Registration & Inauguration
	2.30 p.m. - 3.30 p.m.	Pre-Test
	3.45 p.m. - 5.00 p.m.	Exploratory Session
13.12.88	9.45 a.m. - 10.45 a.m.	Mathematical Logic (VS) - L/D
	10.45 a.m.- 11.45 a.m.	Polynomials (NBB) - L/D
	12 Noon - 1.00 p.m.	Linear Programming (NMR) - L/D
	2.30 p.m. - 3.45 p.m.	Investigatory Study Test on Teaching of Concepts (KD)
	3.45 p.m. - 4.30 p.m.	Group Work on Linear Programming (NMR)
	4.30 p.m. - 5.00 p.m.	Group Work on Polynomials (NBB)
14.12.88	9.45 a.m. - 10.45 p.m.	Polynomials (NBB) - L/D
	10.45 a.m.- 11.45 a.m.	Linear Programming (NMR) - L/D
	12 Noon - 1.00 p.m.	Statistics (KD) - L/D
	2.15 p.m. - 3.45 p.m.	Group Work on Polynomials (NBB)
	4.00 p.m. - 5.00 p.m.	Group work on Mathematical Logic and Linear Programming (VS & NMR)
15.12.88	9.45 a.m. - 10.45 a.m.	Mathematical Logic (VS) - L/D
	10.45 a.m.- 11.45 a.m.	Statistics (KD) - L/D
	12 Noon - 1.00 p.m.	Permutation & Combination (NBB) - L/ D
	2.15 p.m. - 3.45 p.m.	Group Work on. Mathematical Logic (VS) - L/D
	4.00 p.m. - 5.00 p.m.	Group Work on Statistics (KD) - L/D
16.12.88	9.45 a.m. - 10.45 a.m.	Transformation Geometry (NMR) - L/D
	10.45 a.m.- 12.15 p.m.	Statistics (KD) - L/D
	2.15 p.m. - 3.45 p.m.	Group Work on Mathematical Logic (VS)
	4.00 p.m. - 5.00 p.m.	Post-Test
17.12.88	9.45 a.m. - 10.45 a.m.	Sets,Relations & Functions (VS) - L/D
	10.45 a.m.- 11.45 a.m.	Transformation Geometry (NMR) - L/D
	12 Noon - 1.30 p.m.	Post-Test discussion and Administering the Questionnaire among the participants.
	3.00 p. m.- 5.00 p.m.	Valedictory Function

INDIVIDUAL REPORTS

BY THE MEMBERS OF THE

RESOURCE TEAM

DR.V.SHANKARAM

MATHEMATICAL LOGIC

Here we are chiefly concerned with logic of statements. Statements are alternatively called sentences. A statement may be either true (T) or false (F), but not both at the same time.

Open and Closed Sentences

A statement involving a variable x is called an open sentence. The solution set (or truth set) of an open sentence is a set consisting of all numbers which are solutions of the open sentence. For example, $x^2 = 1$ is an open sentence, and the solution set here is $\{-1, +1\}$. Equations and inequations are open sentences.

A statement which is not an open sentence is a closed sentence. A closed sentence is either true or false (but not both). All identities are necessarily true and so closed statements.

Negation and other Logical Connectives:

1. The negation of a given statement is another statement which says that the given statement is not true. The negation of a statement p is denoted by $\sim p$.

2. The conjunction of two given statements p and q (denoted by $p \wedge q$) is true only if p and q are both true, and otherwise false.

3. The disjunction of two given statements p and q (denoted by $p \vee q$) is true if any of p and q is true or both are true. $p \vee q$ is false, if p and q are both false.

4. $p \rightarrow q$ read as "p implies q" or "If p, then q", is true if p is false or if p and q are both true. $p \rightarrow q$ is false if p is true and q is false.

5. $p \leftrightarrow q$ read as "p if and only if q" or "p implies and is implied by q" is true if p and q are together true or false. $p \leftrightarrow q$ is false if one of p and q is true and while the other is false.

A table showing the truth-value of a statement p corresponding to the truth-value combinations of its component statement is called the truth-table of the statement p. Now we give below the truth-table for the statements

p, p q, p q, p q and p q.

Truth table of $\sim p$

p	$\sim p$
T	F
F	T

Truth Tables of Compound Statements

p	q	$p \vee q$	$p \wedge q$	$p \rightarrow q$	$p \leftrightarrow q$
T	T	T	T	T	T
T	F	F	T	F	F
F	T	F	T	T	F
F	F	F	F	T	T

These compound statements can be represented through Venn diagrams(sets).

With the help of the above truth tables which define $\sim p$, $p \vee q$, $p \wedge q$, $p \rightarrow q$ and $p \leftrightarrow q$, we can draw the truth tables of other statements. For the truth table of $\sim p \rightarrow q$ will be as follows:

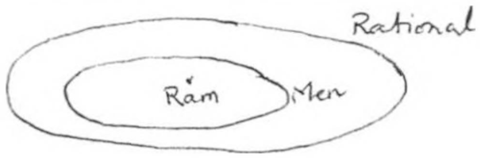
p	q	$\sim p$ q	$p \rightarrow q$
T	T	F	T
T	F	F	T
F	T	T	T
F	F	T	F

Validity of Arguments

Steps for deductive reasoning for arriving at a conclusion from the premises is called an argument. An argument which is correct according to our logic is called a valid argument. An argument may be valid, while the conclusion is false. Also, an argument may be invalid (not valid), while the conclusion is true. We do not attach the adjectives "true" or "false" with an argument.

In argument we generally use the rule of implication (or "modus ponens") . The rule states that "$(p \rightarrow q) \wedge p \rightarrow q$". Here is an example, which is a valid argument. All men are rational. Ram is a man. So Ram is rational. Here p stands for "x is a man". q stands for "x is rational". Now we see that the above argument is reduced to the for "x is a man", "x is rational". "Ram (for x) is a man". So, "Ram is rational".

The set theoretic representation will be as follows:



If p,q,r,..... lead to the conclusion s, then for a valid argument the statement $(p \wedge q \wedge r \wedge ......)$ s should be an tautology (a statement which is true for all the truth-value combinations of its components.

Some of the patterns of valid arguments are the following:-
(1) Modus ponens (2) Rule of conjuctive inference (3) Hypothetical syllogism (4) Rule of contraposition, and (5) Rule of substitution

Different types of implication

The following are types of implication (as given in the truth-table).

p	q	$p \rightarrow q$	$q \rightarrow p$ converse	$\sim p \rightarrow \sim q$ inverse	$\sim q \longrightarrow \sim p$ Contrapositive
T	T	T	T	T	T
T	F	F	T	T	F
F	T	T	F	F	T
F	F	T	T	T	T

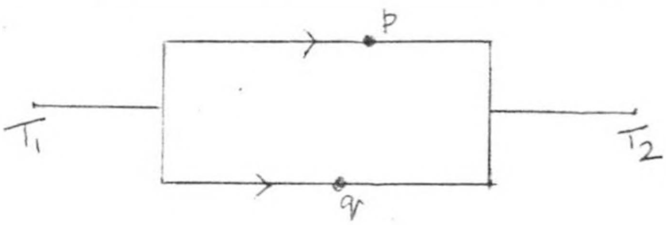
Indirect Proof

Generally the structure of a proof is as follows: "If B is true, then A is true; but B is true, so A is true". This structure of proof is called the "the direct proof". Technically, this pattern is known as "modus ponens".

But many a time we may like to use a pattern of proof called "indirect proof". Proof of a statement by proving its contrapositive is called an indirect proof.

Application of Mathematical Logic in Switching Circuits (Networks)

One application is to determine whether or not the current will flow from one end of the circuit to the other. If the network is the following,



then the compound statement corresponding to the network is p q and will have the following truth-table.

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

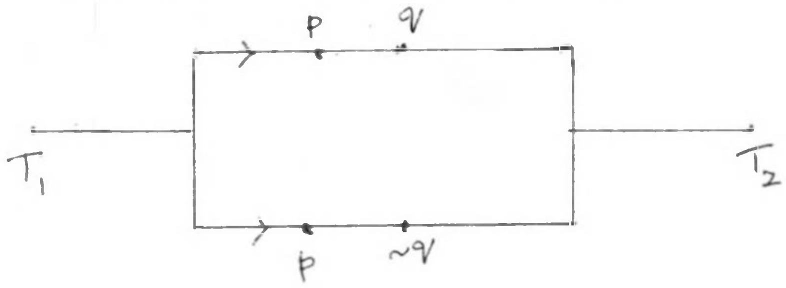
It follows that the current flows when both p and q are open, or when p is open and q is closed, or when p is closed and q is open.

Another application is in finding the network, given the switches and the configurations when current should flow. The problem amounts to finding a compound statement corresponding to a given truth table. We consider the following configuration : Given switches are p and q; and the current flows when (1) both switches p and q are open; and (2) when the switch p is open and the switch q is closed. Now we have to find the network.

Here the Truth-Table of the unknown statement X is as follows.

p	q	X
T	T	T
T	F	T
F	T	F
F	F	F

We see (1) the statement p $\wedge$ q is true only when both p and q are both true, and false otherwise. (2) the statement p $\wedge \sim$ q is true only when p is true and q is false. Now we construct the disjunction of the statements mentioned in (1) and (2) and get the required form of the statement X. So, X has the form (p $\wedge$ q)$\vee$ (p $\wedge \sim$ q). Now the network required is as follows:



Sets, Relations and Functions

The following points were covered in the lecture-cum-discussion session and also in the group work.

1. If R : X$\rightarrow$Y is a relation, X and Y are called domain and co-domain of R respectively.
2. If R : X$\rightarrow$Y is a relation, inverse relation of R is denoted by R^{-1} and defined from Y to X.
3. All functions are relations, but not all relations are functions.
4. A function may be many-one, one-one, into or onto.
5. Functions and their graphs are used in representing many life situations.
6. Two sets A and B are called equivalent if there is a one-one correspondence between A and B. Two equivalent sets need not be equal.
7. A set is infinite if it has a proper equivalent subset.
8. The set of all rationals are countable, but the set of all reals is not countable.

The above points were discussed with suitable examples and non-examples. Participants were encouraged to come out with their own examples.

Dr.N.B.Badrinarayan

Lecture Synopsis 1

POLYNOMIALS AND POLYNOMIAL EQUATIONS, QUADRATIC POLYNOMIALS AND QUADRATIC EQUATIONS

1. Polynomial and Polynomial Equation

A Polynomial in a single unknown x is an expression of the form $a_0 x^n + a_1 x^{n-1} + \ldots = a_n$ where n is any non negative integer and $a_0, a_1 \ldots$ are given numbers. Denoting the polynomial by P(x), we write

$P(x) = a_0 x^n + a_1 x^{n-1} + \ldots + a_n$, a_0 $a_1, \ldots, a_n$ are called the coefficient of P(x) and a_0 is called the leading coefficient of P(x), provided $a_0 \neq 0$.

In other words, a_0 is the coefficient of the highest degree term in P(x). Given $P(x) = a_0 x^n + a_1 x^{n-1} + \ldots + a_n$, $a_0 \neq 0$, n is called the degree of P(x) and we write deg P(x) = n.

P(x) being a Polynomial, P(x) = 0 is called a Polyhomial equation in X, of degree n. If the coefficient of P(x) are all real numbers, then P(x) is called a real Polynomial in x.

2. Polynomial Function

If P(x) is a Polynomial in which x is a variable taking values over a set A, then corresponding to each x A let there correspond a unique value of the Polynomial, namely P(x) belonging to another set B. Then P(x) is a function from A into B. P(x) is called a polynomial function with A as the domainand B as the codomain.

3. Zero of a Polynomial or a root of a Polynomial equation

Let P(x) be a polynomial and a be such that P(a) = 0. Then a is called a Zero of P(x). Also, a is called a root of the equation P(x) = 0.

Result 1: If a is a root of P(x) = 0, then (x-a) is a factor of P(x).

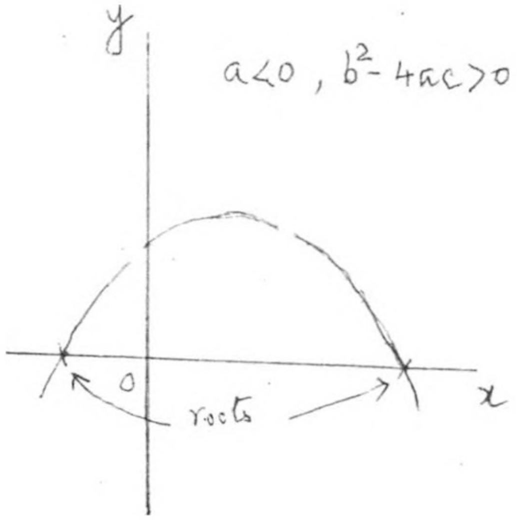
Result 2: Every Polynomial equation P(x) = 0 of nth degree ($n > 0$) has exactly n roots.

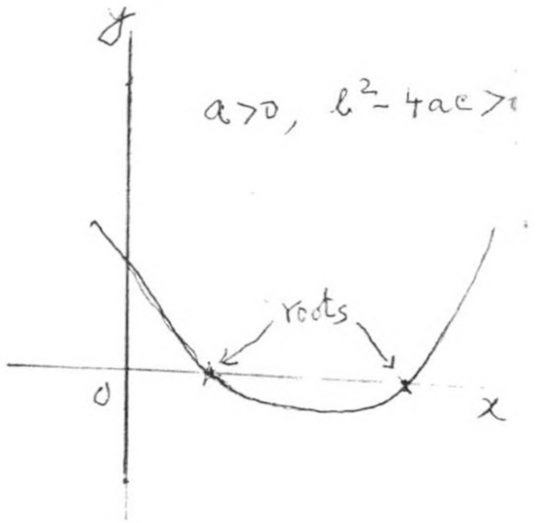
3. Quadratic function/equation

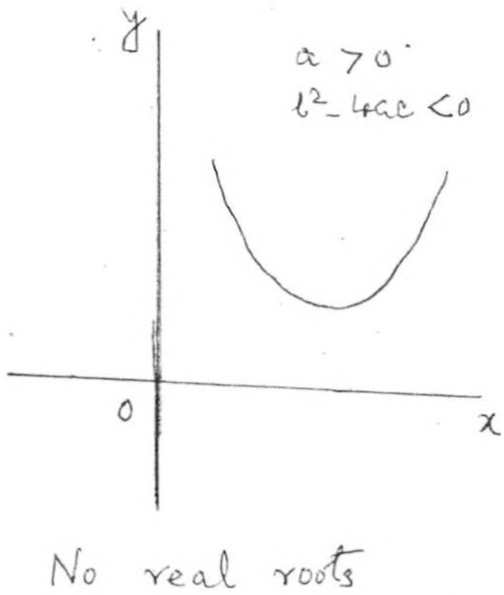
1. A second degree Polynomial $ax^2 + bx + c$ in x is called a quadratic polynomial; a,b,c are the coefficients of the Polynomial.

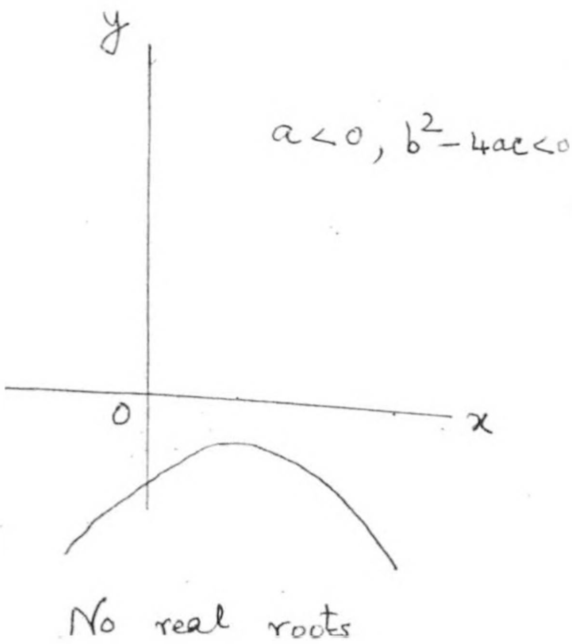
A function given by $Y = ax^2 + bx + c$ for given constants a,b,c is called a quadratic function in x.

As X takes real values, the graph of the function $Y = ax^2 + bx + c$ is a Parabola.









2. Formula for the roots of $ax^2 + bx + c = 0$

$$ax^2 + bx + c = 0, \quad a \neq 0.$$

$$\Longleftrightarrow a \; [\; x^2 + b/a + c/a \;] = 0$$

$$\Longleftrightarrow a \; [\; x^2 + 2.\frac{b}{2a}\, x + (b/2a)^2 + c/a - b^2/4a^2 \;] = 0$$

$$\Longleftrightarrow a \; [\; (x + b/2a)^2 - \left(\frac{b^2 - 4ac}{4a^2}\right) \;] = 0$$

$$\Longleftrightarrow (x + b/2a)^2 = \frac{b^2 - 4ac}{4a^2} \Longleftrightarrow x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

The roots are given by

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}, \quad a \neq 0.$$

This formula gives the roots of the quadratic equation.

The roots are real if $b^2 - 4ac \geq 0$ and imaginary (or complex) if $b^2 - 4ac < 0$.

If $b^2 - 4ac = 0$ the roots are equal to $-b/2a$.

If $b^2 - 4ac > 0$, the roots are real and distinct.

3. Extreme Values

The quadratic polynomial function $Y = ax^2 + bx + c$ can be written as $a(x + b/2a)^2 = Y + \frac{b^2 - 4ac}{4a}$

or $Y = \frac{4ac - b^2}{4a} + a\,(x - b/2a)^2$ ~~always~~ 0

$$\Rightarrow Y \geq \frac{4ac - b^2}{4a} \text{ if } a > 0 \text{ and } Y \leq \frac{4ac - b^2}{4a} \text{ if } a < 0.$$

In other words,

$$Y_{max} = \frac{4ac - b^2}{4a} \quad \text{if } a < 0$$

and $$Y_{min} = \frac{4ac - b^2}{4a} \quad \text{if } a > 0.$$

4. <u>Relation between roots and Coefficient of a Quadratic equation</u>

If L and B are roots of $ax^2 + bx - c = 0$ then $ax^2+bx+c = a\,(x-L)\,(x-B)$
i.e., $ax^2 + bx + c = a\ \ x^2 - (L-B)\,x\ \ LB$
i.e., $ax^2 + bx + c = ax^2 - a\,(x+B)\,x + a \times LB$
$-a\,(L+B) = b$ and $a\,LB = c$
or $L+B = -b/a$ and $LB = C/a$

The sum of the roots = $-\dfrac{\text{Coefficient of } X}{\text{Coefficient of } X^2}$

The Product of roots = $\dfrac{\text{constant term}}{\text{Coefficient of } X^2}$

LECTURE SYNOPSIS 2

CONGRUENCE MODULO n - (MODULAR ARITHMETIC)

1. <u>The Congruence relation on the set of Integers</u>

If $Z = \{0, \pm1, \pm2, \ldots\}$, the set of Integers for a given natural number n, let $a \equiv b \bmod n$ mean that (a-b) is divisible by n. Then the relation $a \equiv b \bmod n$ (read as a is congruent to module n) is <u>an equivalence relation on Z.</u> This results in equivalence classes (0), (1), (2)......(n-1) when a class (x) consists of all integers of such that $X = Y \bmod n$.
i.e. $(x) = \{Y \in Z \mid x \equiv y \bmod n\}$

Now we take (0) = 0, (1) = 1 etc., [(n-1)] = (n-1) and consider the set $Z_n = \{0,1,2,3,\ldots\ (n-1)\}$ module n is called the set of Integers modulo n..

Defining: (1) Addition modulo n (+) on Z_n by $a+b = r$, $0 \le r \le n$ where r is the remainder got by dividing a+b by n.

2. <u>Multiplication modulo n' (X) on Z_n by $a \times b = r$ where r is the remainder got by dividing $a \times b$ by n.</u>

$[Z_n, +, \times]$ possesses the following properties.

1. Closure w.r.t. addition : For $a,b \in Z_n$, $a+b \in Z_n$
2. Associativity w.r.t. addition: for $a,b,c \in Z_n$, $a+(b+c)= (a+b) + c$
3. The Zero element : For any $a \in Z_n$, $0 \in Z_n$ is such that $a+0 = a = 0+a$
4. The negative of an element : For each $a \in Z_n$, $-a \in Z_n$ such that $a+(-a)=0=(-a)+a$

5. Commutativity w.r.t. addition : For $a,b \in Z_n$, $a+b = b+a$.

6. The Cancellation Property w.r.t. addition : For $a,b,c \in Z_n$ $a+b = a+c$ implies $b=c$.

7. Closure w.r.t. multiplication (X) : For $a,b \in Z_n$, $a \times b \in Z_n$

8. Associativity w.r.t. multiplication : For $a,b,c \in Z_n$, $a \times (b \times c) = (a \times b) \times c$

9. The Unity : For any $a \in Z_n$, $1 \in Z_n$ such that $a \times 1 = a = 1 \times a$.

10. Commutativity w.r.t. multiplication : For $a,b \in Z_n$, $a \times b = b \times a$

11. Distributivity: For $a,b,c \in Z_n$, $a \times (b + c) = a \times b + a \times c$.

If further, n is a prime number, then in addition to (1) to (11), the following properties are also satisfied.

12. The equation $a\,x = b$, $a = 0$, for $a,b \in Z_n$ has always solution in Z_n.
From (11) we get the cancellation property w.r.t. multiplication.

13. For $a,b,c \in Z_n$ $a \neq 0$, $a \times b = a \times c$ implies $b = c$ follows.

LECTURE SYNOPSIS 3

PERMUTATIONS AND COMBINATIONS

1. Permutations

Result 1: If a number of things are to be done in succession and if the first thing can be done in l ways, the second in m ways, the third in n ways, then all these things can be done in succession in $l \times m \times n$ ways.

Explanation : A permutation of r things out of n things is an arrangement of r things out of n things.

Notation 1 : The total number of permutations of r things out of n things is denoted by ^nP_r.

2 : $1 \times 2 \times 3 \ldots \times n = n!$ read as factorial n.

Formula 1 : $^nP_r = n(n-1)(n-2)\ldots(n-r+1)$

2 : $^nP_r = n!/(n-r)!$

2. Combinations:

Explanation 2 : A combination of r things out of n things is a selection of r things out of n things without regard to the order of placement of the things.

Notation : The total number of combinations of r things out of n things is denoted by ^nC_r [a more modern notation is $\binom{n}{r}$]

Formula :

(1) $^nC_r = \frac{^nP_r}{r!}$ (2) $^nC_r = \frac{n!}{r!\,(n-r)!}$

(3) $^nC_r = {^nC_{n-r}}$ (4) $^nC_r + {^nC_{r-1}} = {^{n+1}C_r}$

(5) $^nC_0 + {^nC_1} + \ldots + {^nC_n} = 2^n$

(6) $0! = 1$

Binomial Theorem for a Positive Integral Index n :

$$(a+b)^n = {^nC_0}a^n + {^nC_1}a^{n-1}b + \ldots + {^nC_r}a^{n-r}b^r + \ldots + {^nC_n}b^n$$

or $$(a+b)^n = \sum_{n=0}^{n} {^nC_r}a^{n-r}b^r.$$

Here ^nC_r, $r = 0,1,2,\ldots n$ are called the binomial coefficients in the expansion of $(a+b)^n$.

DR.N.M.RAO

LINEAR PROGRAMMING, TRANSFORMATION GEOMETRY AND EXPERIMENTS IN MATHEMATICS

It was found in the pretest that the teachers found it difficult to teach the above topics. Hence the above topics were discussed in detail during the 6-day workshop.

The graphs of the equations and inequations, were discussed, as an introduction to the Linear Programming problems. Most of the problems given in the X class textbook were worked out in the group work sessions. The way of converting a natural problem into a mathematical problem of L-P type, was also discussed in detail. A worksheet containing the problems of Linear Programming, Geometry and Inequation were given to the participants. They worked out these problems in the 'Group Work' sessions with the help of resource persons. A few more problems were given as home assignment (as follow-up measures).

In one of the sessions, the chapter of Transformation Geometry was discussed. The matrix of the general linear transformation (which includes rotation, reflexion and Translation) was calculated. The general guidelines of working out the problems on these chapters were discussed.

On the last day, a few examples were given to show how mathematics teaching can be made more interesting with the help of some experiments. The concept of π (Pi), the area of the circle, mensuration of solids could be taught by some simple experiments. These experiments were actually demonstrated to the participants. Worksheets were given on all the topics.

In the three Lecture-cum-Discussion sessions, the following teaching points were covered.

The meaning of Statistics; need for classification and representation of data in tabular and graphical form; frequency distribution - class interval, mid-point, limits and length of a class interval, cumulative frequency; assumptions underlying the distribution of frequency in a class interval and their use in the graphical representation and computation of different statistics of a frequency distribution.

Properties of a frequency distribution - central location, variation, skew-ness, and kurtosis; measures of central tendency - mean, median and mode; measures of variation - range, interdecile range, quartile deviation and standard deviation; use and interpretation of these measures.

Concept of correlation, coefficient of correlation, Pearson's Product moment and Spearman's rank order correlation coefficients and their interpretations.

Besides clarifying these ideas, the participants were made to realise the importance of understanding the interrelationships among them in connection with teaching and learning of the ideas. The participants were exposed to different ways of motivating students to learn, the nature of the expository strategy, and the moves used in developing mathematical skills. Actually, the use of these pedagogical principles were exemplified in the transaction of the content.

In the Group Work sessions, the participants were made to do exercises on the content and pedagogical aspects. In one of the group work sessions, as a part of a study on the methodology of teaching mathematical concepts a criterion-referenced achievement test was administered to the participants with a view to identifying their levels of understanding of different mathematical concepts and the relevant methodology. The findings will be helpful for planning inservice programmes for mathematics teachers in the future.

The content enrichment programme in mathematics was conducted by the College under the Scheme of Educational Development of SC/ST children. The Secretary of the A.P. Social Welfare Residential Educational Institutions Society was requested to invite 40 participants from secondary schools under his control to attend the programme from 12th to 17th December, 1988, at the Government Comprehensive College of Education, Hyderabad. The Principal and faculty of this College extended full cooperation in the conduct of the programme by making available the required facilities for all the 6-days of the programme. Their contribution in the successful conduct of this programme is gratefully acknowledged.

All the 40 participants (Appendix IV) invited to the programme attended the same and took keen interest in the deliberations. The programme was inaugurated by Sri T.Venka Reddy, IAS, Director of School Education, A.P., Hyderabad. Sri Venka Reddy called upon the RCE, Mysore to do all that was possible to cater to the educational needs of Andhra Pradesh. He desired that proper linkages should be established between the SCERT, AP, and the RCE, Mysore for conducting various educational projects and programmes. Emphasizing the importance of the programme, he pointed out that many children in high schools were scared of the subject of mathematics and had no liking for it. He had, therefore, requested the participants to have a clear understanding of school mathematics and to have a thorough knowledge of the mathematics curriculum. He had requested the Resource Persons from the College, who conducted the programme, to identify the major conceptual weaknesses of the teacher participants and to help them to improve their content competence and methods of teaching the subject.

Presiding over the inaugural function, Dr.T.V.Narayana, Member, A.P. Public Service Commission, called upon the mathematics teachers to create interest in mathematics. For this purpose, he said, the mathematics teachers should continuously read the latest books.

As mentioned earlier, lecture-cum-discussion approach was adopted in dealing with the difficult topics in mathematics of the secondary school curriculum and the problem-solving approach was adopted in group work sessions. The programme concluded on the evening of 17th December, 1988, after a brief valedictory function in which the Director, SCERT, A.P., was the Chief Guest.

APPENDIX I

Date: 12.12.88 | **PRETEST** | Time : 45 Min.

Dear Teacher,

This test is designed to identify the difficult areas in school mathematics so that these difficulties are attended during the workshop.

Name of the Participant :

Instructions: The items are multiple choice items. Please tick ( ) the correct answer to each item.

1. Given that p = My country is great and q = I am happy.
   Symbolic representation of the statement : I am happy if my country is great, is

   a) $p \longrightarrow q$ b) $q \longrightarrow p$ c) $p \longleftrightarrow q$ d) $q \longleftrightarrow p$

2. "He is an intelligent student" is not a statement because

   a) It is not a mathematical expression.

   b) It is never true

   c) It is always false.

   d) It is neither true or false.

3. When is the implication : $p \longrightarrow q$ false? When

   a) both p and q are false.

   b) both p and q are true.

   c) p is true but q is false.

   d) q is true but p is false.

4. If $x \in A \cap B$, then

   a) $x \in A$ and $x \notin B$;

   b) $x \in B$ and $x \notin A$

   c) $x \in A$ and $x \in B$

   d) $x \notin A$ and $x \notin B$

5. The number of subsets of a finite set A is 32. The number of elements in A is

   a) 3 b) 4 c) 5 d) 6

6. Given the relation R = $\{(1,1), (2,1), (3,2)\}$ on A = 1,2,3 , R^{-1} is

a) $\{(1,1), (1,2), (3,2)\}$

b) $\{(1,2), (2,3), (3,2)\}$

c) $\{(1,1), (1,2), (2,3)\}$

d) $\{(2,1), (1,2), (2,3)\}$

7. The relation R = $\{(1,1), (2,2), (3,3), (1,2), (2,1)\}$ is

a) Reflexive and not transitive

b) Reflexive and symmetric

c) Symmetric and not transitive

d) Not reflexive and not symmetric

8. If f = $\{(2,-2), (-2,3), (3,-3), (-3,2)\{$ is a function on $\{2, -2, 3, -3\}$ then $\dfrac{f(-2) + f(-3)}{f(3) + f(2)}$ is

a) -1 b) 1 c) 1/2 d) 2

9. R = the set of real numbers, R^+ = The set of non-negative real numbers, and Z = the set of integers. Which one is a function?

a) $f : R \rightarrow R$ and $f(x) = -\sqrt{x}$

b) $f : R^+ \rightarrow R$ and $f(x) = +\sqrt{x}$

c) $f : R \rightarrow Z$ and $f(x) = +\sqrt{x}$

d) $f : R \rightarrow Z$ and $f(x) = -\sqrt{x}$

10. The region represented by $x+y > 2$ contains

a) (0,0), b) (1,0) c)(1,1) d) (1,2)

11. Given $L_1 : x \leq 0$, $L_2 : y \leq 0$; $L_3 : x + y \leq 1$ and $L_4 : x+y \leq -1$.

The intersection of which three regions form a triangular region ?

a) L_1, L_2 and L_3

b) L_2, L_3 and L_4

c) L_1, L_3 and L_4

d) L_1, L_2 and L_4

12. In the coordinate plane, the intersection $\{x \geq 0\} \cap \{y \geq 0\}$ is

a) ϕ b) The whole coordinate plane

c) the x-axis d) the 1st quadrant

13. In minimising $Z = x+y$ under the conditions $2x+y \geqslant 10$ and $x+2y \geqslant 0$

a) the feasible region is bounded.

b) the minimum value of Z is the nearest vertex of the region from the origin

c) Z has no minimum value

d) minimum value of Z is at (9,0).

14. The distance between A (a+b, c-d) and B (a+c, b+d) is

a) $|a-b|\sqrt{2}$ b) $|b-c|\sqrt{2}$ c) $|c-d|\sqrt{2}$ d) $|a-d|\sqrt{2}$

15. Given that A = (2,-2), B = (-2,2) C = (2,2), D = (-2, -2) which line is parallel to the y-axis

a) AB b) CD c) AD d) BD

16. The centroid of the triangle with vertices A = (1,2), B = (2,3), C= (3,1) is

a) (1,1) b) (2,2) c) 3,3 d) (4,4)

17. Decimal representation of an irrational number is

a) terminating only

b) terminating or recurring

c) recurring only

d) Neither terminating nor recurring

18. In which equation below, the product of the roots is twice the sum of the roots?

a) $x^2 - kx + 2k = 0$ b) $x^2 - 2kx + k = 0$

c) $x^2 + 2kx - k = 0$ d) $x^2 - kx - 2k = 0$

19. If (x-2) and (x +1) are factors of $x^2 = px + qx - 2$, then

a) p = 2, q = 1 b) p = -2, q = 1

c) p = 2, q = -1 d) p = 1, q = 2

20. On simplification $\dfrac{\text{Cosec } \theta}{\text{Sec } \theta}$ is

a) $\cos\theta$ b) $\tan\theta$ c) $\cot\theta$ d) $\sin\theta$

21. The value of $\sin 30^\circ + \cos 60^\circ$ is

a) 1/2 + 1/3 b) 1/2 - 1/3 c) $1/2 + \sqrt{3}/2$ d) 1

22. If $\sin\theta = 1/2$; $0 < \theta < \pi/2$, then the value of θ is

a) $5\pi/12$ b) $\pi/3$ c) $\pi/4$ d) $\pi/6$

23. The distance of the observer from the foot of a tower is equal to the height of the tower. The angle of elevation of the top of the tower is

a) 30° b) 45° c) 60° d) 75°

24. The values of cos θ + sin θ $(0 < \theta < \pi/2)$ cannot exceed

a) 1/ 2 b) 1/2 c) 1 d) 2

25. The length of the class intervals of the distribution

C.I.	40-45	35-40	30-35
f	2	5	3

is

a) 5.0 b) 4.5 c) 4.0 d) 6.0

26. The score in a distribution obtained by the largest number of examinees is called

a) arithmetic mean b) median

c) mode d) none of these

27. The median of the scores 3,5,6,4,5,4, 7,5 is

a) 4.00 b) 4.83 c) 5.00 d) 5.33

28. A class of 25 students was given a 15 item test. If the mean of the distribution is 10, then the sum of the raw scores is

a) 150 b) 250 d) 375 d) 400

29. Which of the following measures is not expressed in the same units as the other three:

a) arithmetic mean b) median

c) Standard deviation d) variance

30. Which of the following measures is not obtained in the same way as the other three?

a) mean deviation b) quartile deviation

c) standard deviation d) variance

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APPENDIX II

Date: 16.12.88 | POST TEST | Time: 45 min.

Instruction: Please tick (✓) the correct response in each item.

1. Given P = Ram is a good student, Q = Ram is intelligent, which of the following will represent "Ram is a good student, though he is not intelligent".

   a) $p \wedge q$ b) $p \wedge \sim q$ c) $p \vee \sim q$ d) $\sim p \wedge q$

2. When is the statement $\sim p \longrightarrow \sim q$ false?

   a) p and q are both true.

   b) p and q are false

   c) p is true and q is false

   d) p is false and q is true.

3. Which of the following is equivalent to the statement $p \longrightarrow \sim q$?

   a) $\sim q \vee \sim p$ b) $q \vee p$ c) $q \vee \sim p$ d) $\sim q \wedge \sim p$

4. If $P \longrightarrow Q$ is true

   a) P is a sufficient condition for Q.

   b) P is a necessary condition for Q.

   c) Q is a sufficient condition for P.

   d) P is a necessary and sufficient condition for Q.

5. Which of the following is a tautology?

   a) $(p \longrightarrow q) \wedge p \longrightarrow q$

   b) $p \wedge q$

   c) $(p \wedge q) \longrightarrow \sim p$

   d) $(p \longrightarrow q) \wedge p \longrightarrow \sim p$

6. If $s = (p \longrightarrow q) \wedge (q \longrightarrow r)$, which of the following is deducible from s?

   a) $q \rightarrow p$ b) $r \longrightarrow q$ c) $p \longrightarrow \sim q$ d) $p \longrightarrow q$

7. Consider to the argument "All boys of this class are football players and Mohan reads in this class. So, Mohan is a football player". In this argument which of the following patterns is used?

   a) Rule of conjunctive-inference

   b) Rule of detatchment

   c) Hypothetical syllogism

   d) Rule of contraposition.

8. The lines $2y + 4x - 1 = 0$ and $4x + 2y - 7/2 = 0$ are

   a) parallel to each other.

   b) perpendicular to each other.

   c) making an angle of $-4/2$ with x-axis

   d) having the slope $-2/4$

9. The point $(-4,3)$ is

   a) above the line $y = (-3/4)\,x$

   b) In the intersection of Q2 and Q3

   c) In the region $2y + 4x \quad 1$

   d) in the region $2y + 4x. \quad 1$

10. In the linear programming problems

    a) all points inside the feasible region give the optional solution.

    b) only the origin gives the solution

    c) all points on the vertices of the feasible region give the optional solution.

    d) some points on the vertices give the optional solution.

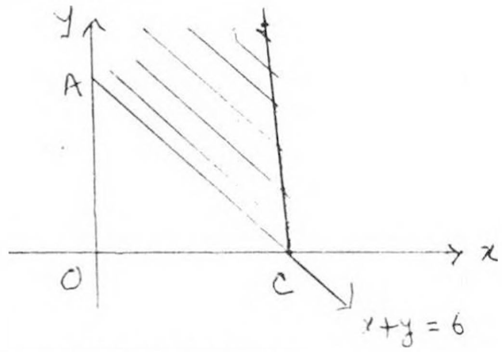
11. In the figure if A B C is the feasible region then the maximum value of $Z = x+y$ is obtained on

    a) the point A.

    b) on the point C

    c) the point B

    d) on every point on the line AC.



12. In the above figure, the minimum value of $Z = x+y$ is attained at

    a) the point B b) the point C

    c) the point A d) on every point on the line AC.

13. The reflexion of the English letter S in a line gives :

    a) The letter S itself.

    b) The inverted letter S.

    c) The integer 5

    d) None of the above.

14. An equilateral triangle has

a) No rotation symmetry
b) Three lines of symmetry
c) Six lines of symmetry
d) None of the above

15. If the point P (x,y) is reflected in the x - axis then the matrix of this transformation is given by

a) $\begin{pmatrix} 1 & 1 \\ 1 & 0 \end{pmatrix}$ b) $\begin{pmatrix} 1 & 1 \\ 0 & 0 \end{pmatrix}$ c) $\begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$ d) None of the above.

16. The assumption that mid-value of a class interval is the value of the observations belonging to the class interval is used in the calculation of

a) Mean b) Median c) Mean and Median
d) Mean and standard deviation

17. The mean of 10 observation is 15 and the sum of 9 observation is 136. The tenth observation is

a) 15 b) 14 c) 10 d) None of the above

18. The mode of the following data is
29, 25, 20, 22, 25, 24, 26, 29, 25, 26, 30, 26

a) 25 b) 25.5 c) 26 d) No modal value

19. The measure of dispersion which is not affected by the extreme values of a distribution is

a) Range

b) Quartile deviation

c) Mean Deviation

d) Standard deviation

20. The more reliable measure of dispersion is

a) Range

b) Mean deviation

c) Quartile deviation

d) Standard deviation

21. What is the most appropriate measure of variation to be used with mean as a measure of central tendency to describe a distribution of observations?

a) Range
b) Mean deviation
c) Quartile deviation
d) Standard deviation

22. Which one of the coefficients of correlation indicate the maximum degree of relationship between two variables ?

a) 0.53 b) -0.96 c) 1.25 d) None of these

23. P(x) and Q(x) are two polynomial and deg (P(x) + Q(x)) = deg. P(x). Then deg Q(x) is

a) not defined b) 0 c) 1 d) less than or equal to deg P(x)

24. If x = a is a root of the polynomial equation P(x) = 0 then $\frac{P(x)}{(x-a)}$ is

a) not a polynomial b) a Polynomial

c) not defined d) zero

25. $P(x) = ax^2 + bx + c$. $P(1) = 0$, $P(0) = 2$, $P(-2) = -2$ then

a) a = 1, b = 0, c = -2

b) a = 0, b = 2, c = -2

c) a = -3, b = 1, c = 2

d) None of the above

26. In Z_8 modulo 8, the equation 4x = 0 has

a) no solution b) one solution

c) two solutions d) four solutions

27. In which of the systems 2x = 1 has no solution?

a) Integer modulo 5 b) modulo 6

c) modulo 9 d) modulo 11

28. Tick the correct statement below when 0 r n .

a) ${}^nP_r \leq {}^nC_r$ b) ${}^nP_r \geq {}^nC_r$

c) ${}^nP_r > {}^nC_r$ d) ${}^nP_r < {}^nC_r$

29. How many numbers between 100 and 1000 can be formed using the digits 0,1,2,3 without repeating any digit?

a) 24 b) 18 c) 12 d) 6

30. The ratio of the circumference of a circle to its diameter is

a) an integer b) a rational number

c) an irrational number d) none of the above.

APPENDIX III

REGIONAL COLLEGE OF EDUCATION, MYSORE 6

A questionnaire to be filled by the participants of the Content Enrichment Workshop for the Teachers of the A.P.S.W. Residential Schools eld at Govt. Comprehensive College of Education, Hyderabad from 12.12.1988 to 17.12.1988.

Name of the Participant :

Instructions: Tick (✓) your choice.

1. Which of the following objectives were fulfilled during the workshop and to what extent?

   a) Content Enrichment : Fully / Partially

   b) Methodology : Fully / Partially

2. Did you like the procedure used to find your requirements through pretest and exploratory session ?

   a) Pre Test : YES / NO

   b) Exploratory session : YES / NO

3. Are the topics selected for discussion in the workshop adequate to meet your classroom needs?

   YES / NO

4. Do you think that the topics were discussed satisfactorily ?

   Satisfactorily / Partially satisfactory / Unsatisfactory

5. Give your opinion about the various activities during the workshop.

   a) Lectures : Too much / Adequate / Less

   b) Group Work: Too much / Adequate / Less

   c) Discussions : Too much/ Adequate / Less

   d) Tests : Unnecessary / Necessary / Adequate

6. Your opinion regarding the duration of the workshop daily and duration of the workshop :

   a) Daily working hours : More / Less /Alright

   b) Duration (Total) of the workshop : More / Less / Alright

7. The instructional materials, worksheets and synopses are :

   very useful / useful to some extent / not very useful

8. List the topics which, in your opinion, should be covered in future workshops.

   1. 2.
   3. 4.

9. Give your opinion on Academic Aspects which are not covered above in two or three sentences below:

APPENDIX IV

CONTENT ENRICHMENT COURSE IN MATHEMATICS FOR TEACHERS FROM A.P.S.W. RESIDENTIAL SCHOOLS CONDUCTED AT GOVERNMENT COMPREHENSIVE COLLEGE OF EDUCATION, HYDERABAD FROM 12th TO 17th DECEMBER 1988

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S.W. Residential School
Kallur, Khammam District

21. G.Srinivas Reddy
P.G.T. in Mathematics
S.W. Residential School
Maidpalli
Karimnagar District

22. G.Krishna Rao
P.G.T. in Mathematics
S.W. Residential School
Asifabad
Asifabad District

23. S.Suresh Babu
P.G.T. in Mathematics
S.W. Residential School
V.M. Home, Saroor Nagar
Hyderabad

24. C.Pratap Reddy
P.G.T. in Mathematics
S.W. Residential School
Nallavagu
Medak District

25. G.Shankaraiah
P.G.T. in Mathematics
S.W. Residential School
Rajapet, Nalgonda District

26. S.Madan Mohan
P.G.T. in Mathematics
S.W. Residential School
Bhongir, Nalgonda District

27. B.D.V.S. Prasada Rao
T.G.T. in Mathematics
S.W. Residential School
Etcherla
Srikakulam District

28. D.Nagaraju
T.G.T. in Mathematics
S.W. Residential School
Gopalapuram
West Godavari District

29. R.Venkateswara Raju
T.G.T. in Mathematics
S.W. Residential School
Pedapavani
Prakasam District

30. A.V. Subba Rao
T.G.T in Mathematics
S.W. Residential School
Chillakur, Nellore District

31. S.Kasi Viswanatham
T.G.T. in Mathematics
S.W. Residential School
Eluru

32. T.R. Seethalakshmi
T.G.T. in Mathematics
S.W. Residential School
Srikalahasthi
Chittoor District

33. R.Hari Prasad
T.G.T. in Mathematics
S.W. Residential School
Pembetla
Adilabad

34. A.Sita Devi
T.G.T. in Mathematics
S.W. Residential School
Adilabad

35. P.Gouri Shankar
P.G.T. in Mathematics
S.W. Residential School
Pargi,RangaReddy District

36. P.Subbalaxmi
T.G.T. in Mathematics
S.W. Residential School
Narsingi
Ranga Reddy District

37. L.Ramachandram
T.G.T. in Mathematics
S.W. Residential School
Ramakkapet,MedakDistrict

38. V.Venkatavijaya Laxmi
T.G.T. in Mathematics
S.W. Residential School
Mattampally, Nalgonda Dist.

39. G.Pushpavathi
T.G.T. in Mathematics
S.W. Residential School
Dharamaram
Nizamabad District

40. D.Muthyal Rao
T.G.T. in Mathematics
S.W. Residential School
Ramanthapur
Hyderabad

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