

Secondary Course

211 - Mathematics

Practical Manual

Course Coordinator
Neeraj Pratap Singh



NATIONAL INSTITUTE OF OPEN SCHOOLING

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Chairman's Message

Dear learner,

As the needs of the society in general, and some groups in particular, keep on changing with time, the methods and techniques required for fulfilling those aspirations also have to be modified accordingly. Education is an instrument of change. The right type of education at right time can bring about positivity in the outlook of society, attitudinal changes to face the new/fresh challenges and the courage to face difficult situations. This can be very effectively achieved by regular periodic curriculum renewal. A static curriculum does not serve any purpose, as it does not cater to the current needs and aspirations of the individual and society.

For this purpose only, educationists from all over the country come together at regular intervals to deliberate on the issues of changes needed and required. As an outcome of such deliberations, the National Curriculum Framework (NCF 2005) came out, which spells out in detail the type of education desirable/needed at various levels of education – primary, elementary, secondary or senior secondary.

Keeping this framework and other national and societal concerns in mind, we have currently revised the curricula of all the subjects at the secondary level, making them current and need based. Textual material production is an integral and essential part of all NIOS programmes offered through open and distance learning system. Therefore, we have taken special care to make the learning material user friendly, interesting and attractive for you.

I would like to thank all the eminent persons involved in making this material interesting and relevant to your needs. I hope you find it appealing and absorbing.

On behalf of National Institute of Open Schooling, I wish you all a bright and successful future.

(Dr. S. S. Jena)

Chairman, NIOS

A Note From the Director

Dear Learner,

The Academic Department at the National Institute of Open Schooling tries to bring you new programmes every now and then in accordance with your needs and requirements. We are now revising the curriculum in all the subjects at the secondary level. In order to bring to you a curriculum which is at par with other boards in the country, we consulted the curriculum in different subjects at the CBSE and Several State Boards of Secondary Education. The National Curriculum Framework developed by the National Council for Educational Research and Training was kept as a reference point. After making a comprehensive comparative study, we developed the curriculum that was functional, related to life situations and simple. Leading educationists of the country were involved and under their guidance, we have been able to revise and update the curriculum.

At the same time, we also had a look at the learning material. We have removed old, outdated information and added new, relevant things and have tried to make it attractive and appealing for you.

I hope you will find the new material that is now in your hands interesting and exciting. Any suggestions for further improvement are welcome.

Let me wish you all a happy and successful future.

(Dr. Kuldeep Agarwal)

Director (Academic), NIOS

A Word With You

Dear Learner,

You might be enjoying Mathematics Book I and Book II provided to you by the National Institute of Open Schooling. Some of the concepts in Mathematics are of abstract nature and in learning such concepts becomes easier when learnt through activities performed in mathematics laboratory. Mathematics activities can be carried out by facilitator and learners to explore, to learn and to create interest of learners in the subject and develop positive attitude towards the subject.

Keeping the above in view, National Institute of Open Schooling has developed a laboratory manual, which is in your hands. This is in addition to the two books of your theory part of mathematics.

In the beginning, this Laboratory Manual has few pages under introduction, given an idea about the importance and meaning of practical work in mathematics.

There are 30 activities given in this manual. Each activity, has detailed instructions about how to perform the experiment and how to take observation to reach at the conclusion.

Though the manual has the scope of recording your observations in tabular form, you are required to maintain a record book, as it carries weightage in practical examination.

In case of any doubt or problem while doing the activity, do not hesitate to write to us.

We hope, you will enjoy performing these activities.

Wishing you all the success.

Yours,

(Neeraj Pratap Singh)
Senior Executive Officer (Maths)

Introduction

It is a general saying that mathematics is by doing only. The concepts for which the proof/verification is done by experimentation or activities are better understood by learners are retained in their brains for longer period of time. Jen Piaget, an psychologists, while writing his thesis on concept formation in children, has brought out that all abstract concepts, can be brought down to the concrete operational stage, and can be understood and retained in a better way. For example, if the abstract concept of number two, is illustrated by showing two apples, two oranges or any other two similar objects, which the learners can touch and handle, the learner understands in better way.

The human brain is capable of storing only limited amount of information. The information (concepts) which are repeatedly learnt and practiced, are permanently stored in the brains of children which help in learning of concepts. The activities which are repeatedly done for understanding concepts help the understanding for those concepts.

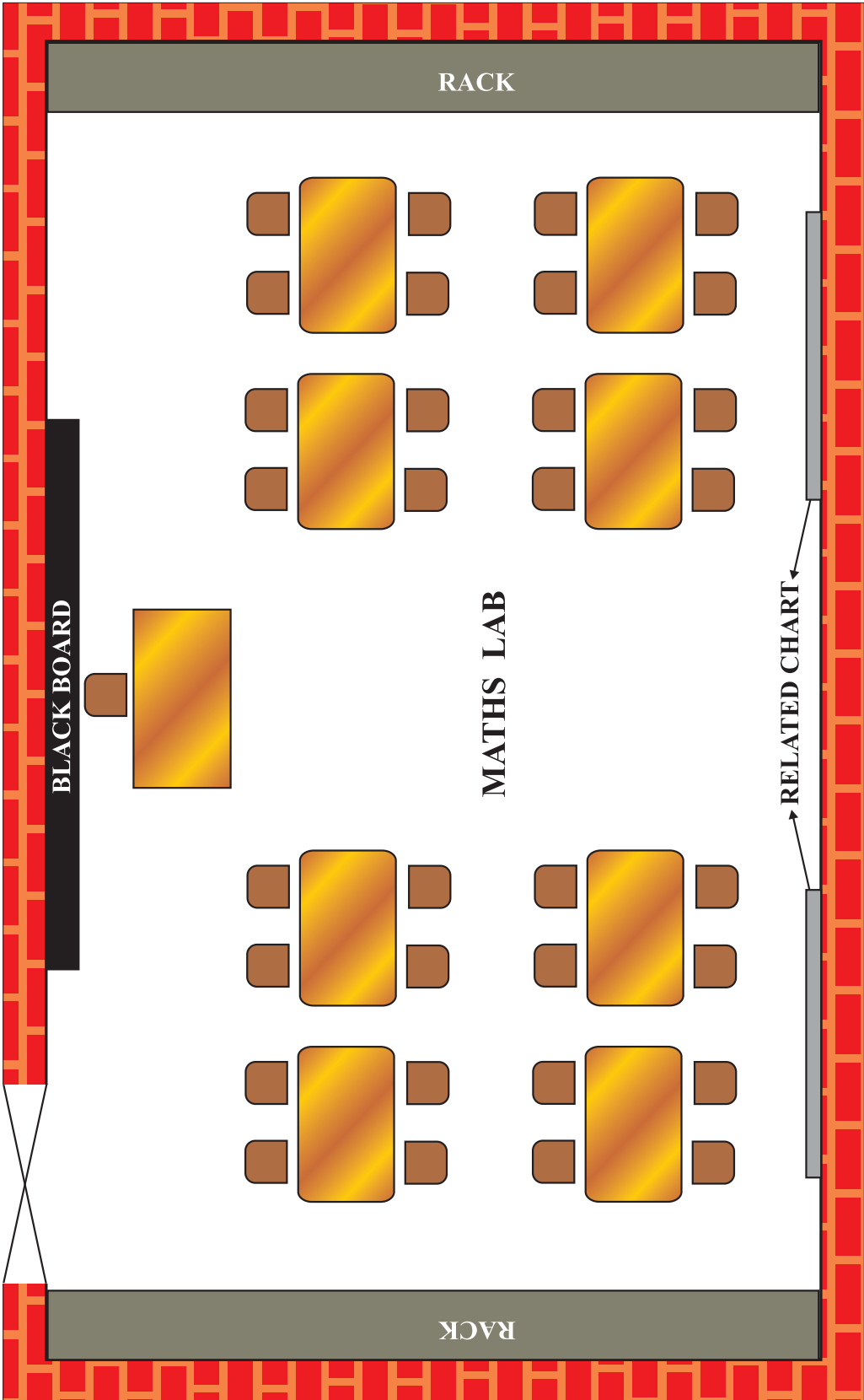
Mathematics laboratory is a place where learners can learn and explore difficult mathematical concepts and verify mathematical facts, formulae and theorems/results through a variety of activities and handling related projects using non-costly materials available in their environment. A mathematics laboratory can create mathematical awareness, skill building, positive attitudes towards the subject and above all ideas of learning by doing.

It is the place where learners can learn certain concepts using concrete objects and verify mathematical facts. Formulae and properties by using modes, measurements and the other activities. Here the learners handle the concrete materials, make models of their own by their own imagination and verify the facts/formulae.

Design and Lay out of the Mathematics Laboratory

In mathematics laboratory there should be sufficient space to accommodate atleast 30 learners for doing activities/experiments at a time.

The rough design is given here:



Materials Required: Sheets of paper of different Colours, Glazed paper scales, Wooden boards, Nails, Threads, Thermo cole piece, Cardboard square and Triangular grids, Pins and Clips, Wooden and paper strip, Cutter (paper), Scissor, Adhesive/fevicol, sketch pen, Gun geometry box (Bigger – Wooden), Graph paper (inches/cm both, Pencils of different colours, Colour box, Knobs, Tracing paper

Human Resource: It is desirable to have a laboratory assistant (with mathematics background), in charge of the mathematical lab. He expected to have special skills required to handle different instruments, needed for practical work. He should be able to repair things, if they are not in order and keep the materials ready for carrying out activities in the following days.

Time – Desired: 15% to 20% of total time for mathematics syllabus to be devoted to mathematics laboratory.

Scheme of Evaluation: 15 marks

The division of marks in the examination can be done as follows:

Activity	Mark
Assessment of Activity Performed/Records of activities prepared	10
Viva – voce	5
Total	15

- i) The proposed practical test is suggested to be held at least 15 days before the theory examination.
- ii) Every students may be given two activities out of which he has to select one and perform it these (in case, the students not comfortable with the given activities, he may be allowed to select one activity of his choice)
- iii) Viva-voce can be done at the examination centre by asking questions related to the activity/project he/she has done.

Contents

S.No.	List of Activities	Pages
	Verification of the identities (1 to 4)	
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3.	$(a^2-b^2) = (a+b)(a-b)$	5
4.	$(a+b)^3 = a^3 + b^3 + 3a^2b + 3ab^2$	7
5.	To find the HCF of two given numbers by division method.	9
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ACTIVITY 4



Notes

Title: Verification of the identity $(a+b)^3 = a^3 + 3a^2b + 3ab^2 + b^3$

Expected background knowledge:

- (i) Knowledge about vertices, edges and faces of cubes and cuboids.
- (ii) Volume and surface area of a cube and a cuboid

Objectives: After performing this activity, the learner will be able to verify and demonstrate the identity $(a+b)^3 = a^3 + 3a^2b + 3ab^2 + b^3$

Materials required:

- (i) Acrylic Sheets
- (ii) Wooden Board
- (iii) Sketch Pens
- (iv) Glazed papers
- (v) Fevicol
- (vi) Pair of Scissors
- (vii) Geometry Box

Preparation for the activity:

Take $a = 3$ cm (say) and $b = 1$ cm making $a + b = 4$ cm.

- (i) Make a cube of side 3 cm from a wooden board
- (ii) Make another cube of side 1 cm from the wooden board
- (iii) Make three cuboids of dimensions 3 cm x 3cm x 1 cm and another three of dimensions 3 cm x 1 cm x 1 cm from the wooden board.
- (iv) Using acrylic sheet, make a cube of side 4 cm.

Demonstration and Use

- (i) The cube of side 4 cm represents $(a + b)^3$ (Fig.5)
- (ii) The cube of side 3 cm represents a^3 (Fig.1)
- (iii) The cube of side 1 cm represents b^3 (Fig.4)
- (iv) A cuboid of 3 cm x 3 cm x 1 cm represents $a^2 b$ (Fig.2)
Thus three such cuboids = $3 a^2 b$
- (v) Similarly a cuboid of 3 cm x 1 cm x 1 cm = ab^2 (Fig.3)
Thus three such cuboids = $3 ab^2$

ACTIVITY 5



Notes

Title: To find the HCF of two given numbers by division method.

Expected background knowledge:

- (i) Factors of numbers
- (ii) Division of numbers

Objectives: (i) After completing this activity, the learner will be able to find the HCF of any two given numbers
 (ii) He will be able to find the largest number by which the two numbers can be divided.

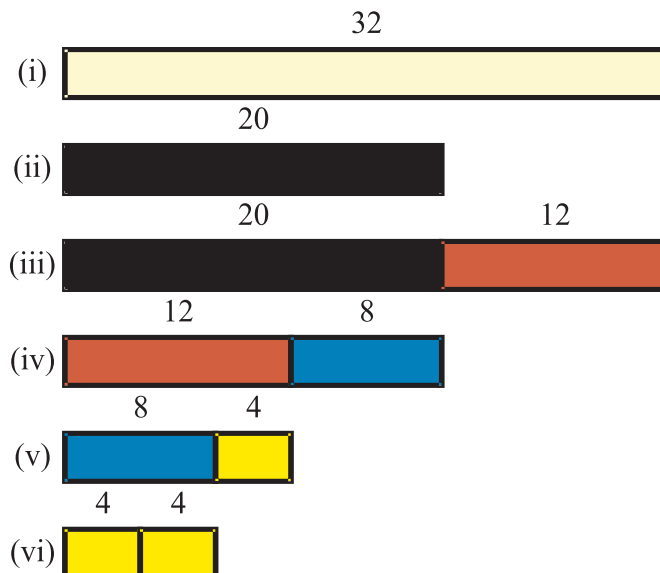
Materials required :

- (i) Cardboard – 5 strips of 2 cm width
- (ii) Sketch Pens
- (iii) Pair of Scissors
- (iv) Fevicol
- (v) Scale
- (vi) Pencil and eraser

Preparation for the activity:

Suppose we have to find the HCF of 20 and 32. Carry out the following steps:

- (i) Cut 2 cm wide cardboard strips to get two pieces of length 32 cm each, two pieces of length 20 cm each, two pieces of length 12cm each, two pieces of length 8 cm each and three pieces of length 4 cm each.
- (ii) Paste the cardboard strips as shown in figure below



ACTIVITY 6



Notes

Title: Equivalent Fractions**Expected background knowledge:** Concept of fractions**Objectives:** After performing this activity, the learner will understand the concept of equivalent fractions.**Materials required:**

- (i) Glazed paper (red)
- (ii) White square sheet
- (iii) String
- (iv) Sketch pens
- (v) Pencil, eraser and Fevicol.

Preparation for the activity:

- a) Mark 6 strips of same size on a square sheet marked S-1, S2, S3, S4, S5 and S6, each strips starting from an initial point representing zero (Fig. ii)
- b) The first strip S1 has 12 squares and represents 1.
- c) The second strip S2 has 2 equal parts of 6 squares each, each part representing $1/2$ (half strip). Thus OA represents $1/2$.
- d) The third strip S3 has 3 equal parts, each of 4 squares. And each part representing $1/3$ (one third of a strip). Thus OB represents $1/3$ and OC represents $2/3$.
- e) The fourth strip S4 has 4 equal parts, each of 3 squares, each part representing $1/4$ (one fourth of a strip). Thus OD, OE and OF on S4 represent $1/4$, $2/4$ and $3/4$ respectively.
- f) The fifth strip S5 has 6 equal parts, each of 2 squares, each part representing $1/6$ (one sixth of a strip). Thus OG, OH, OI, OJ and OK represent $1/6$, $2/6$, $3/6$, $4/6$ and $5/6$ respectively.
- g) The sixth strip S6 has 12 equal parts, each of 1 square, each part representing $1/12$ (One twelfth of a strip) Thus OL, OM, ON, OP, OQ, OR, OS, OT, OU, OV and OW represent $1/12$, $2/12$, $3/12$, $4/12$, $5/12$, $6/12$, $7/12$, $8/12$, $9/12$, $10/12$ and $11/12$ respectively.

Demonstration and Use: Using a glazed paper and a thread, equivalent fractions can be shown in the same vertical line as shown in Fig. (i) and Fig. (ii)Thus $1/2 = 2/4 = 3/6 = 6/12$ and so onHence $1/2$, $2/4$, $3/6$, $6/12$ are equivalent fractionsSimilarly $1/3$, $2/6$, $4/12$ etc. are equivalent fractionsSimilarly $2/3$, $4/6$, $8/12$ are equivalent fractions.



Notes

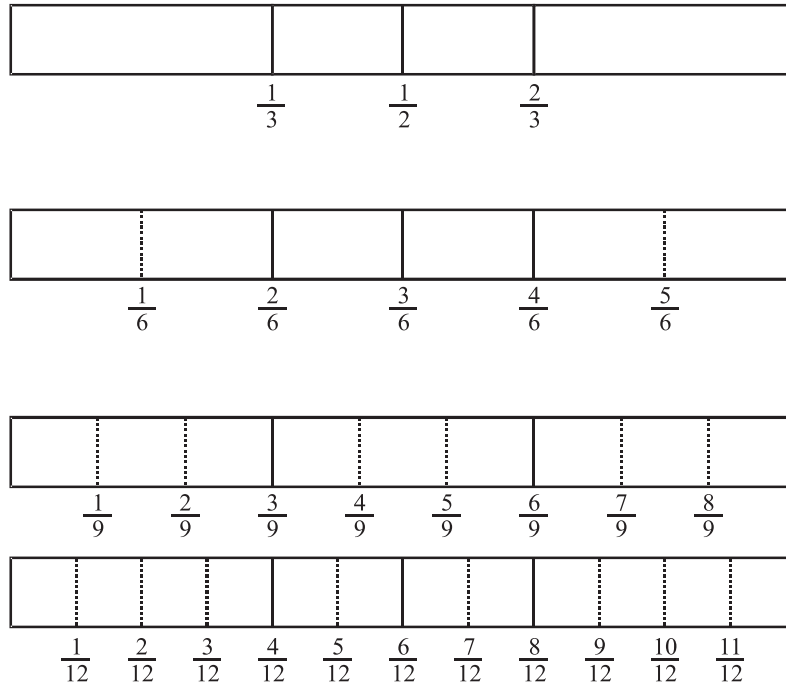


Fig. (i)

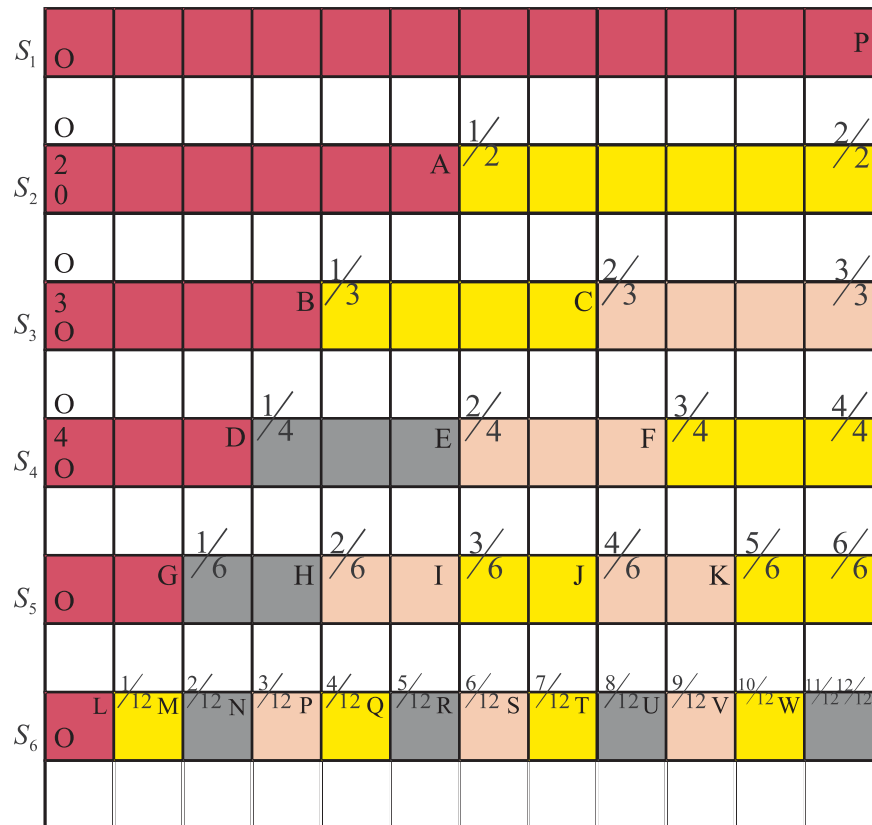
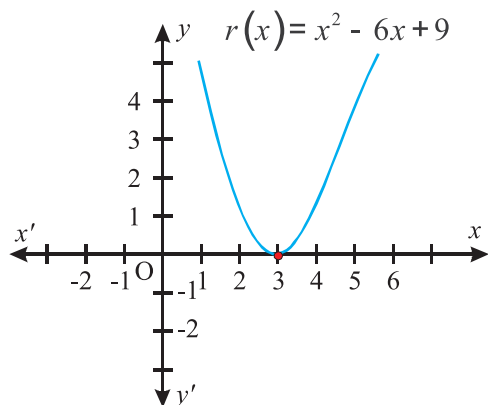


Fig. (ii)

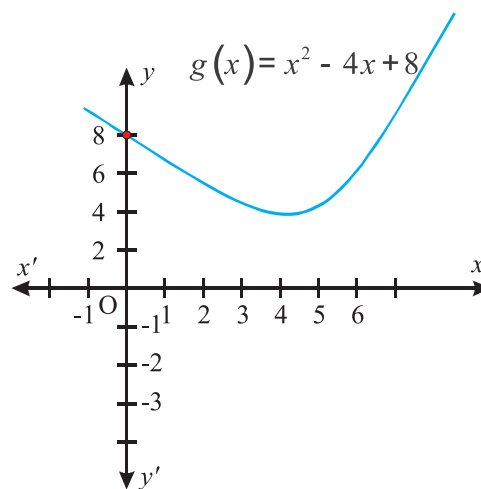


Notes

(iii)



(iv)



Demonstration and Use.

Polynomial	Graph Opening Upward / Downward	Number of Zeroes
$p(x) = x^2 - 5x + 6$	Upwards	Two
$q(x) = 4 - 3x - x^2$	Downwards	Two
$r(x) = x^2 - 6x + 9$	Upwards	One
$g(x) = x^2 - 4x + 8$	Upwards	Nil

Conclusion :

- (i) The graph of polynomial $ax^2 + bx + c$,
 - (a) opens upwards if $a > 0$
 - (b) opens downwards if $a < 0$
- (ii) Number of zeroes of a quadratic polynomial can be at most two.

ACTIVITY 11



Notes

Title: To verify that a given sequence is an A.P.

Expected Background knowledge: Knowledge of a sequence, definition of an A.P.

Objectives: After performing this activity, learner will be able to identify an arithmetic progression out of the given sequences.

Materials required:

- (i) Square papers with squares of size 1 cm x 1cm
- (ii) Pair of scissors
- (iii) Gum/fevicol
- (iv) Ruler, Pencil
- (v) Geometrical instruments.

Preparation for the activity: Consider the following sequences of positive numbers.

- 1, 4, 7, 10, 13, 16, ---
and 2, 3, 6, 10, 15, 17, ---

For first sequence cut rectangular strips from colored papers of different colours of width 1 cm and lengths 1 cm, 4cm, 7cm, 10 cm, --- Paste the coloured stripes in order on a squared paper as shown in the figure given below. [Fig.(i)]

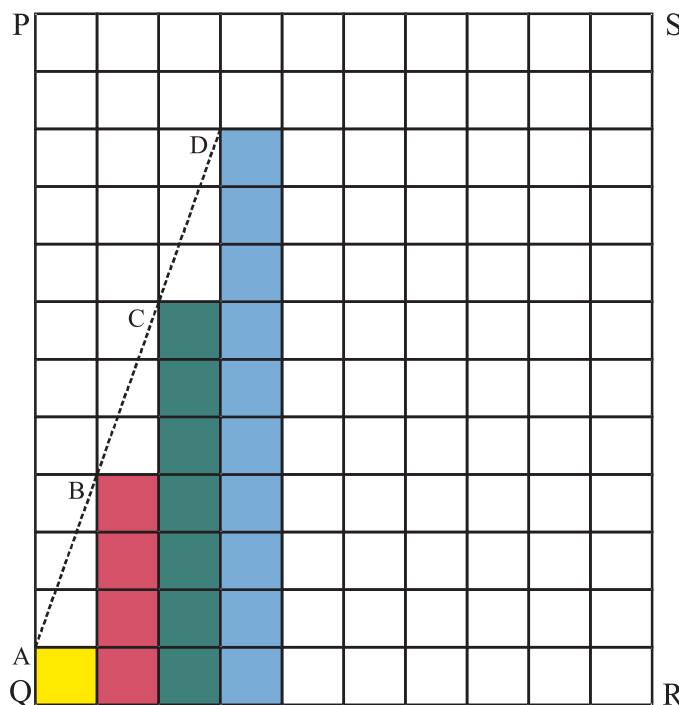


Fig. (i)



Notes

For the second sequence cut rectangular strips from coloured papers of different colours of width 1 cm and length 2 cm, 3 cm, 6 cm, 10 cm... Paste the coloured strips in order on a squared paper as shown in the figure given below. Fig. (ii)

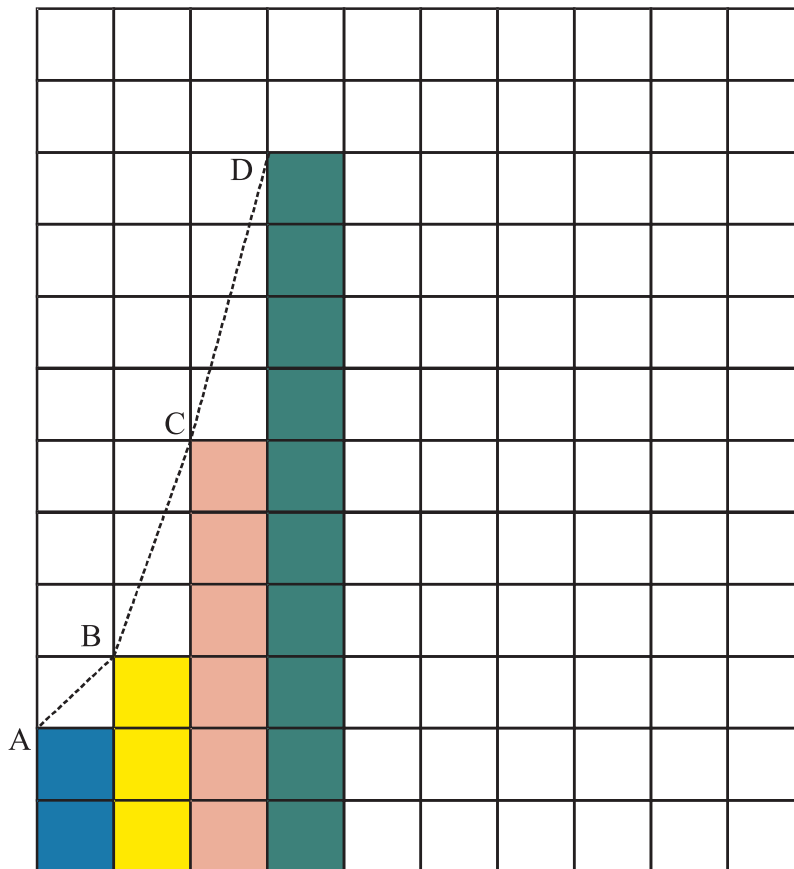


Fig. (ii)

Demonstration and Use

For the first sequence, the coloured strips form a ladder in which the difference between the heights of the adjoining strips is constant (Here it is 3cm). For the second sequence the coloured strips form a ladder in which the difference between the heights of the adjoining strips is not constant.

Conclusion: For the first sequence which is an A.P. the difference between the heights of the adjoining strips of the ladder formed is constant and for the second sequence which is not an A.P, the difference between the heights of the adjoining strips of the ladder formed is not constant.

Hence, if the difference between the consecutive terms of a sequence is constant, then the given sequence is an A.P. otherwise it is not an A.P.

Note: In case of an A.P, the right hand top corners of the strips, when joined, form a straight line, which will not be the case, if the sequence is not an A.P.

ACTIVITY 12



Notes

Title: To find the Sum of first n odd natural numbers.

Expected Background knowledge: (i) Odd natural numbers

(ii) nth odd natural number can be written as $2n-1$.

Objectives: After performing this activity the learner will be able to generalize that the sum of first n odd natural numbers is given by n^2

i.e. $1+3+5+\dots + 2n - 1 = n^2$

Materials required:

- (i) White chart paper
- (ii) Scale, pencil and eraser
- (iii) Coloured ball point pens
- (iv) Pair of scissors
- (v) Geometrical instruments

Preparation for the activity:

- (i) Take a white chart paper and cut out a square of size 10cm x 10 cm from it and mark the boundary of the square.

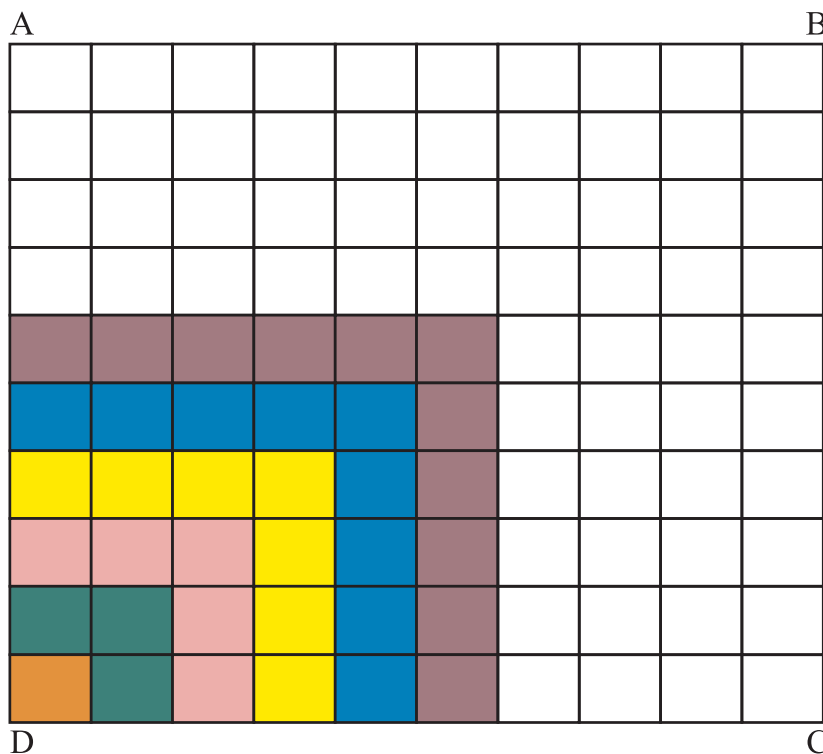


Fig. (i)

ACTIVITY 13



Notes

Title: To find the sum of first n natural numbers.

Expected Background knowledge: (i) Natural numbers and operations on them.
(ii) Area of a square and a rectangle.

Objectives: After performing the activity, learner will be able to find the sum of first, n natural numbers.

Materials required:

- (i) Chart paper
- (ii) Scale, Pencil and Eraser
- (iii) Colour box/ Coloured ball point pens
- (iv) Geometrical Instruments.
- (v) Pair of scissors/cutter

Preparation for the activity:

- (i) Cut out a chart paper ABCD of size 10cmx11cm and mark its boundary.
- (ii) Draw horizontal and vertical lines in the above rectangular paper to mark squares of size 1cmx 1cm as shown in the figure below. [Fig. (i)]

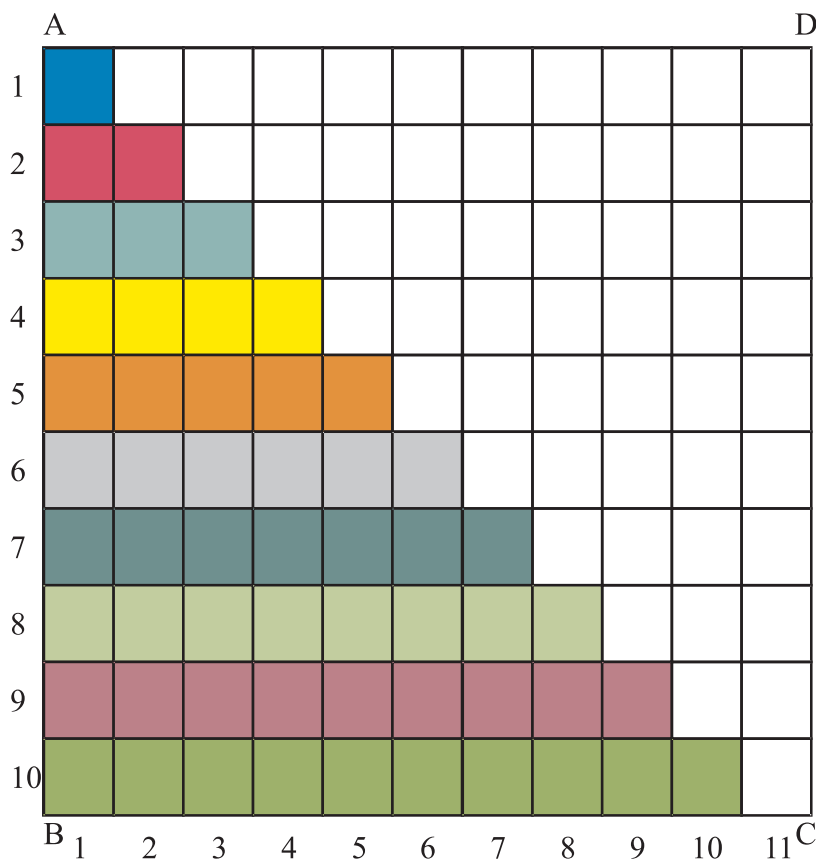


Fig. (i)

ACTIVITY 14



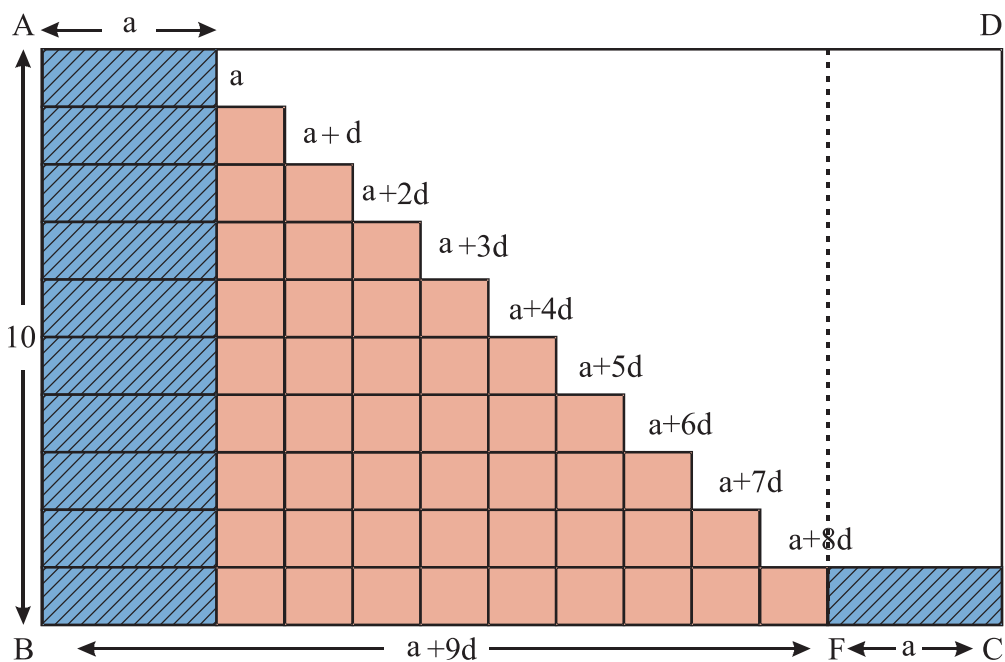
Title: To find the sum of first n terms of an arithmetic progression (A.P.).

Expected Background knowledge: Knowledge of arithmetic progression.

Objectives: After performing this activity the learner will be able to find the sum of any number of terms of an A.P.

Materials required:

- (i) Plastic strips
- (ii) Coloured chart paper
- (iii) Thermocol sheets
- (iv) Fevicol
- (v) Pair of scissors
- (vi) Scale, pencil and eraser



Preparation for the activity :-

- (i) Take a rectangular thermocol sheet ABCD.
- (ii) Cut some plastic strips of equal fixed length, denoted by a and some others of equal length denoted by d .
- (iii) Arrange and paste both types of strips so as to get terms, $a, a+d, a+2d, \dots, a+9d$ placed at unit distance apart and arrange along the rectangle, as shown above
- (iv) The last strip ends in F on BC , extend F To C by a fixed length a .

ACTIVITY 16



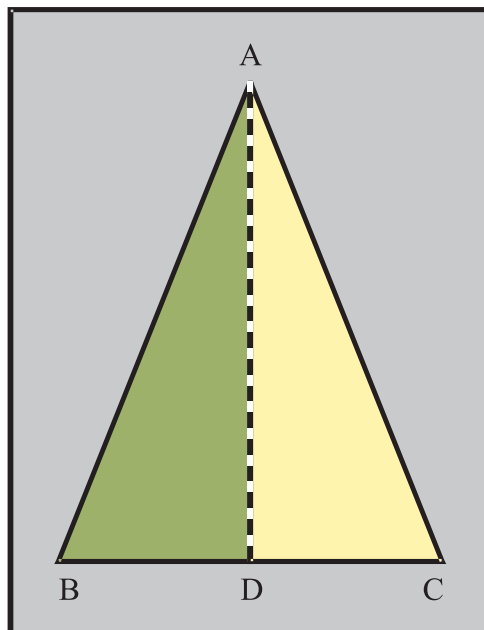
Notes

Title: To verify that the angles opposite to equal sides of a triangle are equal.

Expected background knowledge:

- (i) Construction of triangles
- (ii) Congruency of triangles
- (iii) Paper folding and superposition

Objectives: After completion of the activity, the learner will be able to demonstrate this concept and use it in proving the problems requiring this knowledge



Materials required:

- (i) Grey Card board sheet of size 25 cm x 30cm.
- (ii) Pencil
- (iii) Eraser
- (iv) Fevicol
- (v) Pair of compasses
- (vi) Scale
- (vii) Pair of scissors/cutter

ACTIVITY 17

Title: To verify the Mid-Point Theorem

Expected background knowledge:

- (i) Knowledge of parallel lines
- (ii) Knowledge of parallelograms
- (iii) Criteria for a quadrilateral to be a parallelogram

Objectives: After performing this activity, the learner will be able to:

- (i) recognize the importance of the result
- (ii) use it wherever needed for proving other results

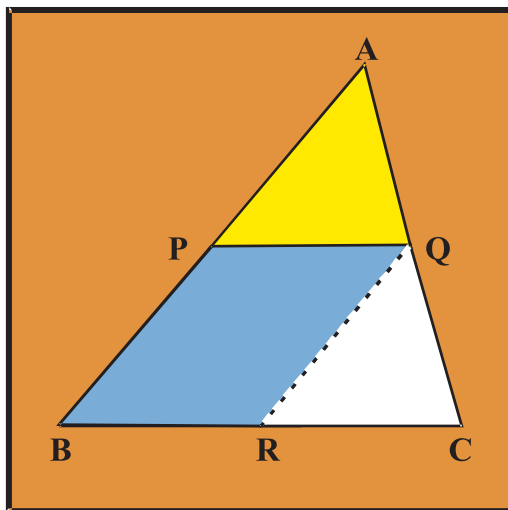


Fig. (i)

Materials required:

- (i) Orange coloured thick board
- (ii) Coloured and white sheets (papers)
- (iii) Gum/Fevicol
- (iv) Pair of scissors/ Cutter
- (v) Pair of compasses
- (vi) Pencils and sketch pens
- (vii) Scale and Eraser



Notes

ACTIVITY 18



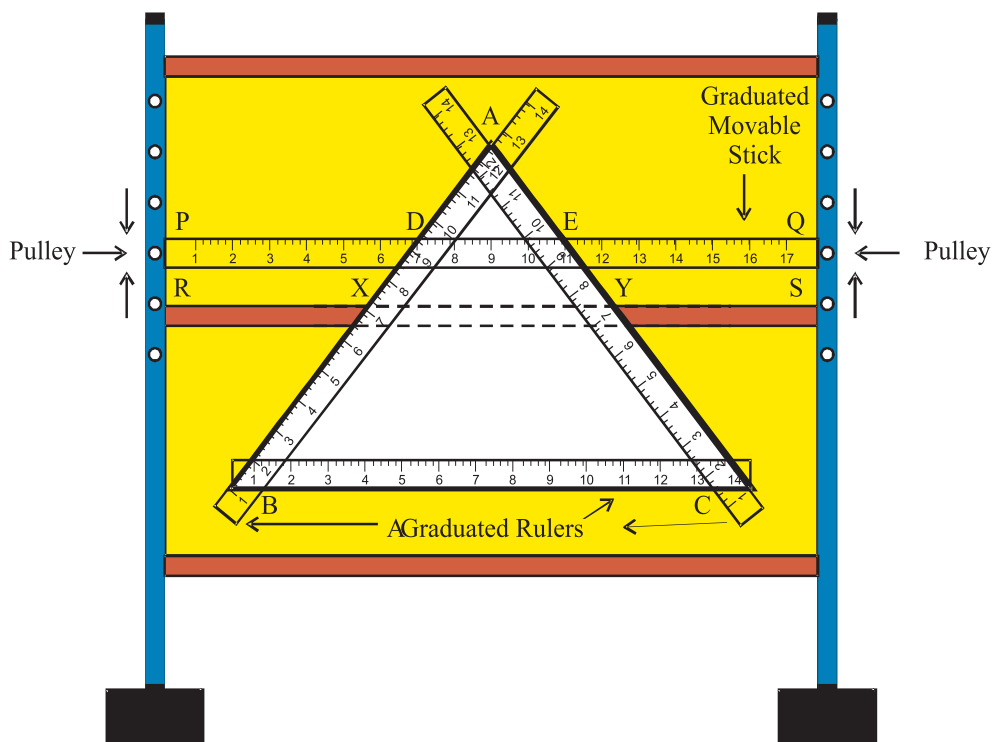
Notes

Title: To verify Basic Proportionality Theorem

Expected background knowledge:

- (i) Knowledge of parallel lines and their construction
- (ii) Knowledge of triangles, triangular regions and their construction
- (iii) Concept of ratio and proportion.

Objectives: After completion of this activity the learner will be able to demonstrate the theorem and apply it in situations, where the conditions of the theorem are fulfilled.



Materials required:

- (i) Stands with grooves so that they can keep any rod, fixed on these through pulleys, straight
- (ii) Wooden board with yellow paint on it
- (iii) A triangular region (of thick paper)
- (iv) Graduated scales (At least 4)
- (v) Screws and screw driver
- (vi) Glue/Fevicol

ACTIVITY 19

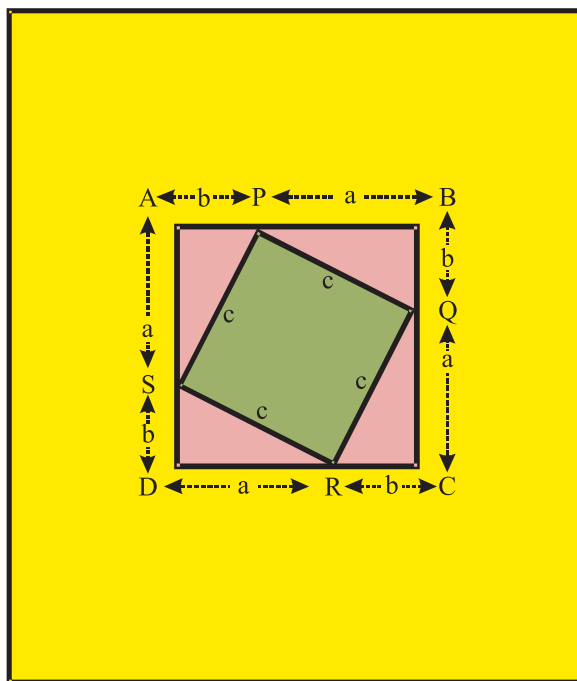
Title: To verify Pythagoras Theorem

Expected Background knowledge:

- (i) Knowledge about triangles and their types
- (ii) Similarity in triangles
- (iii) Idea of ratio and proportion

Objective: After performing this activity, the learner will be able to

- (i) identify right triangles from a given number of triangles
- (ii) use its result, wherever required, to simplify/or solve problems



Materials required :

- (i) Yellow Card Board
- (ii) Various Coloured Papers
- (iii) Pens/markers
- (iv) Fevicol
- (v) Pencil/Sharpner



Notes

ACTIVITY 21



Notes

Title : To find the area of a circle

Expected background knowledge:-

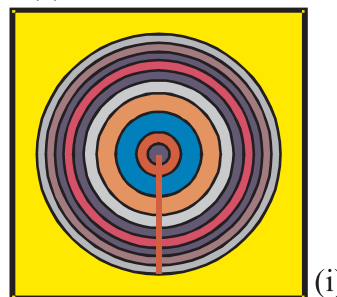
- (i) Concept of area
- (ii) Circle and its related terms

Objectives:- After the start and finish of activity, the learner will be able to quote the area of a circle correctly and use it wherever needed.

Materials required:

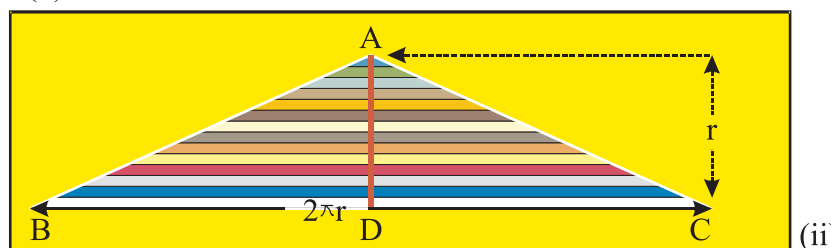
- (i) Threads of different colours
- (ii) Pair of compasses
- (iii) Pencil
- (iv) Pair of scissors.
- (v) Fevicol
- (vi) Yellow Thick cardboard

2(a)



(i)

2(b)



(ii)

Preparation for the activity: -

- (i) Cut-off the yellow thick board of size 15cm x 15cm
- (ii) Using pair of compasses, draw concentric circles as shown in fig. (i)
- (iii) Arrange coloured Threads on the concentric circles as shown in (i)
- (iv) Cut-off the circles from the innermost thread to the outermost thread and arrange them as shown in fig. (ii) as a triangle



Notes

Demonstration and Use

This model can be used to verify that:

- (i) Opposite angles of a cyclic quadrilateral are supplementary
- (ii) Exterior angle of a cyclic quadrilateral is equal to the interior opposite angle

ACTIVITY 23



Notes

Title: To verify that equal chords of congruent circles subtend equal angles at the centres.

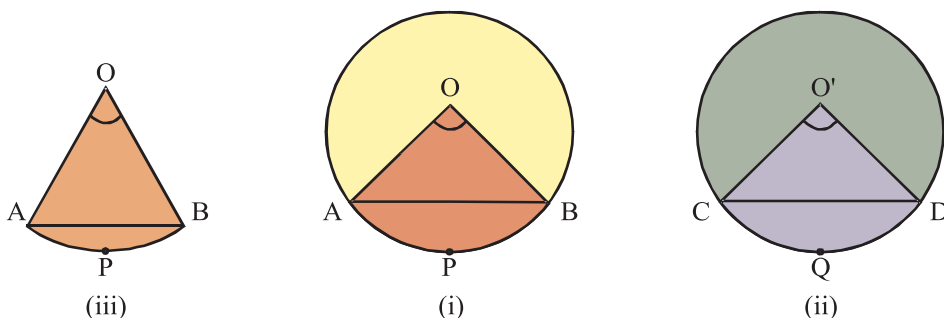
Expected Background knowledge:

- (i) Terms related to circles
- (ii) Congruency of triangles

Objective:- After performing this activity, the learner should be able to state and verify the result of the activity.

Materials required :

- (i) Coloured papers
- (ii) Sketch pens
- (iii) Pencil and scale
- (iv) Eraser
- (v) Pair of scissors
- (vi) Fevicol



Preparation for the activity: -

- (i) Draw two congruent circles (of same radii), one on yellow paper and the other on green paper with centres O and O'
- (ii) On yellow paper, draw a chord AB and on green paper, draw a chord CD of length equal to the length of AB .
- (iii) Join AO and BO and CO' and DO'

ACTIVITY 24



Notes

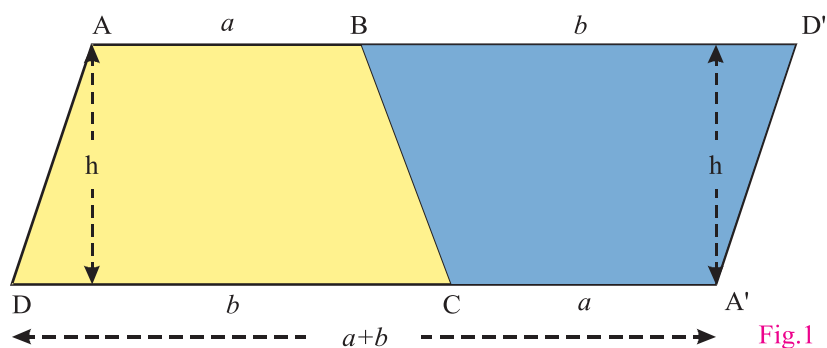
Title : To find the area of a trapezium

Expected Background knowledge: Recognition of a trapezium and knowledge of terms related to it.

Objective:- After performing this activity the learner should be able state the formula and find the areas of different trapezia.

Materials required :

- (i) Coloured papers
- (ii) Geometry box
- (iii) Fevicol
- (iv) Pair of scissor
- (v) Thermocol
- (vi) Hardboard



Preparation for the activity: -

- (i) Take a piece of hardboard
- (ii) Cut two congruent trapezia of parallel sides a and b from yellow and blue papers
- (iii) Paste the two trapezia on the hardboard as shown in Fig. 1.

ACTIVITY 25



Notes

Title: To find the total surface area of a cube

Expected Background Knowledge:

- (i) Knowledge and recognition of solids
- (ii) Characteristics of a cube

Objectives:- After performing the activity the learner should be able to state the formula of surface area of a cube and calculate it when asked for

Materials required :

- (i) White Paper
- (ii) Pencil and eraser
- (iii) Geometrical instruments
- (iv) Sketch pens
- (v) Scale
- (vi) Fevicol

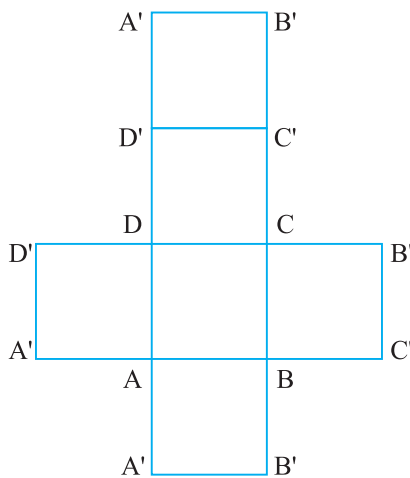


Fig. (i)

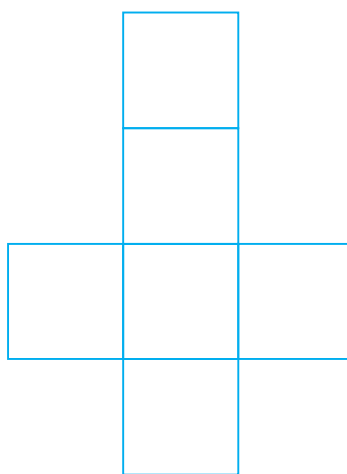


Fig. (ii)

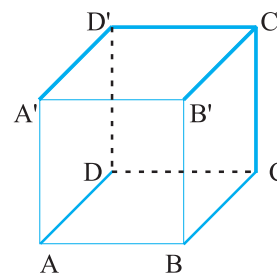


Fig. (iii)



Notes

Preparation for the activity:

- (i) Make two rectangles of dimensions 8 cm x 2cm and 6 cm x 2cm, intersecting along a common square ABCD
- (ii) Take square ABCD as base, and draw lines showing six different squares as shown in Fig.(i)
- (iii) Keep the square ABCD as base, and fold other squares along the edges, as shown in Fig. (ii)

Demonstration and Use :

Fold different squares along the folds to get a cube as shown in Fig. (iii) The total surface area of the cube is sum of the areas of 6 squares which is $6 (\text{side})^2$

Conclusion: The surface area of a cube is $6 (\text{side of the cube})^2$

ACTIVITY 26



Notes

Title : To find the formula for curved surface area of a cone-using the formula for the area of sector of a circle

Expected Background knowledge:

- (i) Idea of a cone
- (ii) Area of sector of a circle
- (iii) Length of arc of sector of a circle.

Objective:- After performing the activity, the learner should be able to state the formula for the curved surface area of a cone and calculate it when asked for.

Materials required :

- (i) Thick white sheet
- (ii) Red paper
- (iii) Sketch pens
- (iv) Pair of scissors/cutter
- (v) Fevicol

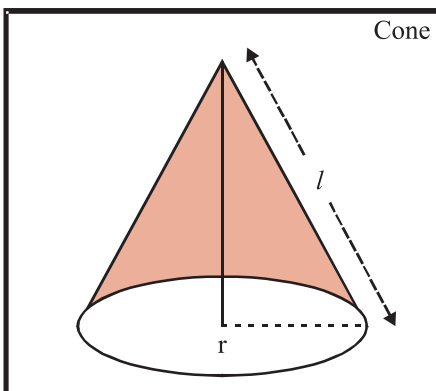


Fig. (i)

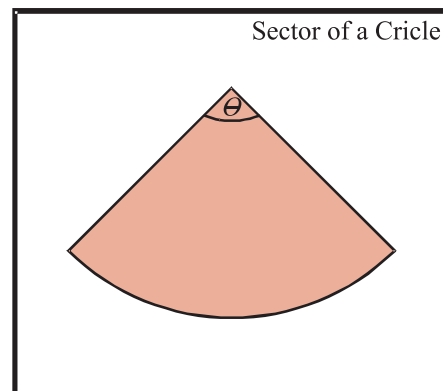


Fig. (ii)

Preparation for the activity: -

- (i) Take a cone made of thick red paper of slant height l and radius r
- (ii) Cut the curved surface of cone along any slant height by a cutter
- (iii) Paste the cut-out in the form of sector of a circle, of radius l on a white sheet of paper [See figure (ii) above]

