RESOURCE MATERIAL FOR SETTING UP OF MATHEMATICS LABORATORY AT UPPER PRIMARY AND SECONDARY LEVEL SCHOOLS IN TELANGANA STATE

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Preface

School mathematics education always faces a lot of difficulties due to the abstract nature of the subject as well as lack of motivation. Children develop fear in learning mathematics due to their bad experiences in understanding fundamentals as well as lack of proper guidance. In recent past many strategies have been attempted by mathematics educators to make mathematics teaching in student-friendly manner. Activity based teaching is one such method which provides hands on experience as well as joy of learning mathematics. The laboratory based approach of teaching mathematics gives ample opportunities for such activities which help to understand and discover the beauty, importance and relevance of mathematics as a discipline. It also correlates the problems to pupil's daily-life experience. Schools which have mathematics laboratory have found that the resulting stimulus have amply justified the experiment. With this background the government of Telangana has requested to take up this programme and accordingly it is formulated

In the beginning two days in-house meeting was held with the faculty of mathematics department and DMS teachers on 14th and 15th September, 2017. In this meeting various content areas from upper primary and secondary levels were identified to develop the activities based on them.

Next, a five-day workshop was conducted during 9th – 13th October, 2017 along with external resource persons at RIE, Mysuru. Based on the guidelines given in the in-house meeting certains activities were designed for the mathematics laboratory in the form of modules.

Next, a five day training program was conducted during 19th – 23rd January, 2018 at RIE, Mysuru. About 40 Key resource persons from Telangana participated in it. During this training programme resource persons conducted several activity based sessions to help the participants in understanding the meaning and the structure of Mathematics laboratory. Also they developed some modules under the supervision of resource persons on certain content areas of algebra, arithmetic, 2D geometry, etc. This training was appreciated and well received by all the participants.

Finally based on the materials developed during these activities some modules are finalised for the resource material after a careful observation.

I would like to submit my wholehearted gratitude to resource persons Prof. N.M.Rao, Sri. Prakashan, Sri. Suresh, Sri. Unnikrishnan and Sri. Gopalakrishnan for their constant support and involvement in the training programme as well as in the preparation of the resource material. I am grateful to our beloved principal Prof. Y. Sreekanth for his continuous encouragement and inspiration throughout the programme. Also I am thankful to Prof. A. Sukumar, head DESM, Prof. C.G. Venkatesha Murthy, Head DEE and Prof. M.U.Paily, Incharge CAL for their support and help.

I am also thankful to Prof. B.S. Upadhyaya, Dr. T. V. Somashekhar, Sri. B. Madhu, Sri. Ajaykumar.K and Sri.SanthoshRao for their support throughout this programme.I am also thankful to the staff of DESM, DEE and CAL for their secretarial help and cooperation.

Last but not the least I am thankful to all the participants for their valuable participation, preparation of materials and continuous interactions. I hope that this material will help them to improve the quality of classroom transactions and facilitate joyful learning in teaching mathematics.

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Mathematics Laboratory

Introduction:

The mathematics laboratory is a place in the school system to study mathematics by the method of 'learning by doing'. It has to make the learning of mathematics more meaningful. In this process of 'learning by doing', the students also learn some applications of mathematics in the real life situations.

Mathematics laboratory should facilitate in doing some simple experiments and projects (at least ten in every class of all students) to develop the following skills among the learners:

1. The skill of drawing the geometrical figures by using the geometry boxes.
2. The skill of doing all geometrical constructions related to the topics in their textbooks using geometry boxes.
3. The skill of derivation, understanding and interpretation of mathematical results.
4. The skill of developing and using some mathematical models, charts, teaching aids, etc.
5. Skill of mathematical games.

It should not be mere demonstration of the teaching aids by the teacher. The students should freely be doing some experiments themselves under the guidance of the teacher.

Materials

The establishment of mathematics laboratory does not involve a high cost. Most of the above skills could easily be developed by using the locally available materials like chart papers, cello tapes, thread, pins, sticks, plywood, cardboard, etc. The geometry boxes (of both sizes) should be made available in the lab. Chart papers of different colours, scissors, knives, blades, sketch pens of different colours, marker pens, short and long scales, transparent plastic sheets, nails, pencils, rubber band, elastic pieces and many items of the above type may be needed depending upon the experiment and teaching aid. The students should be encouraged to prepare the modules and aids themselves instead of procuring them from the market. The students also should be made to understand and explain the mathematical results and implications by using these aids.

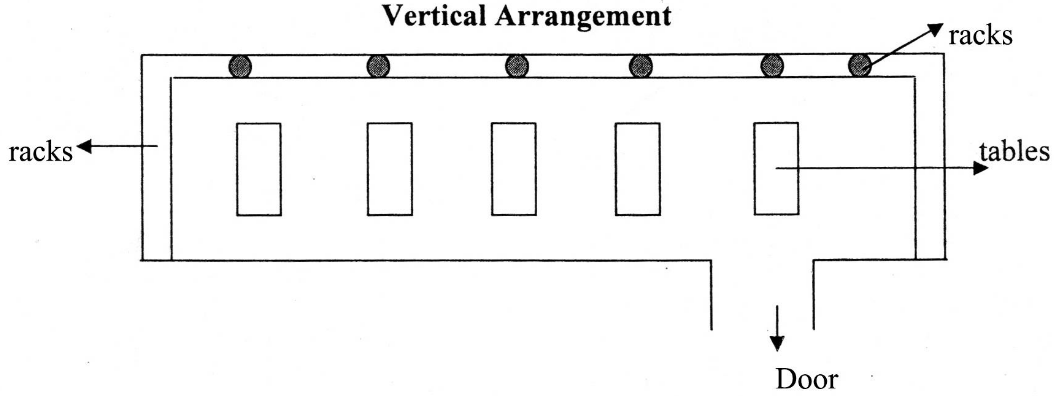
Space

The space required for doing such exercises is quite limited. The schools can try to get a separate room for this purpose. But in the absence of such a separate room, usual classroom can also be used for this purpose. It is the type of work that is being done that matters more than where exactly it is conducted. However, you will need some corner, where you can preserve these items safely for the subsequent uses. Without a proper place, the materials will lose half of its size. The things will remain scattered, unarranged and exposed to dust. They are likely to lose their colour and attraction.

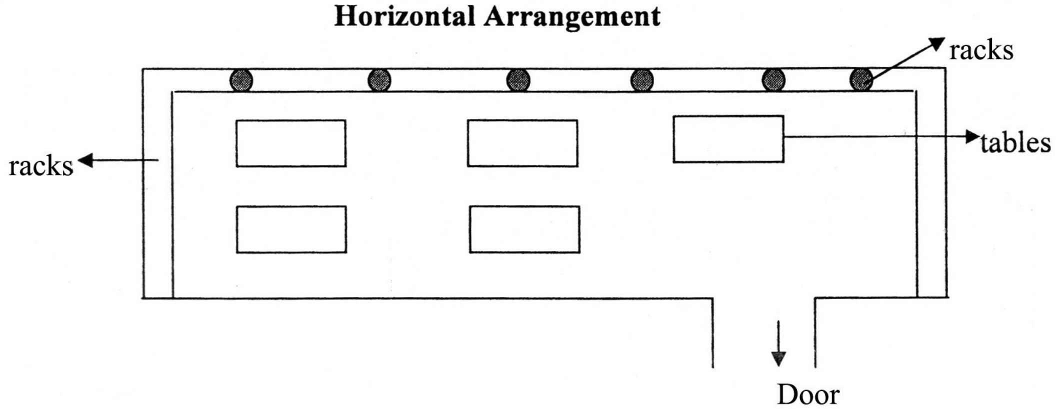
Physical Arrangements

The tables can be arranged either horizontally or vertically as shown below.

Vertical Arrangement



Horizontal Arrangement



There should be racks/ almirahs in the sides to store the items (teaching aids/ models) prepared by the students.

The furniture can be of ordinary type (rough wooden tables), which are suites for the batches of five or six students to sit around it and work. There should be sufficient space to move around.

Computers

If the school has computers, then they can be used to explain how teaching aids and models can be used in the classrooms. Animation techniques cambe used to improve the visuals. Planning is needed to keep these computers in a proper place in the maths lab.

Classification

A register can be maintained to give all the details and explanation about the teaching aid. It is better to classify all these models classwise and conceptwise. For example, all the IX standard paper folding experiments can be put in one place, while all the geometry experiments using a geoboard can be kept adjacent to it.

Practical records

All the students should maintain the practical records of the experiments which they have performed in the laboratory. The following procedure may be adopted.

Title:

Objectives:

Materials needed:

Procedure (with diagrams and details):

Conjecture (expected result/observation):

Analysis (Interpretation of the observation / conjecture):

Proof (Explanation):

Result:

References (if any):

Working Models:

As far as possible, students can be encouraged to prepare the working models instead of the usual charts and graphs, etc. In order to achieve the teaching aids/ models of better quality, appropriate incentives can be given to the children every year evaluating the quality of materials once a year. The method can also be used to discard the old ones and include the new improvised models in the laboratory.

Applications

The laboratory can be used to learn mathematics with the help of concrete objects and speciality for the children who finds it difficult to understand the abstract form of theorems (and results) in mathematics. If the students do some practical work like surveying the filed, finding the height of the tree, measuring the playgrounds, cutting the wood into proper shapes (sphere, cuboid, cone, etc) etc. This will be quite useful for the students after schooling when they take up some vocation of their choice.

The slow learners who cannot be attended to in the regular classroom can be given sufficient help during these practical works in laboratory.

The gifted ones also can consult reference mathematics books kept in the laboratory and take inspiration from the lives, works and anectodes relating to the great mathematicians. Club activities also can be conducted here.

Method

The method adopted in the mathematics laboratory should not be the method of demonstrator by the teacher. Instead, it has to be the '*self-discovery method*', to be adopted by the students. The students should do the experiments themselves. The major steps to be taken are as follows:

1. The children will do the experiment repeatedly under the guidance of teacher and observe the outcome repeatedly i.e the children predict (conjecture) the result experimentally (or inductively) by repeating the experiment several times.
2. Prepare or disprove the prediction by the mathematical methods and conclude the result.
3. Try to generalize the result whenever possible.

Now we give an example to show how the 'discovery method' can be adopted.

Example:

Title: Chord of a circle

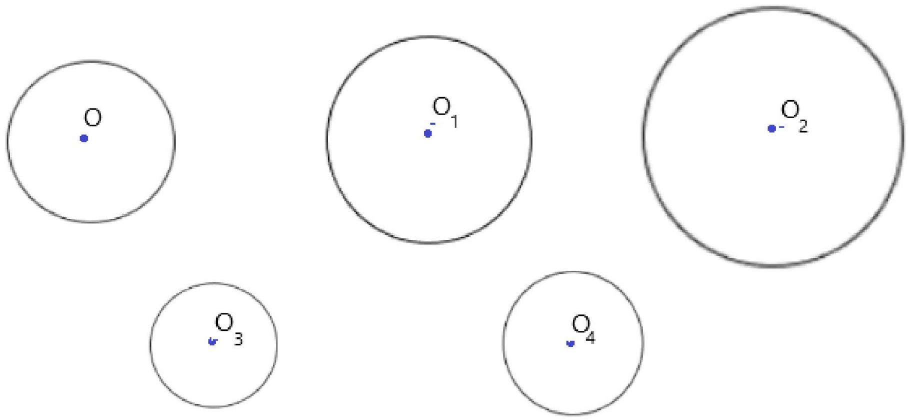
Objective: To show that the perpendicular drawn from the center of the circle to any chord, bisects the chord.

Materials needed:

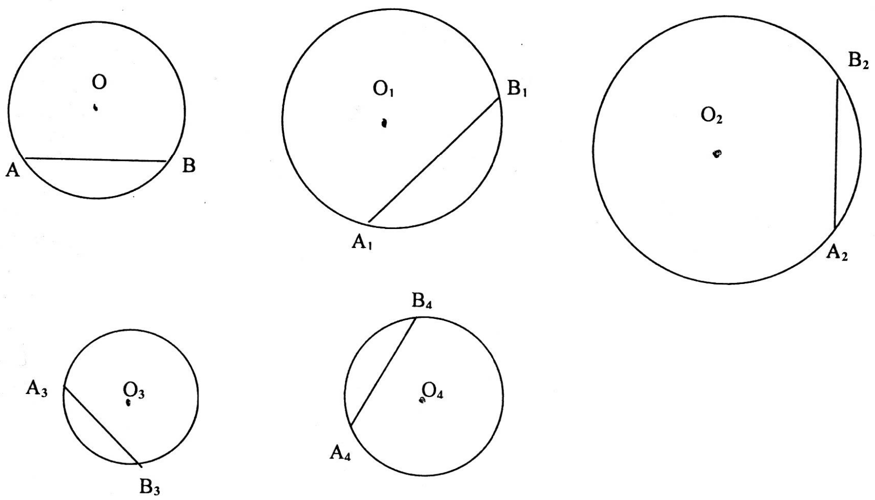
i. About five circles of different radii cut from the paper pieces.
ii. Geometry box
iii. Pencil

Procedure:

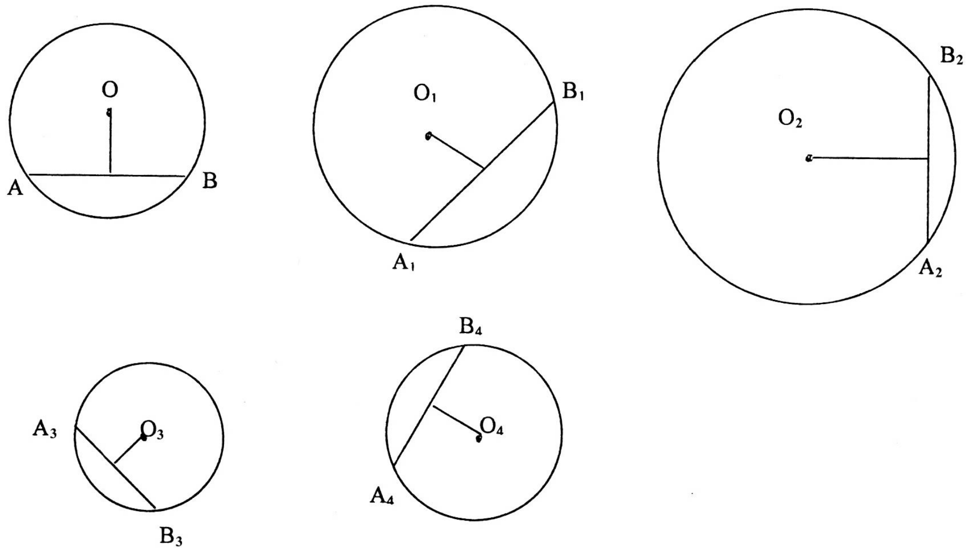
Draw five (or any number) circles of different radii on the chart paper and cut them to form circular shapes, as shown below (with centers O, O_1, O_2, O_3, O_4.)



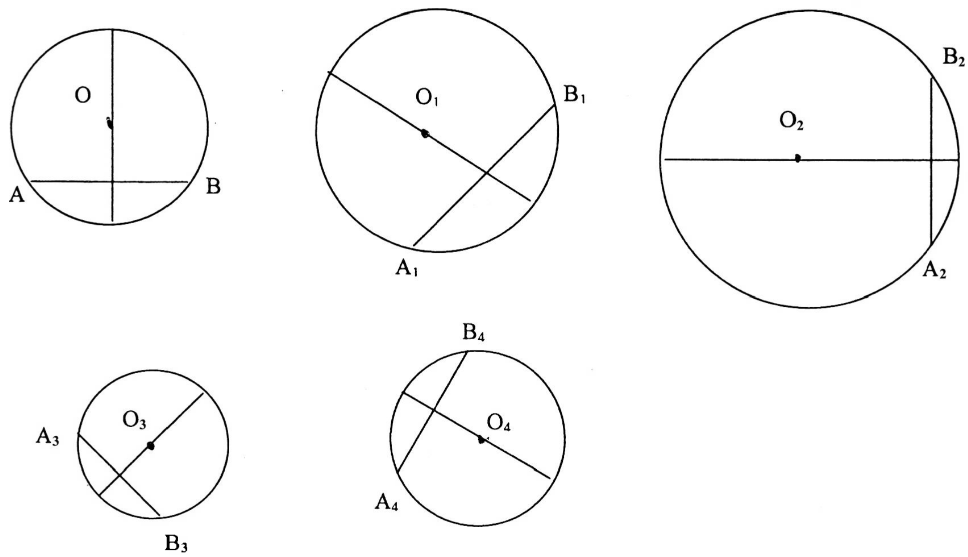
Draw chords AB of different lengths in these circles. For example,



Draw perpendicular OP from O on the chord AB using a set-square. Similarly draw perpendicular O_1P_1, O_2P_2, O_3P_3 and O_4P_4 in the other circles also.



Now, fold all the five circles along OP, O_1P_1, O_2P_2, O_3P_3 and O_4P_4 as shown below.



Now you will observe that in all cases

A coincides with B

A_1 coincides with B_1

A_2 coincides with B_2

A_3 coincides with B_3

A_4 coincides with B_4

A_5 coincides with B_5

The teacher has to insist the students to observe this fact in their cirlces (i.e the end points of chords coinciding).

'A' coincides with 'B' means that the line segment AP is equal to PB. This fact is clear from the other circles also:

$AP = PB$

$A_1P_1 = P_1B_1$

$A_2P_2 = P_2B_2$

$A_3P_3 = P_3B_3$

$A_4P_4 = P_4B_4$

Conjecture (Observation):

The chord AB has been divided into two equal parts

The teacher explains the analytical way of proving the above result in the classroom using the congruence property of triangle

Thus the children conclude that the perpendicular drawn from the center of the circle to any chord of that circle bisects the chord.

ACTIVITY-1

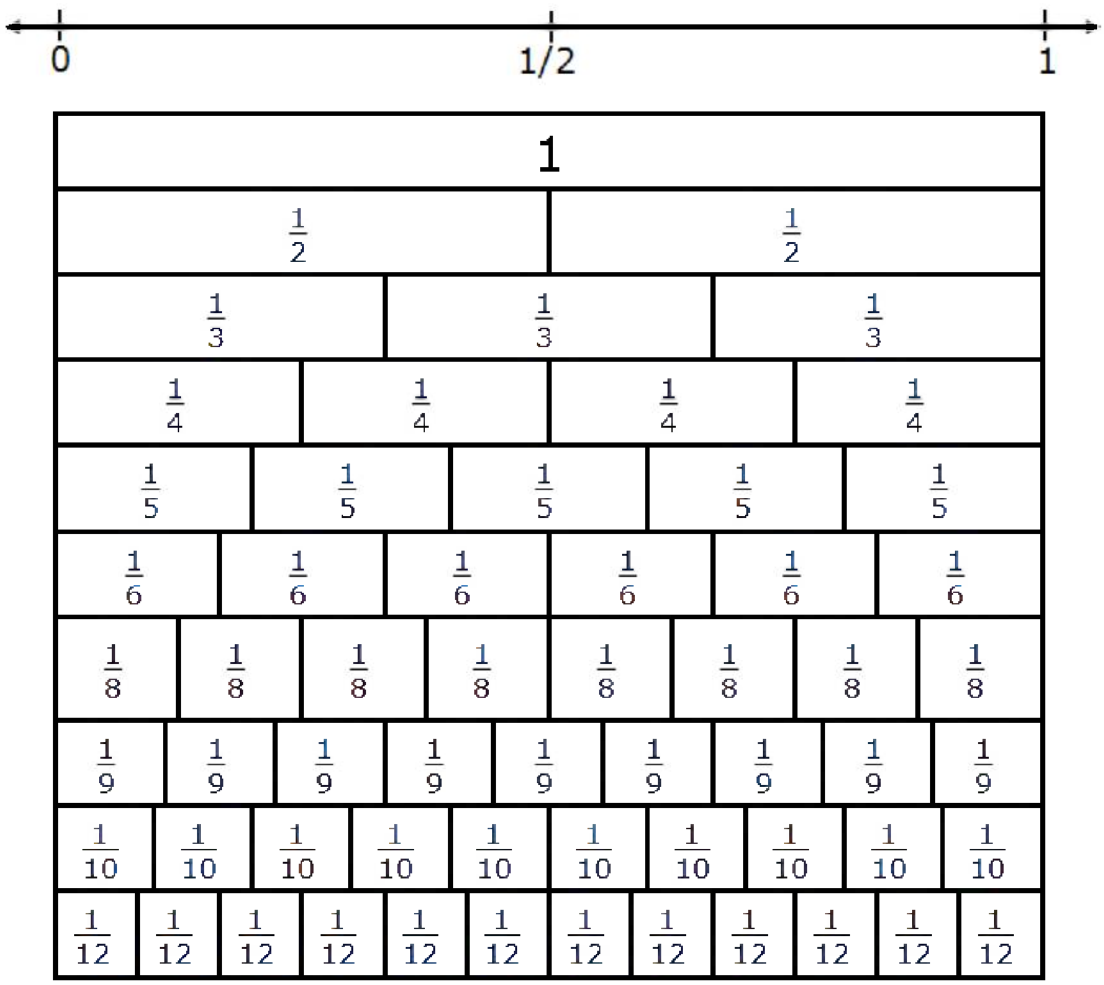
<u>Fraction Board</u>

Learning outcome: Identifying equal fractions

Addition and subtraction of unit fractions

Materials required: Plywood or cardboard, Chart paper, string, and bob

The concept of fractions of a whole is introduced in primary school. Students find it difficult to master and often even understand the concept of a fraction and the meaning of the numerator and denominator. A fraction chart is a very useful teaching aid which can be used for this purpose.



A fraction chart is made from a piece of plywood or thick cardboard which is large enough to be put up on the wall. Narrow strips of chart paper of equal length are pasted on the board at equal distances. Let the first strip represent 1. Divide the next strip into two equal halves and mark the fractions 1/2 and 2/ 2 . Divide the next strip into three equal parts and mark the fractions 1/3 ,2/3 and 3/3 . Continue in this way till all the strips are divided to obtain smaller and smaller fractions.One can make a chart till the fractions 1 /20 , 2/ 20 . . . if space is available. Now suspend two long strings from the top of the board with bobs attached at the end. The strings remains vertical like a plumb line.

The fraction chart can be used for showing the part whole relationship: how many one thirds make up one? Another important use of the chart is to show equivalent fractions. Drop the plumb line over a fraction, and if the chart is aligned vertically all the fractions which coincide with the plumb line are equivalent fractions. The students also learn that any fraction of the form n/n is equal to 1. It is also possible to do some Simple addition and subtraction of fractions with the chart. If two fractions are to be added find their equivalent fractions on the same line of the chart by dropping the plumb line. Now it is possible to add the fractions easily by adding the numerators.

ACTIVITY-2

Fraction game

Learning outcome:

Addition of simple fraction.

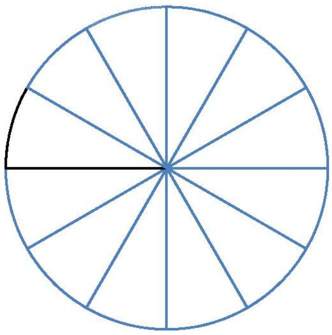
Materials

1) Fraction disc of the fractions of 1/2, 1/3 ,1/4,3/4 1/6,1/12, 2/12,3/12, 4/12,5/12 ,6/12, 7/12,8/12,9/12, 10/12, 11/12

2) Tokens/cards of the same fractions above

1/2	**1/3**	**1/4**	**10/12**	**11/12**

3) 4 et of circles divided to 12 equal parts as shown in figure



Procedure

Put the circle in front of each player. Shuffle the tokens /Cards and pile it in the middle of the group along with the fraction discs .Now you are ready to start the game. The first player takes a token from the pile and takes that part of fraction disc and puts that on the circle places near him and puts the Token below the pile. The second player does the same and so on .the winner is the one who completes circle with fraction discs. Repeat the game by changing the fractions

Reflective Questions

Which fraction is same as ½ in the set?

Develop such a game with fraction 1/24

How will you teach equal fractions using this game?

ACTIVITY-3

Fraction Operation board

Learning objectives:

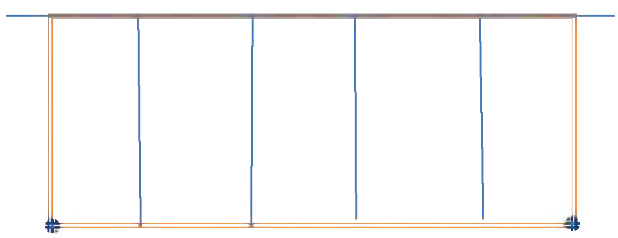
Identify the concept of addition and subtraction of fractions.

Materials

Form board/ Hard board cut in to rectangle shape and put hole in border of all sides as shown in figure, rubber band sticks, Beeds.

Procedure

1. Using the above board child can identify the concept of addition and subtraction of fraction.
   Example: $\frac{2}{5} + \frac{1}{3}$
   Divide the board vertically or horizontally 5 parts using rubber band and stick fixing in the hole as shown in the figure below. (Denominator of first fraction)



Also divide the board 3 parts (Denominator of second fraction) to the other direction.

* *	* *	*	*	*
*	*			
*	*			

2. Put the beeds in the columns as shown in figure above, First put 6 beeds to 6 columns so that it represents $\frac{2}{5}$ part of the board. Then put 5 beeds to 5 columns so that it represents $\frac{1}{3}$ part of board.
3. Count the number of beeds in the board.
   6+5=11 beeds, Total number of column is 15 that is $\frac{2}{5}+\frac{1}{3}=\frac{11}{15}$
4. Repeat the activity by changing the fractions and generalize the concept.
5. How is this used in subtraction?
6. Suppose $\frac{2}{5}-\frac{1}{3}$
   Number of beeds which represents $\frac{2}{5}$ is 6, also the number of beeds representing $\frac{1}{3}$ is 5. So by taking 5 from 6 the remainder beed is 1.
   i.e 1 out of 15
   There fore $\frac{2}{5}-\frac{1}{3}=\frac{1}{15}$.
7. Repeat the activity by changing the fractions and generalize the concept.
8. Can this be possible for improper fraction? If so how can we arrange the columns?

ACTIVITY-4

Fractometer (Fraction meter)

Learning Objective:

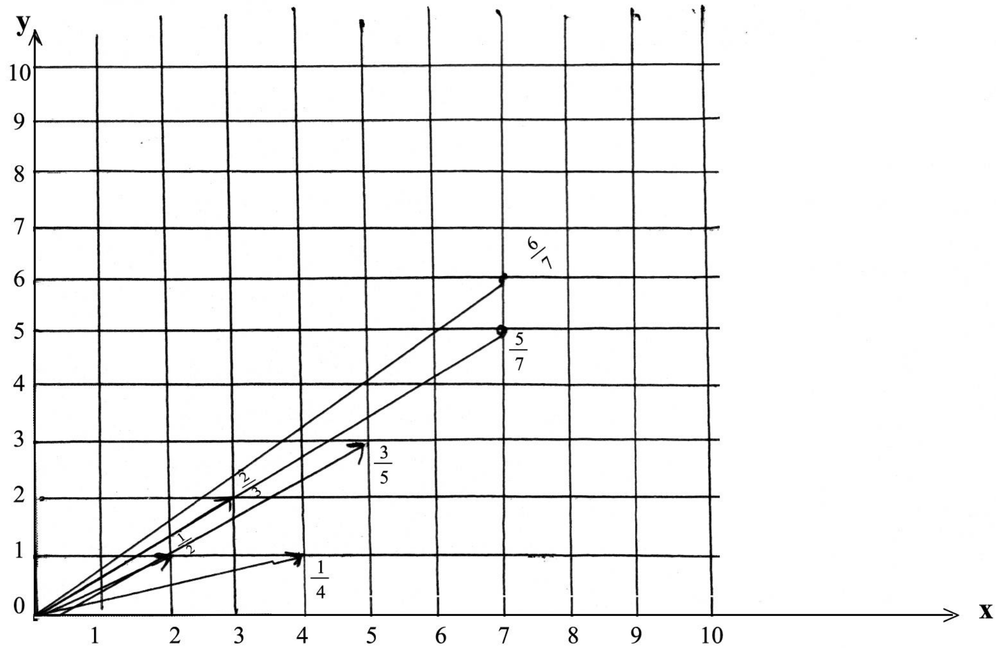
Compare different fractions geometrically.

Materials

Sun pack sheet, twins pin graph paper etc

Procedure

Let us consider some fractions for example $\frac{1}{2}, \frac{2}{3}, \frac{5}{7}, \frac{1}{4}, \frac{6}{7}, \frac{3}{5}$. For comparing these fractions we have to identify a common denominator. But in fraction meter we can compare the fractions by measuring an angle. Paste the graph paper on the sun pack sheet. Draw X and Y axis and mark Numerator on Y-axis and Denominator on the X-axis as shown in the following figure. Plot each fraction and put at that point. Fix twin from origin to each pin.



Here the line represents $\frac{1}{4}$ makes a smallest angle with the X-axis. Similarly the biggest angle here is for $\frac{6}{7}$.

If the angles with X-axis become larger and larger, the fractions also will become larger and larger. By this observation itself we can say that

$$\frac{1}{4} < \frac{1}{2} < \frac{3}{5} < \frac{2}{3} < \frac{5}{7} < \frac{6}{7}$$

Reflective questions

1. Plot the points $\frac{1}{1}, \frac{2}{2}, \frac{3}{3}$ etc and write the observations.
2. Mark $\frac{1}{2}, \frac{1}{5}, \frac{3}{5}, \frac{3}{8}, \frac{3}{2}, \frac{4}{5}, \frac{7}{5}, \frac{10}{3}$ and compare them.

ACTIVITY-5

GAME BOARD

Learning objectives: Addition and subtraction of positive and negative integers

Materials: Game board (foam board), 2 dice, on one dice numbers marked with -1,-2,-3,4,5,6 and on the other 1,2,3,-4,-5,-6 and tokens.

Winner 31	30	29	28	27	26	25	24	23
14	15	16	17	18	19	20	21	22
13	12	11	10	9	8	7	6	5
-4	-3	-2	-1	→ Start ←	1	2	3	4
-5	-6	-7	-8	-9	-10	-11	-12	-13
-22	-21	-20	-19	-18	-17	-16	-15	-14
-23	-24	-25	-26	-27	-28	-29	-30	-31 Out

Rules of the game:

- Two or more than two students can play the game
- Use different colour token for each participant
- Place all token at the start position
- Throw two dice together and add or subtract the numbers on the dise. Whichever is maximum may be selected.
- Move the tokens according to the answer noted in notebook by adding or subtracting the numbers on dice.
- The person who reaches the position 31 is the winner and those who reach the position -31 will be out of the game

ACTIVITY-6

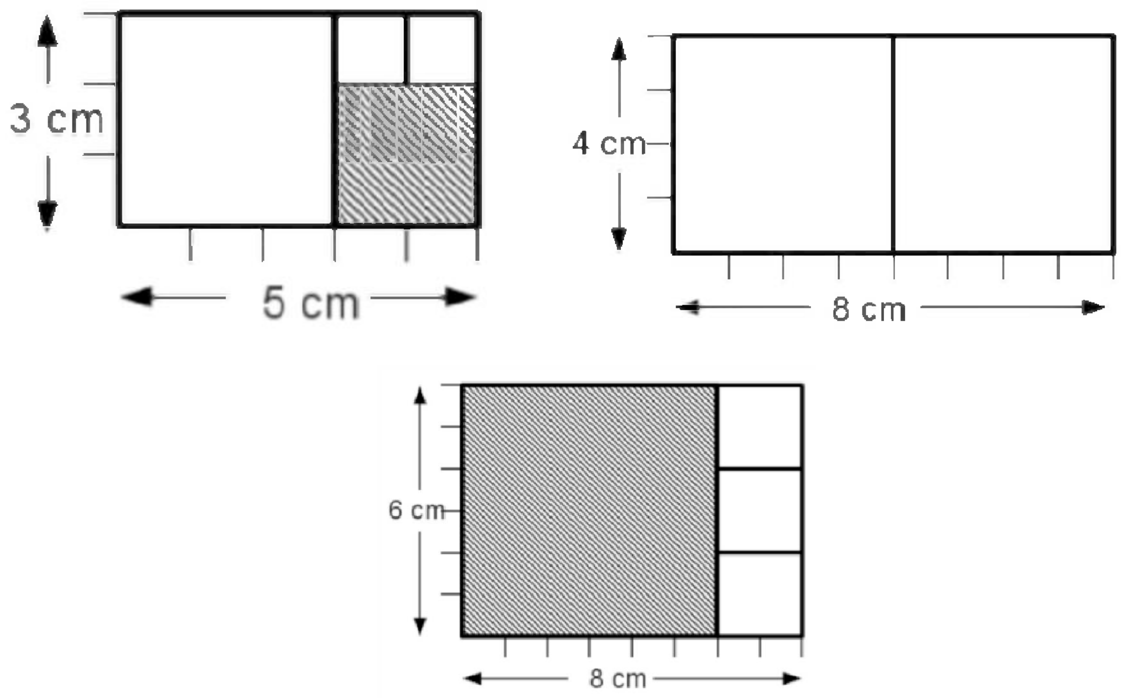
Highest common Factor

Learning outcome: To find the H.C.F Geometrically

Materials required: a piece of paper, a scale and a pencil.

Procedure

The H.C.F of a pair of integers can be found by an interesting geometric method. (H.C.F. of a set of integers is the largest integer which can divide all the numbers without remainder). In order to do this, we only need a piece of paper, a scale and a pencil.



Suppose the two integers whose H.C.F. is to be found are a and b. First draw a rectangle on the paper of length a and breadth b. (If a and b are large take the length and breadth as a/2 and b/2 , or in some suitable proportion). From this rectangle, mark off the largest possible square. If 'a' is greater than b, this will be a square of side b. After marking off the square, the portion which remains is a rectangle with sides b and a – b. Again mark off the largest possible square from this rectangle. Continue this process till you obtain a square instead of a rectangle. The measure of the side of this square is equal to the H.C.F. of the original pair of numbers.

This method is based on the fact that if ‘a’ and ‘b’ are both divisible by a number, then a – b will also be divisible by the same number. The same principle is applied recursively to obtain the H.C.F.

ACTIVITY-7

Multiplication using OHP sheet

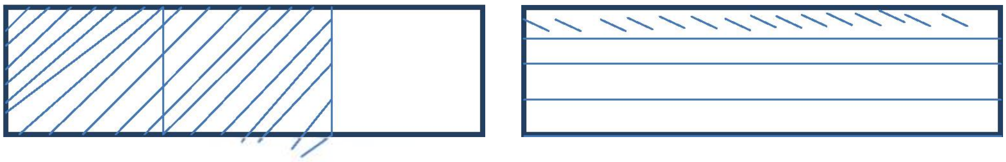
Learning Objectives: Identify the concept of multiplication of fractions.

Material: OHP Sheets, Permanent marker

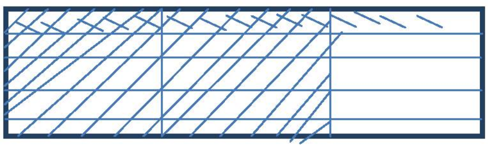
Procedure: Child can generate the concept of multiplication

Eg: $\frac{2}{3}$ X $\frac{1}{5}$ i.e $\frac{1}{5}$ of $\frac{2}{3}$.

- Take 2 pieces of (same size) rectangle in OHP sheet.
- Mark $\frac{2}{3}$ in one sheet and mark $\frac{1}{5}$ on the other. (Mark with different colour/shade the corresponding portions) as shown in the fig.



- Put the second sheet on the first one as shown in the figure below



- Identify the number of columns crosses. Also identify total number of such columns. Here no. of crossed columns is 2. Total number of columns is 15. Therefore

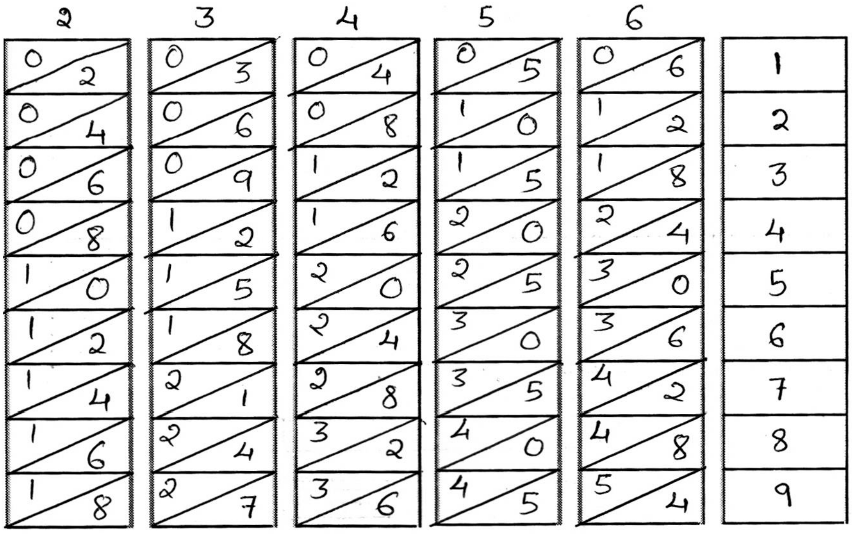
$$\frac{1}{5} \times \frac{2}{3} = \frac{2}{15}$$

ACTIVITY-8

Easy multiplication by Napier's strips

Learning objectives: To solve problems involving multiplication of integers

Materials: Foam board sheet or chart paper, strips 3 or 4 sets of 1 to 9 strips of equal size, as shown in figure



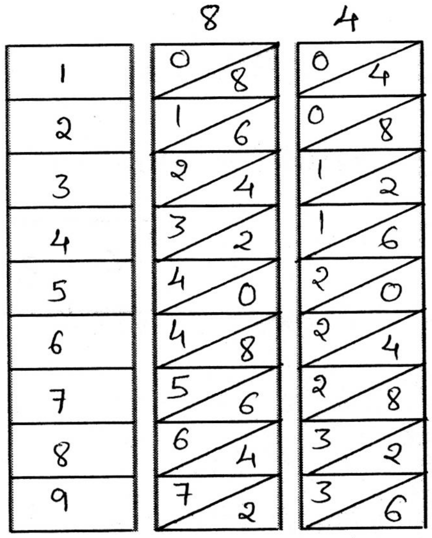
The Napier strip 2 contains all multiples of 2 as shown above. Similarly the other strips 3,4,5,... etc. are also prepared as shown above.

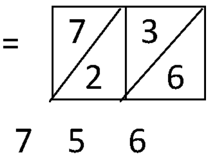
Procedure:

Multiplication of big numbers can be done using the Napier strips.

Example: i) 84 X 9

Arrange the two strips 8 and 4 side by side as shown below./ It becomes a multiplication table for 84.

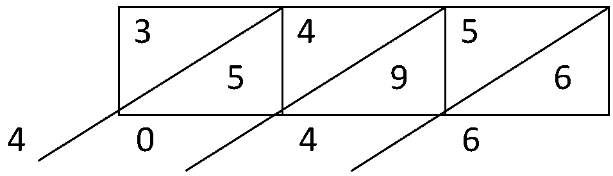


From the arrangement, it is clear that 9 X 84 = 

= 756

ii) 578 X 7

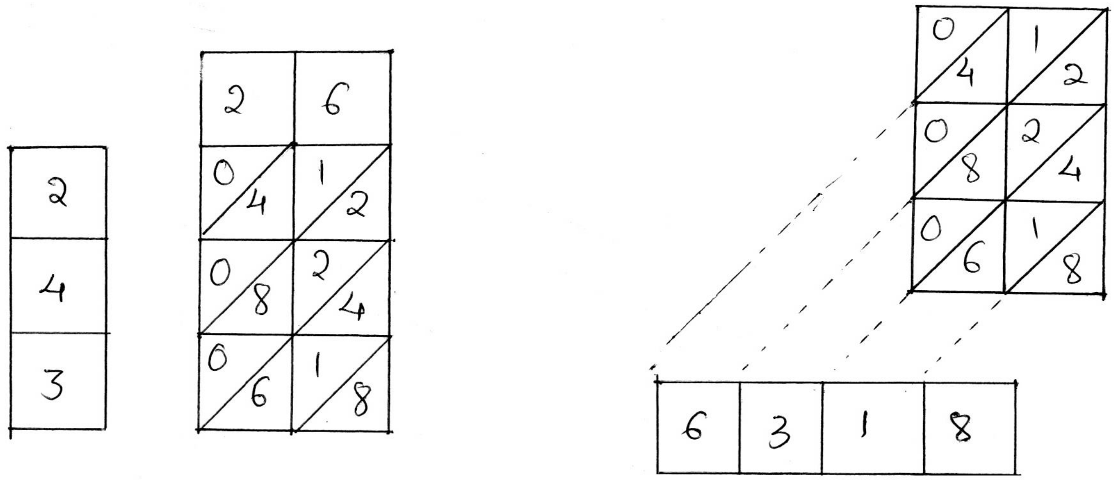
Arrange the three stripes 5,7,8 side by side in the similar way and find the product.



= 4046

Example II:

Consider 243 and 26 as shown below.



Therefore 243 X 26 = 6318.

- Try to find the justification for writing the product in two places and adding diagonally.
- When the strips of 5,7,8 are arranged in 7,8,5 order it becomes a multiplication table of 785.

Questions:

1. Can you find the product of 93587 and 8?
2. Can you find 9876543 X 9 using Napier strips?
3. Can Napier's strip be used to find the product of two digit numbers with three digit numbers? How is it possible? Eg: 382 X 26 = ______?

ACTIVITY-9

Percentage-Board

Outcomes:

Identify the geometrical vision of percentage in solving problems related to daily life.

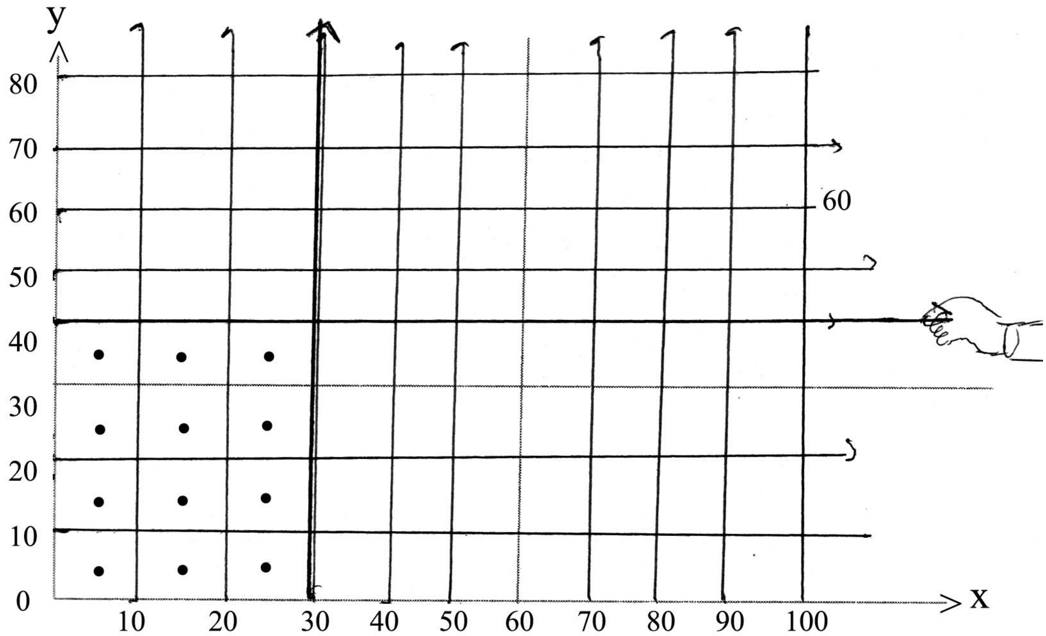
Materials required

A 10×10 unit square board using form board, pin and twins.

Procedure:

What is the relation between 40% of 30 and 30% of 40?

Construct a 10×10 unit square form board and mark 10, 20, 30,….,100 on on the bottom and left side left side as follows.



Here students are identifying 40% of 30 by using pin and twins as shown in the figure, same way as 30% of 40.

In both the cases they identify a rectangle, a 12 number of unit squares.

i.e. 30% of 40 = 40% of 30 = 12

How many different ways we can arrange a rectangle using 12 unit squares.

Taking different examples they can come out.

12 = 20% of 60

12= 60% of 20 etc.

And 30% of 40 = $\frac{30}{100} \times 40 = 12$

Area of rectangle is 20, Find the relation between its length and breadth. Explain this in terms of percentage.

Reflective questions.

1) Using 10x10 form find the following.
   a) 25% of 30
   b) 10% of 120
   c) 50% of 50
2) A group work for identifying different levels of the concept percentage (length, weight, money etc.)
3) Teachers give the following different materials to each group and asking tnem to mark 50%, 25%, 20% and 10%.
   a) Meter scale
   b) Twins
   c) Paper strip
   d) News papers
   e) Circles
   f) Rupee 60
   g) 1 Kg rice
4) Shade a 20x20 grid as following using colors with the explanation
   1) 6% of red
   2) 2% of blue
   3) 10% green
   4) 21% yellow

ACTIVITY-10

Place Value board

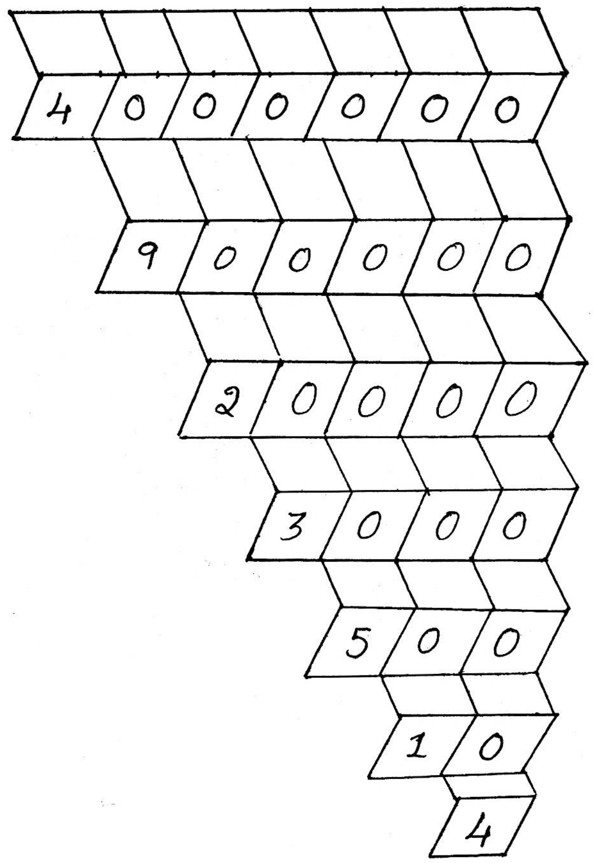
learning objectives: The concept of place values

Materials: Sunpack sheet, Cello tape, OHP sheet, Rigid sheet, cutting knife

Procedure:

- Cut the sunpack sheet/cardboard sheet into 4cm width scale type. Then join the pieces using cellotape so that we can fold the parts or sclae (fold both sides).
- Fix the OHP sheet on each scale for fixing the number card.

Example: 4923514 = 4000000 + 900000 + 20000 + 3000 + 500 + 10 + 4



ACTIVITY-11

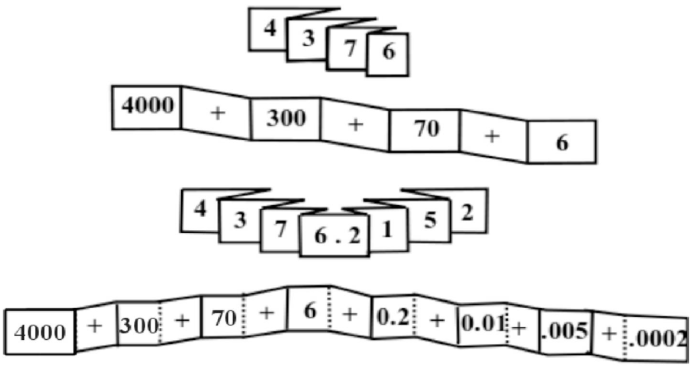
Place value Snake

Learning outcome : to understand the concept of place value

Materials required: Strip of paper, pen

Procedure

To make a place value snake, take a strip of paper and fold it in the manner shown in the figure.



Write a number; say 4376, on the visible part of the folds as seen in the figure. Hidden away in the folds of the paper are zeros and '+'s. When the snake is opened, the expanded form of the number appears.

Any child can make the place value snake and show it to his friends. In the course of doing this he learns to associate the place of a digit with a power of 10. The snake can also include decimal numbers as shown in the figure.

ACTIVITY-12

Products of decimal numbers

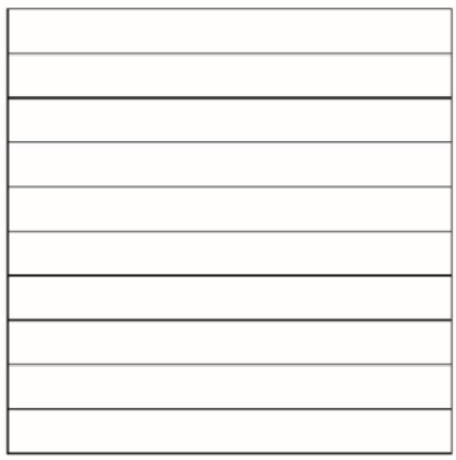
Learning Objective: To understand the multiplication of decimal numbers

Materials Required : Sketch pens, square paper, pencil and a ruler.

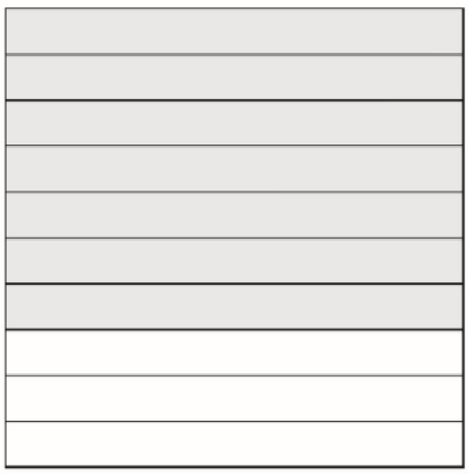
Procedure :

Step 1. Take a square sheet of paper.

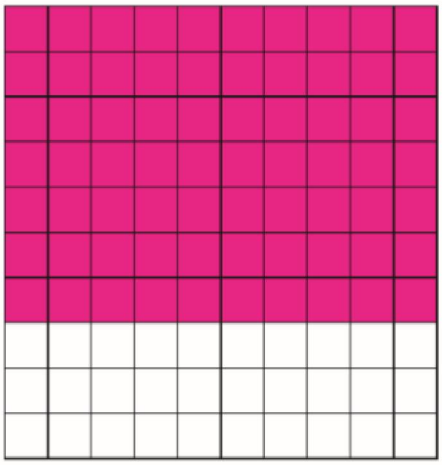
Step 2. Divide this square into10 equal parts by drawing horizontal lines as shown below. Each part represents 1/10 = 0.1



Step 3. Shade 7 parts out of 10 so as to represent 0.7 as shown below

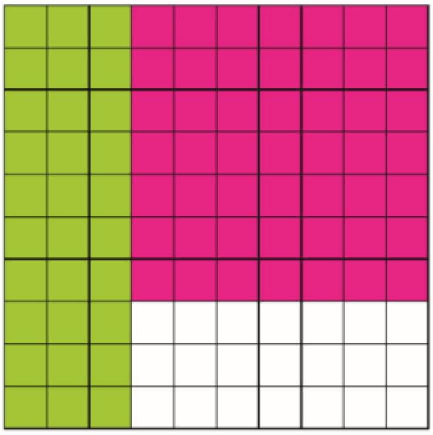


Step 4. Now draw, 9 vertical lines on the same paper at equal distances such

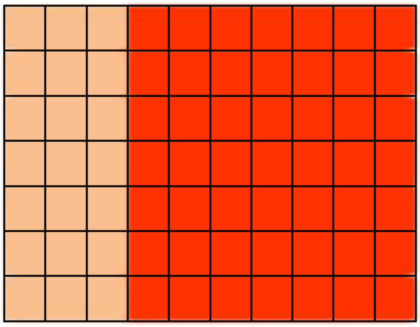


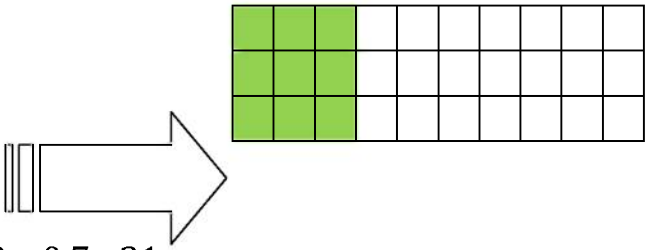
that each vertical part represents 1/10 or 0.1 as shown below

Step 5. Shade 3 vertical parts so as to represent 0.3 as shown in shown below



Step 6. The double shaded portion represents the product 0.3 x 0.7.





0.3 x 0.7=.21

Reflective questions: Represent the product 0.5 x 0.5. using another square sheet.

ACTIVITY-13

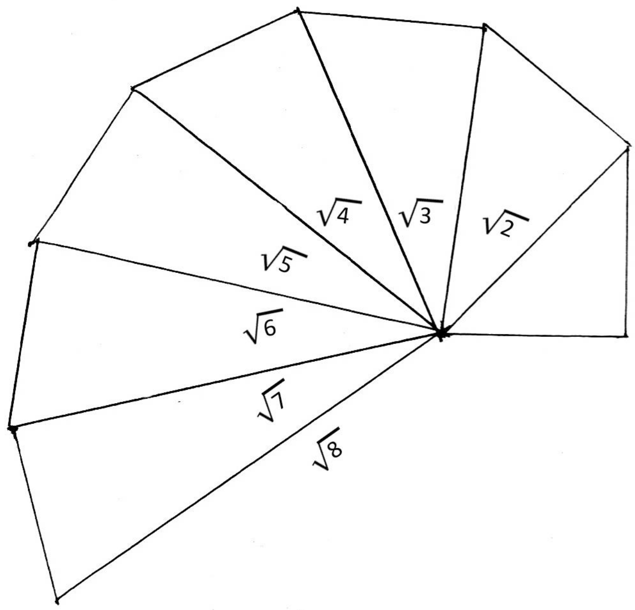
Representation of Irrational Number Using Twain and Foam Board

Materials:

Foam board, Twain, Pase pin and set square.

Procedure

1. Take 50×50 cm Foam board, Mark a right angle on the board as shown below.
2. Draw one unit perpendicular to the hypotenuse of the triangle.
3. Draw again the hypotenuse and so on. Then the hypotenuse in orderly $\sqrt{2},, \sqrt{3}, \sqrt{4}, \sqrt{5}, \sqrt{6}, \sqrt{7}, \ldots \ldots$ in spiral form.



4. The students can be encouraged to predict how the irrational numbers repeat among the numbers in the spiral.
5. Predict the shape of this spiral after completing one round.
6. Among the numbers represented in spiral form find out which numbers are rational and irrational.
7. Find the patterns to decide how the irrational numbers appear in between the rational.

ACTIVITY-14

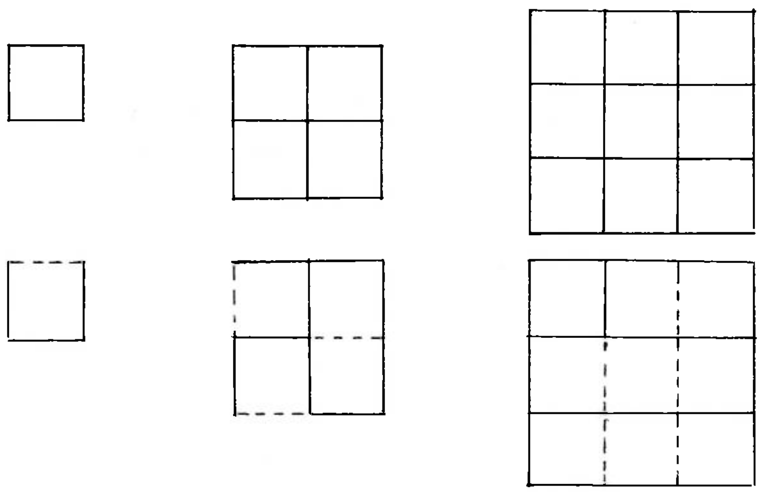
Systematic order in successive geometric moves. Patterns!

Learning Objective: To show that a series of successive moves leads to a common series

Materials required: Toothpicks

Procedure:

(I) Use toothpicks to set up the following arrangements. What is the minimum number of toothpicks to be removed in each the following figure (n X n squares) so that no square remains?



The pattern that evolves from the systematic removal of toothpicks is shown in the table:

Number of small squares in a row	1	2	3	4
Minimum number of toothpicks removed	1	3	6	10

In each case the number of removed toothpicks is equal to the successive partial sums i.e. 1+2+3+4+5+.. It happens to be the sequence of triangular numbers.

(II) Another example for this is by counting the number of segments determined by increased number of points on a line segment AB.

Figure	**No. of points between A and B**	**No of segments**
A B	0	1 = 1
A C B	1	1+2 = 3
A C D B	2	1+2+3 = 6
A C D E B	3	1+2+3+4 = 10
A C D E F B	4	1+2+3+4+5 = 15
A C D E F G H B	5	1+2+3+4+5+6 = 21

ACTIVITY-15

Triangular numbers and square numbers

Learning Objectives: To enable the students to get the knowledge of patterns of numbers.

Materials required: Foam board and tokens/coins/stickers/bindis

Procedure: Numbers can be arranged in certain patterns.

I. The triangular numbers are related to sums as follows:

$$1 = 1$$

$$1 + 2 = 3$$

$$1 + 2 + 3 = 6$$

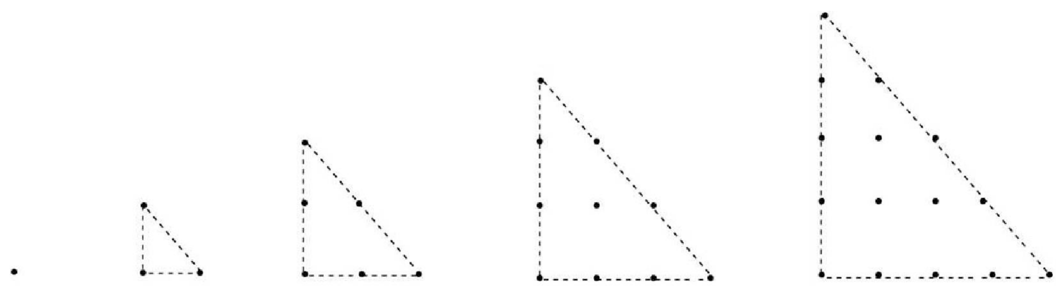
$$1 + 2 + 3 + 4 = 10$$

.

.

.

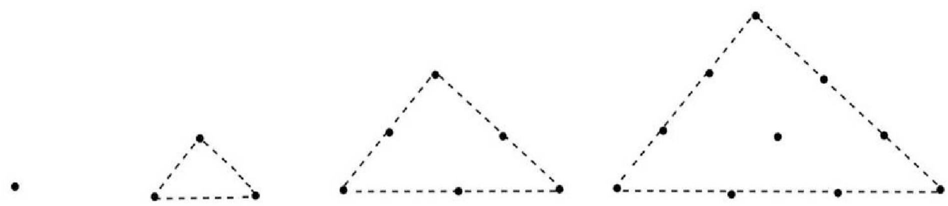
It can be formed on a foam board using bindis.



1 3 6 10 15

It can also be represented as equilateral triangles

II. Square numbers are also obtained by adding two triangular numbers. This can be represented as follows



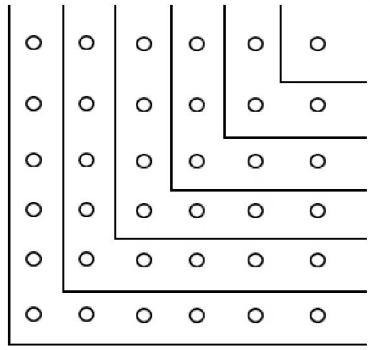
1 3 6 10

III. Square numbers can also be arranged as sum of consecutive odd numbers:

$$1 = 1$$
$$1 + 3 = 4$$
$$1 + 3 + 5 = 9$$
$$1 + 3 + 5 + 7 = 16$$

Square numbers can also be arranged in the following way.

$$1 + 2 + 1 = 4$$
$$1 + 2 + 3 + 2 + 1 = 9$$
$$1 + 2 + 3 + 4 + 3 + 2 + 1 = 16$$
$$1 + 2 + 3 + 4 + 5 + 4 + 3 + 2 + 1 = 25$$



Reflective questions:

- $(1 \times 3) + 1 = 4 = 2^2$,
  $(2 \times 4) + 1 = 9 = 3^2$,
  $(3 \times 5) + 1 = 16 = 4^2$
  $(4 \times 6) + 1 = 25 = 5^2$
  Continue this and arrive at a conclusion

ACTIVITY-16

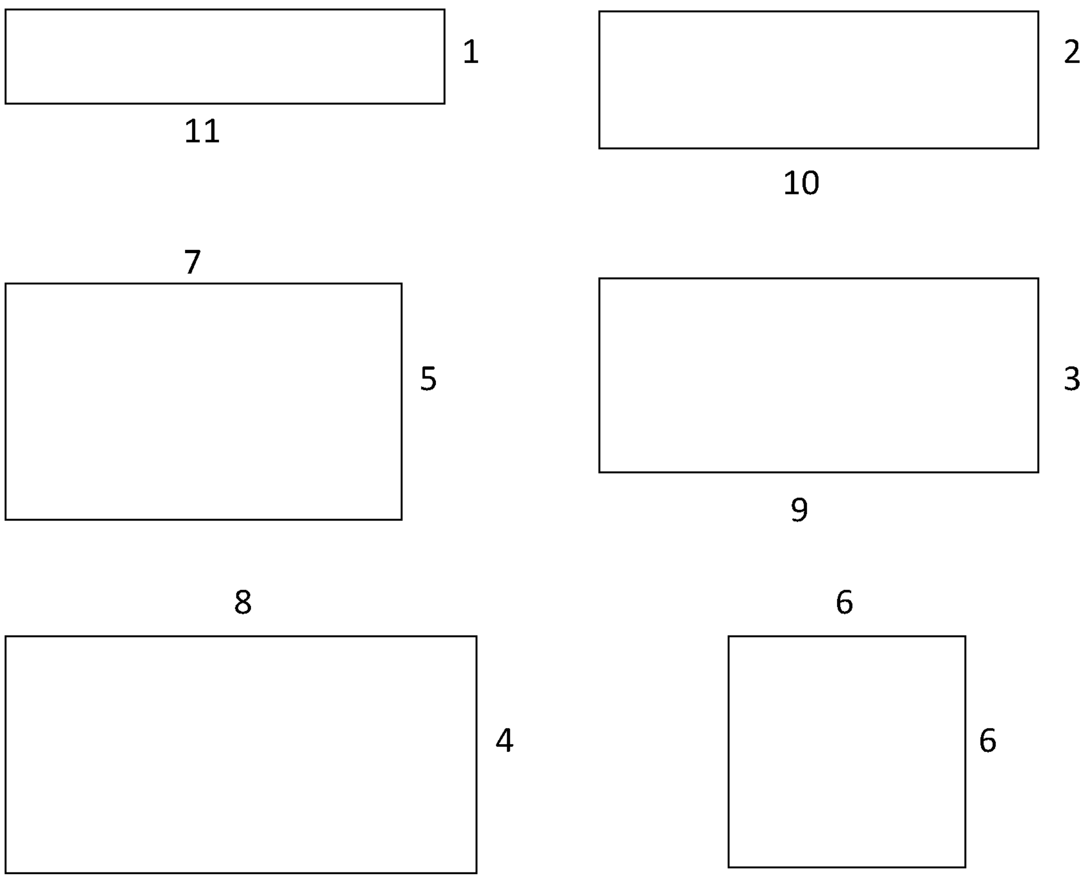
Area and Perimeter

Learning Objectives:

- To verify that rectangles with same perimeter have different areas.
- To explain the squares have the maximum area compared to other rectangles with same perimeter.

Materials:

6 different rectangles cut from foamboard and marked unit squares on it using permanent marker (As shown in figure below)



Procedure:

- Find out the area of each figure (rectangle) and complete the table.
- Generalize your findings

Sl. No.	Length	Breadth	Perimeter	Area
1	11	1	24 units	11 sq. units
2	10	2	24 units	20 sq. units
3	9	3	24 units	27 sq. units
4	8	4	24 units	32 sq. units
5	7	5	24 units	35 sq. units
6	6	6	24 units	36 sq. units

- Repeat the activity by taking different rectangles of same perimeter
- When shall we get the maximum area?
- What about rectangles of same area and different perimeter? Can you draw any conclusion?
- Find all possible rectangles whose perimeter is numerically equal to its area? And what conclusion can you draw from this?

ACTIVITY-17

Area of different Polygons

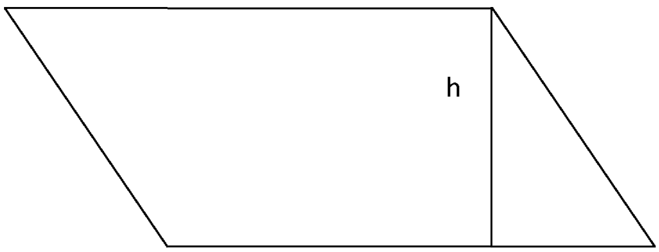
Learning outcome : To find the area of different Triangle, parallelogram, trapezium and quadrilateral by converting them in to rectangles.

Materials required : foam board, cutting knife, glue cello tape, Metal scale etc.

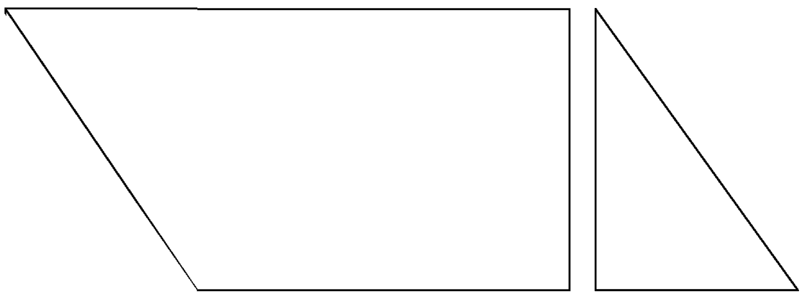
Procedure

Finding the area of Parallelogram.

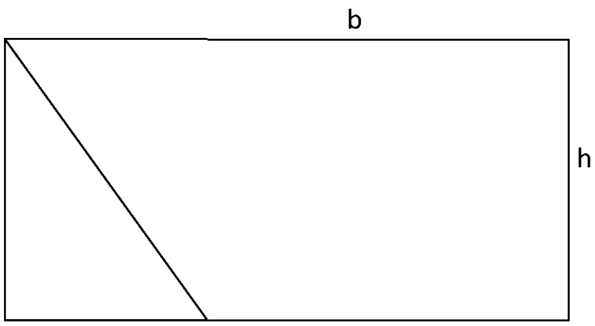
From foam board cut a parallelogram as shown in figure.



In the figure the base of parallelogram is ‘b’ and height is ‘h’ Using knife cut the parallelogram through its height then we will get the following figures.



Now we can place the triangle to th left side we will get the folowing figure

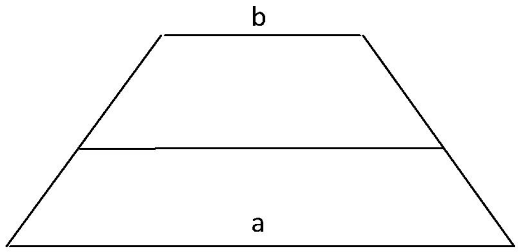


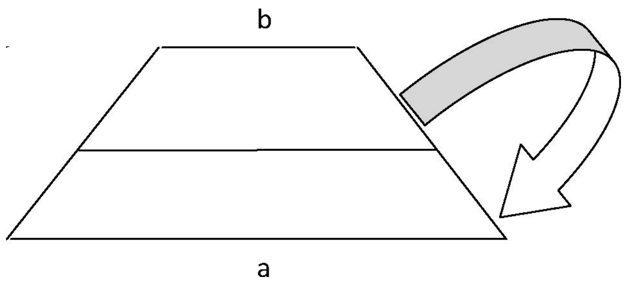
The area is b x h.

Case 2

How to find area of a Trapezium

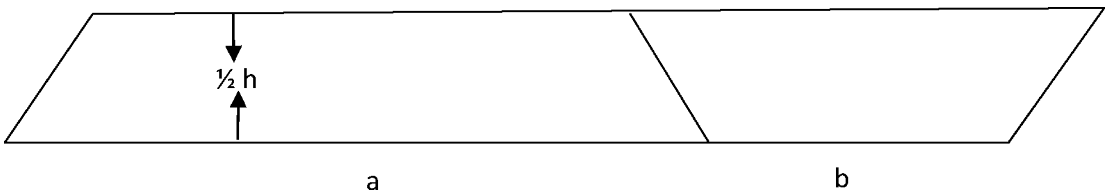
Cut down a trapezium from the foam board sheet. Cut the trapezium through the midpoint of its height. Place it adjacent to the other piece as shown in figure





you will get a parallelogram like the figure .now what is the area of this parallelogram

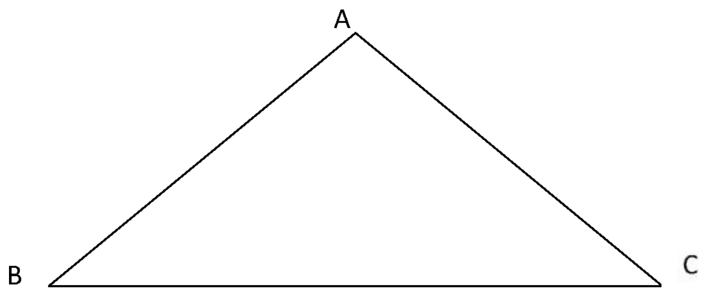
The length of the parallelogram is a+b and height is h

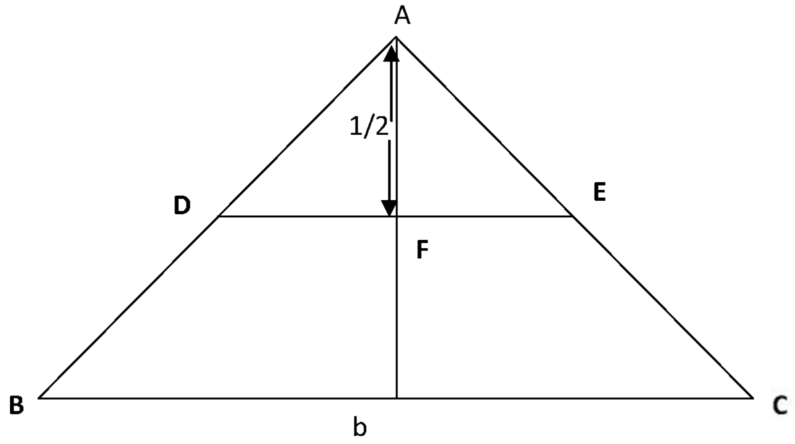


Case 3

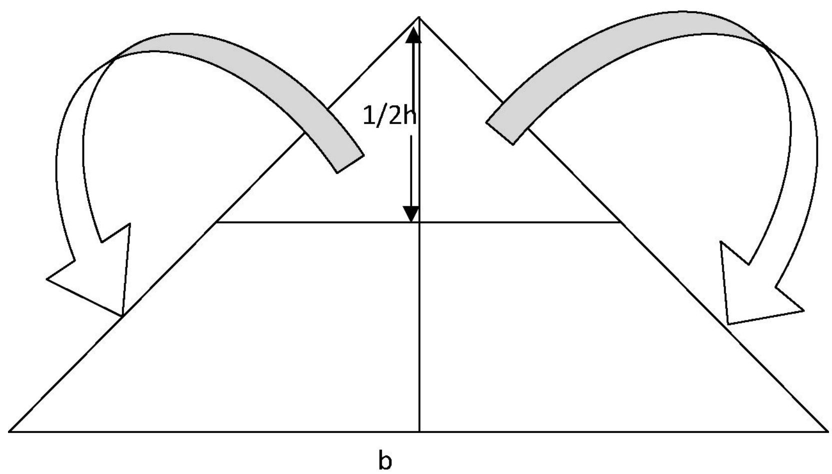
Area of Triangle

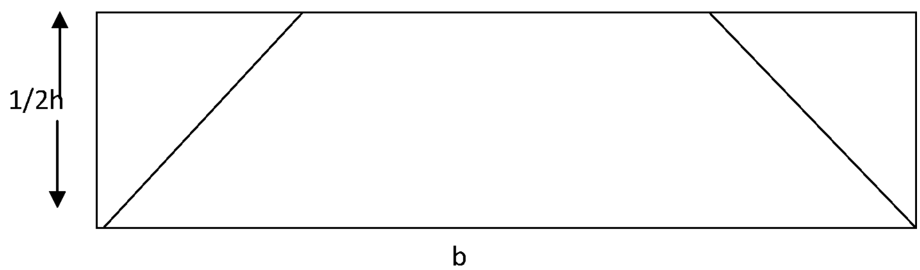
Cut a triangle from the foam board as shown below





D and E are the midpoint of the sides AB and AC of the triangle through DE to get the triangle ADE. Again cut Triangle ADE through AF to get Triangles ADF and AFE fix these Triangle a cello tap so that it can move the point E.





Reflective Question

In the same fashion make a device to find area of a quadrilateral

ACTIVITY-18
Clinometer

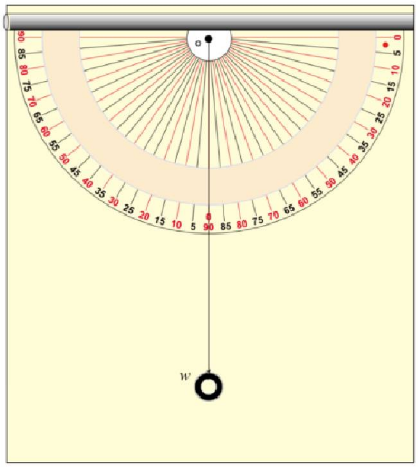
Learning Outcome: Students learn how to determine the angle of elevation of an object and use it to determine the height of an object at a known distance.

Materials required

Stiff card, small pipe or drinking straw, thread, a weight (a metal washer is ideal)

Procedure:

1. Prepare a semi-circular protractor using any hard board and fix a viewing tube (straw or pipe) along the diameter.



2. Mark degrees on the protractor both clockwise and anticlockwise).
3. Punch a hole (o) at the centre of the semicircle.
4. Suspend a weight {w} from a small nail fixed to the centre.
5. Ensure that the weight at the end of the string hangs below the protractor.
6. First measure the distance of the object from you. Let the distance be d.
7. Look through the straw or pipe at the top of the object. Make sure you can clearly see the top of the object.
8. Hold the clinometer steady and let your partner record the angle the string makes on the scale of the clinometer. Let this angle be θ.

Using trigonometric ratio :

tan θ = height / distance = d h

h=d × tan θ If, for example, d=100 m and θ=450 h= 100 × tan 450=100 m

Learning outcome Students learn how to determine the angle of elevation of an object and use it to determine the height of an object at a known distance.

Remark Students may be asked to change the distance of the object (by either moving the object or by changing their position) and note how the angle of elevation varies. They will notice that though d and θ will vary, the product h = d tanθ will be constant (within measurement error).

ACTIVITY-19

Pythagoras Theorem

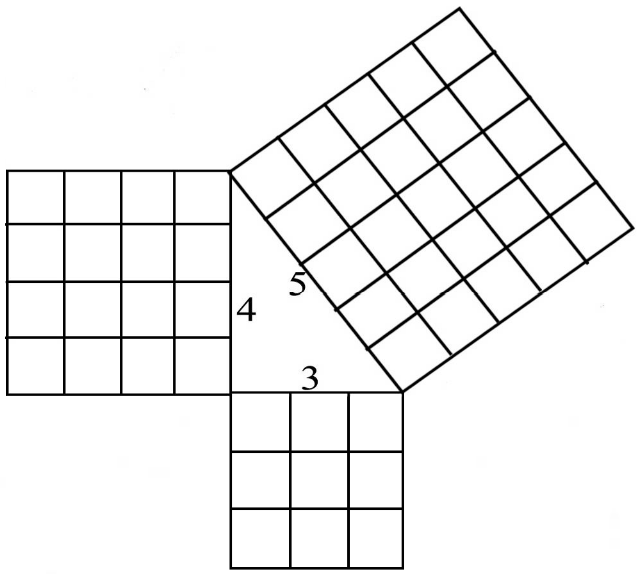
Learning Objectives: Explore different proofs of Pythagoras theorem

Materials: 3 different squares made from foam board, permanent marker

Procedure:

Activity-1:

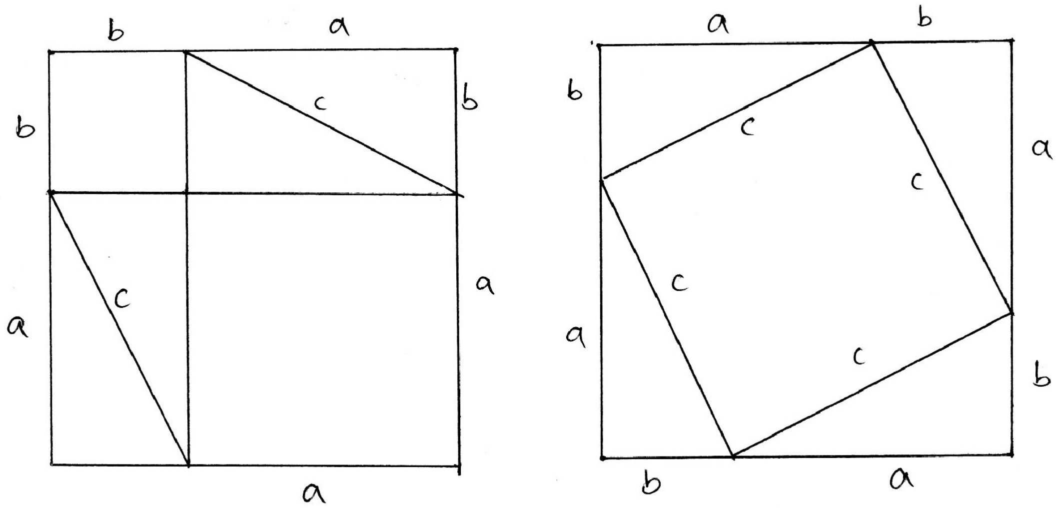
- Arrange the unit squares on the base and altitude of the right angle to hypotenuse as shown in the figure.



- Can you identify the relation between the unit squares on each sides of the right angled triangle?
- Instead of squares can you verify the theorem with circle and other shapes?

Another proof:

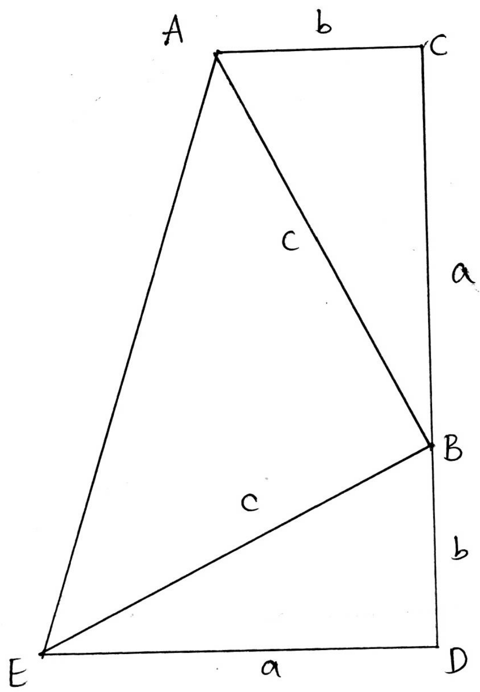
Material: Cardboard sheet/foam board sheet. Arranged as shown in figure below.



- The above two squares have the same area.
- The one on the left is composed of four congruent right triangles and two squares, the total area of which is equal to $4(ab/2) + c^2$
- After establishing that the quadrilateral inside the square at the right is also a square with side length c, we can conclude that $a^2 + b^2 = c^2$.

Proof-2:

Material: Cardboard/foam board arranged as shown in figure below.



Select D on BC so that BD = AC CBD is straight angle. Consider DE perpendicular to CBD so that DE = BC. We can show that quadrilateral ACDE is a trapezoid. Also area of triangle ABC = Area of the triangle BED and AB = BE.

$$\text{Area of trapezium ACDE} = 1/2\ CD\ (AC + DE)$$

$$= 1/2\ (a + b)\ .\ (a + b)$$

$$= 1/2\ (a + b)^2$$

$$\text{Area of triangle ABE} = 1/2\ .AB\ .\ BE = 1/2\ c^2$$

Also,

$$\text{Area of triangle ABC} = 1/2\ .AC\ .\ BC = 1/2\ ab.$$

However,

Area of trapezoid ACDE = Area of triangle ABE + Area of triangle ABC.

Substituting we get $a^2 + b^2 = c^2$.

ACTIVITY-20

Sum of angles of a triangle

Learning objectives

Verify the sum of interior angles of a triangle is 180^0

Procedure

Fold the 3 angles so that they form a straight angle as shown in figure.

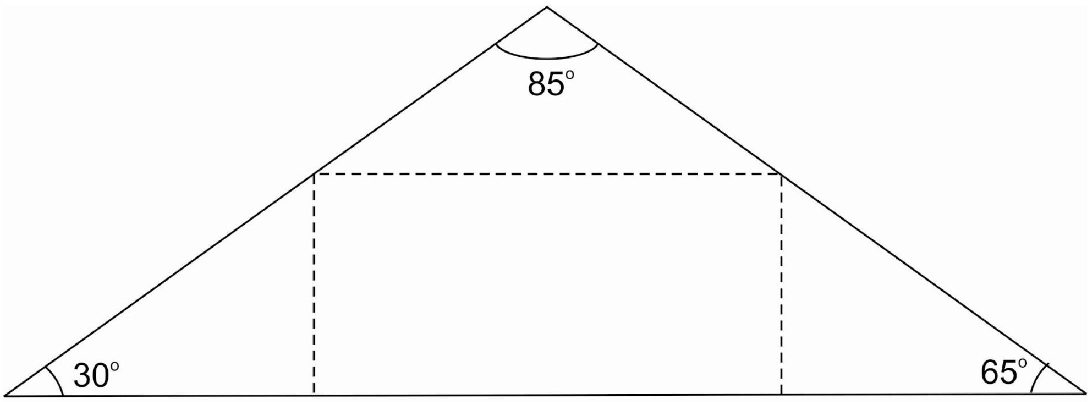


Fig (1)

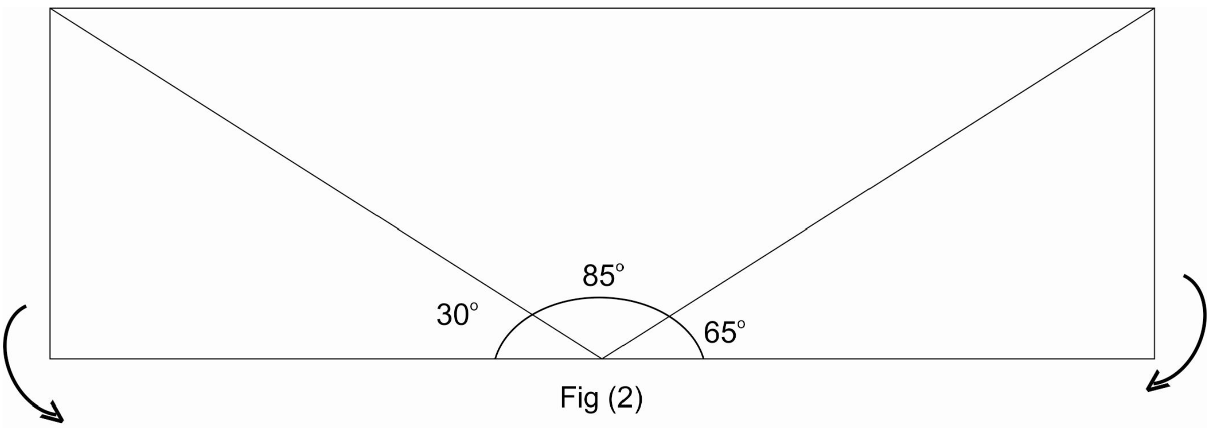


Fig (2)

Or cut four pieces as shown in figure (1) or join them using cello tape so that we can fold the three triangles /angles to a straight line.

Another Method

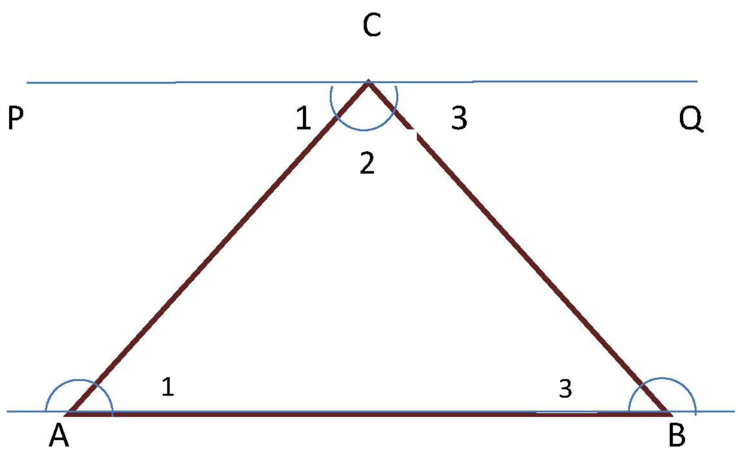
Sum of the angles of triangles is 180^0

Materials

Different triangles cut from chart/ form board/Sun pack sheet, Straight line drawn and cut either OHP sheet or plastic sheet, 3 protractors.

Procedure

Take the triangle and keep one straight line parallel to any one side of triangle as shown in below figure



Here AB II PQ

There fore $\angle BAC = \angle ACP$ and $\angle ABC = \angle BCQ$

So sum of three angles is 180^0.

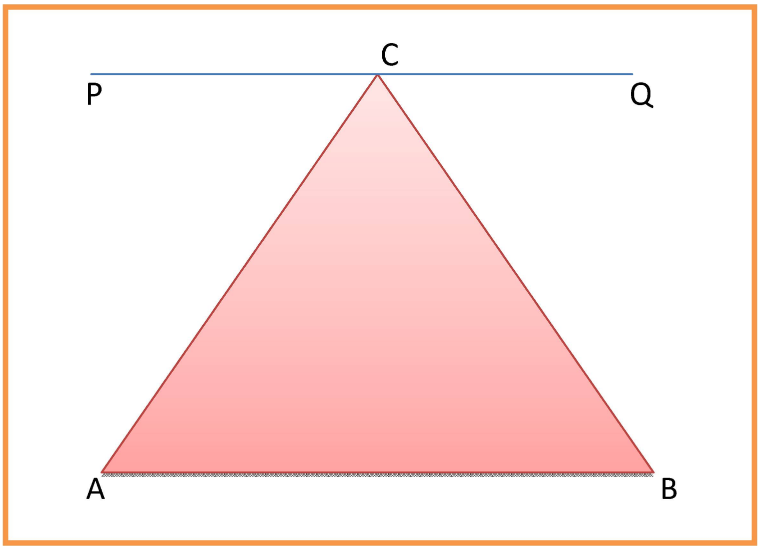
OR

Materials

$50cm \times 50cm$ Cardboard or form board, protractors made from OHP sheets and pins.

Procedure

1. Make 2 points A and B on the $50cm \times 50cm$ board as shown in figure.



2. Draw a line parallel to AB.
3. Use OHP sheet protractor and fix the protractor using pin in the points A, B, and C. Join the points using rubber bands.

Reflection Questions

1. What happens if the position of the point changes on the line PQ?
2. When point C moves through the line PQ, What observations can you make from it?

ACTIVITY 21

Properties of Triangles using matchstick puzzles

Learning objectives

Explain the different properties of triangle by making triangles using match sticks.

Materials

Matchsticks, gum, Chart paper

Procedure

1. Ask the students to make a triangle using 3 match sticks, everybody get same type of triangle.
2. Is it possible to make a triangle using two match sticks? 4 match sticks (without cutting the length)
3. Why is it not possible?
4. What about 6 match sticks?
5. How many different triangles we can form using 5 match sticks?
6. Similar way ask the students to make different types of triangles using 6, 7, 8, 9, 10 match sticks (within 5 minutes)
7. Ask them to identify the properties they identified from the activity.
8. Classify your triangles according to the length of sides of each.
9. Also classify according to the angles

Reflective Questions

1. If the lengths of two sides of triangle are 9 units and 1 unit respectively, what is the perimeter of the triangle? (By taking natural numbers)
2. Can you name the triangle whose length of the side is one unit? (By taking natural numbers

ACTIVITY-22

Parallel lines and transversal

Learning objectives

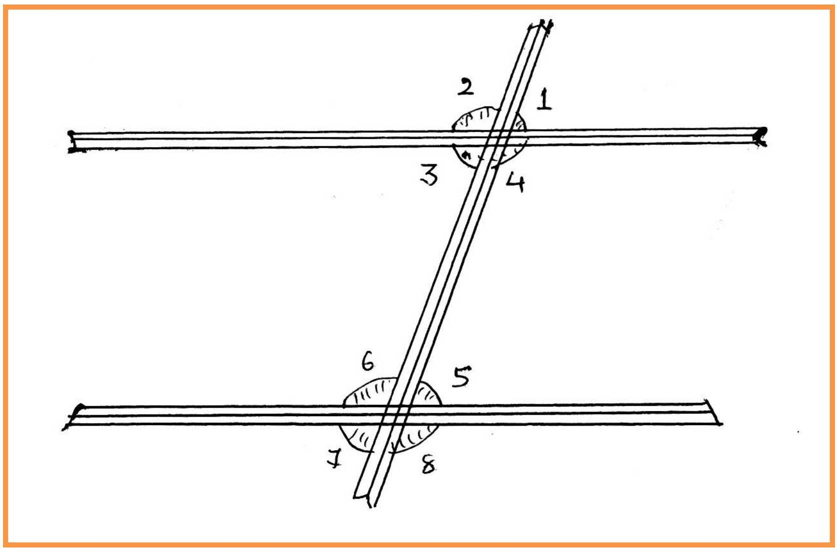
To verify the relation of different pairs of angles formed by a transversal with two parallel lines

Materials

50×50cm form board. Two full protractor, 3 wooden raper, form sheet scale type. OHP sheet, permanent marker, flies screws.

Procedure

1. On 50×50cm form board, parallel lines are arranged as shown below.



2. Take 3 strips and two full and 2 full protractors and fix them with the help of fly screws on the board in such a way that two strips are parallel to each other and the third strip is a transversal to them as shown in above figure.
3. How would you check whether two strips are parallel or not?
4. Measure all the angles so formed numbered from 1-to -8 and complete the following tables.

<u>Table A: Corresponding angles</u>

S.N	Name of angle	Measure of angle	Name of angle	Measure of angle	Observation (Relationship)
1	**1**		**5**		
2	**2**		**6**		
3	**3**		**7**		
4	**4**		**8**		

<u>Conclusion:</u>

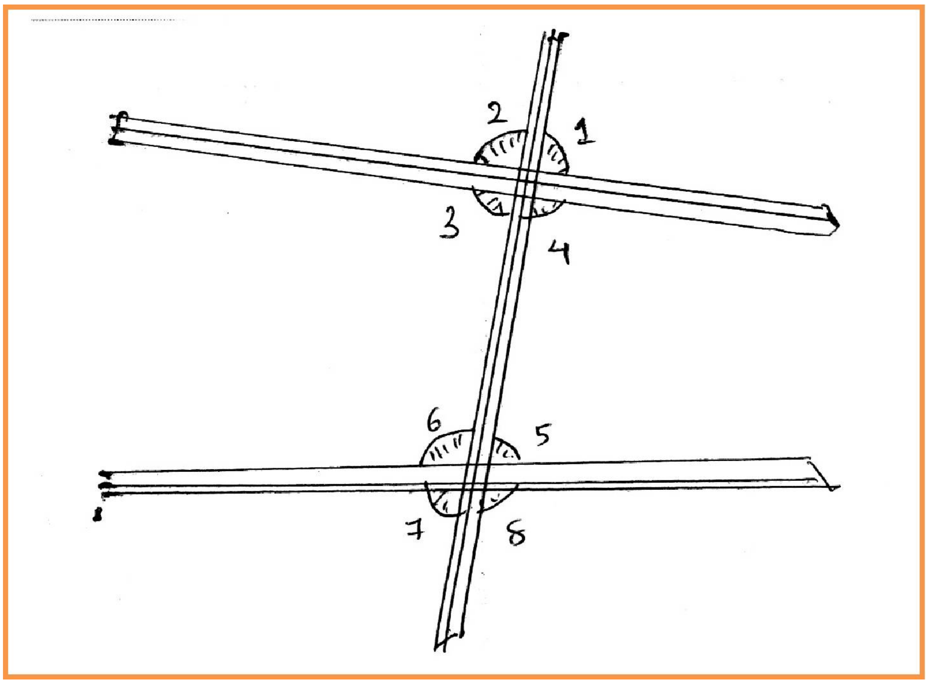
<u>Table B: Alternate intoror and exterior angles</u>

S.N	Name of angle	Measure of angle	Name of angle	Measure of angle	Observation (Relationship)
1	**3**		**5**		
2	**4**		**6**		
3	**1**		**7**		
4	**2**		**8**		

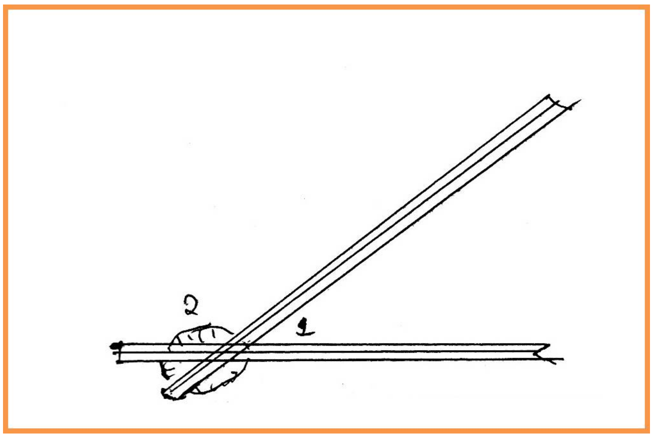
<u>Table C: Interior angle on the same side of transversal</u>

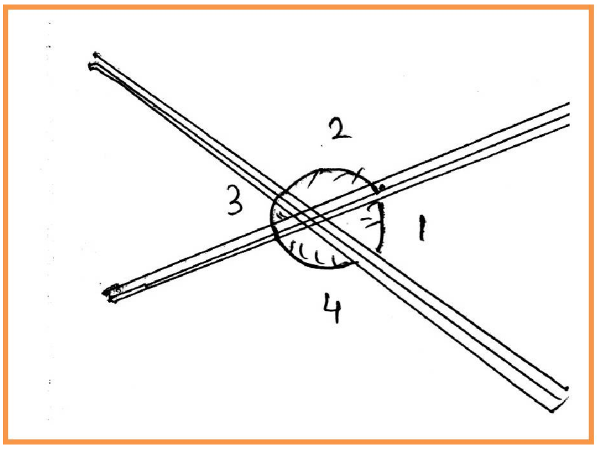
S.N	Name of angle	Measure of angle	Name of angle	Measure of angle	Observation (Relationship)
1	**4**		**5**		
2	**3**		**6**		

5. Now fix these strips and two protractors on the board in such a manner that the two strips are not parallel to each other and third strip is transversal to them as shown in figure below.



6. Repeat the activity and fill the tables A, B and C given above.
7. Also verify that the properties of vertically opposite angles and linear pair using steps arranged in the following way on the board.





ACTIVITY-23
Algebra tile

<u>Outcome:</u>

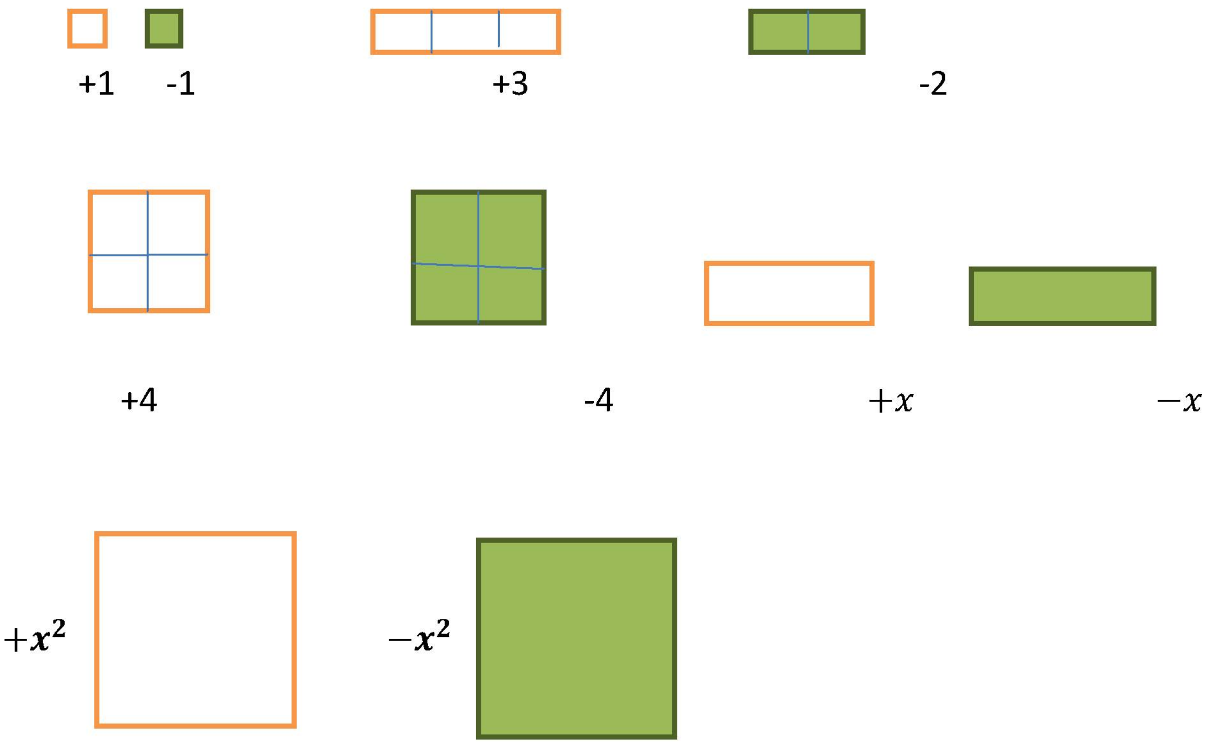
To examine the addition, multiplication and factorization of polynomials geometrically.

<u>Materials:</u>

Algebra tiles (synthetic rubber, plywood etc.)

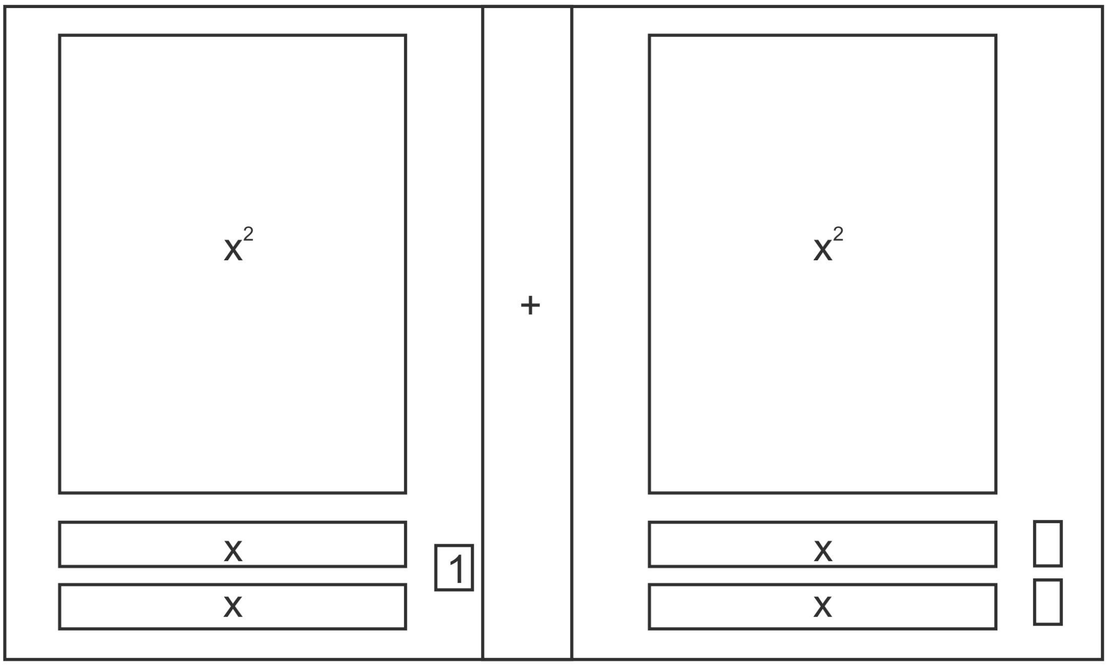
<u>Procedure</u>

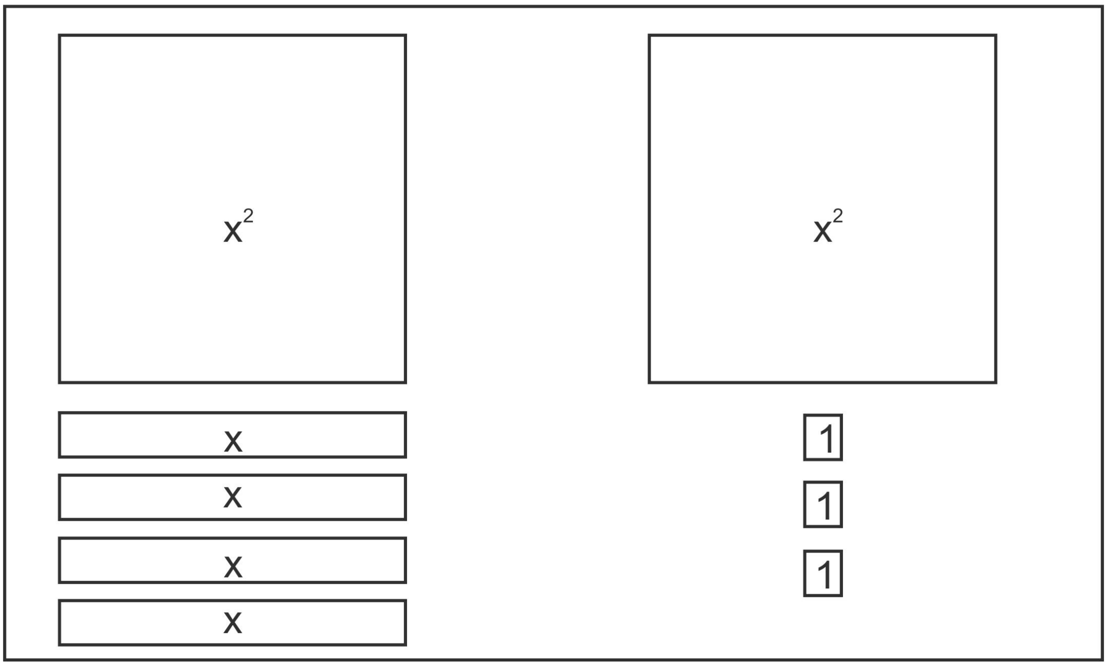
The use of algebra tiles has enhanced the teaching of abstract concepts and has helped to make working with polynomials more comfort. Each student should have 10 of each type of tile. Hence the non-shaded tiles represent positive numbers and the shaded tiles represent negative numbers.



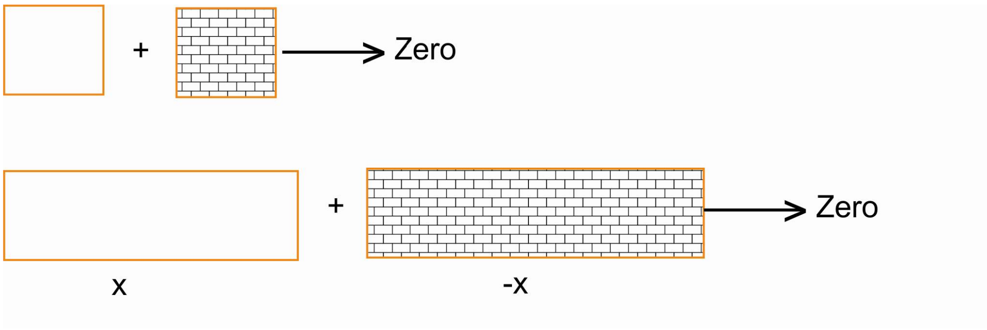
1. How to add $x^2 + 2x + 1$ and $x^2 + x + 2$

Visual Procedure: Addition is also viewed as combining or putting together question box.

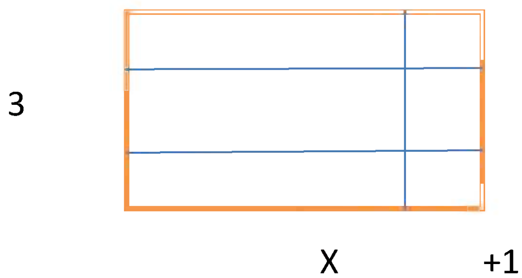




When +1 and -1 are put together, they eliminate each other and add up to zero. Similarly +x and –x also form zero pair.

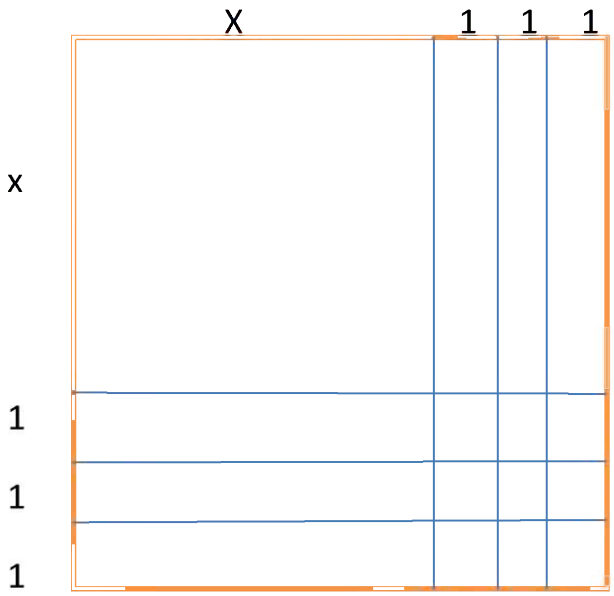


2. **How to multiply $x+1$ by 3 Using algebra tiles?**
   A rectangle is to be created with area $(x+1)3$ it should have length $(x+1)$ and width 3. Here students build such a rectangle with their tiles as follows.



Consider the product $(x+3)^2$

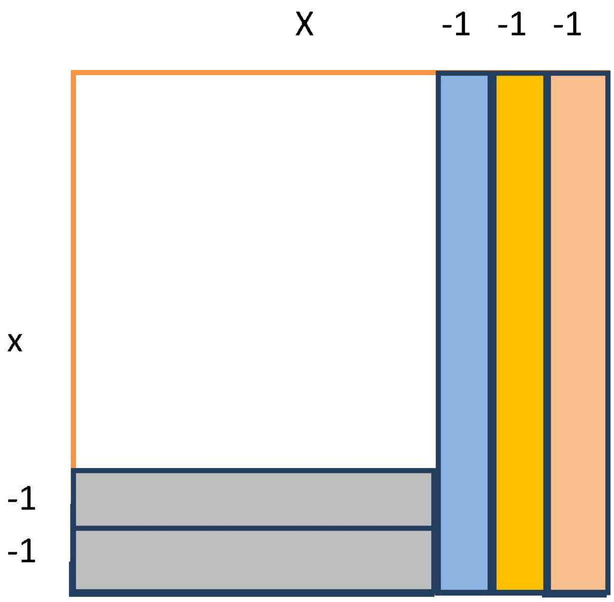
Here we have to construct a square with side $(x+3)$



By by counting in the resulting square gives one x^2 tile, six x tiles and nine unit tiles for a total area x^2+6x+9

3. **For multiplying $(x-3)(x-2)$**

   In this product students must have a special care to use convert sign. Here $(-1) \times (-1)$ gives an answer of $+1$ which means six unit squares on the bottom must not be shaded.

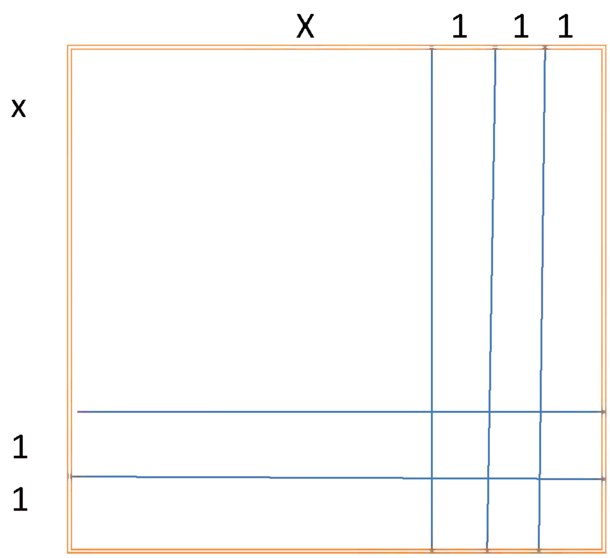


   Here the product is easy to read as $x^2 - 5x + 6$

4. **Factorizing polynomials**

   What two binomials have the product $x^2 + 5x + 6$.

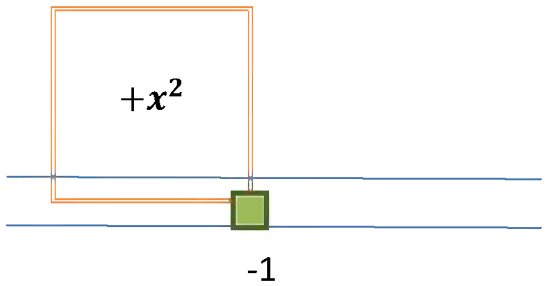
   Here we need to construct a rectangle with area $x^2 + 5x + 6$. Students should take one x^2 tile, five x tiles and six unit tiles.



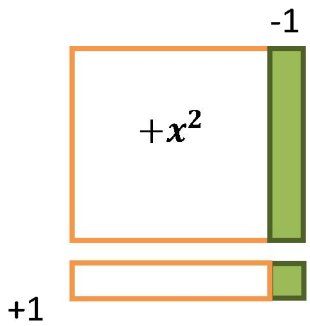
Students should realize that they must arrange six unit tiles in to a small rectangle in the bottom.

5. How can we factorize $x^2 - 1$.

   Students should begin with two tiles as follows:



By completing a square using one positive x tile and one negative x tile we are virtually adding zero. Thus the factors of $x^2 - 1$ are $(x+1)(x-1)$



Reflective Questions

- Multiply $(x+4)(x-5)$using algebra tiles.
- Find the factors of $x^2 - x - 6$ using algebra tiles.
- Explain how division of polynomials can be explained using algebra tiles?
- Factorize $2x^2 - 7x + 6$

For further practice to find the product of 2.5 and 3.5, draw the line joining the points (2.5, 6.25) and (-3.5, 12.25) to line segment meet at 8.75 which is the product.

Division is an inverse operation of multiplication, we can see that could have been used to find the quotient of 8.75÷3.5.

Students can do more practice to find the product and division of numbers.

ACTIVITY-24

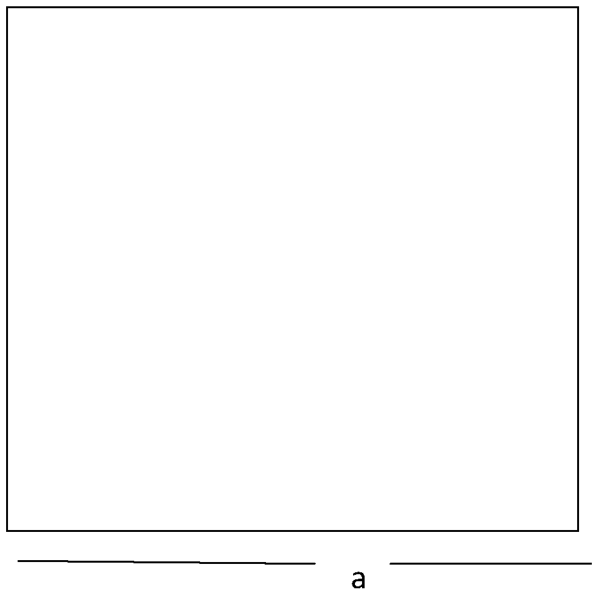
Identity $(a+b)(a-b)=a^2-b^2$

Learning outcome: Identifying geometrical proof of $(a+b)(a-b)=a^2-b^2$

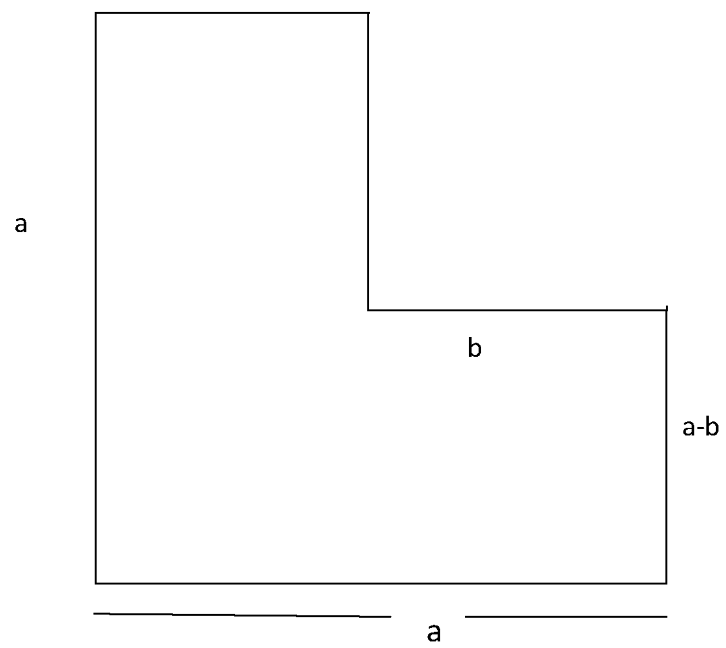
Materials required : Foam board sheet ,pair of scissors , pin

Procedure

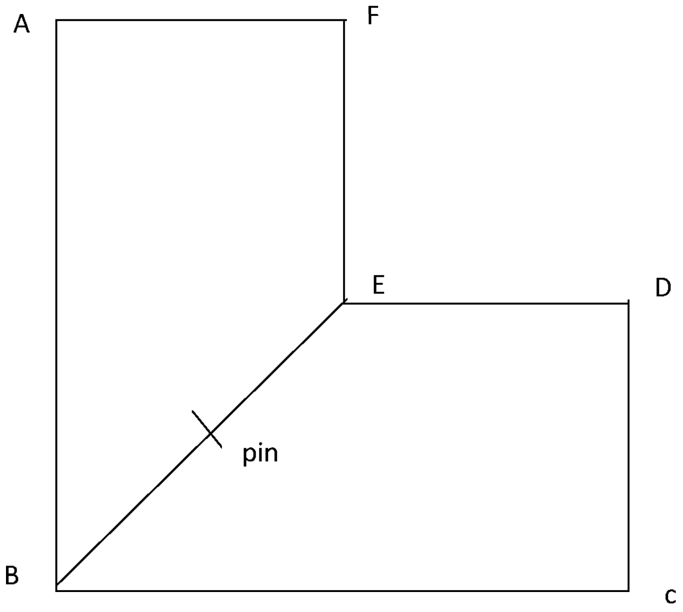
From the foam board Cut a square of side a unit



From this square cut away a square of b units

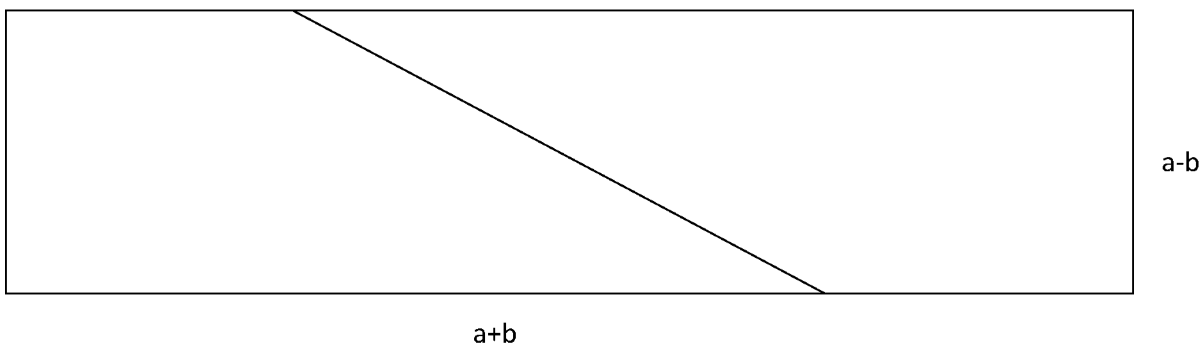


area of the shape is a2-b2



Cut the shape through BE . We get 2 pieces of foam board ABEF and BCDE.

insert a pin at the centre of BE to join the 2 pieces together as shown in figure. Rotate a piece through the pin. We will get a rectangle with length a+b and Breadth a-b



Reflective Questions

How will you demonstrate the geometrical proof of $(a+b)^2$

ACTIVITY-25

Mid-Point Theorem

Learning Objectives

Students Understand and explain the mid-point theorem.

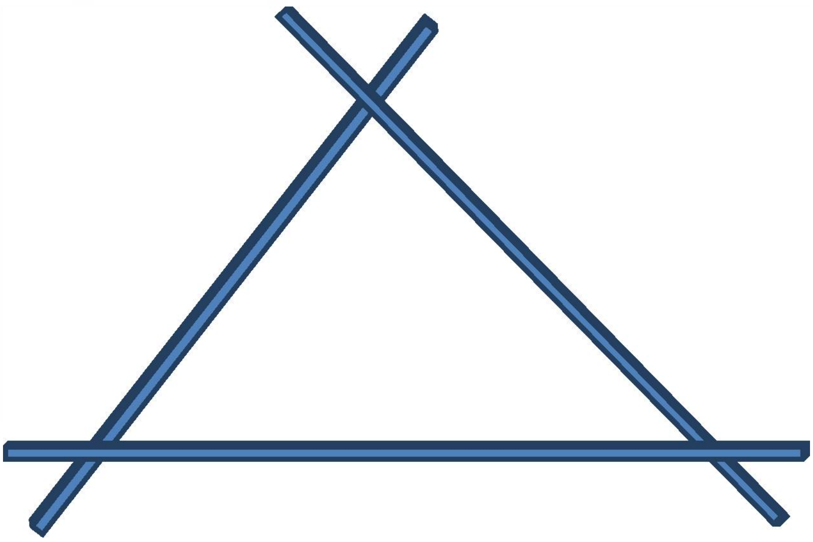
'A line drawn joining midpoints of any two sides of triangle is parallel to third side and half of it.'

Materials

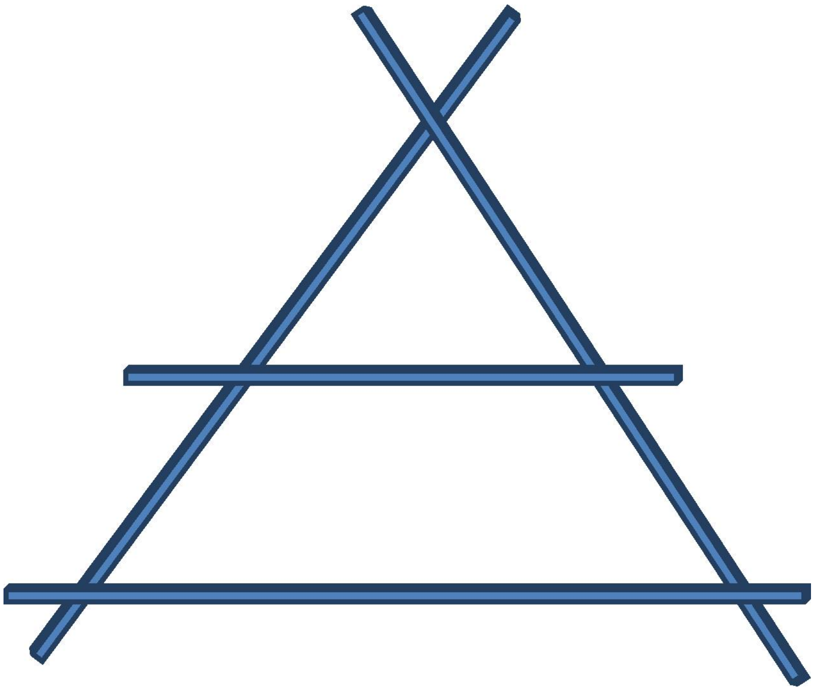
A set of four plastic/form board /OHP sheet, strips as shown in figure, fly screws, two half protractors.

Procedure

1. Fix three strips to form a triangle ABC and a half protector at one of the vertices say B as shown in below figure.



2. Fix another strip at the midpoint D of one of the side AB of the triangle along with a half protractor
3. Adjust this strip so that it also passes through the midpoint say E of another side AC. As shown in the figure given below.



Activity 1

1. Measure the angles shown by the two protractors.
2. Measure the length of sides BC and DE
3. Repeat the activity by forming different types of triangles (Using different strips) and generalize the relation by completing table below.

S.N	$\angle 1$	$\angle 2$	Is $\angle 1 = \angle 2$	Length of BC	Length of DE	Is $DE = \frac{1}{2}$BC

Activity 2

1. Adjust the 4th strip so that the angles shown on the two protractors are equal so strip DE II BC
2. Measure the lengths of AE and EC
3. Repeat the activity by following different types of triangles and complete the following table.

S.N	AE	EC	Is AE=EC

4. What generalization we get from this activity?

Activity-3

1. Measure AD, DB and EC.
2. Repeat the activity by forming different types of triangles and generalize the result by tabling..

S.N	AD	DB	AD:DB	AE	EC	AE:EC	Is AD:DB= AE:EC

Another Method Using Paper folding.

Materials

Chart paper, cutting of different triangles.

Procedure

1. Take any triangle
2. Mark the midpoints of two sides by folding the paper (fig 1)
3.

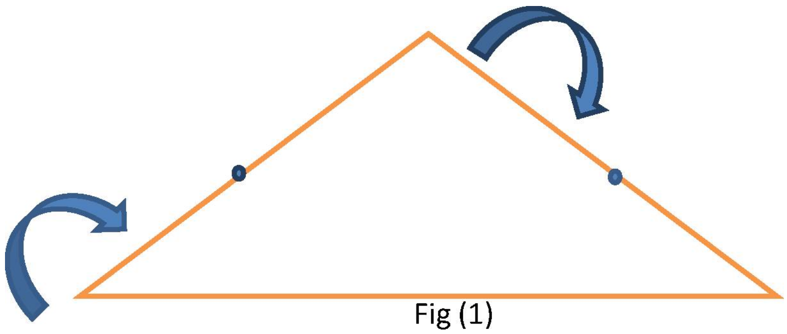


Fig (1)

4. Fold the papers through the marked points parallel to the third side (fig ii)

Fig (2)

5. From fig iii it is clear that length of the side of rectangle formed by joining the midpoints is half of the third side because length of the third side is 2 times the length of rectangle.

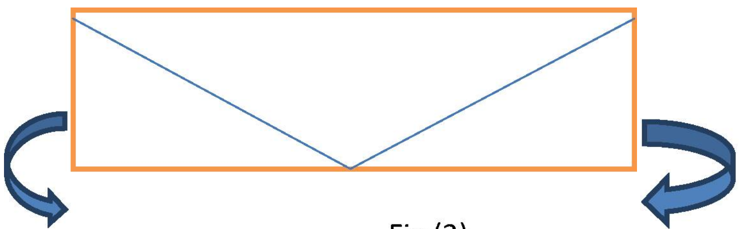


Fig (3)

<u>Reflective Questions</u>

To prove the converse of midpoint theorem how can we fold the triangle?

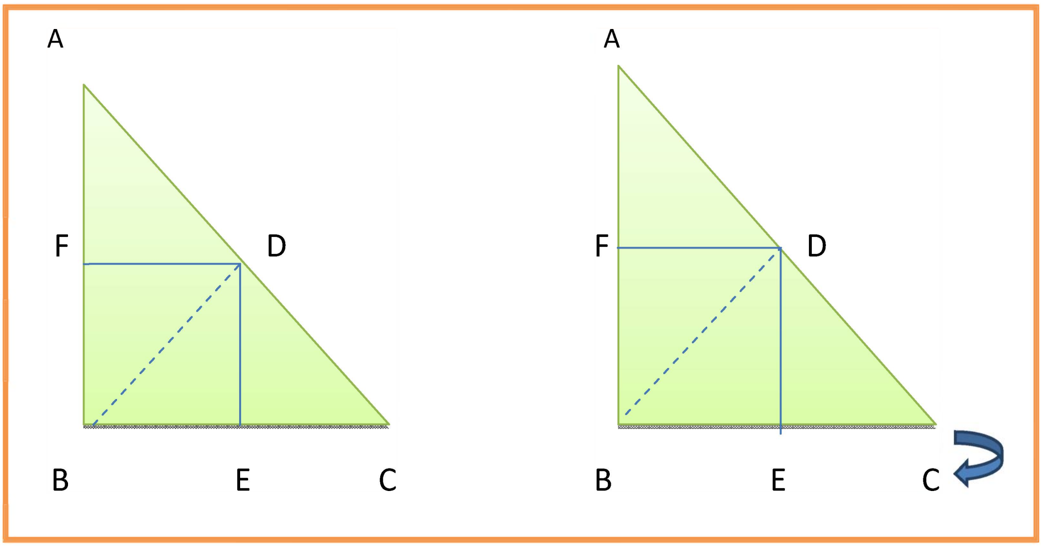
Mid-Point of the Hypotenuse

<u>Learning Objectives</u>:

To verify the midpoint of the hypotenuse of a right angled triangle is equidistant from all vertices of triangle

Materials

Chart paper, cuttings of right angled triangles as shown in figure.



Procedure

1. Prepare a model of a right-angled triangle ABC with $\angle B = 90^0$, The triangle ABC can be folded along BD, DE and DF.
2. Fold triangle ABC along BD at D, The vertex C and vertex A coincide. Therefore we can infer that D is the midpoint of AC, AD=DC.
3. Fold the triangle along DE (vertex C and Vertex B coincide) therefore BE=EC
4. Fold the triangle ABC along DF and DE. Then the vertices A, B and C coincide..Thereore BD=DC. So AD=BD=DC

Reflection Questions

1. By folding along FD, One can see that triangle AFD is congruent to triangle BFD, By folding along DE, We can see that Triangle BDE is congruent to Triangle CDE.
2. What are the other results you get from this?
3. Is there any other point on the triangle which is equidistance from all vertices?
4. In Scalene triangle, Which is the point which is equidistance from all the vertices?

GeoGebra

GeoGebra is dynamic mathematics open source (free) software for learning and teaching mathematics in schools. It was developed by Markus Hohenwarter and an international team of programmers. RIE Mysore has organised various programmes to train teachers of southern states in using GeoGebra in secondary and senior secondary level. GeoGebra combines geometry, algebra, statistics and calculus. You can download it for

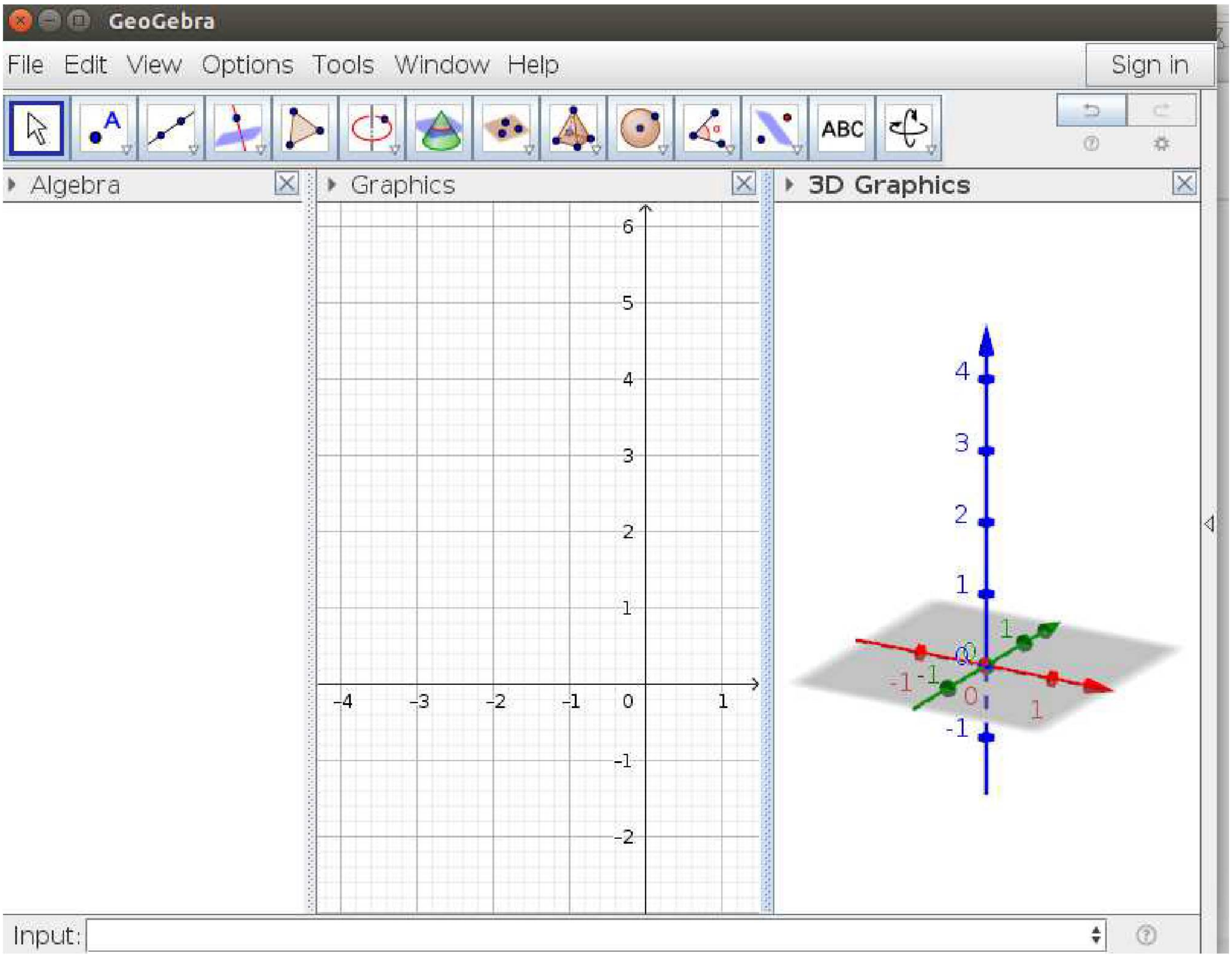
free from http://www.geogebra.org.

(Part of this article an screen shots are taken from GeoGebra in 10 lessons by GerritStols, University of Pretoria South Africa gerrit.stols@up.ac.za)

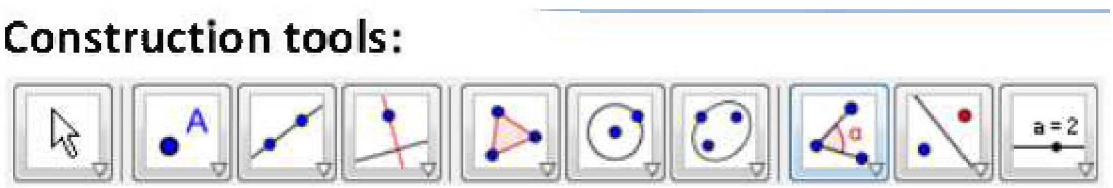
1. Intefaces of GeoGebra

The GeoGebra basic interface is divided into three sections:

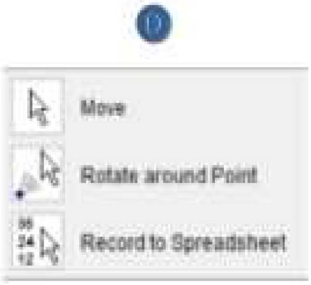
Input bar, Algebra View, and Graphic View. In grphics view one can have two dimensional as well as three dimensional view

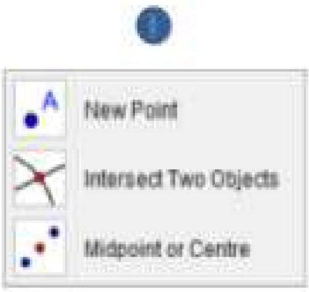


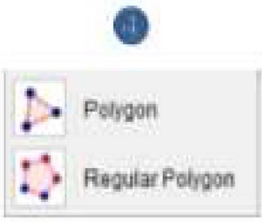
Brief description of tools :



Construction Tools



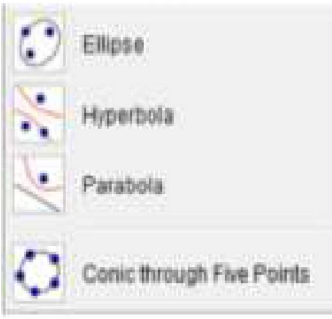




5


Circle with Centre through Point
Circle with Centre and Radius
Compasses
Circle through Three Points
Semicircle through Two Points
Circular Arc with Centre between Two Points
Circumcircular Arc through Three Points
Circular Sector with Centre between Two Poin
Circumcircular Sector through Three Points

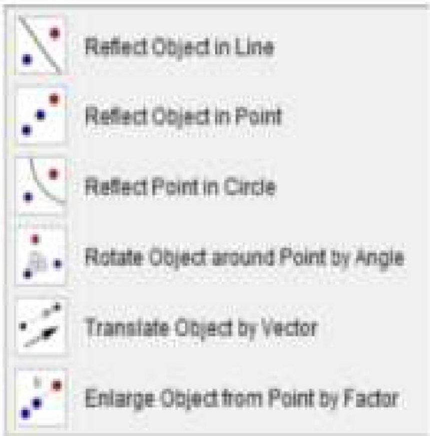
6


Ellipse
Hyperbola
Parabola
Conic through Five Points

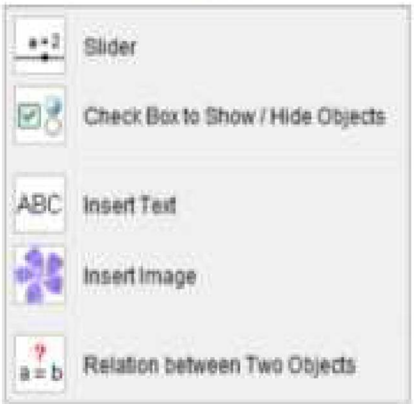
7


Angle
Angle with Given Size
Distance or Length
Area
Slope

8


Reflect Object in Line
Reflect Object in Point
Reflect Point in Circle
Rotate Object around Point by Angle
Translate Object by Vector
Enlarge Object from Point by Factor

9


Slider
Check Box to Show / Hide Objects
ABC
Insert Text
Insert Image
a = b
Relation between Two Objects

10


Move Drawing Pad
Zoom In
Zoom Out
Show / Hide Object
Show / Hide Label
Copy Visual Style
Delete Object

Now we will list some of the activities :

1. Angle sum property of a triangle

Here we will construct a GeoGebra applet to verify that the sum of the angles of a triangle is 180^o

1. Draw a triangle using ***polygon tool.***
2. Select the ***Angle tool***
3. Select the three vertices counter clockwise to measure the angle.
4. Repeat the process to measure the three angles as α,β,γ
5. In input bar type **s= α+β+γ**
6. Select Text tool
7. Type Angle sum =
   - Choose from the object drop down menu α,β,γ and connect them with + symbol
   - Type =
   - Choose s from the object drop down menu
   - enter

8. Drag vertices of the triangle and observe.

2. Thales Theorem

Here we will construct a GeoGebra applet to verify that the angle in a semicircle is 90^o

1. Draw a semicircle using the tool semicircle through two points A,B .
2. Draw diameter using segment tool.
3. Mark a point C on semicircle.
4. Use move tool to check the construction.
5. Join AC and AB.
6. Construct angle at C.
7. Move C and observe.

3. Construction of triangle with given sides

For construction of triangle we can use polygon tool. But then we cannot construct a triangle with given sides. Here we use a method from high school geometry to construct a triangle with sides 8,6 and 4.

1. Choose **line segment with given size** tool.
2. Select any point on the plane and enter length as 8. Second vertex be B.
3. Select **circle with radius** tool.
4. Select center as A radius as 6
5. Select center as B radius as 4
6. Select **point of intersection** tool
7. Click on circles one by one.
8. Join sides to complete triangle.

4. Construction of triangle with given perimeter and base.

This is similar to the previous construction. Let us construct a triangle ABC with AB=8 unit and perimeter 20 units.

1. Choose **line segment with given size** tool.
2. Select any point on the plane and enter length as 8. Second vertex be B.
3. Choose slider tool
4. Construct slider with range 0 to 12
5. Select **circle with radius** tool.
6. Select center as A radius as a (slider name)
7. Select center as B radius as 12-a
8. Select **point of intersection** tool
9. Complete the construction as above.

5. Orthocenter

There are different points related with a triangle like centroid, circumcenter, orthocenter, incenter etc. Here we construct orthocenter of a triangle which is the poit of intersection of the medians of a tringle.

1. Construct triangle ABC with polygon tool.
2. Select perpendicular line tool

3. Choose vertex A of the triangle.
4. Choose the opposite side BC of tringle.
5. Select point of intersection D of perpendicular line l with BC.
6. Hide line l.
7. Join AD with segment tool.
8. Repeat steps 2 to 7 with other vertices and opposite sides.
9. Find point of intersections of altitudes.

Activity Based Teaching in Mathematics

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Mathematics has become important because "it works". By working we mean that mathematics has become an integral part of the world in which we live. Mathematics helps us to understand our environment. It is not an oversight and exaggeration that mathematics controls the nature. Our primary purpose should be to understand nature in order that we may learn better to shape the bountiful awards of nature and co-exist on this earth with all living things. We have all seen the results of man's attempt to master his environment, construction of dams across rivers, construction of bridges, tunnels, etc. Mathematics is an invaluable tool to understand the nature.

Mathematics is the language of science and directly related to this is the fact that mathematics is the means for communication between scientist. If we emphasize the language role that mathematics is fulfilling we not only add interest and importance to subject but we also point out important consideration for learning of the subject. If a pupil is conversant with symbolism of maths and what it represents, if s/he has good head, start on learning how to explore the variety of concepts that attracts her/him. Maths is still an abstract system of ideas and must be seen as such by our students if we are to present an accurate picture to them. Thus as the student use maths to solve problems, we shall have to be prepared to indicate clearly, how the mathematics things and physical things are needed for being one and the same. This becomes particularly important in the study of geometry as it is easy to confuse and visual representation of mathematical concepts with concepts themselves. Helping students begin to formulate concepts of nature of mathematics is equally important. Mathematics perhaps the finest creation of mind of man as such it stands as an example of what heights man may reach when he relies upon her/his power and reasoning, Certainty and permancy are not the characteristic of many fields of endeavour in present century society. But they are accessible to ideas in mathematics, through the use of logic. This alone would serve to establish an unusual position for mathematics among many field of endeavour that abound in modern society. Finally we must consider mathematics as a study of possible patterns both in the world around us and in the structure of discipline of mathematics itself. There are regularity and similarities in nature, we can classify the thing of nature into one-dimensional, two-dimensional, --- so on to n-dimensional spaces. The most remarkable fact of about all these is the study of problems in the real world triggers the development of new mathematics. Thus in the teaching of school mathematics we may be able to make an important beginning in helping students to realise the importance of the search for patterns through their own participation in the search.

Mathematics is called science of space and figures; Science of numbers in general, It is a subject which develops thinking among pupils. This thinking leads to reasoning through How and Why – which leads to permanent learning. Its language is called mathematical language and its knowledge is called mathematical knowledge. It uses mathematical knowledge in the daily life situations there by solves the problem and becomes gate and Key for other subjects. It has precision and accuracy, verification of results. All these leads to mental satisfaction.

The subject mathematics though it has been made as the core subject at school education, is the central focal point, many of the students tries to run away from the subject. Citing various reason like- fear, phobia or disliking etc. The major reason is that they have attempted to learn the language of mathematics and then try to understand mathematics. Even the mathematics teacher does not realize this aspect but goes on teaching mathematics mechanically. Mathematics is discipline having its own language and structure. It has more symbolic notations, its own way of reading and writing, its grammar and discourse are different from other disciplines. All this necessitates a different approach to learn mathematics by understanding its own language.

Mathematics though abstract in nature, is widely utilized and applied knowledge. It also facilitates in understanding the other branches of science. Hence Caulson says" Mathematics is the gate and Key to all other Knowledge". Therefore learning of mathematical language becomes more essential.

Mathematics is full of notations starting with numeric symbols, fundamental operation symbols- +, - , X,/., , and other symbols like <, >, =, %, @ etc makes it unique. While using these symbols with a set rule, it forms its grammar. With the usage of Variables it has enhanced the arithmetic nature of mathematics and becomes more algebraic with usage of expressions and equations. When these mathematical ideas gets transformed into spatial form it becomes geometrical, which we see abundantly in the physical world in which we are living. With advent of new mathematical ideas and translating into practical reality gives wider scope for evolution of different branches of mathematics.

Mathematics has its own vocabulary (notations), grammar, syntax, discourse, community and structure. It is in the form of symbols, variables, axioms, postulates, formulae's, and theorems. Unless one does not understand the context of their usage, then it becomes redundant. But mathematical knowledge has wider utility and applied in other branches of knowledge to make it more meaningful.

Mathematics is the language of science and mathematics is the means for communication between scientists. If we emphasize the language role that mathematics is fulfilling we not only add interest and importance to subject but we also point out important consideration for learning of other subjects also.

The knowledge of Mathematics is gained by adopting various approaches like- Inductive, Deductive, Analytical, synthetical, Heuristic, Inquiry, Activity Based and Problem-solving. Each of these methods helps in either construction or utilization of knowledge. All these approaches have their own merits as well as demerits. Some of these suitable for beginners while some are suitable for gifted learners also. Hence learning of mathematics has wider approaches and methodologies.

Activity Based teaching- learning is also one of the approaches where the learner becomes very active and gets involved in the learning process and either verifies the existing knowledge or tries to visualise the abstract mathematical ideas in concrete form by creating a model. This approach has the following assumptions:-

- Significant learning takes place as perceived by the learners relevant to their own purpose
- Learning by doing
- Learning is facilitated by responsible participaation in the process
- Self-initiated learning leads to permanent learning.

When the learner is engaged in this approach, we can enhance their higher order thinking skills- i.e., analysis, synthesis, evaluative abilities and skills; totally engaged in the activities; hence it leads to exploration of their own attitudes and values towards mathematics.

Strategies used in Activity based approaches are:-

- Discovery approach either using inductive or deductive method
- Appropriate practical work suitable mathematical concepts or generalization
- use of suitable teaching aids
- Adopting co-operative learning strategy
- Discussion forum to share and exchange of ideas

Activity based teaching of mathematics is essential because learner has to know "Doing Mathematics". Doing mathematics means integrating mathematical thinking, using mathematical knowledge and using mathematical inquiry methods. All these are very essential whenever the learner encounters various problematic situations. Hence doing mathematics become crucial and these can be tested through activities and different strategies can be evolved. Also it provides learner to explore all the mathematical ideas independently and gain confidence of doing mathematics successfully.

Whenever the teacher designs any task as an activity, he/she must ensure that it has "richness of task" built in it. The richness of task is to be visualised as- its complexity, its novelty or its requirement for analysis, systhesis or evaluation. If these are ensured, then learning becomes more interesting and challenging also.

The NCTM (1998) has identified five imperative needs for all learners. They are:-

1. Become mathematical problem solvers
2. Communicate the knowledge
3. Reason mathematically
4. Learn to value mathematics
5. Become confident in one's own ability to do mathematics

Even today, these needs are pervasive and one can thing of satisfying these needs through activity based teaching in mathematics to the maximum extent.

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Somashekar T V and et.al (2014), *Methods of Teaching Mathematics,*Neelkamal Publications Pvt Ltd Hyderabad.

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Suggested Activities in Mathematics Laboratory

Activities on Triangles:

1. To show that the area of a triangle is half of the product of its base and height.
2. To verify the triangles on the same base and between the same parallel lines are equal but equal area may not be congruent,
3. To find the in center, circumcenter, orthocenter, medians and centroid of a triangle by paper folding.
4. To verify midpoint theorem by paper folding (i.e the straight line joining midpoints of any two sides of a triangle is parallel to the third side and is half of it).
5. To find the area of a triangle using geoboard activity.
6. To verify that the sum of three interior angles of a triangle is 180□ by using the activity of paper cutting and folding.
7. To verify using coloured strips that (a) the sum of lengths of two sides of a triangle is greater than the length of the third side, (b) the difference of the lengths of two sides of a triangle is less than of the third side.
8. To verify Pythagoras theorem by method of paper folding, cutting and pasting.
9. To find the height of a tree or width of a road or river by using similarity of the triangles.
10. To verify that the ratio of areas of two similar triangles is equal to the ratio of the sequences of their corresponding sides.
11. To find out the sum of perpendicular distances from any arbitrary point inside an equilateral triangle to the sides is always a constant and that it is equal to the altitude of the triangle.
12. To show that the relationship between the radius of the incircle of a right angled triangle and the sides of the triangle is given by r = $\frac{a+b-c}{2}$.
13. To show that the midpoint of the hypotenuse of a right angled triangle is equidistant from all the vertices of the triangle.
14. To prove that the area of the equilateral triangle constructed over the hypotenuse of a right angled triangle is equal to the sum of the areas of the equilateral triangles constructed on the other two sides.

15. To calculate the distance between the earth and the moon during the lunar eclipse using similar triangle property.
16. To show that $1 + 3 + 5 + \ldots + (2n-1) = n^2$ with the help of right isosceles triangles.
17. To prove that in any right angled triangle, the perpendicular drawn from the right angled vertex to the hypotenuse divides the triangle into two triangles and which are similar to each other and to the given triangle.
18. To show that ratio of the in-radii of similar triangles is equal to the ratio of the sides.
19. To see that he converse of Basic Proportionality theorem (i.e. if a line divides any two sides of a triangle in the same ratio, then it is parallel to the third side.
20. To show that medians of a triangle meet at a point which divides the median in the ratio 2:1.
21. To show that a median in a triangle divides the triangle into the triangles of equal area.
22. To show that in a right angled triangle, the height of the perpendicular drawn from the right angle to hypotenuse is equal to the sum of the in-radii of the three circles.

Activities on Quadrilaterals:

23. To show that a diagonal of a parallelogram divides it into two congruent triangles.
24. To verify that the diagonals of a parallelogram bisects each other.
25. To explore similarities and differences in the properties with respect to diagonals of quadrilaterals like parallelogram, square, rectangle and rhombus.
26. To verify that the quadrilateral formed by joining the midpoints of the sides of a quadrilateral is a parallelogram.
27. To verify that the area of a rhombus is obtained by taking half of the product of the lengths of its diagonals.
28. To show that the area of a parallelogram is the product of its base and height.
29. To derive the formula for area of a trapezium in different ways.
30. To find the area of different quadrilaterals like square, rectangles, parallelogram, rhombus ...etc by using Geoboard activity.

31. To verify using activity of paper cutting and folding that the sum of four angles of a quadrilateral is 360^{o} .
32. Using paper folding activity to verify that the sum of either pair of opposite angles of a cyclic quadrilateral is supplementary (i. e. 180^{o}).
33. Using paper folding activity to verify that in a cyclic quadrilateral the exterior angle is equal to the interior opposite angle.
34. To show that for any quadrilateral whose four sides are tangential to any given circle, the sum of the opposite sides are equal.
35. Tangrams – To form the geometrical shapes like square, rectangle, hexagon, trapezium, ..etc, from the given pieces and to improve the mental ability of students.
36. To convert any polygon into a square of a same area as that of a polygon.
37. To show that if a circle touches all the four sides of a quadrilateral, then sum of the angles subtended by the opposite sides of a quadrilateral at the centre of circle are supplementary.
38. To find the golden ratio through golden rectangle (the golden ratio is $\frac{1+\sqrt{5}}{2}$ and a rectangle with these dimension is called as golden rectangle).
39. To verify the properties of parallelogram using wooden scale model of a parallelogram.
40. To find the sum of the areas of the squares obtained by joining the midpoints of previous squares.

Activities on Circle:

41. To verify that the line drawn through the centre of circle to bisect a chord is perpendicular to chord.
42. To verify that the perpendicular drawn from the centre of the circle to a chord which is not a diameter bisects the chord.
43. To verify that the perpendicular bisector of a chord of a circle passes through the centre of the circle.
44. To verify that that chords equidistant from the centre of a circle are equal.
45. To verify that equal chords of a circle are equidistant from the centres.
46. To verify that chords of a circle subtend equal angles at the centres of the circle.
47. To give suggestive demonstration of the formula that the area of a circle is half the product of its circumference and radius.

48. To locate the position of the centre of a circle whose circumference is given, using paper folding and cutting method.
49. By paper cutting, pasting and folding, verify that the angle subtended by an arc at the centre of the circle is twice the angle subtended by the same arc at any other point on the remaining part of circle.
50. To verify that the angles in the same segment of a circle are equal, using the paper folding, cutting and pasting.
51. To verify that the angles in a semicircle is 90^0.
52. Using the method of paper cutting and folding to show that the angle in a major segment is acute and angle on a minor segment is obtuse.
53. To verify that the length of tangents drawn to a circle from an external point are equal by using the method of paper folding.
54. To find the area of circle using the area of circles.
55. To show that in case of concentric circles any chord of the larger circle, which is tangential to the smaller circle is bisected at the point of contact.
56. To show that if three circles of equal radius touch each other externally then the triangle formed by joining the centres of these circles is equilateral triangle.
57. To illustrate that the path of the moving chord of constant length inside a circle is a circle and to find out the radius of this inner circle.
58. To show that the locus of the centres of the circle passing through two given points is the perpendicular bisector of line segment joining the points.
59. To illustrate that when two circles are tangents to each other, then their centres and the point of contact of circles are collinear.
60. Developing the teaching aid to show the relation between ellipse and circle.
61. To show that the circle drawn touching out three semicircle is one sixth of the diameter of the bigger circle.
62. To verify the property of intersection of chords of circle.
63. To find the area inscribed by four equal circles.
64. To show that when a chord is parallel to a tangent of circle, the triangle formed by joining the two ends of the chord and the point of tangency is an isosceles triangle.

Activities on Algebra

65. To find the square root of natural number using its geometrical representation.
66. To obtain length segments corresponding to square roots of natural numbers using a model of graduated wooden sticks.
67. To find the factors of quadratic polynomial $ax^2 + bx + c$ where $c \neq 0$.
68. To verify the algebraic identities by using working models.

a) $(a+b)^2 = a^2 + 2ab + b^2$

b) $(a-b)^2 = a^2 - 2ab + b^2$

c) $(x+a)(x+b) = x^2 + x(a+b) + ab$

d) $(x+a)(x+b)(x+c) = x^3 + x^2(a+b+c) + x(ab+bc+ca) + abc$

e) $(a+b+c)^2 = a^2 + b^2 + c^2 + 2ab + 2bc + 2ca$

f) $(a+b)^3 = a^3 + 3a^2b + 3ab^2 + b^3$

g) $(a-b)^3 = a^3 - 3a^2b + 3ab^2 - b^3$

h) $a^3 + b^3 = (a+b)(a^2 - ab + b^2)$

i) $a^3 - b^3 = (a-b)(a^2 + ab + b^2)$

69. Introduction to one of the many useful calculation methods from vediv mathematics.
70. To obtain the condition for consistency of system of linear equation in two variable by graphical method.
71. To verify that the given sequence is a Athematic progression by paper cutting and pasting activity.
72. To verify that the sum of first n natural numbers is $\frac{n(n+1)}{2}$.
73. To verify that the sum of first n odd natural numbers is n^2 by using cutting and pasting method.
74. To find the formula for n^{th}term and to obtain the sum of an arithmetic progression geometrically.
75. Conversion of numbers from Denary to Binary system through a mod4el.
76. To enable the students to solve the quadratic equation using quadratic equation solver.
77. Triangular numbers, Pythagorean numbers, square numbers, pentagonal numbers and tetrahedral numbers.
78. To find the square root of a number by Guess average method.
79. To enable the students to understand the conjunction and disjunction of two statements and draw their truth table.

80. To show the physical meaning of Fibonacci sequence.(i.e the sequence 1,1,2,3,5,8,13,21,34,55,89, ... is Fibonacci sequence).
81. To enable the students to understand the construction of irrational numbers on number line in the spiral form.
82. To find the product of two numbers of two digits and three digits in a different way.
83. Nomo gram – To perform addition operation of numerals with respect to base 8.
84. To present the geometrical models for the finite geometric series.
85. To show that the total number of different square boards of all sides in a board of size n x n is equal to Σn^2.
86. Easy multiplication by Napier's strips.
87. Addition and subtraction of integers using number line.
88. To multiply any two numbers by diagonal relationship method.
89. Miracle addition puzzle.
90. To teach the mathematical operation by using Spike Abacus.

Activities in three-dimensional geometry:

91. To locate a point in three dimensional space.
92. To obtain the formula for total surface area of Right triangular prism and Pyramid.
93. To make a right circular cylinder of given height and circumference of the base.
94. To obtain the formula for the curved surface area of a right circular cylinder of given radius of its base and height.
95. To obtain the formula for the total surface area of a closed right circular cylinder
96. To give a suggestive demonstration of the formula for the volume of a right circular cylinder in terms of its height and radius of its base.
97. To make a right circular cone of a given slant height and the base circumference and to get the formula for the area of the lateral surface of a cone by using paper cutting and folding activity.
98. To relate the volumes of a right circular cone and a right circular cylinder and obtain a suggestive formula for the volume of a right circular cone.

99. To give a suggestive demonstration of the formula for surface area and volume of a prism.
100. To study the shape of the solids obtained by revolving different geometric shapes around an axis and around any given line.
101. To see the relation between the volume of the original sphere and the volume of the interior of the simple cube constructed from the sphere.
102. To find the number of cubes of all sizes in a given cube
103. To find the surface area and the volume of a torus

Activities in probability

104. To familiarize with the idea of probability of an event through an activity of throwing a pair of dice.
105. To show that the marbles flowing through a series of nails in the form of Pascal's triangle, will settle down in the shape of a normal probability curve using a wooden model.
106. To show that if we toss N coins simultaneously, the probability of getting head and tail are equal to N/2 by using coin tossing machine.
107. To introduce the concept of probability through probability disc.

Activities in Trigonometry

108. To make a clinometer and use to measure the height of an object
109. Activity on building the trigonometry tables
110. To measure vertical heights and horizontal distances using a Stadia tube.

Activities on Paper folding

1. **Create a Line:** Take a sheet of paper. Fold the paper once. The fold got is a straight line.
2. **Create a Point using two intersecting lines:** Fold the paper twice so that one fold cuts the other fold. The intersection of two folds (two lines) is a point (The point of intersection of two lines).
3. **Show that one and only one line passes through two given distinct points:** Mark two points on a sheet of paper. Fold it so that, it contains both the marked points. A single fold (only one line) is got.
4. **Create a perpendicular to a line:** Fold the sheet. One line $l$is got. Refold the sheet so that the fold passes through a point on l and the path of the line are brought to conclude. The second fold got is the line l^1 perpendicular to the given line l.
5. **Create a perpendicular to a given line through a point (a) on the given line (b) outside the given line:**

   (a) **Fold the sheets to get the given line** l. Mark a point on l. Fold the paper through P perpendicular to l. The l^1 so got passes through P and is perpendicular to l.

   (b) **Mark P outside the line** l (obtained by folding the sheet). Fold the sheet through P perpendicular to line l. The line l^1 so got passes through P and perpendicular to l.
6. **Fold a pair of parallel lines and create a parallelogram:** Fold the sheet of line$l_1$on a rectangular sheet of paper. Fold the sheet again so that the fold got l_1^1 is parallel to the earlier fold l_1. Now l_1 is parallel to l_1^1.

   Similarly create two parallel linesl_2 and $l_2^1$where l_1 and l_2 intersect on the sheet. The two pairs of lines l_1, l_1^1,l_2, l_2^1 form a parallelogram.
7. **Create (a) The perpendicular bisector of a line segment, (b) the angle bisector of a given angle:**

   (a) **Mark a line $l$and mark points A and B on l. Fold the sheets so that A and B are brought to coincidence. The fold so got is perpendicular bisector of AB.**

(b) Create an angle with vertex at O. Fold so that the crease passes through $O^1$and the arms of the angle are brought to coincidence. The fold got is the angle bisector.

8. Getting the (a) Centroid,(b) Orthocenter (c) Incentre and (d) the circumcentre of triangle. Mark a triangle ABC on a sheet of paper.

(a) Mark the mid points of the sides BC,CA and AB as D, E, F respectively**.** Fold the sheet trice passing through A, D, D, E and E, F. The folds AD, BE and CF which are the medians pass through the centroid G of the triangle.

(b) Fold the sheet trice so that the folds pass through the vertices and perpendicular to the opposite sides. These folds are the altitudes of the triangle passing through the orthocenter of the triangle.

(c) Fold thrice to get the angle bisector of the triangle which passes through the incentre of the triangle.

(d) Fold thrice to get perpendicular bisectors of the sides. These pass through the circumcentre of the triangle.

SCHEDULE FOR FIVE DAY TRAINING PROGRAMME

TITLE: TRAINING ON SETTING UP OF MATHEMATICS LABORATORY IN UPPER PRIMARY AND SECONDARY LEVEL-TELANGANA STATE

(FROM 19/01/2018 TO 23/01/2018)

Programme Coordinator: Prof. V S Prasad

Venue: RIE, Mysuru

	9.30-11.15	**11.30-1.00**	**2.00-3.30**	**3.45-5.30**
19/01/2018 Friday	Registration and Inauguration	Introduction to Maths Lab **Prof. N M Rao**	Activities in Algebra-I **Prakashan**	Activities in geometry-I **Suresh**
20/01/2018 Saturday	Activities in Algebra-II **Prakashan**	Maths lab activities **Prof. N M Rao**	Activities in geometry-II **Unnikrishnan**	Mathematical games and Puzzles **V S Prasad/ Suresh**
21/01/2018 Sunday	Hands-on Activities **Unnikrishnan**	Hands-on Activities continued **Prakashan/ Gopalakrishnan**	Geogebra Activities **B. Madhu**	Geogebra Activities **B. Madhu**
22/01/2018 Monday	Activities in Arithmetic-I **Prakashan**	Activities in Arithmetic-II **Gopalakrishnan**	Geogebra Activities **B. Madhu**	Geogebra Activities **B. Madhu**
23/01/2018 Tuesday	Activities in 3-D geometry-I **Gopalakrishnan/ Suresh**	Activities in 3-D geometry-II **Prakashan/ B Madhu**	Activity based teaching **T V Somashekhar**	Valedictory Function