EDUCATIONAL HANDWORK

INTERMEDIATE COURSE

BY

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PREFACE

This book has been prepared for use in the Intermediate Classes of Elementary and Preparatory Schools. It deals essentially with "first principles", and forms not only a basis for an intelligent idea of the various mathematical processes, but an educational medium to the other subjects of the school curriculum. The exercises and models have been designed with the object of arousing the interest of the child, of training his powers of observation, and developing his instinctive and inherent tendencies to construct and manipulate material

The teacher will not limit the lessons to those which are given in this course, but will encourage the pupils to measure various objects, and to construct models of these to a suitable scale. Rough working drawings should in all cases be made

CONTENTS

INTRODUCTION

A training based on Froebel's gifts and occupations such as is given in our Infants' Departments, and which aims at the development of a child's mind through its natural activities, is of the highest educational value. The child learns by doing How unfortunate it is that this method is not continued throughout his career at school. The junior classes have, as a rule, no systematic form of hand-training, and this is a serious drawback in our educational system

Sir James Crichton Browne, in a presidential address at the Salt School, Shipley, said·

The nascent or growth period of the hand centres probably extends from the first year of life to the end of adolescence, its most active epoch being from the fourth to the fifteenth year, after which these centres, in the large majority of persons, become somewhat fixed and stubborn Hence it can be understood that boys and girls whose hands have been altogether untrained up to the fifteenth year are practically incapable of high manual efficiency ever afterwards We know that each brain centre has its nascent period, which is sometimes short and sometimes long. But whether the nascent period be long or short, it is of paramount importance that it should be taken advantage of while it lasts, and that the organs related to the centre should be duly exercised during its continuance. If the nascent period is permitted to slip past unimproved, no subsequent labour or assiduity will compensate for the loss thus sustained.

In most towns selected children are sent to Woodwork centres when they reach the higher classes; but owing to the lack of motor training in the senior departments of our schools, they are generally unfitted to take full advantage of the course of instruction. It is the aim of this book to supply a scheme of work which will effectively deal with this break in our educational system, by providing such occupations as may be performed by the average child under ordinary conditions, and which will in addition provide a suitable scheme of Manual Training for Rural Schools. Too many handbooks deal with Manual Training as though it were a separate subject It should, however, be treated as a "method" of training the activities of the child, in order to simplify the approach to such subjects as Arithmetic, Mensuration, Geometry, and Drawing

The object of the teaching should be the development of the individual — the hand, eye, and brain being trained to work in harmony through the construction of suitable objects

The materials required in the earlier stages are such as may be found in every school—brown paper, drawing paper (plain and squared), rulers, set-squares, dividers, and scissors. For more advanced work thin cardboard will take the place of paper, the knife being substituted for scissors.

Lesson Plan

Preferably a completed model made by the older children should be distributed to each pupil, in order that all may have the opportunity of discovering how it is made. Should this not be possible, however, two models should be exhibited: one a finished specimen, and the other fastened together by fix clips. The children discuss the shape, colour, &c., and then proceed to analyse. Measurements are taken, and this affords the teacher an opportunity of associating the work with arithmetic, mathematical drawing, &c.

If there are only two models, the plan must be drawn on the blackboard; but this is not necessary when all are supplied, as the measurements can be taken directly from the model

In order that the colour sense may be trained, the pupils should be allowed to choose the shade of paper they prefer, and may also occasionally ornament their models by direct drawing with the brush or crayon This gives an added interest to the work

As much practice in measurement as is possible should be given, as it is of the greatest benefit to the children. They should be encouraged to bring dimensioned hand sketches of suitable models for construction. This develops *originality*, *initiative*, and *power*

Diagrams

Kinds of Lines:—

Construction lines: thin ————————

Cutting lines: thick ————————

Folded lines: dash — — — — — — — — — —

Backward folds: dash and stroke —|—|—|—|

Materials required for Intermediate Course

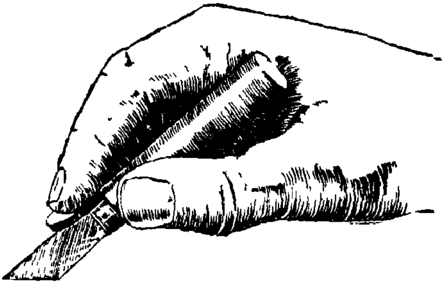
Materials:—

Stout cartridge paper, carton paper, and thick cardboard (four sheet).

Knife:—

"London" pattern, with finger rest as illustrated.

This may be procured from the Lloyd Tool Company, Sheffield.



Adhesive:—

Duckett's Pastem, 6*d*. per packet; Le Page's liquid glue, 2*s*. per pint, Higgins's photo mounter, 4*s*. 6*d*. per dozen.

Ruler:—

Safety ruler (Charlecote), 6*d*.; Charles & Dible

Millboards:—

Cutting boards, 6*s*. per gross.

Scissors:—

5*s*. 6*d*. per dozen.

Stencil Brushes:—

Reeves's, 2*s*. 6*d*. per dozen.

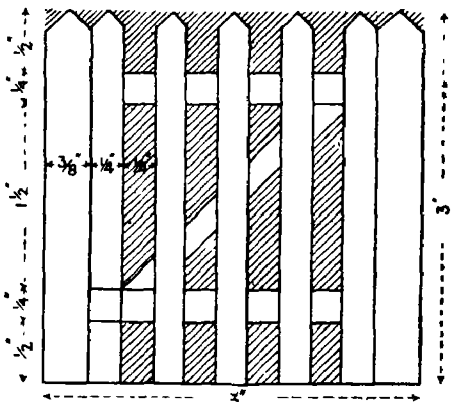
The Use of the Knife

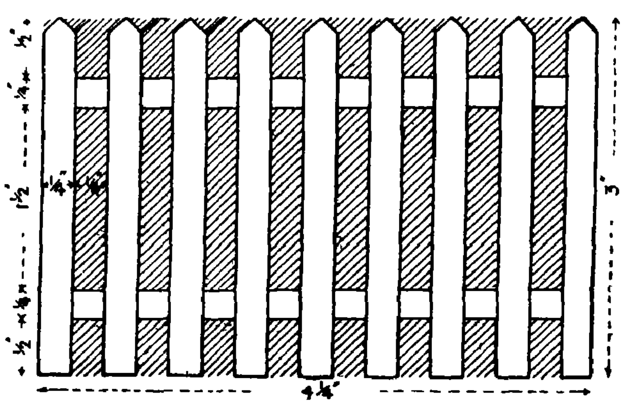
Special attention is necessary to the correct method both of holding and using the knife. It should be grasped firmly with the forefinger on the rest. (See p. 10).

Several light cuts are preferable to one heavy cut. The ruler should always be placed on the drawing, so that a slip could only damage the waste part to be cut off. Care should be taken to cut the line through its entire length before removing, so as to leave a clean edge.

Suggested Exercises:—

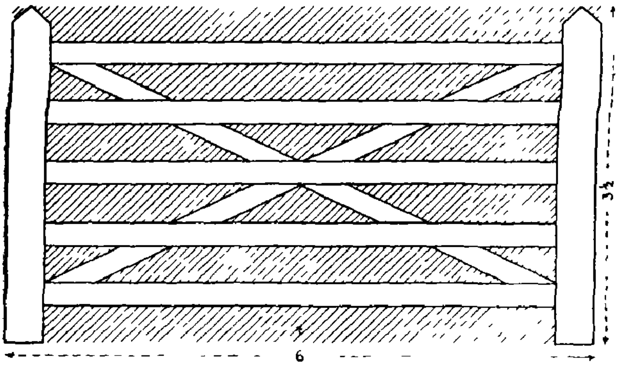
1. *Wooden palings.*—Measure a suitable fence in the neighbourhood of the school, and reduce it to





the scale of 1″ to 1′. Cut out as indicated in the sketch.

2. Make a dimensioned sketch of a five-barred gate, and afterwards draw to scale and cut out.



3. Similarly make a scale drawing of a school window, and cut out so as to show the frame

Educational Handwork

Intermediate Course

THE CUBE AND RECTANGULAR PRISM

Examination of an Inch Cube

Materials required: Each child should be provided with 27 in cubes, set-squares, and inch rulers.

The children examine the cube, and make written and oral statements from their own observations.

Faces. (1) The cube has six faces.
(2) Each face is a square

Angles: The cube has 24 right angles.

Edges The cube has 12 equal edges.

Practice has already been given in using the *inch* as a unit of length and the *square inch* as the unit of area. The object of this exercise is to give notions of solidity, and to explain the use of the *cubic inch* as the unit for measuring volume.

Exercises in Building Solids of various Dimensions

Ex 1.—Without any previous instruction except such as is given above, require the pupils to construct (*a*) a two-inch cube, (*b*) a three-inch cube.

Criticize and discuss their efforts. Special emphasis should be laid on the fact that the area covered by the base of the solid is equal to the number of cubic inches in the bottom layer, i.e. each cubic inch covers an area of 1 sq. in

Ex. 2.—Using the same number of inch cubes as in (*a*) and (*b*) above, construct other rectangular solids, and write down their dimensions.

Ex. 3—Measure various cubical and rectangular solids, i.e. boxes, &c., and find their volume in cubic inches.

Ex. 4.—Measure larger rectangular solids Using the kindergarten cubes, construct these to a scale of 1″ to 1′, and find their volumes.

Ex. 5.—(*a*) Find the distance round *one* face of the cube if the edge is 1″, 2″, 3″, 4″, &c.

(*b*) Find the length of *all* the edges if each measures 1″, 2″, 3″, 4″, &c.

Ex 6.—As an introduction to mathematical generalization, a cube which the pupils had not previously examined should be placed before them; and oral exercises should be given as follows:—

(*a*) If we call one edge x'', what would be the length of 2, 3, 4, &c , edges?

(*b*) If each edge be increased by 1″, what will be the length of 2, 3, 4, &c., edges?

(*c*) If each edge be diminished by 1″, what will be the length of 2, 3, 4, &c., edges?

$$(x - 1) \text{ in.} \times 2 = (2x - 2) \text{ in.}$$
$$(x - 2) \text{ in.} \times 2 = (2x - 4) \text{ in., \&c.}$$

(*d*) If we call each edge $2x''$, what would be the length of 2, 3, 4, &c., edges?

(*e*) If each edge be increased by 1″, what will be the length of 2, 3, 4, &c., edges?

$(2x - 1)$ in $\times 2 = (4x - 2)$ in.
$(2x - 1)$ in. $\times 3 = (6x - 3)$ in., &c.

It should be recalled that the area of a 2-in. square $= (2 \times 2)$ square inches, and that of a 3-in. square $= (3 \times 3)$ square inches, and it should be pointed out that for convenience we write 2^2, 3^2, 4^2, x^2. Oral and written exercises should follow on the squares of numbers.

The teacher will be guided entirely by the capacity of the class as to how far he will make use of the various exercises (Some may be deferred.)

1. The Cube

CONSTRUCTION.

Each child should roll a completed specimen on paper, marking the plan at each stage

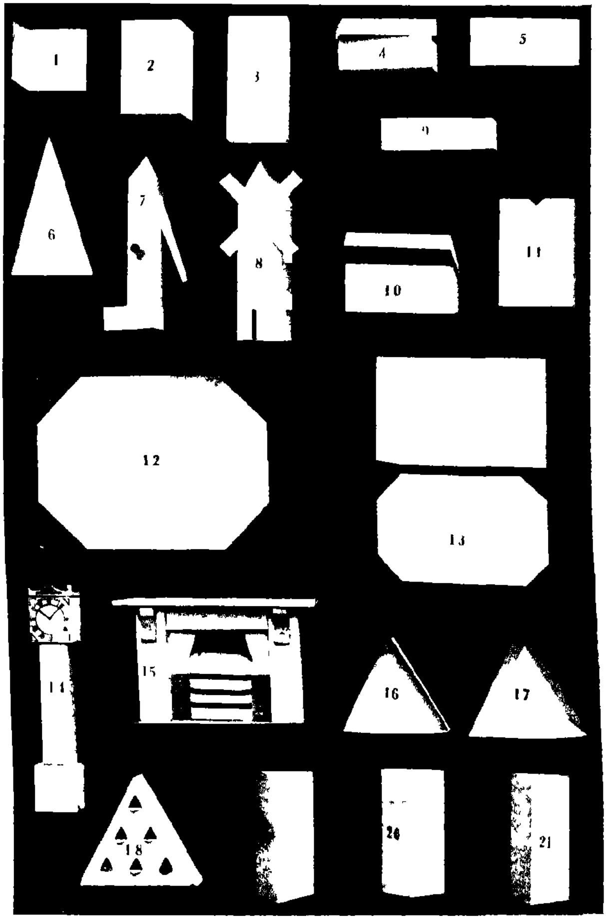
The development should then be drawn. Folds should be made along all the dotted lines. The flap A should be fixed to flap B first This should be done by folding across the middle line. This allows of the first join being made in the flat position. The ends are then fixed, all flaps being inside.

EXERCISES.

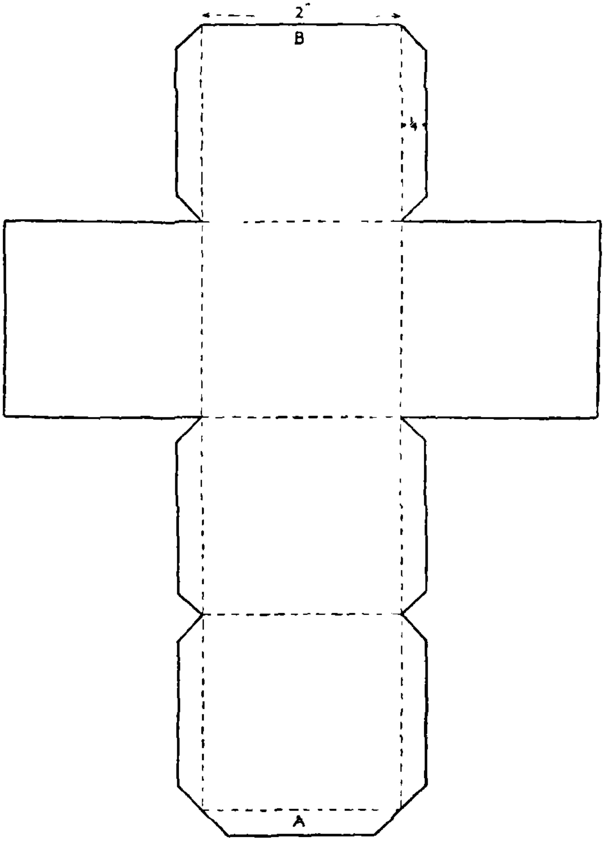
1. Combine models to make larger cubes, and calculate their volumes.
2. Let children measure the dimensions of certain cubical solids and vessels, and calculate their volumes and capacities.
3 (*a*) For large objects, show the necessity for a larger unit than the "cubic inch", i.e. the "cubic foot". A cardboard model of a "cubic foot" should be exhibited, and its volume in cubic inches found. Note that it is composed of twelve layers of 144 cub in. = ($12 \times 12 \times 12$) cub in.

   (*b*) $2^3 =$; $3^3 =$; $4^3 =$
4. A drawing of the completed model should now be made.
5 Find the surface area of the cube
6. How many cubic inches would the model hold? Compare a 2-in. cube and 2 cub in., a 3-in. cube and 3 cub. in., a 2-in. cube and a 3-in. cube.

PLATE I. MODELS 1-21



1, The Cube 2, Square Prism 3, Oblong Prism 4, Box With Lift-off Lid. 5, Money Box 6, Square Pyramid 7, Pump 8, Windmill 9, Sliding Match-box 10, Box with Hinged Lid 11, Card Case 12, Blotting Pad. 13, Postcard Holder 14, Grandfather's Clock 15, Fireplace 16, Triangular Tray 17, Equilateral Triangular Tray 18, Dovecot 19, Triangular Prism 20, Right-angled Triangular Prism 21, Scalene Triangular Prism


2"
B
¼
A

7. Complete the following:—

Edge of cube	1	2	3	4	5	6	7	8	9	10	x	$2x$	Units
Area of one face													Square units
Volume of cube													Cubic units

8. Count the number of horizontal and vertical lines there are when a cube is lying on one of its faces

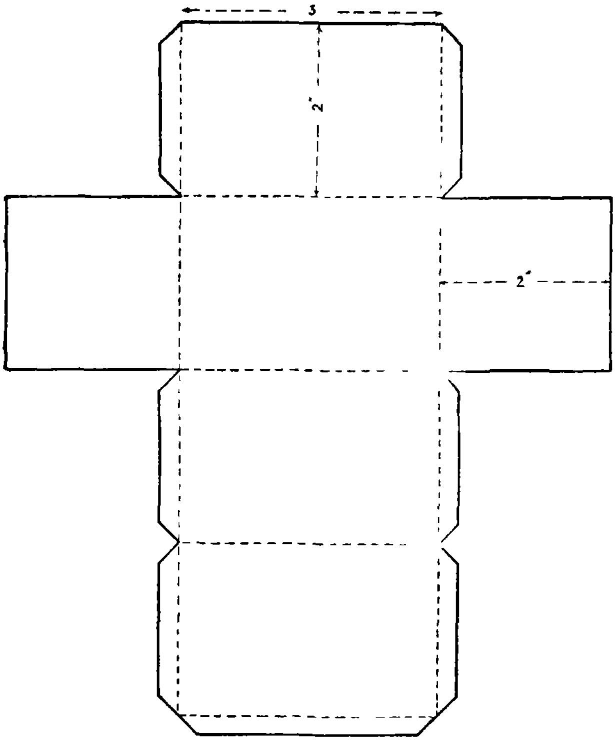
9. Tilt the cube on one of its edges. Let its face rest on the edge of a set-square. (*a*) How many oblique lines are there? (*b*) Are there any horizontal lines?

10 If a long hatpin were pushed through the cube diagonally, and it were run vertically through into a desk, how many edges would be oblique? How many faces would be oblique?

2. Square Prism

EXAMINATION AND COMPARISON

A few completed specimens of square prisms, $2'' \times 2'' \times 3''$, should be passed round the class for examination. The pupils will readily note that the base of the cube in the last model and that of the square prism are equal, but that the heights are unequal. They should then be required to make a sketch of the model and insert the dimensions



CONSTRUCTION.

Proceed exactly as in the last exercise. Place the rectangular side on paper and revolve, marking the plan at each stage as before.

Such questions as the following should then be asked

1. How many faces are there? edges?

2. What is the area of each long face? of each short face? of the whole prism?
3. What is the greatest number of faces, edges, and corners which can be seen at any one time?

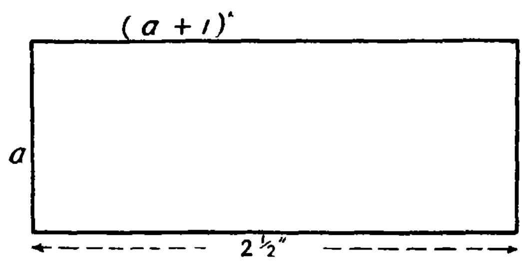
EXERCISES.

1. Square prisms should be built with inch cubes, and the rule for volume developed.

$$\text{Volume} = \text{Base Area} \times \text{Height.}$$

2. Calculate volume, using the oblong side as base.
3. Find the volume of a square prism having a base of 3″ and a height of 5″.
4. A cistern has a square base of 2 ft. side and a height of 3½ ft. Draw the development (scale 1″ to 1′), and find the area of a long side, and the capacity of the cistern.
5. Find the perimeter of the rectangular sides of a square prism if the short side is a in. and the long side is 1″ longer.

   Find the length of all the edges of the prism.

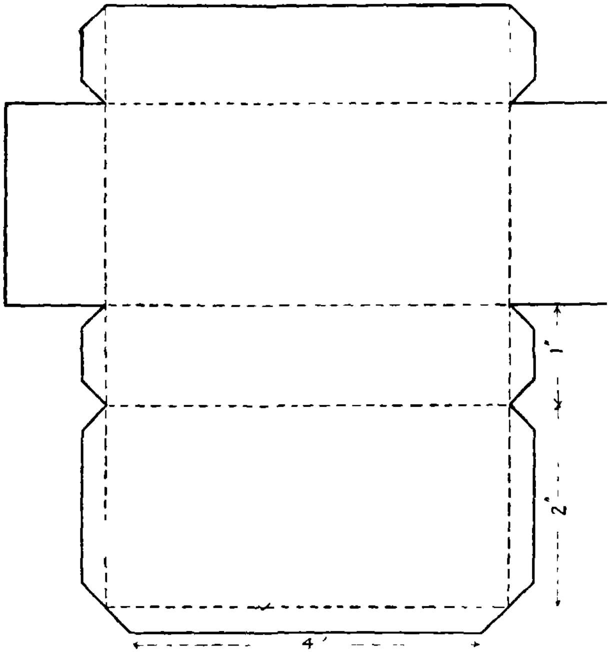


6. Find the perimeter of the rectangular sides of a square prism if the short sides are x in. and the long sides y in.
7. Find the perimeter of all the edges of the prism in the last exercise if the edges are all increased by a in.
8. Find the perimeter if the short edges are increased by a in. and the long edges diminished by a in. What would be the length of two short edges and two long edges?
9. Draw the plan of a square prism having a base of $2\frac{1}{2}$ in.
10. Draw the elevation of a square prism having the sides of its square base $2\frac{1}{2}$ in. and its height 4 in. Find its volume.

3. Oblong Prism

EXAMINATION AND COMPARISON.

A few completed specimens should be distribute for examination. The edges should first be mea



sured, and the pupils will readily notice that there are three dimensions, differing in length.

A sketch showing dimensions should then be made

CONSTRUCTION.

Proceed exactly as in last exercise.

The principles, as to volume, established in the previous exercises will render it unnecessary to construct oblong prisms using inch cubes

EXERCISES.

1. Find the area of the smallest sides; of the largest sides; of the two other sides.
2. Write, in your notebook, statements as to the differences and resemblances between the cube, square prism, and oblong prism.
3. Find the volume of various oblong prisms, e g. boxes, drawers, &c.
4. Calculate the volume of a brick to nearest inch ($9'' \times 4\frac{1}{2}'' \times 3''$).
5. What is the perimeter of all the edges of a brick?
6. If the shortest edge of a brick measure a in., what would the longest measure? Find the perimeter, calling the shortest edge a inches.
7. Make a drawing showing the plan and two elevations of a brick to scale (half-size).
8. If the base of an oblong prism containing 81 cub. in. has an area of 9 sq. in., what is the height?
9. If the three dimensions of an oblong prism are x, $x + 2$, and $x + 3$ inches, find the perimeter.
10. If the base of a square prism has an edge of x in., and the long edges are each y in.:

    (*a*) How would you express the total length of the short edges? of the long edges? of all the edges?

(*b*) What is the area of the base in square inches? What is the area of the two square ends?

(*c*) Make a sketch of the long face, marking one edge x in. and the other y in. What is the area of one long face? of all the long faces?

(*d*) What is the area of all the faces?

(*e*) Multiply the area of the base by the altitude, and so find the volume.

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4. Box with Lift-off Lid

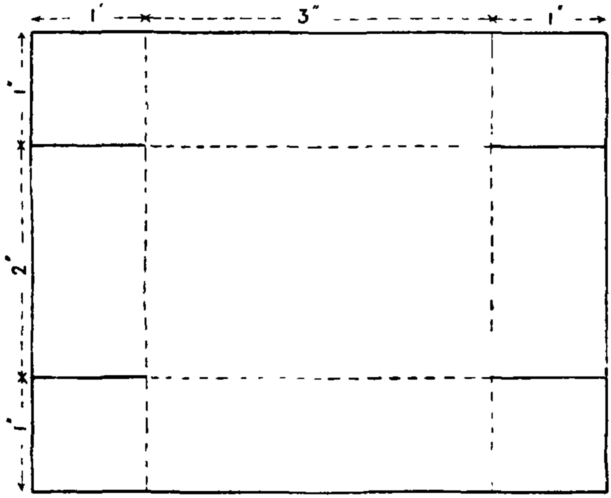
CONSTRUCTION.

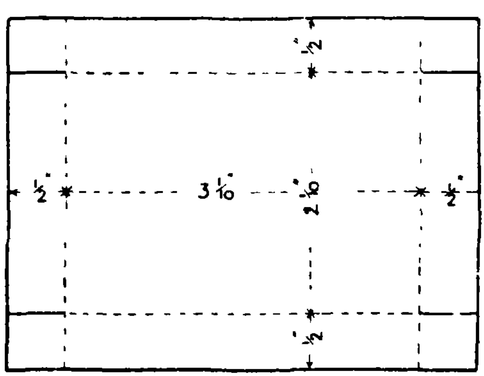
Completed models should be distributed, and the children should be required to measure the dimensions of each edge of the box and then of the lid. They will note the allowance of $\frac{1}{10}''$ in the top of the lid. The teacher should question as to the amount of paper required for the two parts of the model.

EXERCISES.

1. Discuss the theory of fitting lids to boxes. Note that the inside measurement of the lid should equal the outside measurement of the box together with a small allowance for fitting.
2. Discuss the advantages of lids: a protection of contents, &c.
3. Examine each side of the box. Find its area.
4. How many square inches of paper could be pasted round the four sides of the box?
5. How many inch cubes would fill the box?

6. How many inch cubes would a box $5'' \times 2'' \times 1''$ hold? How many would it hold if its height were increased $1''$? $2''$?





THE LID

The development of the lid should again be drawn, and the dimensions filled in. The attention of the pupils should be called to the other method of writing $3\frac{1}{10}''$ (3·1), and with the help of the scale ruler divided in tenths it may readily be elicited that $\frac{1}{2}'' = \frac{5}{10}''$ and may be written ·5″.

Simple exercises would follow on the addition, subtraction, and multiplication of decimals to one place.

The pupils will readily see that 3·1 may also be read as 31 tenths, &c.

If thought advisable, this lesson should be followed by simple lessons on the metric system. The children should examine their rulers and note the centimetre; that each centimetre is divided into ten parts each called a millimetre. The completed model should then be measured in centimetres and parts of a centimetre, thus: Box—

Long edge,	7·6 cm.	7 cm. 6 mm.	76 mm.
Short edge,	2·5 cm.	2 cm. 5 mm.	25 mm.
Other edge,	5·1 cm.	5 cm. 1 mm.	51 mm.

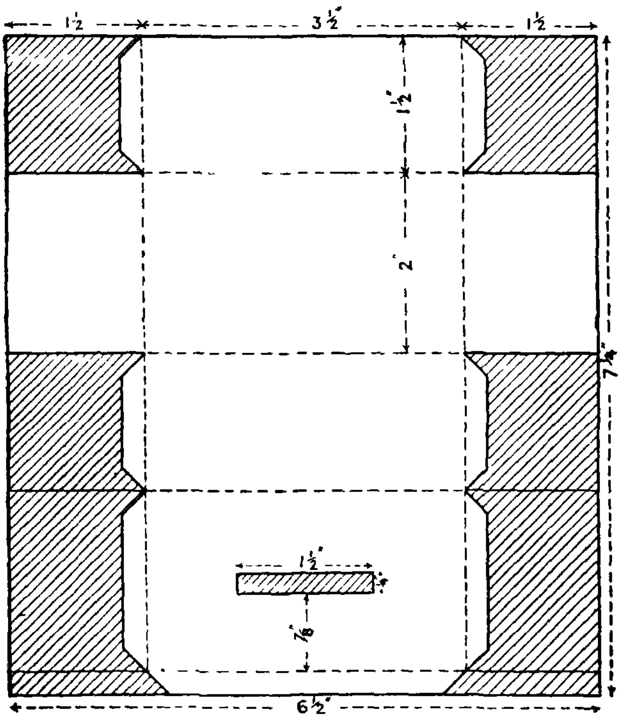
EXERCISES.

1. Find the perimeter of the largest oblong in centimetres and parts of a centimetre. Find the perimeter of each of the other oblongs.
2. Draw lines $4\frac{1}{2}''$, $3\frac{3}{4}''$, $5\frac{1}{2}''$, 6″, and find their length in centimetres and millimetres.
3. Draw lines 5·3 cm., 4·6 cm., 7·8 cm., 10 cm. in length.
4. Make a box having sides of 10 cm., 5·5 cm., and 2·5 cm.

5. The Money Box

CONSTRUCTION.

The pupils will readily observe that the model is an "Oblong Prism". The method of procedure is



precisely similar to that employed in that exercise. Care must be taken in marking the position and in cutting the slot. The whole of the development should be drawn without any assistance from the teacher. In order that the slot may be correctly placed, such exercises as the following may be given before the slot is marked:—

1. How long is the model? How much longer is it than the slot? What distance must be left on each side so that the slot may be exactly in the centre?

   Draw dotted lines 1″ from each side in the bottom rectangle of the development.

2. How wide is the bottom rectangle? the slot? How many 8ths of an inch in 2″? How many 8ths in ¼″? What is the half of fourteen 8ths?

   Carefully measure ⅞ths down each side in the bottom rectangle. The bottom line of the slot may be obtained by measuring from the lower edge of the model.

EXERCISES.

1. What is the perimeter of the base of the model?
2. Measure a long edge. If the long edge is x in., what is the perimeter of one end? of two ends? of the middle-sized rectangle?
3. What is the area of the bottom? of the ends?
4. How high is the money box? If the height were 3″, what would be the area of one side?

   (3½″ × 3″) = 10½ sq. in.
   (3½″ × 1½″) = sq. in.

5. Find the area of the slot.

   1½″ × 1″ = 1½ sq. in.
   1½″ × ½″ = sq. in.
   1½″ × ¼″ = sq. in.

Find the area of the remaining portion of the top.

6. Find the volume of the oblong prism.

7. An oblong prism is 10 cm. high, 12·5 cm. long, and 7·6 cm. wide: (*a*) Find the area of each of its four largest sides; (*b*) find the perimeter of all its edges;

(*c*) (12·5 cm. × 10 cm.) = sq. cm.
(7·6 cm. × 10 cm.) = sq. cm.

Find the difference between these results.

(*d*) (4·9 cm. × 10 cm) = sq. cm.

Compare the last two answers.

8 Measure the edges of the completed model of the money box in centimetres and parts of a centimetre. Complete—

	cm.			cm.
Long edge =	;	Two long edges	=	.
Short edge =	;	Two short edges	=	.
Other edge =	;	The two other edges	=	.
Total =	;	Total	=	.

9. How much longer are two long edges than two short edges?

10. How much longer are two long edges than the other edges?

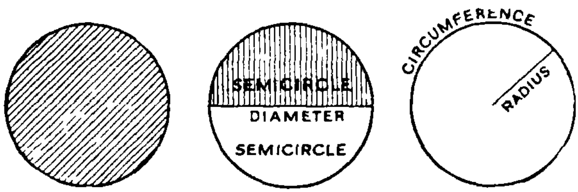
The Circle

(Each child should be provided with a kindergarten circle, say 6″ diameter.)

The children should be asked to compare the circle with the square. How many edges, corners, angles, &c., does it contain?

They should next fold the circle into two equal parts. (*Semicircle.*)

They should be asked to make statements about the edges of a semicircle. It is partly curved and partly straight.



Let them measure the length of the diameter.

The circle should then be opened, and folded again into two equal parts along a new diameter. Measure the diameter again. Repeat this several times.

Call the attention of the class to the point through which all the diameters pass. (*The centre.*)

They should then be required to draw a line AB 3″ long, and then draw from A four other lines, in various directions, 3″ long.

Compasses should then be used to describe a circle having point A as the centre—the radius being 3″. Note the five lines drawn from the centre A to the outside of the circle.

Each of these lines is called a *Radius.*

The boundary line is called the *Circumference.*

There should be no confusion between what is meant by the terms *Circle* and *Circumference.*

Compare the radius of a circle and its diameter.

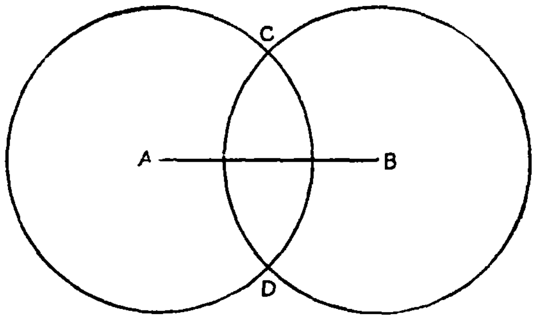
EXERCISES.

1. Draw and cut out circles having a radius of $2\frac{1}{4}''$, $1\frac{3}{4}''$, and $1\frac{1}{2}''$.
2. Draw and cut out circles having a diameter of $5''$, $4\frac{1}{2}''$, and $2\frac{1}{2}''$.
3. Draw a line AB $5''$ long Mark the centre C, and with a radius of $2\frac{1}{2}''$ describe a circle.

   From point A draw five lines passing through the circle to touch the circumference.

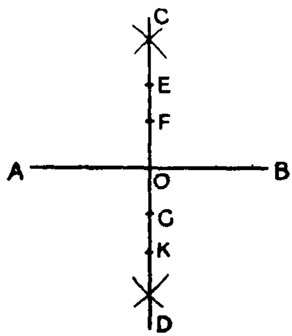
   Compare the lengths of these lines with AB.
4. Fold a circle into four equal parts, called *quadrants*, and with the set-square test the angles at the centre.

Lines, Angles, and Triangles



1. Take any two points A and B 5 cm. apart.
   With centres A and B and radius 3·5 cm., describe two circles. What points are 3·5 cm. from both A and B?

2. *To bisect a line AB*—
   (*a*) Take a radius more than half the line, and describe two arcs with A and B as centres.
   Let the arcs cut in points C and D.
   Join C and D, cutting AB in point O.
   Measure AO and BO.
   The line AB has been bisected.



(*b*) Take any other points in CD, as E, F, G, K, and measure from A and B to each of them.

(*c*) Draw an arc AB, and bisect it in the same way.

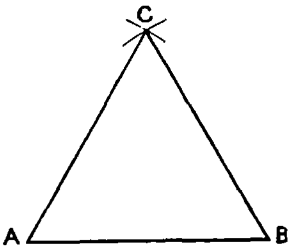
3. *To describe an Equilateral Triangle*—

Draw AB 4·5 cm. long.

With radius 4·5 cm. and centres A and B, describe two arcs intersecting at C.

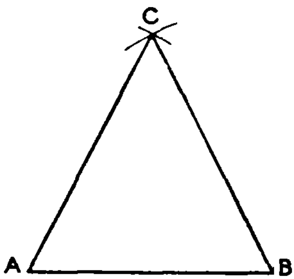
Join CA and CB.

ABC is an Equilateral Triangle.



4. *To describe an Isosceles Triangle*—

Draw AB 4·5 cm. long.



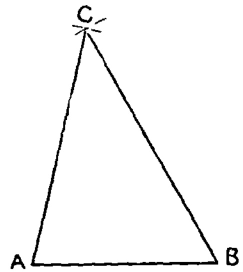
With radius 5 cm. and centres A and B, describe two arcs intersecting at C.

Join CA and CB.

ABC is an Isosceles Triangle.

5. *To describe a Scalene Triangle*, having sides 3·5 cm., 4·5 cm., and 5 cm.

Draw a base AB 3·5 cm.



With centre A and radius 4·5 cm., draw an arc; and with centre B and radius 5 cm., draw another arc intersecting the previous one at point C.

Join CA and CB.

---

6. The Square Pyramid

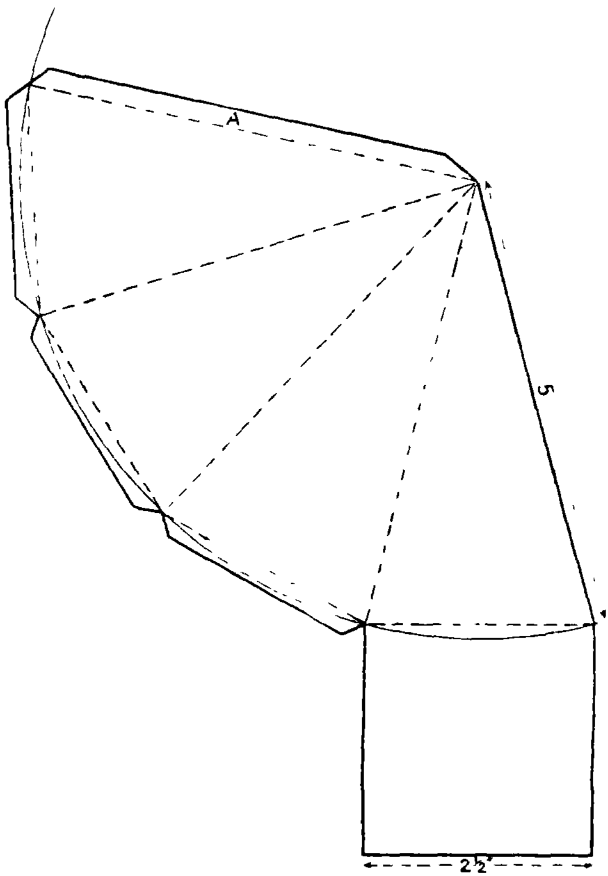
EXAMINATION AND CONSTRUCTION.

The children will discover for themselves that the model has a square base (2½″ side) and four isosceles triangles for its sides.

The method of constructing the development may be shown by cutting down one of the long edges and opening out the square base As an alternative, place the base of the model on the paper, and, after marking round the edges with a pencil, tilt the model so that a triangular face touches the paper, and revolve until the four triangles have been marked.

The construction affords a valuable exercise for proving that the radii of a circle are equal

Note that flap A should be pasted first



EXERCISES.

1. Make a hand sketch of the pyramid, inserting the various dimensions.
2. (*a*) Construct four isosceles triangles having sides of 5″, 5″, and 2″.
   (*b*) Cut out the triangles. Bisect one of them by drawing a line from the apex to the centre of the base. Cut along the line. Measure the length of this bisector.
   Arrange the triangles so as to form a rectangle. Find its area.
3. What is the total surface area of the pyramid if the short edge is *a* cm. and the height of one of the triangles is *b* cm.?

7. The Pump

CONSTRUCTION.

Draw the development. Cut and fold as indicated.

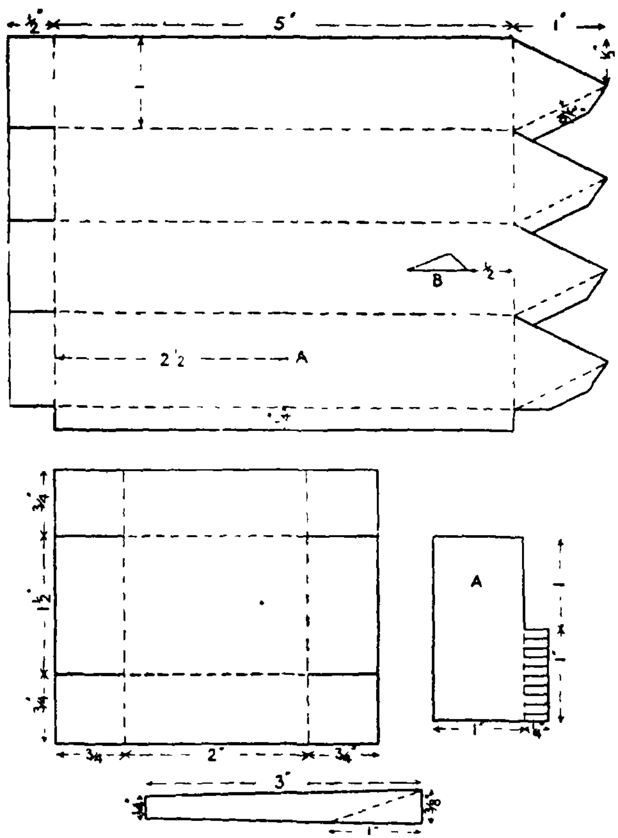
1. Body of Pump.—The side flap should be fixed first; then the bottom.

Paste the four flaps at the top. Place in position, and hold till fixed.

2. Spout.—Roll round a lead pencil. Unroll and paste portion A. Roll again, and hold till fixed.

The narrow flaps should be spread out to form a star. Fix to the body of the pump at A, 2½″ above the base.

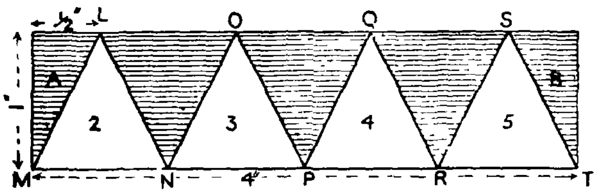
3. Fix the handle at B, ½″ from the top of the rectangle, and fasten the trough as indicated.



EXERCISES.

1. What is the area of the base of the pump?
2. What is the height of the pump from the base to the edge of the slope? What is the capacity of the pump, excluding the pyramidal top?

3. Find the area of the four sides of the trough; of the base. How many cubic inches of water will the trough contain?
4. Draw and cut out a rectangle 4″ × 1″, and divide as shown below.



(*a*) What is the area of the whole figure?

(*b*) Cut out the triangle B, and place it by A so as to form another triangle. Are the areas equal?

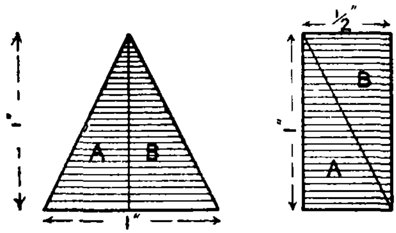
(*c*) Measure the line LM and LN; then ON and OP.

(*d*) Cut out the portion marked A, and by placing the two parts AB on the triangle LMN, compare the triangles. Test the other triangles in the same way.

(*e*) Using the part marked A, find an angle equal to the angle LMN. Test if this angle will exactly fit in the opposite angle LNM. How many angles in each of the triangles are equal to the angle LMN?

(Note that each triangle has equal sides and equal angles, and that the whole rectangle has an area of 5 sq. in., and elicit from the pupils that the area of each triangle is ½ sq. in.)

(*f*) Compare the area of the triangle and the rectangle formed by placing the two parts as shown.



Find the area of a triangle having a base of 4" and a perpendicular height of 6".

Make a rectangle containing 12 sq. in. and cut it into two equal parts, so as to form a triangle having a base of 4" and an altitude of 6".

5. Make a sketch of the finished model

APPLICATION.

Discuss the construction and use of the pump.
If possible, show a working model.
Note the use of the trough.

8. The Windmill

CONSTRUCTION.

Proceed as in last model. Fasten the side flap first, and then the bottom.

Fold windows outwards.

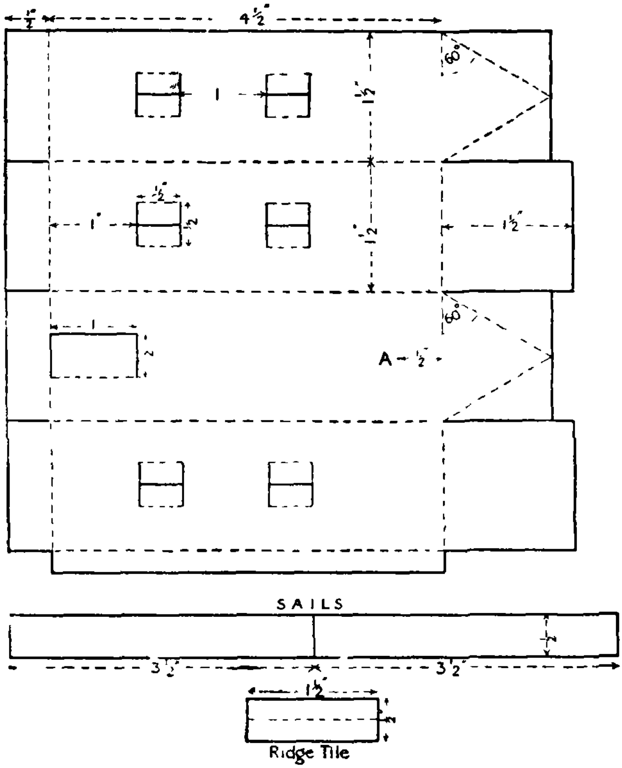
Paste sails at right angles to each other to form a cross, and then fix at point A. The roof and ridge tile may be coloured red before pasting.

EXERCISES.

1. Make a drawing of the completed model.
2. What is the area of all the windows? of the door? Find the area of the remaining portion of the sides of the windmill.

APPLICATION.

Discuss the use and motive power of the mill.



½"
4½"
60°
1
1½"
½"
1"
1½"
1
60°
A ½"
SAILS
3½"
3½"
1½"
Ridge Tile

9. Sliding Match-box

CONSTRUCTION.

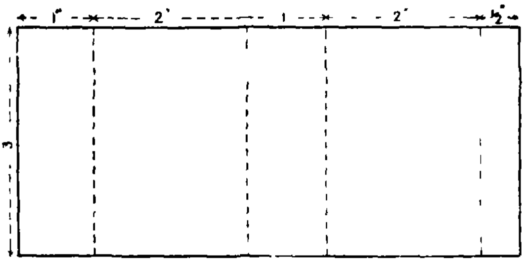
Completed specimens should be examined before the development of each part is drawn. The allowance of $\frac{1}{16}''$ in the width and height of the box will necessitate careful measurement, in order that a good fit may be secured.

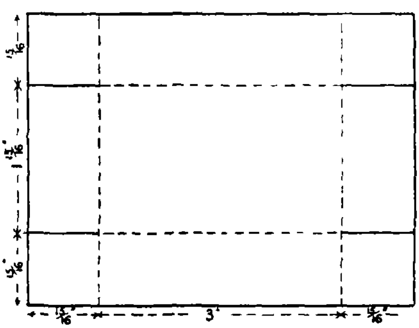
EXERCISES.

1. Find the area of the base of the box.
2. Find the volume of the box.
3. Find the area of each of the sides of the cover.
4. Find the internal area of the box.
5. How many square centimetres does the top of the cover contain?
6. What is the total area in square centimetres of all the four sides of the cover?
7. Make a hand sketch of the cover, and insert the measurements of all sides in centimetres and decimals of a centimetre.
8. Draw a plan and end elevation of the cover.

APPLICATION.

Make a sliding pencil-case. The length of the pen or pencil should be the standard of length.


1"
2"
1
2"
½"
3


15/16
1 15/16"
15/16"
15/16"
3"
15/16"

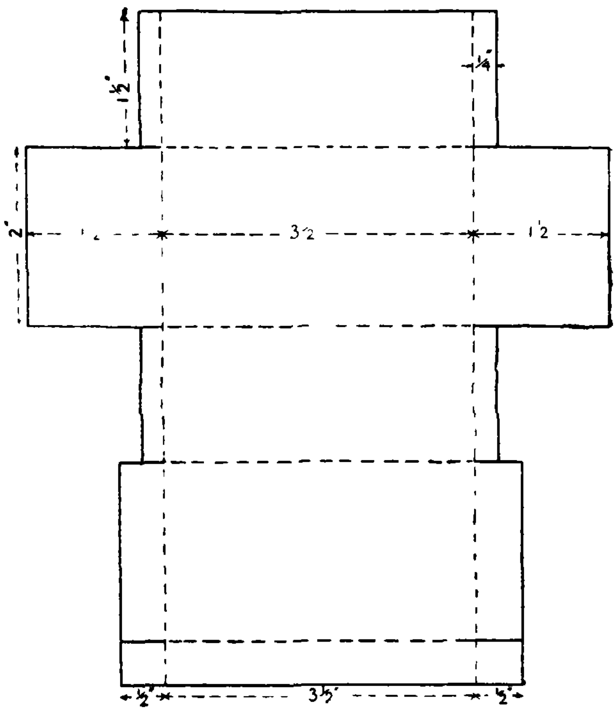
10. Box with Hinged Lid

CONSTRUCTION.

Draw the development. Cut and fold as indicated. In the drawing, the size of the lid is identical with that of the box. In order to secure a fit, it will be necessary to fold the box lines slightly inside the lines, and the lid lines slightly outside.

EXERCISES.

1. Make a sketch of the box—corner view—inserting all dimensions.
2. Find the area of the base.
3. Measure the height and find the volume.
4. Measure other boxes, and calculate areas and volumes.
5. How many inch cubes could be put into a drawer 8″ × 5″ × 4″? How many would there be in the top layer?


1½"
¼"
2"
3½
1½
½"
3½"
½"

11. The Card Case

CONSTRUCTION.

An ordinary playing-card should be measured The pupils will readily understand that some allowance should be made in the width of the box to enable the cards to slide in easily (⅛″). The length of the box should be identical with that of the card.

The thumb-hole should be drawn by using the 45° set-square.

Flap A should be fastened first

Place all flaps inside.

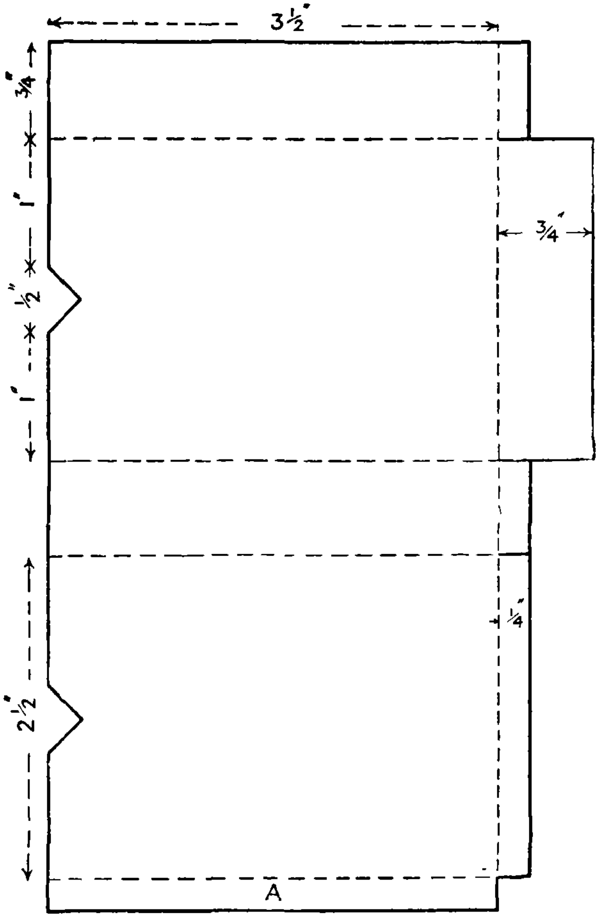
EXERCISES.

1. Form a square, using the pieces cut out for the thumb-hole; rearrange the two pieces to form one triangle. What kind of triangle is it? What is its area?
2. Draw a front elevation of the box.
3. Cut out a playing-card to fit the box.

APPLICATION.

1. Discuss the uses of the box; to keep the cards together; free from dust, &c

2. The pupils should make a cover for the box, calculating the necessary allowance.


3½"
¾"
1"
½"
1"
2½"
¾"
¼"
A

12. Blotting Pad

CONSTRUCTION.

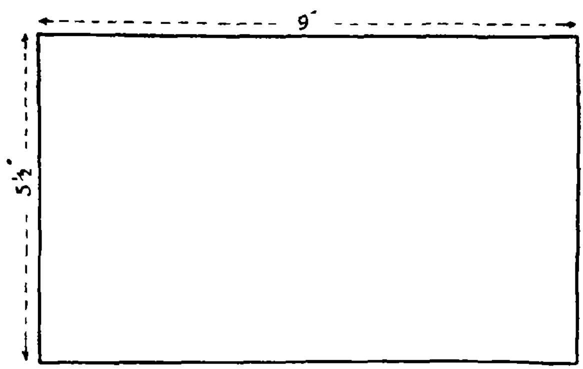
Supply each child with a few sheets of blotting paper of the size used in school, say 9″ × 5½″.

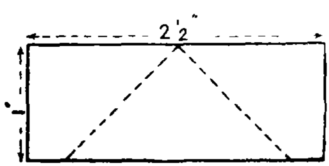
Cut a piece of brown paper the same size as the blotting paper.

Cut the four corner pieces, and fold as indicated in the sketch.

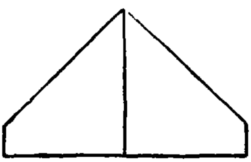
Place the blotting paper on the backing, and fix the corner pieces behind.

Fix the whole to a piece of thin card of equal dimensions.





Corner Piece


Corner Piece
folded (Back View)

13. Postcard Holder

CONSTRUCTION.

MATERIAL: Brown paper or thin card. Each child should be supplied with three or four postcards.

Cut a piece of paper the exact size of a card.

Cut the corner pieces, and fold as in last exercise.

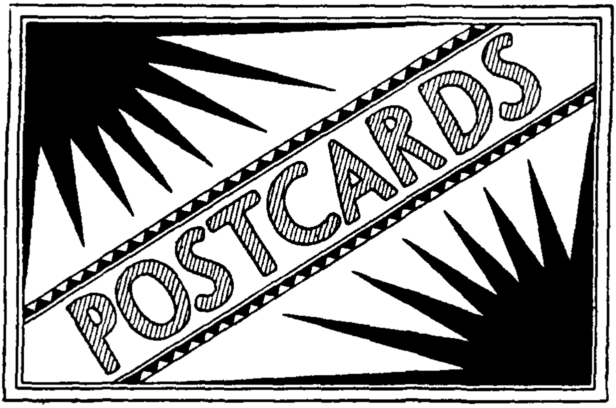
Place the cards on the piece of paper used as a backing, and paste the corner pieces behind.

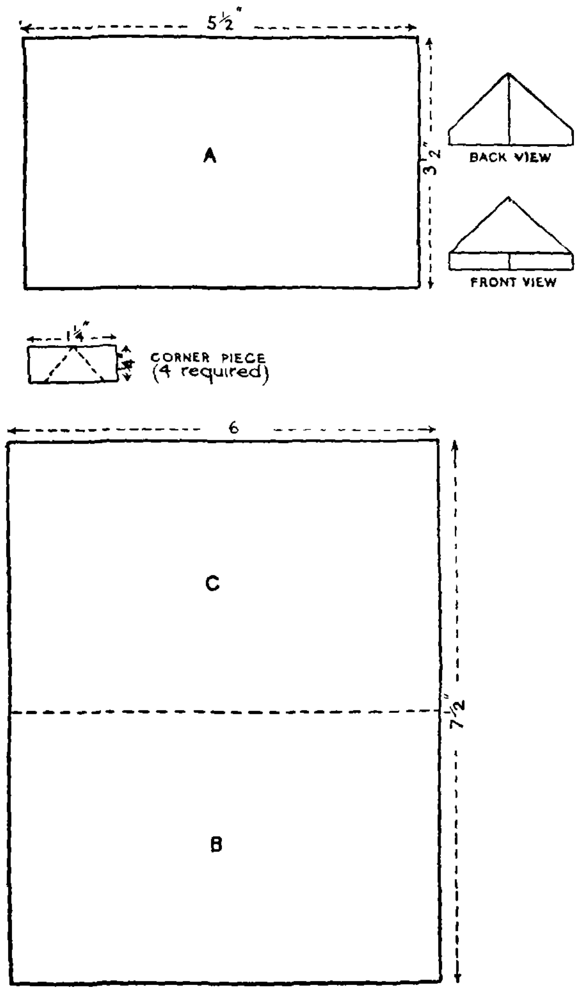
Cut out the cover $7\frac{1}{2}'' \times 6''$, and paste the back of the paper holding the cards centrally to the bottom half (B).

Cut a piece of blotting paper $5\frac{1}{2}'' \times 3\frac{1}{2}''$, touch the corners with paste, and fasten centrally to the upper part (C).

EXERCISE.

Make a suitable design in brush work for the front of the holder (see sketch).




5½"
A
3½"
BACK VIEW
FRONT VIEW
1¼"
CORNER PIECE
(4 required)
6
C
7½"
B

14. The Grandfather's Clock

EXAMINATION AND PRELIMINARY EXERCISES.

Specimens should be distributed, and the pupils required to find the dimensions, first of the two end prisms, and then of the middle one. It will then be observed that the model is composed of three oblong prisms.

Ex.—Construct circles by using compasses of 2½″, 2″, and 1½″ radius, and divide into six equal parts.

Bisect one of the arcs thus obtained, and step round with the same radius from the point of bisection.

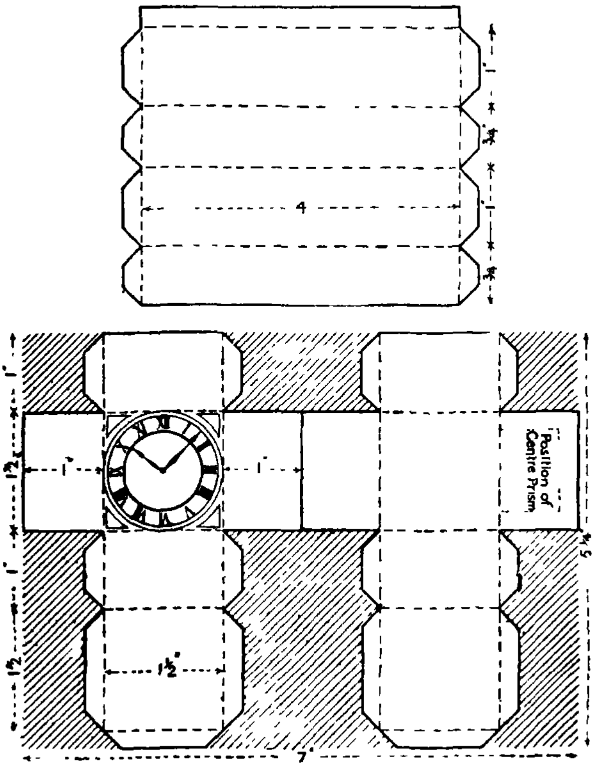
This gives the position of the figures on the clock face.

CONSTRUCTION.

This should offer no difficulty. It will be observed that the three prisms are flush at the back, and that the central prism is placed exactly ¼″ from the three remaining sides of the top of the base.

EXERCISES.

1. Make a sketch of the clock. Note the figure IIII on the dial.
2. Make a suitable ornament for the top of the clock. (See plate p. 16.)
3. Find the total area of the top and bottom prisms. Compare with the central one.
4. Measure the sides of the base in centimetres (2·7, 3·8). Find the perimeter; the area (2·7 × 3·8 sq. cm.).


4
7"
Position of Centre Prism

5. Find the perimeter of all the edges of the bottom prism.
6. If each long edge of the clock face is $3n$ cm. long, what is the perimeter of the face? what is the area?
7. If each short edge of the top prism is $2n$ cm. and each long edge $3n$ cm., what is the perimeter of all the edges of the top and bottom prisms? what is the total area?
8. If the lengths of the edges of the central prism are $3y$ cm., $4y$ cm., and $16y$ cm. respectively, (*a*) find the perimeter of all the edges; (*b*) find the area of the base, the front, the side.

---

15. The Fireplace

CONSTRUCTION.

The essential parts of this model consist of three oblong prisms; the two uprights being of equal dimensions, 4″ × 1″ × ½″, 3½″ × 1″ × ⅜″.

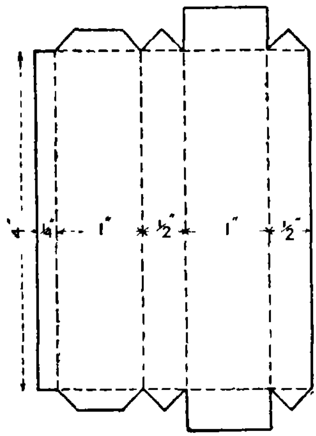
The mantelpiece is 7″ × 1½″, and has the front and side edges turned down, thus giving an appearance of solidity.

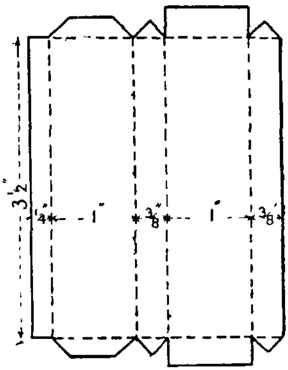
When the bars are fitted into the space, they should project a little from the back.

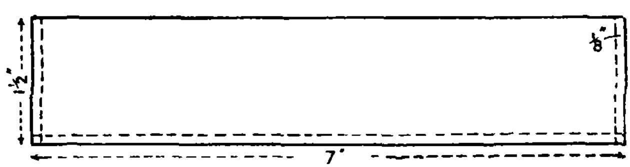
The uprights, cross-piece, and bars should be fitted to a piece of thin cardboard, 5½″ × 4″.

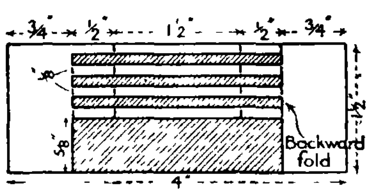
The base or hearth is formed of a piece of thicker cardboard, 5½″ × 1″.

The brackets or shelf supports are constructed from strips of paper, 7″ × ½″, rolled to form an "S"-shaped scroll.









EXERCISES.

1 Make a drawing of the completed model.

2. Measure the fireplace at home, and bring a dimensioned sketch.

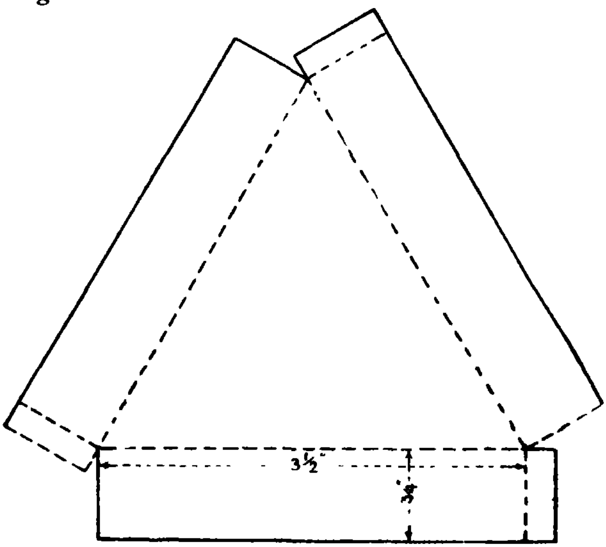
16. The Triangular Tray

(Rectangular Sides)

EXAMINATION AND CONSTRUCTION.

Cut open completed specimens, to show that the development consists of a rectangle, $3\frac{1}{2}'' \times \frac{3}{4}''$ on each of the three sides of the triangle.

A flange of $\frac{1}{4}''$ is added to each rectangle. The flange is fastened inside.



EXERCISES.

1. Find the length of all the edges of the tray.
2. Find the area of the three rectangular sides of the tray.

Area $= (3 \times 3\frac{1}{2} \times \frac{3}{4})$ sq. in. $= 7\frac{7}{8}$ sq. in.

3. Draw an equilateral triangle, side $3\frac{1}{2}''$. Mark the centre of the base, and join to the apex.

(*a*) How long is the line?

(*b*) Find the area of the triangle.

$$\text{Area} = \tfrac{1}{2}bh.$$

4. Each side of the triangle is approximately 6 cm. Test this statement. Each short side of the rectangle is 1·9 cm.

(*a*) Find the perimeter of the three rectangles.

(*b*) Find the area of a rectangle in square centimetres.

$$1 \cdot 9 \times 6 = 11 \cdot 4 \text{ sq. cm.}$$

5 Make a sketch of a rectangular side of the tray. Call each long side $7a$ in. long, and each short side $3b$ in. long.

(*a*) Find the area of the rectangle.

$$(3b \times 7a) = 21ab \text{ sq. in.}$$

(*b*) Find the area of the three rectangular sides.

$$3(3b \times 7a) = 63ab \text{ sq in.}$$

(*c*) Find the perimeter of the nine edges.

$$(7a \times 6) + (3b \times 3) \text{ in.} = (42a + 9b) \text{ in.}$$

(*d*) Find the difference in length between all the long edges and all the short edges.

$$(7a \times 6) - (3b \times 3) \text{ in.} = (42a - 9b) \text{ in.}$$

17. Equilateral Triangular Tray

(Sloping Sides)

CONSTRUCTION.

Completed specimens should be distributed, and the pupils should be required to measure the triangular base. They should measure the size of the angles with their protractors.

The model should then be cut and opened out.

It will be easily elicited that the development is obtained by constructing an equilateral triangle of 6 in. side, and setting out as in diagram.

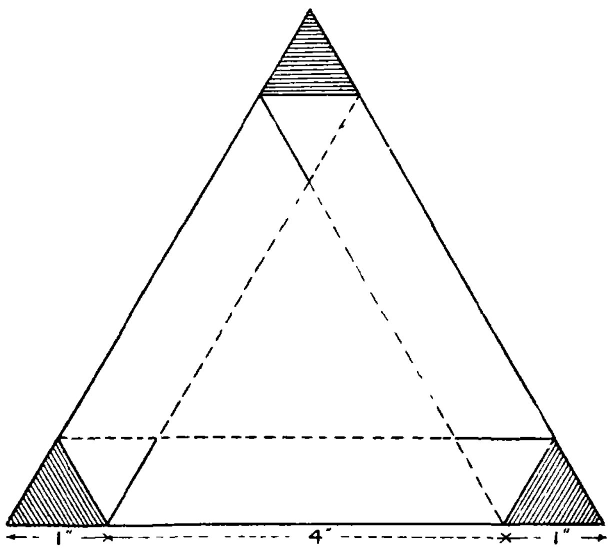
Attention should be called to the parallel lines, and the use of the set-square for drawing such lines should receive attention.

EXERCISES.

1. Find the perimeter of the bottom edges in centimetres and decimals of a centimetre.
2. Construct an equilateral triangle having its sides 10 cm. Join the centre of the base to the apex. Measure the altitude and find the area.

$$a = \tfrac{1}{2}bh = (\tfrac{1}{2} \times 10 \times 7{\cdot}8) \text{ sq. cm.} = 39 \text{ sq. cm.}$$

3. Measure the length of the top edge of the tray. Construct an equilateral triangle having sides equal to this, and find the area in square centimetres.
4. If each edge of the triangular base is $5x$ cm., and each edge of the triangular top is $5y$ cm., and the other edges $2z$ cm., what is the total length of all the edges?


1"
4"
1"

18. The Dovecot

EXAMINATION AND CONSTRUCTION.

The children should be asked to measure the edges of a completed model. It will be found that (*a*) the front and back are equilateral triangles; (*b*) that there are six equilateral triangular openings in the front; (*c*) that the base is a rectangle, 4" × 1"; (*d*) that the two sides are rectangular, and are 1¼" × 1".

Call attention to the two end flaps in the base of the model. Let the pupils suggest what the flaps join to the base of the model.

In this way, elicit that there are two rectangles, 4" × 1", bent backwards and fixed under the sides which are seen.

Note that the construction of this model forms a very valuable lesson on the use of the 60° set-square in the construction of equilateral triangles, and also in the use of the set-square for drawing parallel lines.

1. Begin with the rectangular base.

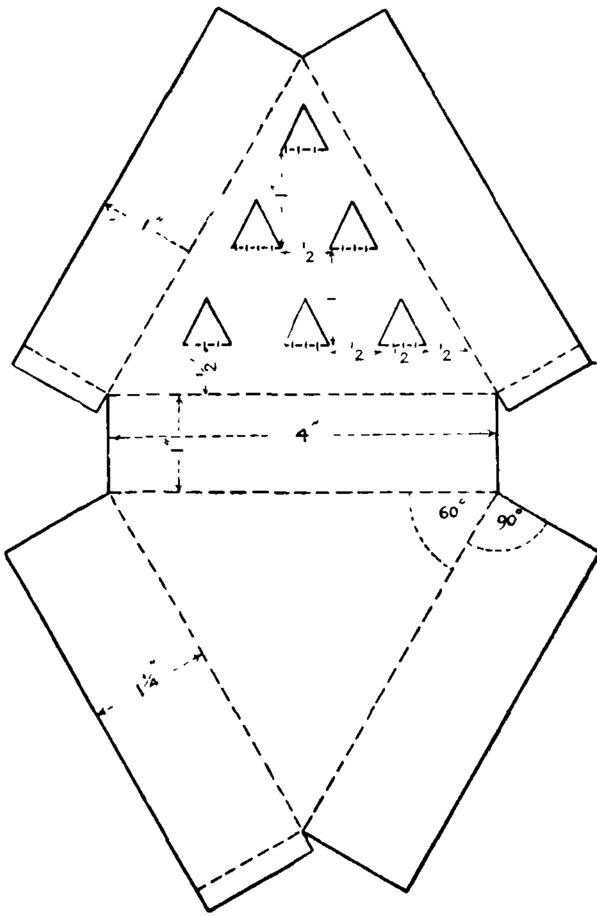
2. Construct the two larger equilateral triangles, using compasses.

3. Construct the rectangles as shown on each side. (Use set-squares.)

4. The rest of the triangles should be obtained by using the set-square to draw three parallel lines at the given heights.

The other sides are easily obtained by drawing lines parallel to each side.

Care will be necessary in cutting out the alighting boards.


1"
½
½
½
½
½
4"
60°
90°
1¼"

EXERCISES.

1. Make a dimensioned sketch of the model.
2. Find the area of the three rectangular sides
3. How many right angles are there? How many equilateral triangles? How many angles of 60°?
4. Construct a triangular upright with struts and proper base for supporting the dovecot

---

19. The Triangular Prism

EXAMINATION AND CONSTRUCTION.

Completed specimens should be provided, one between every two pupils

The children should be required to make statements as to the number of faces, edges, corners.

They should also test which angles are right angles and which acute.

It will be observed that the model has three rectangular sides and two triangular ends.

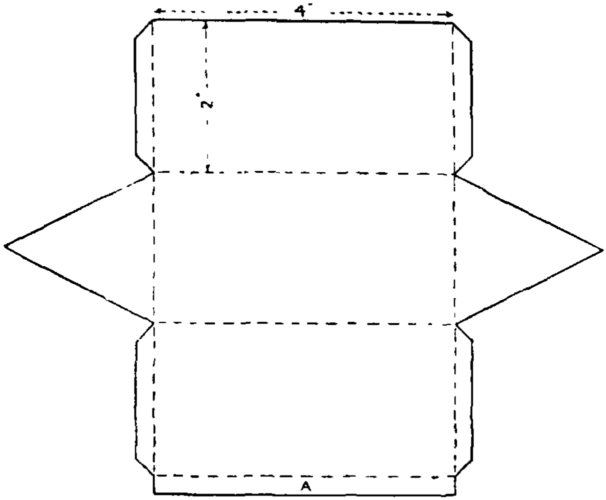
Recall the former lessons on the square prism and the rectangular prism, and contrast these with the model under consideration—the *Triangular Prism.*

Measure the length of the sides of the triangles.

The specimen models should be cut and opened out. (See development.)

The pupils will readily observe that it will be necessary in the first place to construct the three rectangles which form the sides of the solid, and then the equilateral triangles which form the ends.

Allowance is necessary for the flanges, which should be placed inside. Flange A should be fixed first.



EXERCISES.

1 Draw the development of a triangular prism having its rectangular sides 12·5 cm. × 6·4 cm , and the side of triangular ends 6·4 cm.

2. Find the total area of the three rectangular sides (12·5 × 6·4 × 3) sq. cm.

3. Find the area of the two triangular ends.

4. Find the total area

5. A triangular prism has each of its long edges x'' in length, and the short edges y'' in length

(*a*) What is the area of each rectangle? of the three rectangles?

(*b*) Find area of each triangle; of the two triangles

(*c*) What is the length of all the edges?

6. Complete the following statements: A triangular prism has edges, faces, corners.
7. What is the greatest number of faces, edges, and corners which can be seen at any one time?
8. Make sketches of the model from three different points of view.
9. Draw the development of a triangular prism having sides 4″, 4″, 1½″, and whose length is 2″.

   Such a prism is sometimes called a wedge.

20. The Right-angled Triangular Prism

EXAMINATION AND CONSTRUCTION.

The children should examine completed specimens, and be asked to compare this model with the last.

The triangular ends should be tested. Measure the lengths of the sides of the triangle. How many sides are equal?

Find, by using tracing paper or thin tissue paper, if any two angles are equal.

The pupils should be invited to suggest the method of setting out the development.

EXERCISES.

1. How many edges, corners, and faces has the model?
2. What is the total area of the two equal rectangular faces?
3. Find the total area of the two triangular faces.

4. (*a*) Construct two right-angled triangles having bases of 5 cm. and their altitudes also 5 cm.

   (*b*) Cut these out and place together, with the two right angles opposite to each other. What figure is formed? What is its area?

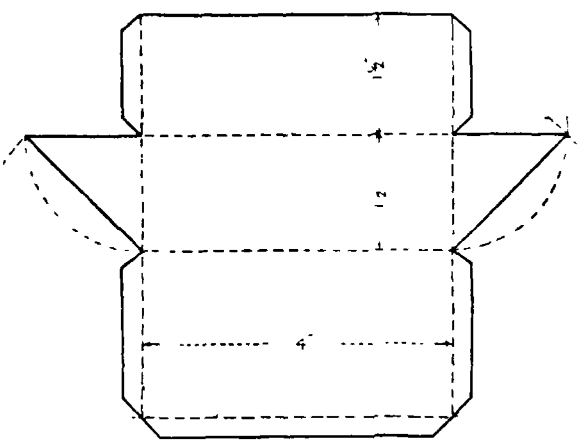
5. Place two completed models together, having their two largest faces touching each other.

   (*a*) What model is formed?

   (*b*) Find area of base

   (*c*) Find the volume of the solid thus formed

   (*d*) What would be the volume of the triangular prism?



21. The Scalene-triangular Prism

EXAMINATION AND CONSTRUCTION.

Completed specimens should be provided for examination as before.

The development may be found either by cutting open the model or by rotating, as in the previous exercise.

Ask the name of the triangle forming the ends.

EXERCISES.

1. What is the area of the smallest rectangular side?

   $(4 \times 1\tfrac{1}{2})$ sq in. $=$ 6 sq. in.

2. Find the total area of the two other sides

   $(3\tfrac{3}{4} \times 4)$ sq in $=$ 15 sq. in

3. What would the area of the rectangular surfaces be, if the model were twice as high?

   $(5\tfrac{1}{4} \times 8)$ sq. in. $=$ 42 sq. in

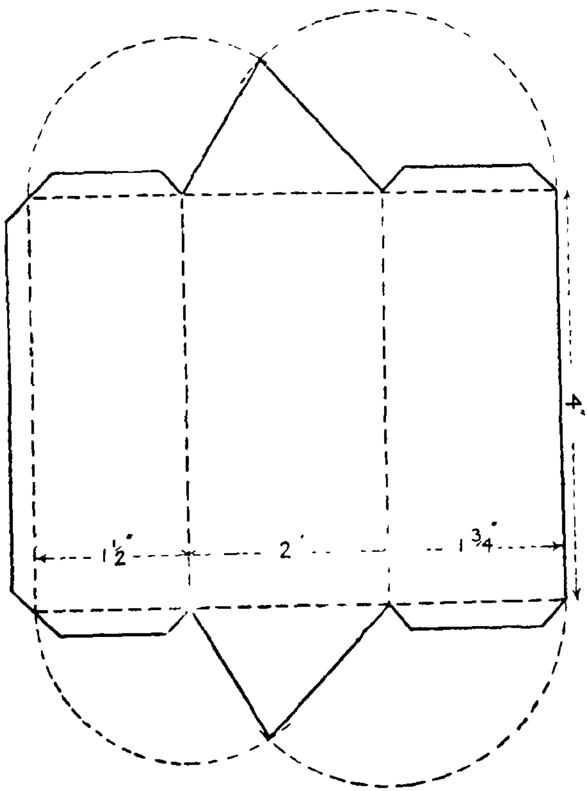
4. Construct a scalene triangle having sides equal to those of the triangular base of the prism. From the apex, drop a perpendicular to the base by means of the ruler and set-square.

   (*a*) Measure the altitude.

   (*b*) Find the area of the two triangular ends of the prism.

   $$\begin{aligned} \text{Area of 2 triangles} &= \tfrac{1}{2}bh \times 2 \\ &= (\tfrac{1}{2} \times 2 \times 1\tfrac{1}{4} \times 2) \text{ sq. in.} \\ &= 2\tfrac{1}{2} \text{ sq. in.} \end{aligned}$$

5. Place two completed models together so that equal faces are touching each other exactly. Examine the solid thus formed, and make statements about the figure forming the base



22. The Tetrahedron

EXAMINATION AND CONSTRUCTION.

Open out a completed specimen by cutting down the oblique edges.

The development will be seen to consist of four equilateral triangles, forming equal parts of a large equilateral triangle.

Draw an equilateral triangle 6″ side.

Join the centres of the sides. Place flanges as shown.

Note alternative method of discovering development. Place the model on the centre of the paper, and trace round the basal triangle.

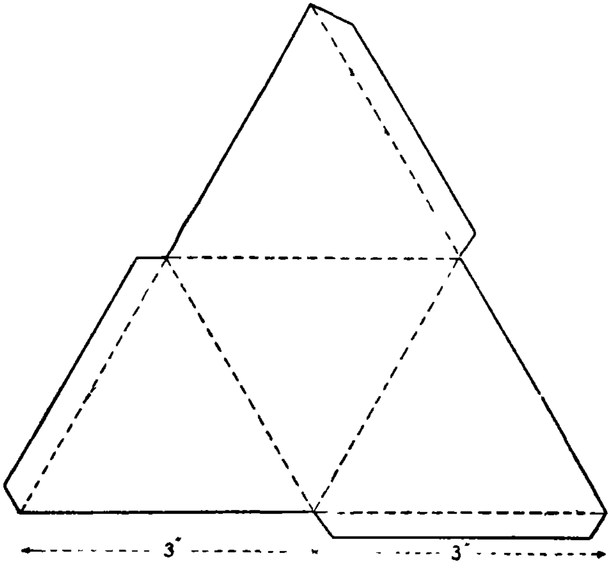
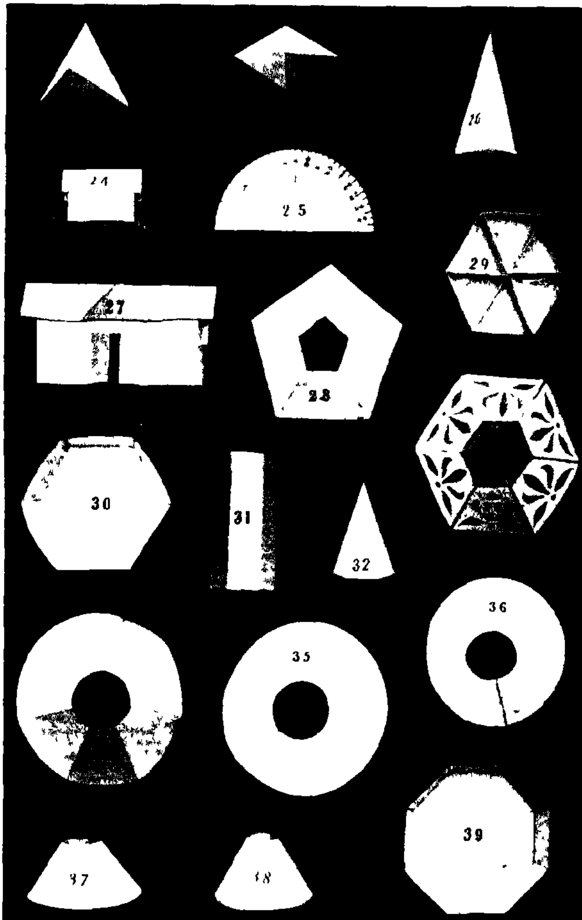


PLATE II. MODELS 22-39



22, The Tetrahedron. The Hexahedron. 24, Dog Kennel. Protractor. Triangular Pyramid. The Box. Pentagonal Lampshade. Hexagonal Tray (Rectangular Sides). Hexagonal Tray (Sloping Sides and Curved Edges). 31, Hexagonal Prism. Hexagonal Pyramid. Hexagonal Lampshade. 34, Heptagonal Lampshade. Candle Shades. Octagonal Tray.

Rotate the model on each line thus drawn, tracing the edges in each case.

EXERCISES.

1. How many corners has a tetrahedron? edges?
2. What is the greatest number of faces you can see at one time?
3. Describe an equilateral triangle of 3 in. side.
   On one of the equal sides describe another equilateral triangle.

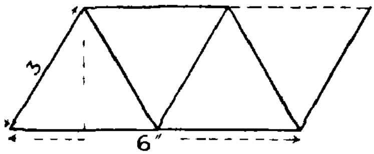


Fig 1

   Measure each side of the figure thus formed.
   How does it differ from a square?
4. How many obtuse angles does the rhombus contain? How many acute?
5. Draw an equilateral triangle 6 in. side.
   Join the centres of the sides (See development.)

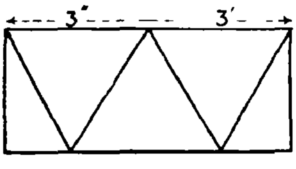


Fig 2.

   Cut and arrange as in fig. 1.
   In the first triangle, join the apex to the centre of the base. Cut down the central line. Arrange as in fig. 2. Measure the height and find the area.

23. The Hexahedron

EXAMINATION AND CONSTRUCTION.

Each pair of pupils should place their models of the tetrahedron base to base. The resulting six-sided solid is called a "Hexahedron".

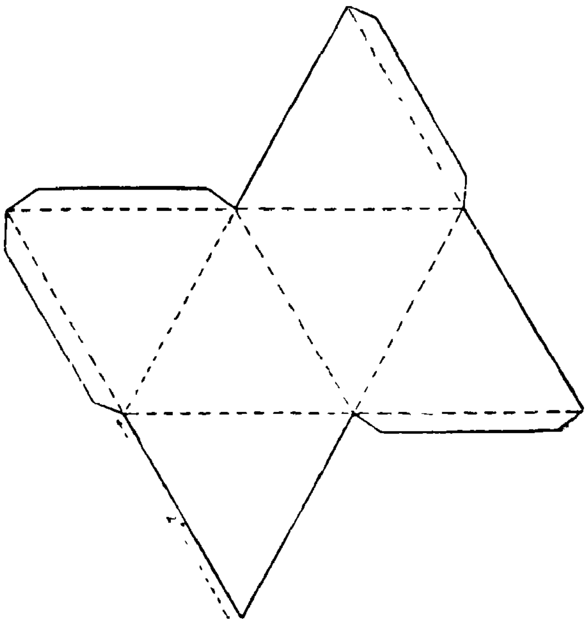
A completed model should be shown, and the pupils invited to explain how it is that a six-sided solid is formed when two four-sided solids are placed base to base.

The development presents no difficulty. It can easily be found by rotating, as in the last model, and adding two additional triangles.

N.B.—The triangle without flanges should be fixed last.

EXERCISES.

1. How many edges has a hexahedron?
2. How many corners has a hexahedron?
3. How many edges meet at each corner?
4. What is the greatest number of faces which can be seen at any one time?
5. Make sketches of the model in three different positions.



24. The Dog-kennel

CONSTRUCTION.

The development of this model is formed from a rectangle $5\frac{3}{4}'' \times 5\frac{1}{4}''$.

The completed specimen should be opened out, and it will be noticed that there are five equal rectangles, forming the base, sides, and roof of the kennel. The ends consist of a square and equilateral triangle in each case. The door consists of an opening $\frac{3}{8}'' \times \frac{1}{2}''$.

Flanges are cut for the two sides, but the roof projects $\frac{1}{4}''$ each end.

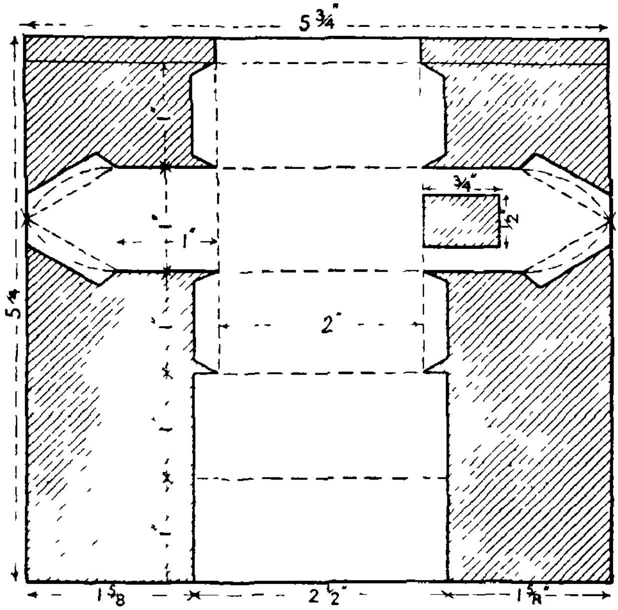
The sides should be fitted first with flanges inside. Bend in and paste all the roof flanges. Fix the roof, and hold till dry.

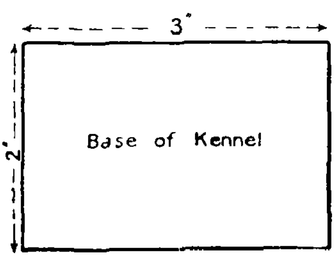
N.B.—Care should be taken not to bend in roof flanges too far.

The whole should be fixed to a base of thin cardboard, leaving a border of half an inch all round.

EXERCISES.

1. Make a sketch of the completed model.
2. What is the total area of the roof? Find the difference in area between two sides and the roof.
3. Find area of the door.


5 3/4"
5 1/4
1"
1"
1"
1"
1"
3/4"
1/2
2"
1 5/8
2 1/2"
1 5/8"


3"
2"
Base of Kennel

25. The Protractor

EXAMINATION AND CONSTRUCTION.

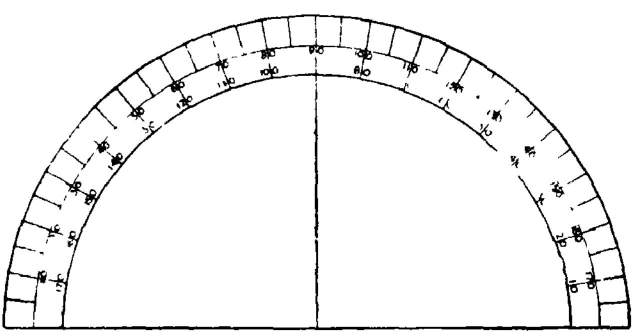
Completed specimens should be passed round the class for examination. It will be observed that the protractor has the following properties:—

1. It is in the form of a semicircle.
2. It is graduated from 0° to 180°, both in the clockwise and the anti-clockwise direction.
3. The centre is marked.

Recall previous lessons on angles, and the pupils will remember that up till now they have considered angles as being greater or smaller than "Right Angles". Explain the markings on the protractor

Construct a semicircle $2\frac{1}{2}$" radius.

Bisect the arc. Trisect each of the right angles. Number the points of division 30°, 60°, 90°, 120°, 150°, 180°. Bisect a right angle. This gives 15°



which should be stepped off round semicircle. The intermediate points may be found by trial.

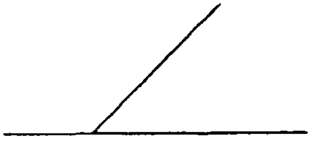
EXERCISES.

1. Give plenty of practice in measuring the sizes of various angles, such as those of the various triangular prisms, the hexagonal prism, and the angles on the set-squares.
2. Let pupils draw two lines touching as below.

   (*a*) Measure each angle.

   (*b*) How many degrees do they make together?

   (*c*) How many right angles is this equal to?



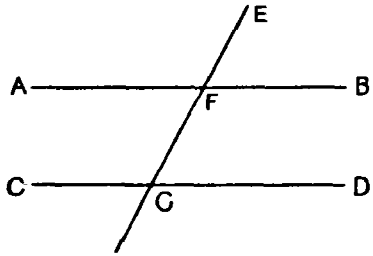
3. Draw four lines radiating from a point Measure each of the angles. How many degrees do they make together?
4. (*a*) Draw two straight lines crossing each other, and measure the four angles so formed.

   (*b*) Repeat two or three times Notice the opposite angles in each case.
5. Measure the shadow thrown by a 6-ft. pole at noon. On squared paper draw the lengths of pole and shadow to scale. Complete the triangle, and measure the angle of the sun's height above the horizon with the protractor. This exercise should be performed at regular intervals throughout the year.

6. Use the set-square to draw two parallel lines AB and CD, and a line EH crossing them.

(*a*) Compare angles EFB and FGD; AFG and FGD; AFG and CGH; FGD and CGH.

(*b*) How many degrees are there in the sum of EFB and BFG; AFG and BFG; BFG and FGD; BFG and CGH?



7. Make six triangles of different shapes. Call each ABC. Use the protractor to measure the angles, and complete the following statement.

Triangle	Angle A	Angle B	Angle C	Sum of all the Angles
1.				
2.				
3				
4.				
5.				
6.				

8. Use your protractor to draw angles of 50°, 80°, 120°.
9. Draw two straight lines of equal length at right angles to each other. Join their extremities. Find the size of the other two angles.
10. Draw a line XY $3\frac{1}{2}''$ long. At X draw a line XZ $3\frac{1}{2}''$ long, making an angle of 60° with XY. Join YZ. (*a*) How long is it? (*b*) Measure each of the angles of the triangle.
11. Through how many degrees does the minute hand of a watch turn in 1 min.; 5 min.; 15 min.; 35 min.; and 50 min.?

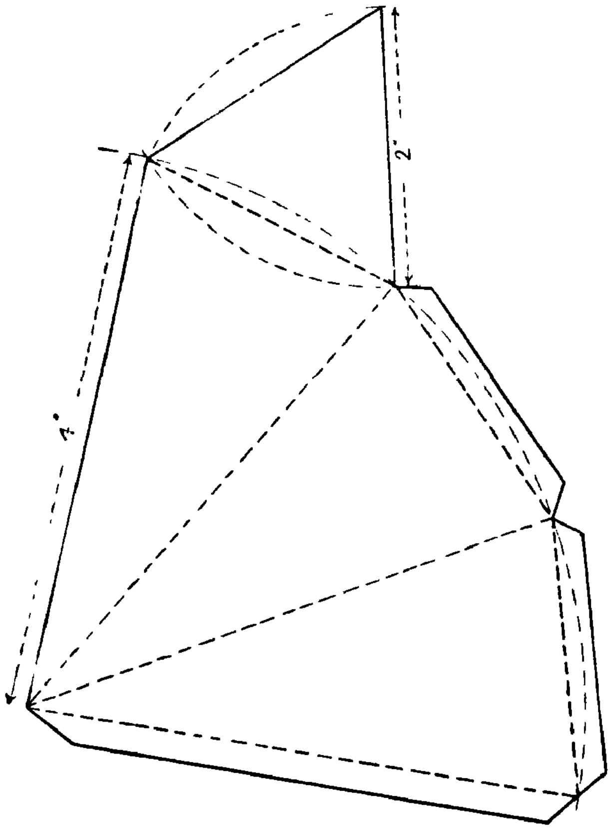
APPLICATION.

Give a lesson on the Mariner's Compass, and let the pupils construct a "Compass Card", showing all the points.

26. The Triangular Pyramid

CONSTRUCTION.

The method of obtaining the development may be discovered either by revolving the model on its sides,



or by cutting down one of the long sides and along two of the sides of the triangular base, and opening out.

The pupils should be required to measure the completed specimen models, and the construction should present little difficulty.

The long flap should be fastened first. All flaps should be placed inside.

EXERCISES.

1. Use the protractor to test the size of the angles of the various triangles Describe the triangular sides of the pyramid
2. How many corners has a triangular pyramid?
3. How many edges meet at each corner?
4. What is the perimeter of all its edges?
5. If each short edge is a cm in length, and each long edge $a + b$ cm. in length, what is the sum of all the edges?
6. Make a sketch of the pyramid in two different positions
7. Construct pyramids having bases which are scalene triangles and right-angled triangles.

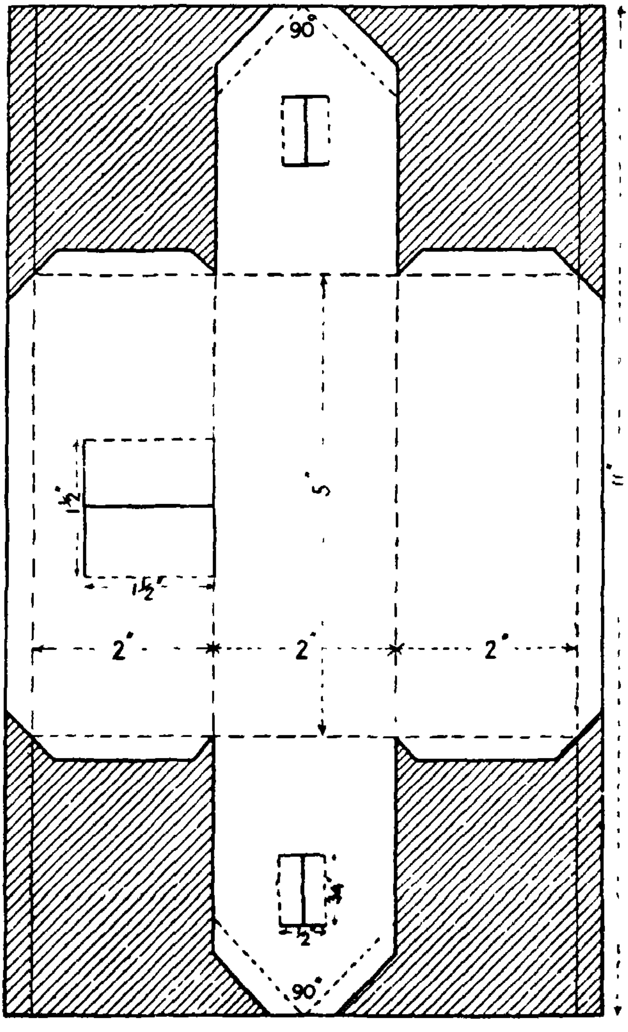
---

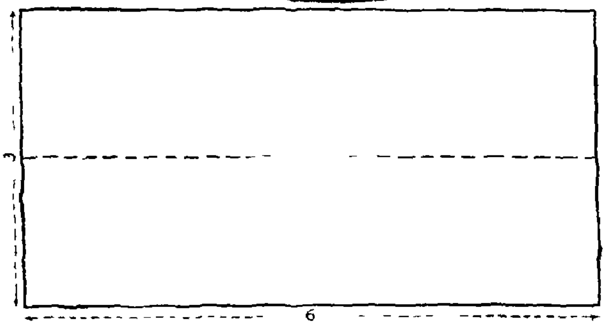
27. The Barn

CONSTRUCTION.

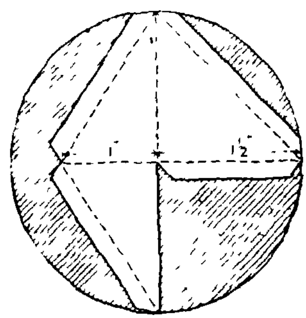
The floor and sides of the barn are cut out from an oblong 11″ × 6½″. The roof is an oblong 6″ × 3″, and projects ½″ over each gable.

The secondary gables, which form a useful exercise in the consideration of the inclination of one plane to another, are modified tetrahedrons.


90°
1½"
1½"
5"
2"
2"
2"
11"
¾"
½"
90°



Roof of Barn



Gable of Barn
(2 required)

EXERCISES.

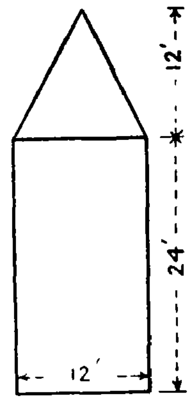
1. Make a drawing of the barn.
2. Find the areas of doors and windows.
3. Note size of doors. Give reasons for exceptional size. to allow wagons to enter, &c.
4. Why is the window capacity smaller than that of a house? (Windows for ventilation only—little light required.)

The gable end of a barn is 12 ft. wide and 24 ft. high to the roof The height above the eaves is 12 ft

(*a*) What is the area of the end?

(*b*) If it is 40 ft. long, how many square feet of floor boards will be required?

(*c*) What will be the area of the four rectangular walls?



28. Pentagonal Lamp-shade

EXAMINATION AND CONSTRUCTION.

An examination of completed specimens shows that the model has five long edges, and that the sides slope to five shorter edges.

Give the name pentagon; contrast with hexagon.

It will be noticed that one of the sides is pasted to exactly cover the next side

The pupils will readily understand that the development will be formed by constructing a hexagon having a side of 3 in., and within and parallel to it, another hexagon, sides 1 in.

Cut along the thick line, and paste side A to B.

EXERCISES.

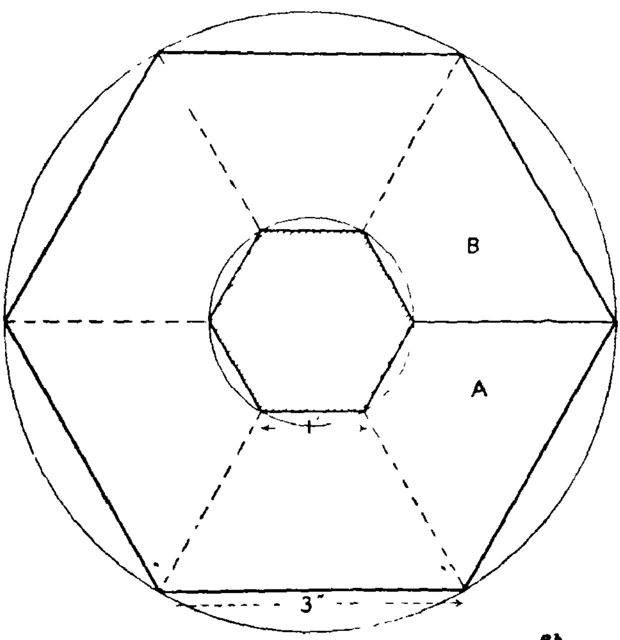
1. (*a*) Divide the hexagon which has been cut from the centre of the model into six triangles by drawing the three diameters

(*b*) Measure each of the angles, using the protractor; and then measure the obtuse angle formed by a short side of the model and one of the lines, dotted in the diagram.

Compare the result obtained by adding two of the first angles and contrasting with the size of the obtuse angles.

(*c*) Draw any triangle. Produce one of its sides. Using the protractor, test which two internal angles contain the same number of degrees as the angle formed by producing one side of the triangle.

2. Colour the inside of the shade green, and make a suitable brushwork design for the outside.



29. The Hexagonal Tray

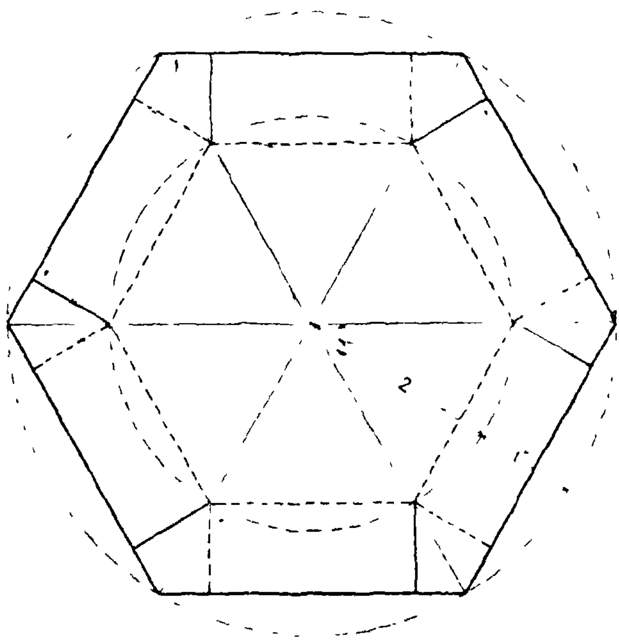
(Rectangular Sides)

EXAMINATION AND CONSTRUCTION.

It will be observed that the model is hexagonal in shape, and that all the sides are rectangular.

The pupils should be invited to discuss the method of drawing the development, and also the amount of paper which will be required for the model.

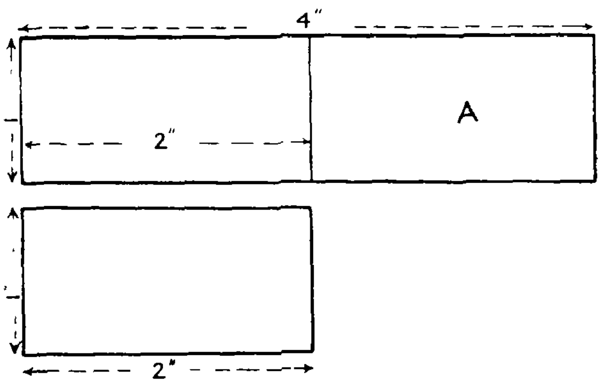
Great care will be necessary in the construc-

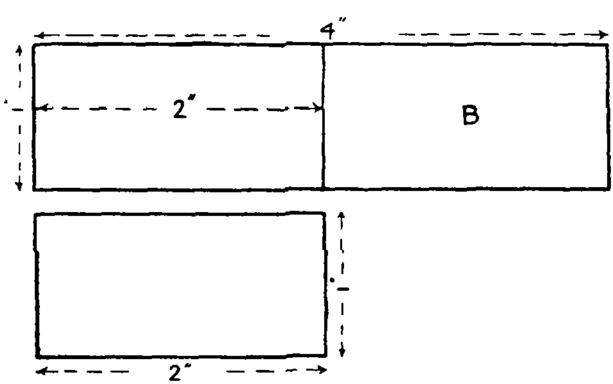


tion of the rectangles on the sides of the inner hexagon.

Divisions may be made in the tray by cutting out strips of the dimensions below. Cut A vertically half way, and insert in B.

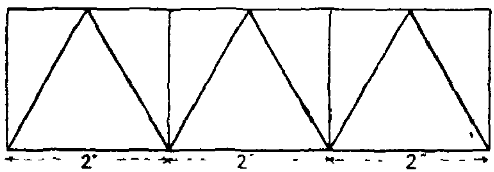
All flaps should be placed inside.





EXERCISES.

1. Measure the number of degrees in each angle of the hexagon.
2. What is the total area of all the rectangular sides?
3. Construct a regular hexagon having sides of 2", and join each alternate point to the centre.



(*a*) What figures are formed?

(*b*) Divide so as to show six equilateral triangles.

4. (*a*) Cut out the six equilateral triangles, and arrange as shown in the drawing.
   (*b*) Measure the height, and find the area of the rectangle.

---

30. The Hexagonal Tray

(Sloping Sides and Curved Edges)

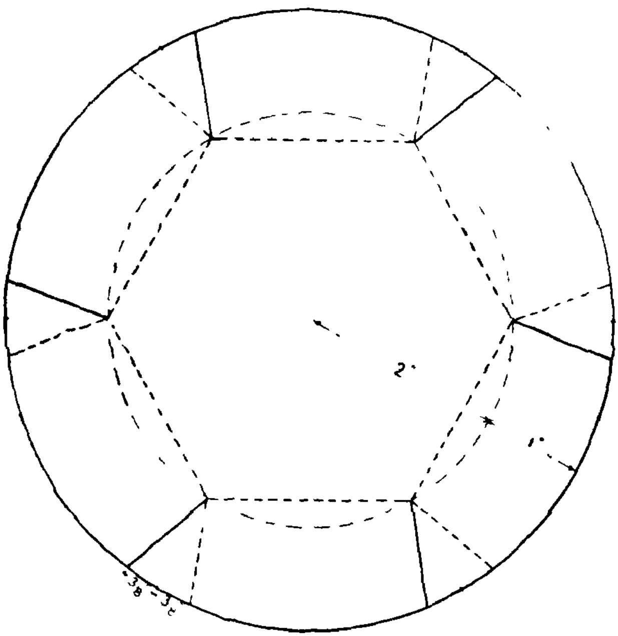
EXAMINATION AND CONSTRUCTION.

Contrast this model with the previous tray. Note the sloping sides and curved edges.

Open out a completed model, and invite pupils to find the radius of outer circle and the length of each side of the hexagonal base.

Note the method of obtaining flaps. Draw three diameters of the hexagon passing through the opposite angles. Produce these lines to the circumference of the outer circle. Measure 3/8″ on each side of each of the points in the circumference

The flaps should be folded and cut as indicated. They should be placed outside.



EXERCISES

1 Make a sketch of the model, and insert all dimensions.

2 Make a brushwork design for the bottom and sides of the tray.

31. The Hexagonal Prism

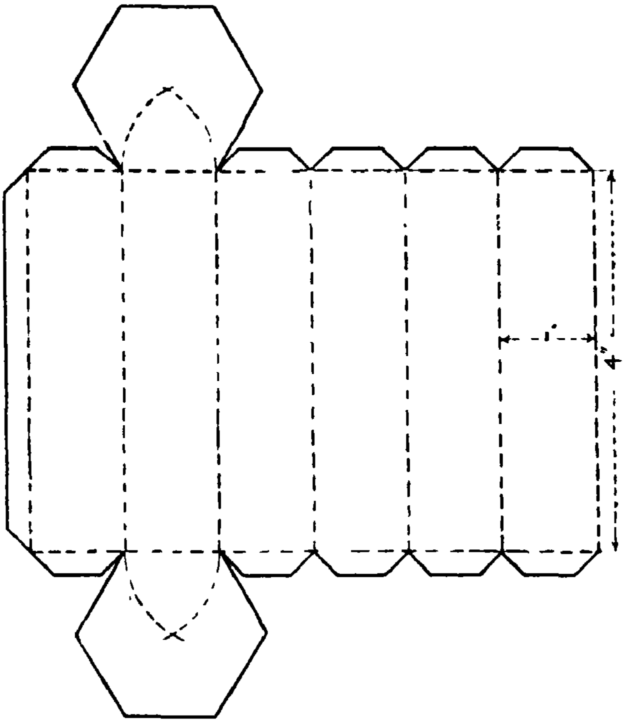
EXAMINATION AND CONSTRUCTION.

This model has six equal rectangular faces, and its two ends are regular hexagons.

The pupils should be required to measure the specimen models, and to set out the development without assistance.

EXERCISES.

1. What is the greatest number of faces which can be seen at one time?
2. How many corners has a hexagonal prism? how many edges?
3. How many angles are right angles? how many obtuse?
4. If a hexagonal prism has a face area of 10 sq. cm., and a volume of 95 cub. cm., find its height.
5. Measure the length of each edge in centimetres and decimals of a centimetre. Find the total length of all the edges.
6. If each short edge is $2x$ cm., and each long edge $(2x + 2y)$ cm., what is the total length of all the edges?
7. Make a sketch of the completed model.


1"
4"

32. The Hexagonal Pyramid

EXAMINATION AND CONSTRUCTION.

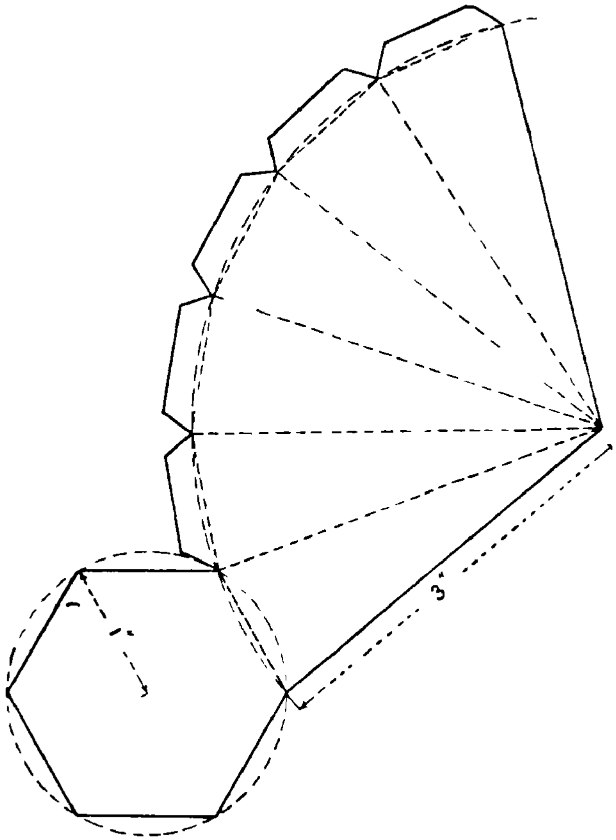
Examine the sides of the square prism, the hexagonal prism, the square pyramid, and the hexagonal pyramid. The regular prisms have equal rectangular faces, whilst the regular pyramids have, with one exception, isosceles triangular faces.

Examine the pyramids already made and find which pyramid has faces which are not isosceles triangles.

Questions should be asked as to the length of the edges, &c. The development presents no new difficulty

EXERCISES.

1. Test the triangular faces of the pyramidal models. How many degrees are contained by the angles of each triangle?
2. (*a*) Construct six isosceles triangles having two sides 3″ and a base of 1″.
   Cut one of the triangles as before, and arrange the whole to form a rectangle.
   (*b*) Measure the height, and find the area of the rectangle.
3. How many acute angles does the model contain? How many obtuse?
4. If a hexagonal prism had each of the six edges of the base $2a$ cm. long, and its other edges $5a$ cm. long, what is the total length of all the edges?


1"
3"

33. Hexagonal Lamp-shade

As this model is based on an Octagon, it will be necessary to show the method of constructing this figure.

The children should be provided with a paper circle, and be required to fold it into four equal parts. (Recall previous lesson dealing with the Quadrant.)

Let them suggest the method for dividing the circle by folding into eight equal *sectors*.

The octagon should then be completed and cut out.

Questions should be asked as to the number of degrees in each of the angles round the centre. The other angles should be tested by means of the protractor.

EXAMINATION AND CONSTRUCTION.

Completed specimens should be examined, and the pupils should be asked to suggest the method of construction. It may be necessary to state that the model is formed from two octagons. It will be observed that the central figure and one sector is cut out.

Paste sector A on B.

How many sides has the model?

How many sides to an octagon?

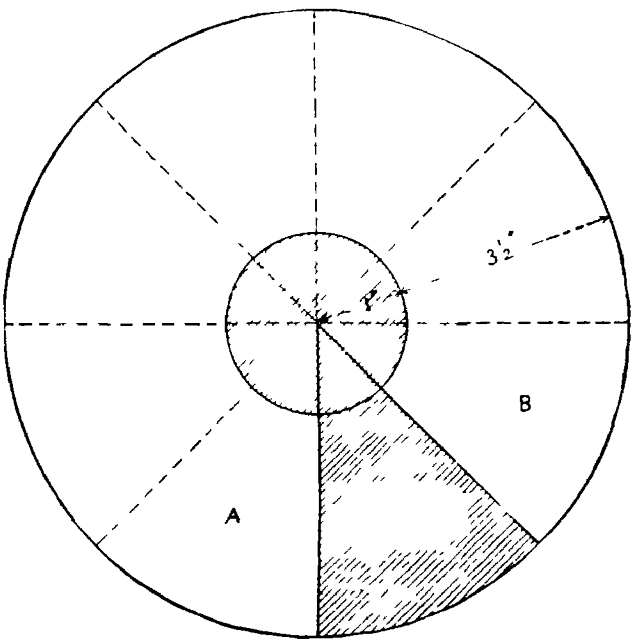
EXERCISES.

1. The model should be decorated with a brushwork design.

2. Find the perimeter of one of the faces of the model.
3. Make a sketch of the lamp-shade.

APPLICATION.

A lesson may follow on the "Trapezoid". Previous models may be examined, and the pupils asked to measure the dimensions of trapezoids.

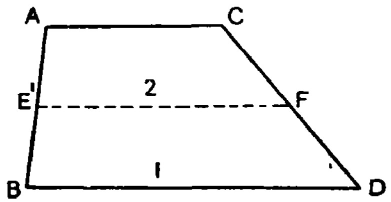


INVESTIGATION EXERCISES.

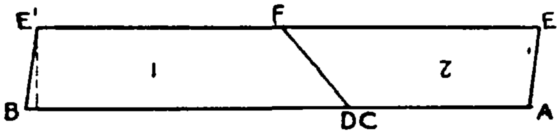
1. Make a rectangle equal in area to a trapezoid.

(1) Draw a trapezoid ABCD, and cut it out.

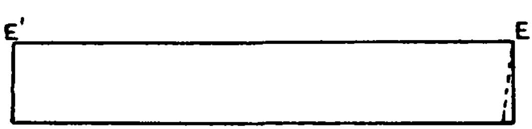
(2) Fold AC to meet BD, and cut along the middle line E′F.



(3) Place AEFC as shown, and drop a perpendicular from E′; cut along dotted line.

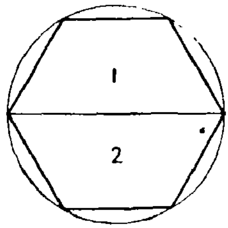


(4) Place as in last diagram.

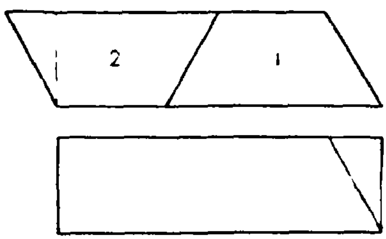


Find the area of a trapezoid.

2. Construct a hexagon. Draw the diameter, and so divide it into a double trapezoid.



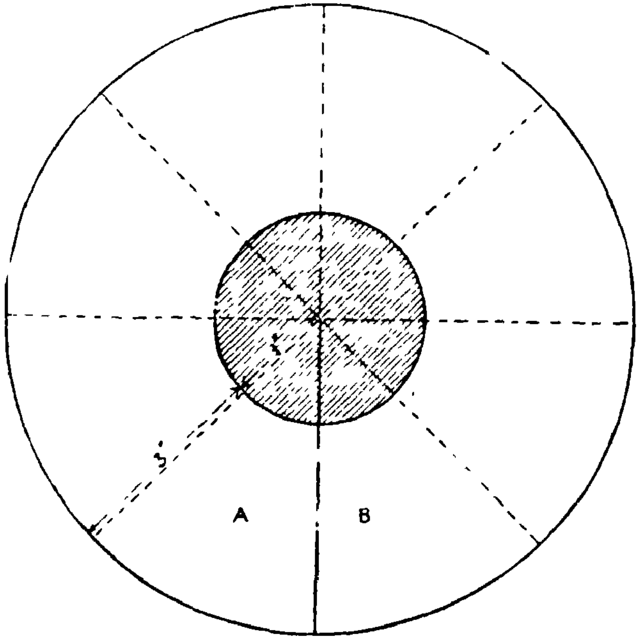
Make a rectangle equal in area to a hexagon.



34. Heptagonal Lamp-shade

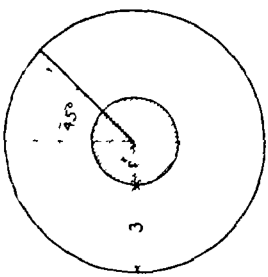
EXAMINATION AND CONSTRUCTION.

The construction of this model calls for no comment. It will be readily suggested by the pupils. A suitable brushwork design should be made on the outside after the inner circle has been cut out. Care will be necessary in cutting out the circle so that the edges are not left jagged

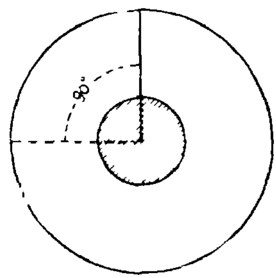


35–38. Candle-shades

These four models form a good exercise on the principle of the cone. The children experiment by cutting angles of increasing size, and thereby discover that the greater the angle cut the steeper the slope of the frustum.

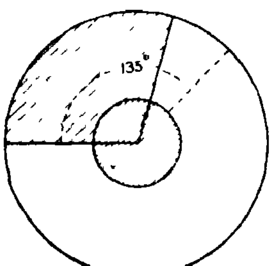


(35)

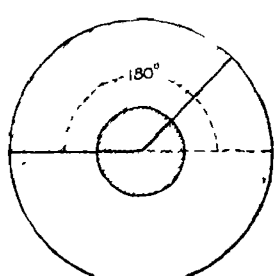


(36)

(37)



(38)



Note in this case the model should not be folded along the dotted line. This indicates the limit of the area to be pasted after the cut has been made as shown.

In the case of Nos. 37 and 38 the whole of the area need not be pasted, the part shaded being cut out.

EXERCISE

Any or all of these shades may be decorated with simple designs in brushwork or stencilling before being fixed (see examples in the illustration).

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39. Octagonal Tray

EXAMINATION AND CONSTRUCTION.

Completed specimens should be examined. The pupils should measure the diameter of the base and the height. This will give the necessary measurements for constructing the two concentric circles.

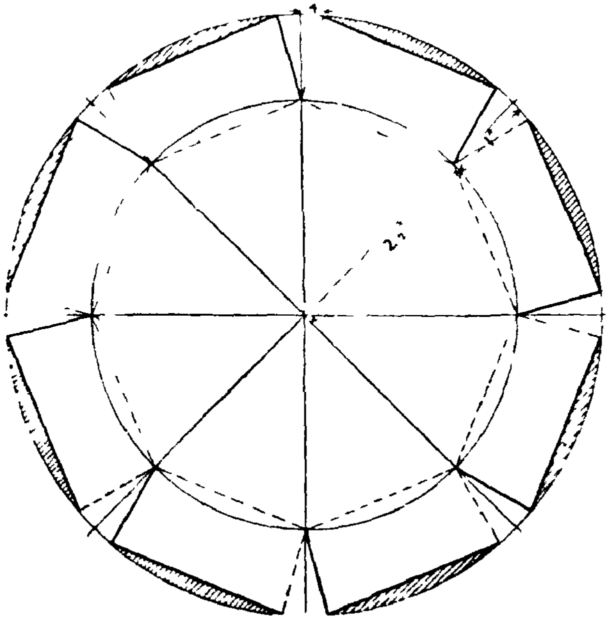
Construct the inner octagon first, and produce the radii of the inner circle to touch the circumference of the outer circle. Carefully measure ¼" from each of the points so obtained, and join them to the sides of the inner octagon as indicated.

Note that the flaps form isosceles triangles. These should be placed outside In making the cuts it is preferable to cut from the inside.

EXERCISES.

1. Make a suitable brushwork design for the inside of the tray.
2. Test the size of each of the three angles in one of the triangles shown in the development.

3. What is the total number of degrees contained in all the angles surrounding the centre of the octagon?
4. How many degrees are there in each of the angles formed by the junction of two sides?
5 What is the total perimeter of the top and bottom edges of the tray?
6 If each short edge is $2n$ cm. and each long edge $3y$ cm., what is the perimeter of all the edges?
7 Make a rectangle equal in area to an octagon.



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