DOCUMENT RESUME

ED 187 547 SE 030 878

AUTHOR	Evans, Richard C.; Wixson, Eldwin A.
TITLE	A K-12 Handbook of Inexpensive or Easy to Make Metric Measuring Materials With Suggestions for Classroom Use by Grade Level.
SPONS AGENCY	Office of Education (DHEW), Washington, D.C.
PUB DATE	Jun 77
GRANT	G007603978
NOTE	77p.: Prepared for the Northeastern States Metric Education Consortium. Not available in hard copy due to copyright restrictions.
AVAILABLE FROM	E. A. Wixson, Mathematics Department, Plymouth State College, Plymouth, NH 03264 ($5.00 includes postage in U.S.; Discounts on quantity orders).
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Bibliographies; Educational Games; Elementary Secondary Education; *Games; *Manipulative Materials; *Mathematics Education; Mathematics Instruction; *Mathematics Materials; *Measurement; *Metric System; Resource Materials

ABSTRACT

This handbook describes inexpensive or easy to make metric measuring materials for use by teachers of grades K-12. Materials for teaching length, area, volume, and temperature concepts are suggested. In addition, there is a chapter on games and aids and a bibliography which provides further references. The introduction includes some hints on teaching measurement. (MK)

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A K-12 HANDBOOK OF INEXPENSIVE OR EASY TO MAKE METRIC MEASURING MATERIALS WITH SUGGESTIONS FOR CLASSROOM USE BY GRADE LEVEL

BY

RICHARD C. EVANS
ASSISTANT PROFESSOR OF MATHEMATICS

AND

ELDWIN A. WIXSON
PROFESSOR AND CHAIRMAN OF MATHEMATICS

PLYMOUTH STATE COLLEGE
PLYMOUTH, NEW HAMPSHIRE

JUNE 1977

This document was prepared for the Northeastern States Metric Education Consortium under a grant from the U.S. Office of Education, Metric Education Program, Grant Number G007603978.

SE 030 878

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CHAPTER 1

INTRODUCTION

General Comments

Our objectives in this project are (1) to prepare a handbook of inexpensive or easy to make metric measuring materials, and (2) to reference the handbook in such a way that it will be readily useful for a teacher of any of the grades K-12.

We have made and/or used all of the metric measuring devices shown in this handbook. Most of our students have been teachers and they have either borrowed our materials or made their own and used them in a variety of classroom situations in schools or adult education settings. Hence, suggestions for activities and hints for teaching measurement are based on a compilation of our experiences and the experiences of these teacher colleagues.

You will find that many of the devices are described in such a way that your students can make them readily. We feel this has two important benefits. The first is that there is value in a student making her/his own measuring device. The second, aside from the fact that you are producing many measuring devices at low cost, is that a student will take his own measuring device home, thus furthering the cause of metric education.

Hints on Teaching Measurement

There are some important points to keep in mind and to emphasize.

when helping a child understand the concepts involved in the measurement process. The first of these deals with appropriately identifying an attribute of an object to measure and then picking an appropriate unit to measure that attribute. An object has many attributes which could be measured, some of which are more readily measured than others. For example, consider a block of wood. You could measure the length; width, height, area of a particular surface, the volume, the weight, the color, the density and so on. Thus, it should be made clear to the child exactly which attribute is to be measured.

Another important idea to consider at the onset of the measurement process is the concept of conservation of the quantity of the attribute during the actual process. Quite often in the measurement process, the object to be measured is moved or changed in some manner. Usually, this action on the object does not change the quantity of the attribute being measured. However, the Swiss psychologist, Jean Piaget, who has spent many years observing how children learn, has found that a child may not yet realize that the quantity of the attribute has not changed.

For example, Piaget has an experiment where two sticks of the same length are placed side by side on a desk and the child is asked "Are the sticks the same length or is one longer than the other?" Usually, the response is that they are the same length. Then, one stick is pushed "up higher" on the desk and the child is asked the same question. Children vary in their response.

The authors performed this experiment with many children up to and including the sixth grade. Our results were consistent with Piaget's findings, namely, every child through the third grade responded that the one "up higher" was now longer! It is not until the end of the third grade (8-9 years old) that the child realizes that the two sticks are still the same length, i.e., the child demonstrates "conservation of length".

Measurement readiness tasks, such as the one described above, should be given to see if the child can conserve the quantity of the attribute to be measured prior to a measurement task. Excellent sources for such tasks are in references 36 and 37 by Copeland.

You should note, also, that conservation of one attribute, such as length, does not imply conservation of another, such as area or volume. In fact, a child may conserve an attribute, such as area, that seems to us to be "more complicated", before that same child conserves a "less complicated" (to us) attribute, such as length.

The second step in the measurement process is to pick an appropriate unit to measure the desired attribute. The general feeling among mathematics educators is that the units first used to measure should be non-standard units. For example, if you are measuring the length of an object, you might start by using the length of your foot or your hand-span as a unit. If you are measuring the weight of an object, you might use beans, washers or nails as units. If you are measuring area or volume you might use equilateral triangles or ping pong balls, respectively. (The class activities on these last two topics lead very well into discussions of tessellations in the plane or in space in a secondary school level mathematics classroom.)

The work done with the non-standard units will lead the student to an appreciation of standard units and the need for a system of units in which conversions are easily done, such as the metric system. Upon completion of the measurement activity with a non-standard unit, the child now measures that attribute using a basic unit from the metric system.

A great deal of emphasis in grades 3-6 should be placed on choosing an appropriate unit and an appropriate device to measure the attribute. For example, if a child is to measure the length of a hall-way in your school, then the unit most likely will be the meter and the device for measuring should be something like a trundle wheel or a 3-meter tape, rather than using the centimeter as a unit and a 30-centimeter rule.

As the child starts to gain some facility in measuring, discussions can now be centered on the fact that a measurement is an approximation of the quantity of the attribute, and not an exact determination. By the end of elementary school years, each child should realize that when one says something is 17 centimeters long, it is meant that it is closer to 17 centimeters than to 16 centimeters or 18 centimeters. That is, if one says that X is 17 centimeters, one means that 16.5 cm $\leq$ X $\leq$ 17.5 cm.

Once the above concepts are understood, the student can be introduced to the concept of precision. Here the idea is taught that given two measurements of the same object, one is more precise than the other if it uses a smaller unit. For example, if you measure the length of this piece of paper in decimeters, it is 3 dm long. However, if you measure the length in centimeters it is 28 cm long. The length given in centimeters is more precise than the length given in decimeters, since centimeters is a smaller unit. This is an excellent example of the fact that if something is 3 dm long, it need not be 30 cm long!

Other concepts related to precision are those of greatest possible error, relative error, and accuracy. These topics are generally not introduced until seventh and eighth grade (12-14 years old). The concept of significant digits is left until eighth or ninth grade.

Hints on Using This Handbook

Alternative methods of constructing some of the devices listed are referenced by numbers enclosed in parentheses next to the word "Construction". These refer to the Bibliography at the end of the text. Similarly, if you are seeking alternative activities, the numbers next to the section entitled "Activities" are some of the references which have other useful activities.

You will notice the letters "A", "B", "C", and "D" under the section on activities. This is a coding system we are using to group the activities by grade levels.

A -- refers to Grades 1-3

B -- refers to Grades 4-6

C -- refers to Grades 7-9

D -- refers to Grades 10-12

Another notation we use in this text is the "( )" notation. These occur after a subheading for a measuring device and contain the approximate cost of making the item yourself versus the cost if purchased through a commercial producer of educational equipment. The cost listed for a commercial product is neither the highest nor the lowest, but an average of prices listed in catalogues. It is difficult to tell you how much it will cost to make a device, since quite often many of the materials needed are commonly found in a school or home workshop.

The devices listed were chosen because they will probably be used frequently in a classroom and because they might be used to enrich a class. Other devices are not included, since the homemade devices in terms of time and money cannot compete with the commercial products. An example of this is a metric 1½ meter tape. These can be purchased commercially for about 50¢.

CHAPTER II

LENGTH

We briefly discussed the concepts involved with measurement in a general way in the Introduction. With respect to conservation of linear measurement, this is usually achieved at about age seven and one-half. Basically, this means a child understands what can be done to an object without changing its length. Copeland said:

> Measurement in its operational form (with immediate insight rather than by trial and error) is not achieved until eight or eight and one-half years of age.
>
> This study indicates then that if systematic measurement is to be "taught" it should not be presented before the latter part of what is usually the third grade. Even then, for most children it will have to be an experimental or trial-and-error readiness-type experience. The necessary concepts, as usual, develop from within rather than without for operational understanding. You cannot tell children how to measure; they should be provided with materials similar to those just described and be allowed to experiment and try to solve measurement problems for themselves. The teacher should play the role of questioner in moving toward the objective desired, in this case, measurement. The necessary concepts will develop (1) when the child is old enough (eight to eight and one-half, according to Piaget), and (2) when he is allowed to operate on (experiment with, manipulate) objects used in measurement. Both conditions are necessary for the operational thought necessary to perform measurement.[1]

Another very important concept the child must understand is the concept of subdivision, since most objects to be measured must be subdivided into units the same length as the measuring unit. There is a very close relationship between these ideas and the concepts involved in understanding number. However, it is felt that the understanding of

[1]Copeland, How Children Learn Mathematics, p. 269. (37)

number precedes the ability to measure.

The basic SI unit for measuring linear distances is the meter. The most commonly used prefixes in real life applications are the kilo and the centi. The other prefixes are useful from a pedagogical standpoint because they help a child understand the structure of the metric system.

Meter Stick, 30 cm Ruler and 100 mm Ruler
(10¢, 5¢, 5¢ vs. $1.25, 20¢, 15¢, respectively)

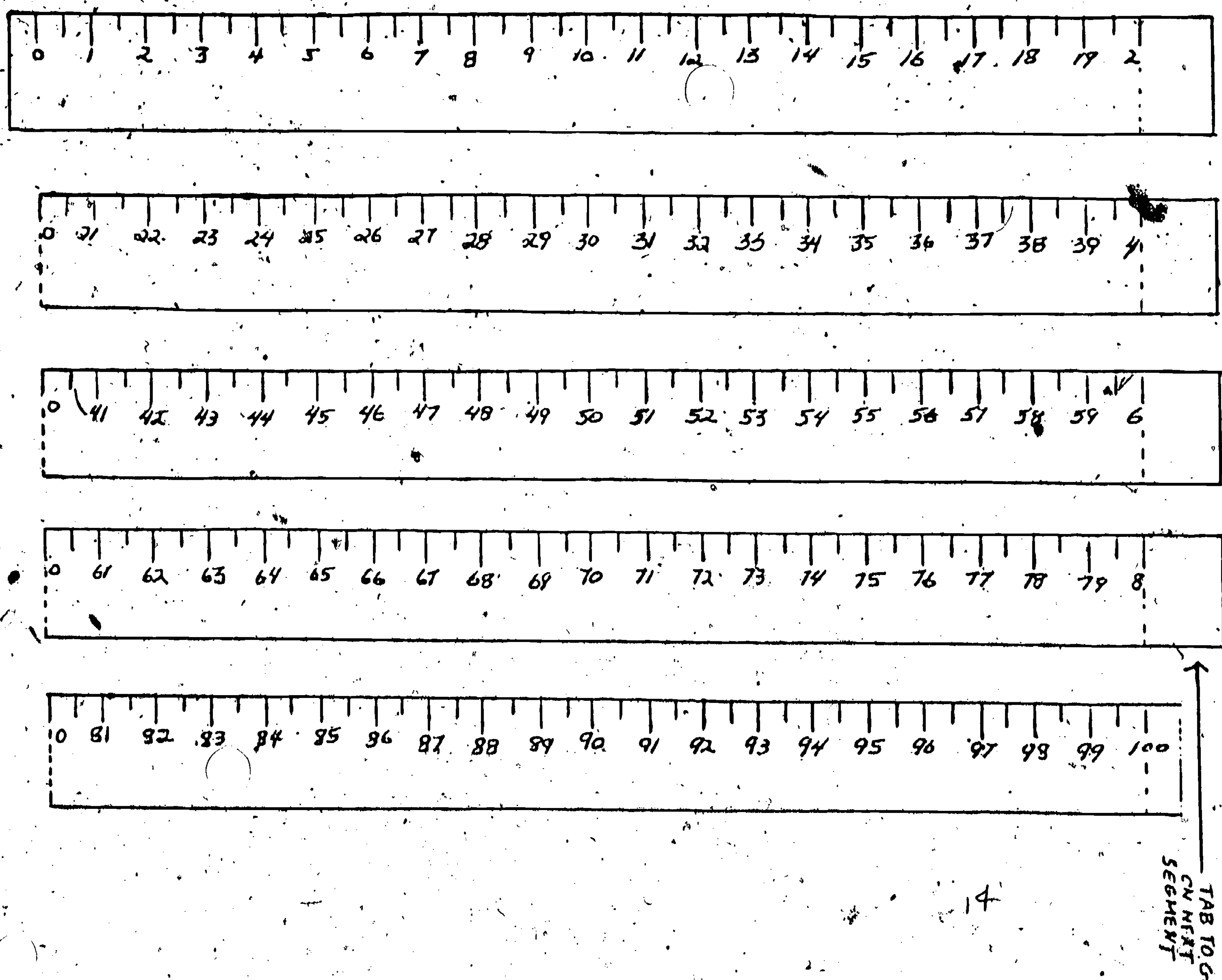
Materials

1. Copy of Figure 1
2. Oak tag strips or thin sticks 2 cm wide and 150 cm long altogether
3. Glue or tape
4. Scissors

Construction (16, 21, 22, 26)

Figure 1 is a meter stick which can be used to make a thermofax copy on a ditto or a stencil copy on a gestetner so that each child in your class could have a meter stick. These could be cut out and pasted onto oak tag or a small 2 cm wide stick for stability.

Note that the "0" and "100" cm markings are not at the end of the strips. This was done on purpose to allow for general wear and tear at the ends of the meter stick. At the end of the first four strips in Figure 1, you will see a tab, which is used to glue the first part of the next strip onto it. Thus, when the second strip is glued onto the tab of the first strip, you should be able to read the numeral "20". Figure 2 consists of a 30 cm ruler and a 100 mm ruler which can be copied and

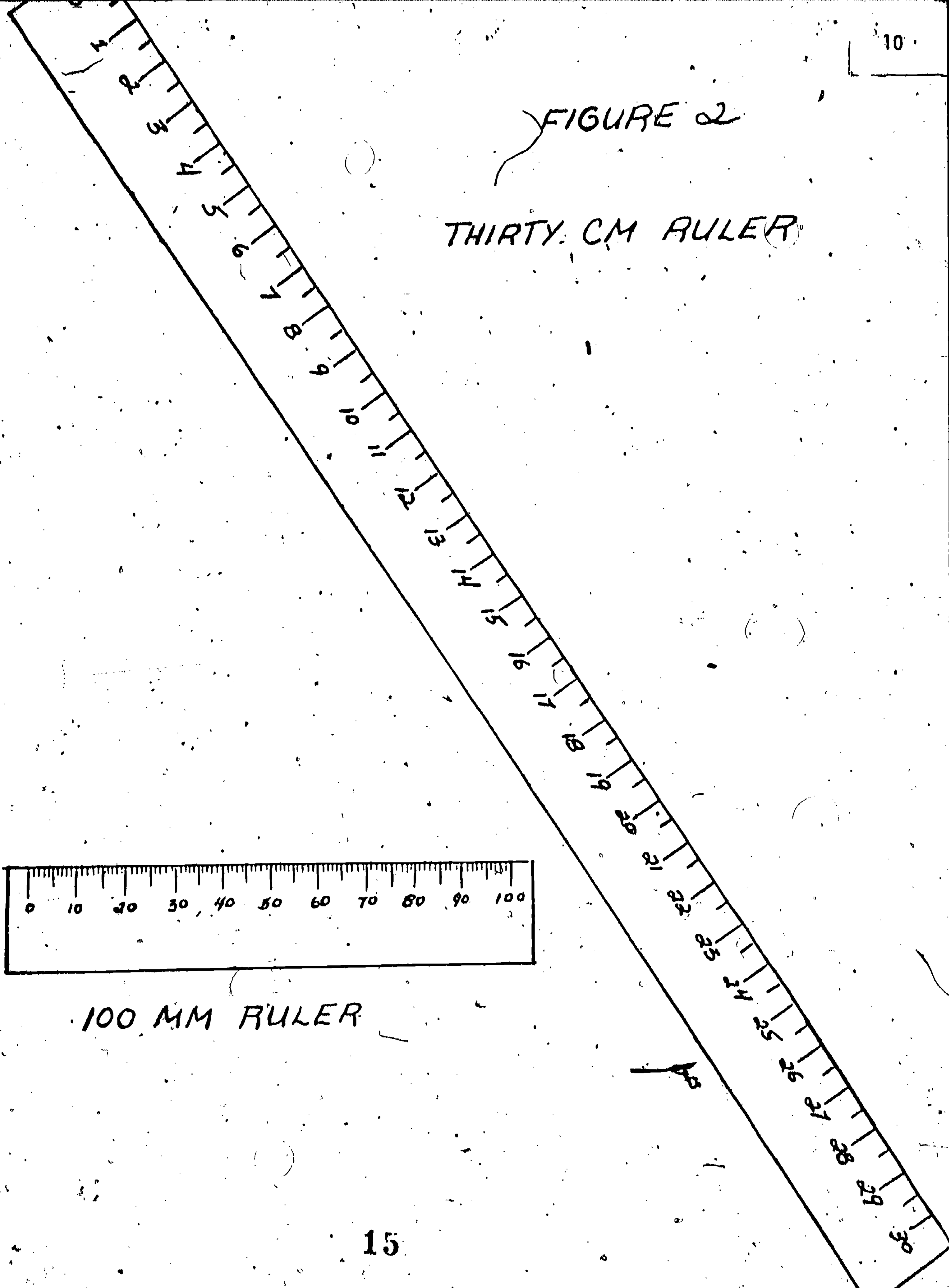


METER STICK

FIGURE 1

FIGURE 2

THIRTY CM RULER



100 MM RULER

and put on oaktag as was the meter stick

Activities (2, 4, 8, 11, 12, 13, 18, 22, 26, 40, 41)

A. 1. Have students make a list of objects by classifying them into 3 groups:

(a) things longer than a meter

(b) things about one meter in length

(c) things shorter than a meter.

They can do this by comparing their meter sticks to the object.

2. Another interesting activity would be for each child to measure various parts of his body, such as his arm length, waist, hand span, head, neck and so on, and put these sizes down on a picture he draws of himself.

3. Another fun activity is to have a scavenger hunt. That is, have the students break up into 4 or 5 groups and find objects which are various lengths. The first group to do this wins.

B. 1. Activities 1, 2 and 3 from Part A could be done or variations of them. One very important variation of this is to have them estimate the objects before measuring them.

Another important variation is to see if your class's measurements fit some of the following patterns:

(a) armspan fingertip to fingertip = height

*(b) height ÷ distance from floor to your naval = 1.618

*(c) top of your head to elbow ÷ top of head to armpit = 1.618

(d) distance around 2nd knuckle of thumb = ½ distance around wrist = ½ distance around neck = ½ distance around waist

(e) (length of foot) x $6\frac{1}{2}$ = height

*(The value 1.618 is the approximate value of the Golden Ratio.)

2. Many activities could be derived which require the child to find the perimeter of things as a room, the school yard, a desk or a book.

3. Another enlightening activity is to have the children measure the same object to the nearest meter, centimeter and decimeter. (Thus, the students can gain some intuitive ideas about precision and accuracy.)

C & D. 1. Activities from Parts A and B would be applicable. Activity B3 can be expanded to include formal definitions of precision, greatest possible error, relative error and accuracy.

2. Activities involving scale diagrams should be done. For example, the child could construct a diagram of the school yard drawn to scale or a diagram of a "Dream House" or "Dream Room" (that is, the house he/she would want to live in or the ideal room he/she would like to have.) Activities having the students making maps showing how to go from the school to home or some other place near the school are appropriate at this age level.

Trundle Wheel ($2.50 vs. $9.00)

<u>Materials</u>

1. Piece of pine 1 meter long, 6 cm wide and 1-$1\frac{1}{2}$ cm thick
2. Square piece of plywood (hardboard, old paneling, etc.) 32 cm or more on a side
3. Piece of spring steel (an old hack saw blade works very well)
4. 8 cm bolt, nut and 6-10 washers

5. 1 brad or nail

Construction (19, 21, 22)

Take the square piece of plywood 32 cm on a side and construct and cut out a circle of radius $\frac{100}{\pi} = 15.9$ cm. (You can construct a circle using a string attached to a nail at the center of the circle you are constructing.) Use a jigsaw to cut out the wheel you have made. The circumference of this wheel is approximately 1 meter. Using the diagram in Figure 3, construct the handle as indicated. Drill holes in the center of the wheel and at points 4 cm from the bottom of the handle to attach the wheel.

A piece of spring steel (a hacksaw blade works well) should be attached to the handle as in the diagram and a nail or brad on the wheel. Thus, every time you walk a meter, you should hear the spring steel snap.

Since the cut in the handle where the wheel is to be attached is 2 cm wide and the wheel is only 1 cm wide, washers should be placed between the wheel and the sides on the handle. This will keep the wheel from wobbling.

Activities (8, 12, 13, 18, 22, 40, 41)

A. 1. Any activities, where relatively long distances are to be measured and are accessible by walking, can and probably should use an instrument like the trundle wheel. For example, children could measure the lengths of rooms, hallways, driveways, playgrounds and so on by rolling the trundle wheel along.

B. 1. Activities involving any of the ideas in Part A are applicable.

2. An activity which the children in the upper elementary grades love is a treasure hunt. The treasure hunt could emphasize

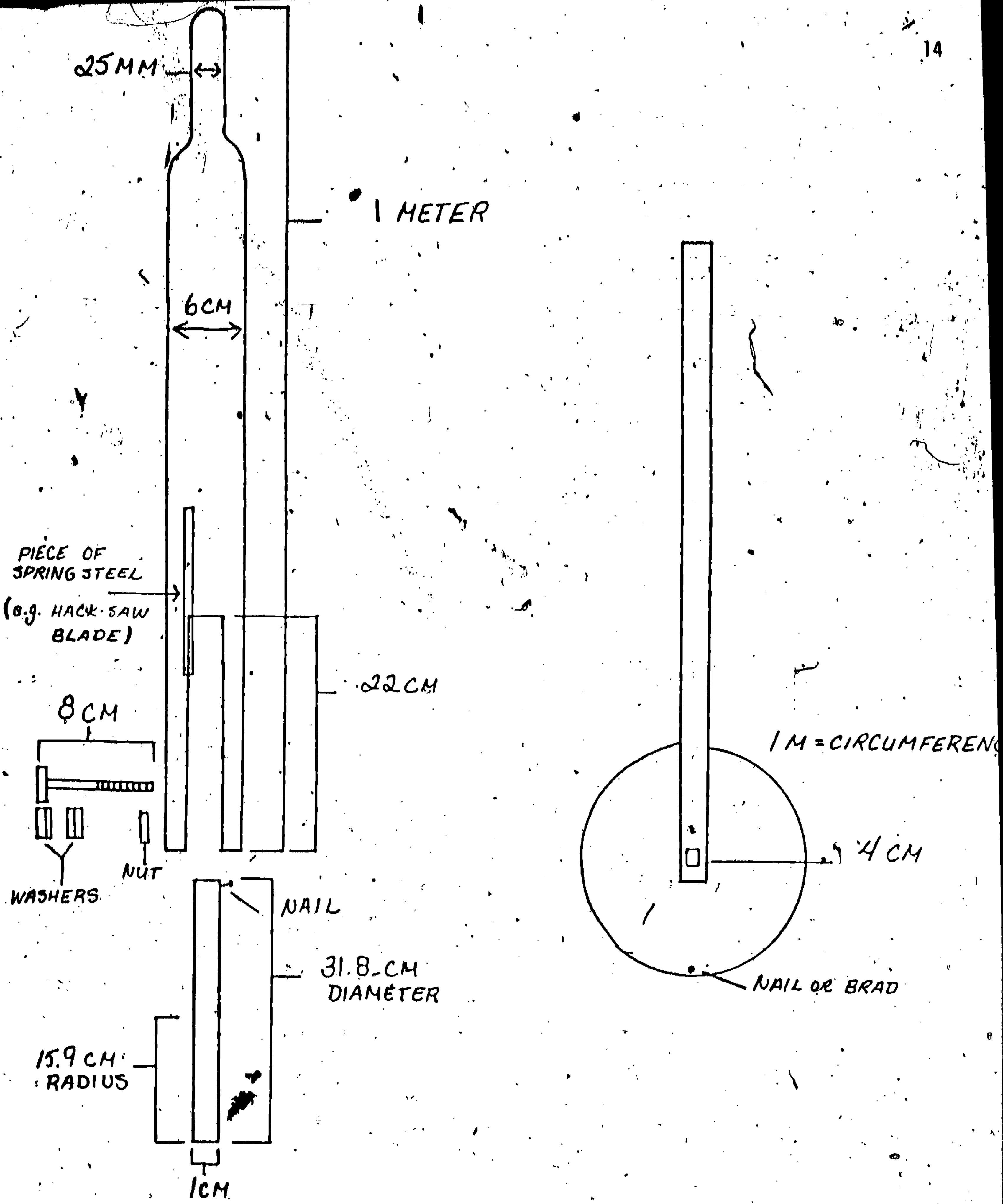


FIGURE 3

TRUNDLE WHEEL

various concepts such as conversions within the metric system itself, other SI units such as liters, grams and degrees Celsius, or simplification of arithmetic expressions.

3. You can use the trundle wheel to help you find perimeters, areas or volumes of rooms, buildings or pieces of land.

C & D. 1. Activities in Parts A and B apply. An extension of B3 could be done at this level by having the children draw scale diagrams of the rooms, buildings or pieces of land that they measure.

Clinometer (50¢ vs. $8.00)

A clinometer is an instrument for measuring the heights of objects which are not readily accessible. The one in Figure 4 is based upon the concepts involved in similar triangles. In the diagram, $\Delta ABC \sim \Delta A'B'C'$.

$$\therefore \frac{B'C'}{A'C'} = \frac{BC}{AC}$$

$$\therefore \left(\frac{B'C'}{A'C'}\right) \cdot (AC) = BC$$

That is, in order to find the height from your eye level to the object you want, do the following:

(a) Sight the object at point B through the straw on your clinometer

(b) Read off on the graph paper where the nylon filament or string hangs (i.e. the length of B'C')

(c) Measure the distance from where you are standing to the projection of the object B to the ground (i.e., the length of AC)

(d) Multiply the distance in c above by the ratio of the reading in (b) above to 20, since A'C' = 20 cm.

(e) Therefore, in order to find the height of the object, add the height of your eye level to the answer you got in part (d) above.

Materials

1. Square piece of plywood (paneling or hardboard) 25 cm one side
2. Square piece of cm graph paper 20 cm on a side
3. 30-35 cm piece of nylon filament or string
4. Ordinary drinking straw
5. Washer or nut and nail
6. Glue or tape

Construction (19, 20, 40)

Glue or tape the piece of cm graph paper close to the left edge of the square piece of plywood. Attach the nylon filament to the upper right hand corner of the graph paper by a nail or by making a hole and tying a knot on the opposite side. Tie the washer to the end of the nylon filament so it hangs freely as in Figure 4. Tape or glue the straw to the top of the graph paper and close to the left edge.

Activities (13, 19, 20, 40)

A. 1. The clinometer gives you an excellent opportunity to have some fun outside measuring the heights of buildings, trees, flag poles and the like.

2. Some indoor activities could be to find the height of the room, the gymnasium, the basket, a clock or other such things.

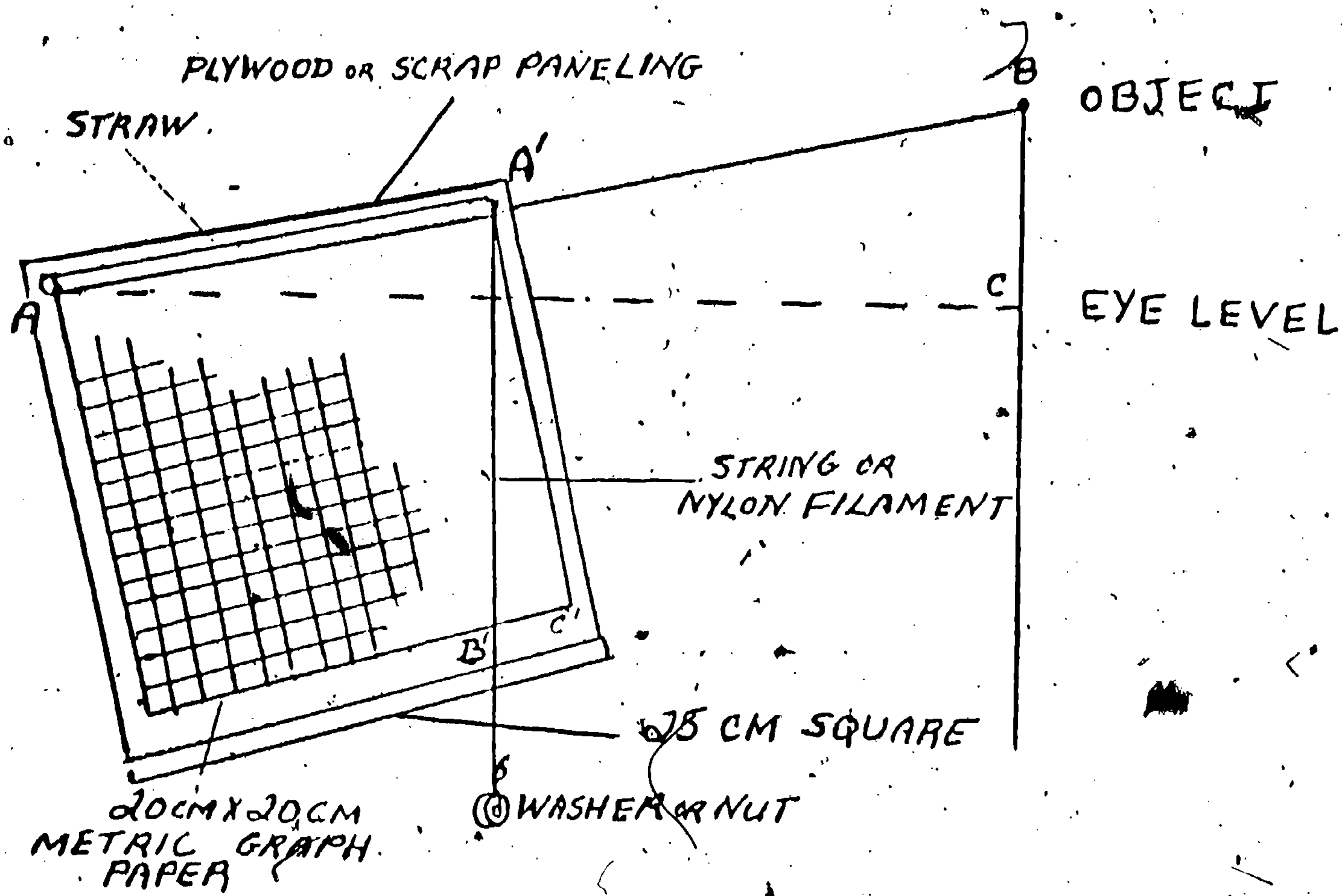
Armspan and Height Charts (50¢ vs. $2.50)

Materials

1. 2 pieces of oak tag at least 1 meter long and 2 dm wide to be marked as in Figure 5

CLINOMETER

FIGURE 4.



ARM SPAN AND HEIGHT CHARTS

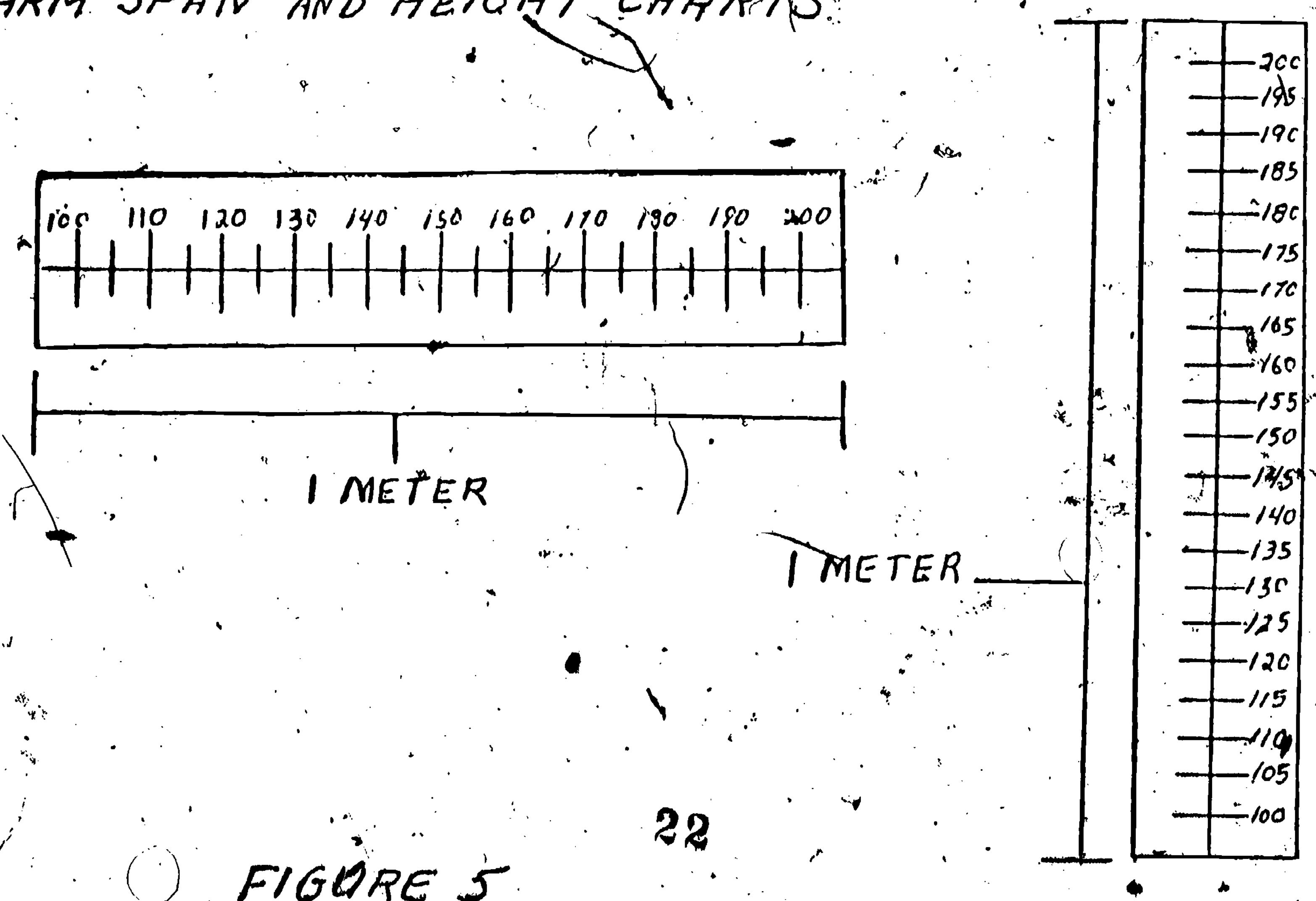


FIGURE 5

Construction (12, 18)

Draw a line down the middle of the chart. Then make centimeter markings and label them every 5 cm or 10 cm. The armspan chart should be placed from the corner of a room so that the 100 cm marking is 1 meter from the corner. The height chart should be put so that the 100 cm mark is 1 meter from the floor.

Activities (8, 12, 13, 18, 40)

A & B. 1. Have a child measure his arm span and his height with the charts. Then have them compare the two (they should be about the same. That's right, you are a square!)

C & D. 1. A nice extension of the above activity is to record the results and have a table to indicate the difference between a person's armspan and his height. Some results will probably be positive and some negative. After adding all the positive numbers in the table and all the negative numbers in the table, add the positive and negative sums. Is it close to zero?

2. The above activity can lead to other interesting facts about the proportions of various parts of the body. Have each student measure the following parts of their bodies: (a) foot, (b) handspan (distance from outstretched little finger to outstretched thumb), and (c) from the top of his head to the bottom of his jaw. Now form a ratio by comparing the height of a person, h, to a, b, and c mentioned above. Results: $\frac{h}{a} \approx 6.5$, $\frac{h}{b} \approx 7.5$ and $\frac{h}{c} \approx 7.5$. Make a table indicating the results for the class. Find the averages of the above for the class. Leonardo Da Vinci was one of the first painters who applied knowledge about such ratios in his works. In fact, he made a statement to the effect that anyone who is not a mathematician, should not study his works.

Plane Table ($1.50 vs. $10 or up)

The plane table is a device which can be used to find inaccessible distances using some simple trigonometry or it can be used to make a map of a relatively small area such as a playground. (The board should be on a level surface when used.)

Materials

1. Square piece of plywood 40 cm on a side and 1 cm thick
2. Circular graph paper
3. Ordinary drinking straw
4. Nut, bolt and 2 washers
5. 2 small nails or brads used for sighting the object
6. Piece of wood 2 cm wide and 30 cm long used as a pointer
7. Glue or tape

Construction (19)

Drill a hole in the center of the 40 cm-square piece of plywood and in the piece of wood to be used as a pointer. Place a piece of circular graph paper (Figure 6A) on the plywood so that it is concentric with the plywood. (You may want to laminate the circular graph paper so that you could mark on it and wash it off later.) Attach the pointer to the board and on top of the graph paper. Attach the straw to the pointer by glue or tape. Put 1 brad near the end of the pointer and 1 in the straw. As you peer through the straw, these brads should line up.

Activities (19)

A & B. We do not recommend the use of this device at these levels since the ideas involved are probably beyond the understanding of most students.

C. 1. Have the students draw a simple map indicating the

PLANE TABLE

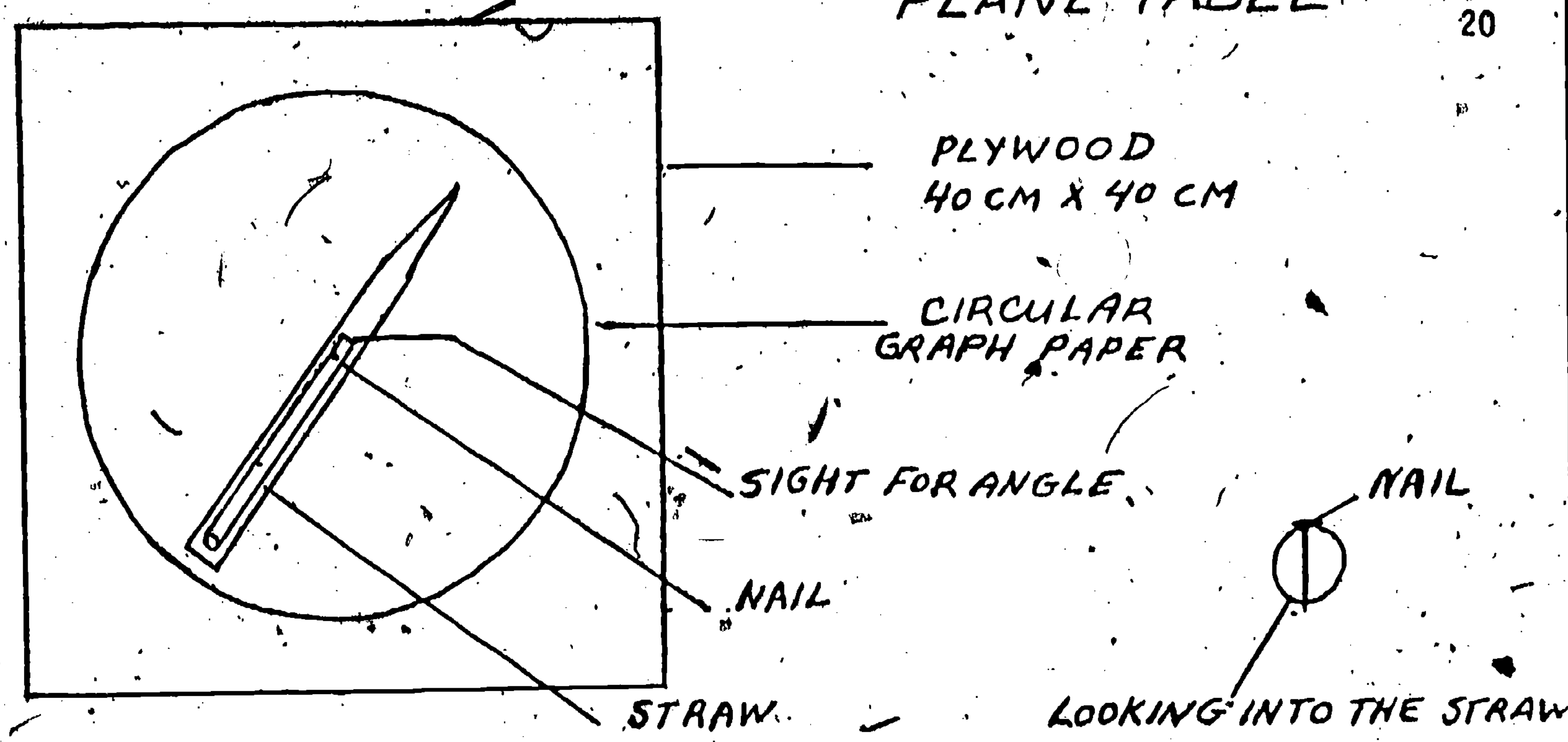


FIGURE 6

CALIPER

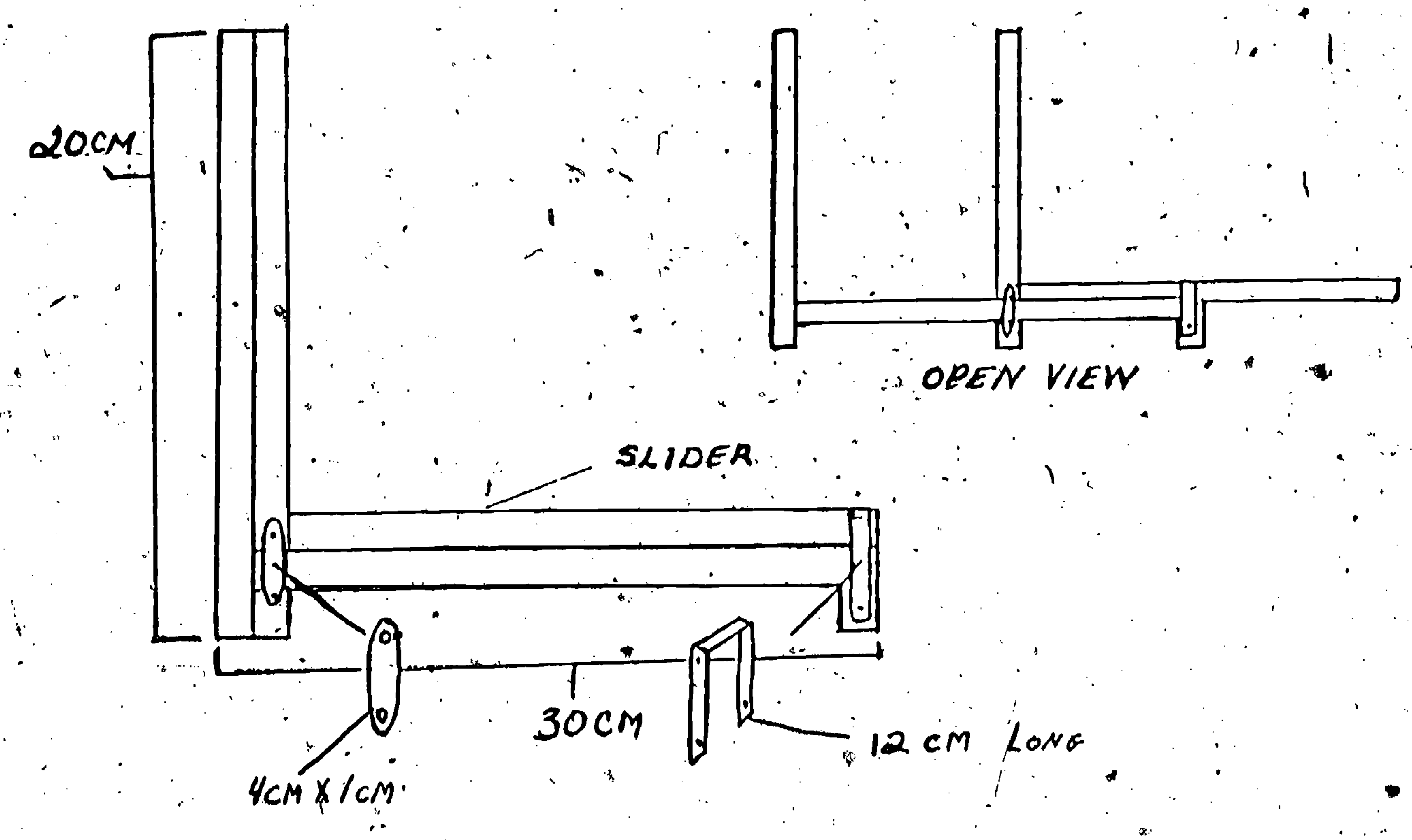
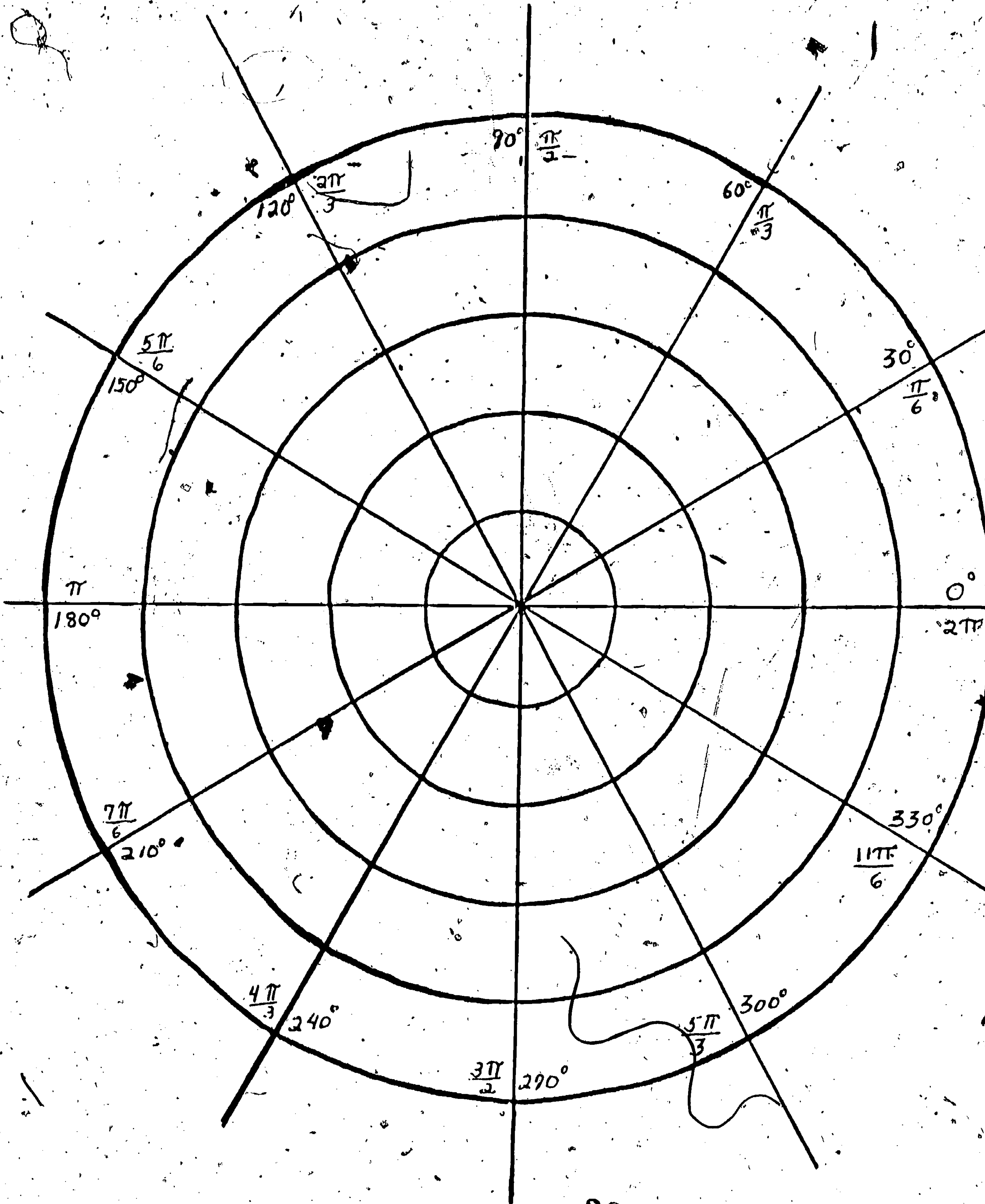


FIGURE 7



90°
π/2
2π/3
120°
60°
π/3
5π/6
150°
30°
π/6
π
180°
0°
2π
7π/6
210°
330°
11π/6
4π/3
240°
300°
5π/3
3π/2
270°

26

FIGURE 6A

relationship of 3 objects such as a tree, a building and a telephone pole. Have them stand at one of the objects and sight the other 2 by using the board and indicating the angle and distances involved.

2. After they have gained some ability to draw simple maps to scale, have them draw more complex areas such as the school yard or a neighborhood block.

D. 1. Same as the activities listed in Part C.

2. Use the plane table as you would a sextant in order to help you find measurements for inaccessible distances. Here the students can employ the sine law or the cosine law.

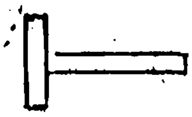
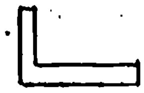
Caliper ($2.00 vs. $12.00) (Figure 7, page 20)

The caliper shown in Figure 7 can be used to find the diameter of a sphere, such as a baseball, basketball, or globe or to find the outside diameter of a cylinder, such as a tin can or a pipe.

Materials

1. 1 piece of wood 20 cm long, 2 cm wide and 2 cm thick
2. 1 piece of wood 16 cm long, 2 cm wide and 2 cm thick
3. 1 piece of wood 28 cm long, 2 cm wide and 2 cm thick
4. 1 piece of wood 26 cm long, 2 cm wide and 2 cm thick
5. 2 pieces of wood 2 cm on all sides
6. 6 screws 1-½ cm long
7. 4 nails 3-3½ cm long
8. 2 rigid metal strips 4 cm long and 1 cm wide
9. 1 flexible metal strip 12 cm long

Construction (19) (See Figure 6)

Attach the 28 cm piece of wood to the 20 cm piece by nails or screws and 2 cm up from one end of the 20 cm piece forming a shape like this  . Now attach the 16 cm piece to the 26 cm piece at the end so it looks like this  . Now put the second one on top of the first one and hitch it to one of the cubes 2 cm on a side by use of the 2 rigid metal strips. Attach the other cube 2 cm on a side to the bottom of the first piece at the right hand end of it. Now use the flexible metal strip to help hitch parts 1 and 2 above together. Mark off on the 28 cm piece centimeter (or millimeter) marks from where it is attached to the 20 cm piece.

<u>Activities</u> (18, 22, 40, 41)

A. For the most part, we do not recommend this device for children at this age level.

B. 1. Use the caliper to find the diameter of a tennis ball, volley ball, or any other sphere or circle which could be placed within the caliper.

C. 1. Same as Activity 1 in Section B.

2. An excellent activity is to have the students find the diameters and circumferences of many spherical or circular objects and form the ratio of the circumference to the diameter. Thus, the students should see that this ratio is a constant called π.

CHAPTER III

AREA

Conservation of area and length develop at about the same time. Yet, area concepts are usually not taught at the same time as linear concepts. Area should be introduced as a "covering" process. That is, how many of these will it take to completely cover that. The method of finding the area of a given figure by use of formulas should not be introduced until the child reaches the formal operations stage at around age 11 or 12.

Centimeter Graph Paper
(30¢ for 100 sheets vs. $3.00)

Materials

1. Access to a Thermofax "Secretary" Copier/Transparency Maker and a thermal spirit master
2. Figure 8
3. Paper

Construction (9, 11, 12, 14)

Using a machine similar to a Thermofax "Secretary" Copier/Transparency Maker (or draw by hand on a regular ditto master), make a ditto of Figure 8. (A stencil could be made on a Gestetner, but it would probably cost more.)

Activities (9, 11, 12, 13, 22, 40)

A. 1. Cut out some rectangular regions of various sizes and 30 squares 1 cm on a side. Have the students see how many squares it takes to completely cover a rectangle so that no square overlaps another. Make the process easy by having the rectangle's sides be integral units, such as 3 cm by 4 cm.

B. 1. The same as the activity in Part A. An extension of this would be to have the students place the rectangular regions on a piece of cm graph paper and find out how many squares 1 cm on a side it covers. This activity can be made more complex by using non-integral units for the measure of the sides or by using figures other than rectangles.

C. 1. The same activity as in Part B.

2. Once students understand the method of finding the area of an object by a covering process and have grasped the fundamental ideas of probability theory, then they are ready to find areas of irregularly shaped objects such as a leaf, an outline of a hand or a shadow. This can be done by having them trace the leaf, hand or whatever onto the cm-graph paper. Then have them count all the squares which are completely enclosed within the tracing. Next, have them count up all the squares which are only partially enclosed. Now use the principle that if a line is drawn such that it goes through the interior of a large number of squares, then approximately half the area enclosed by those squares lies on one side of the line and half on the other side. Thus, add one half the total number of squares which are partially contained within the tracing to the total number which are enclosed within the tracing.

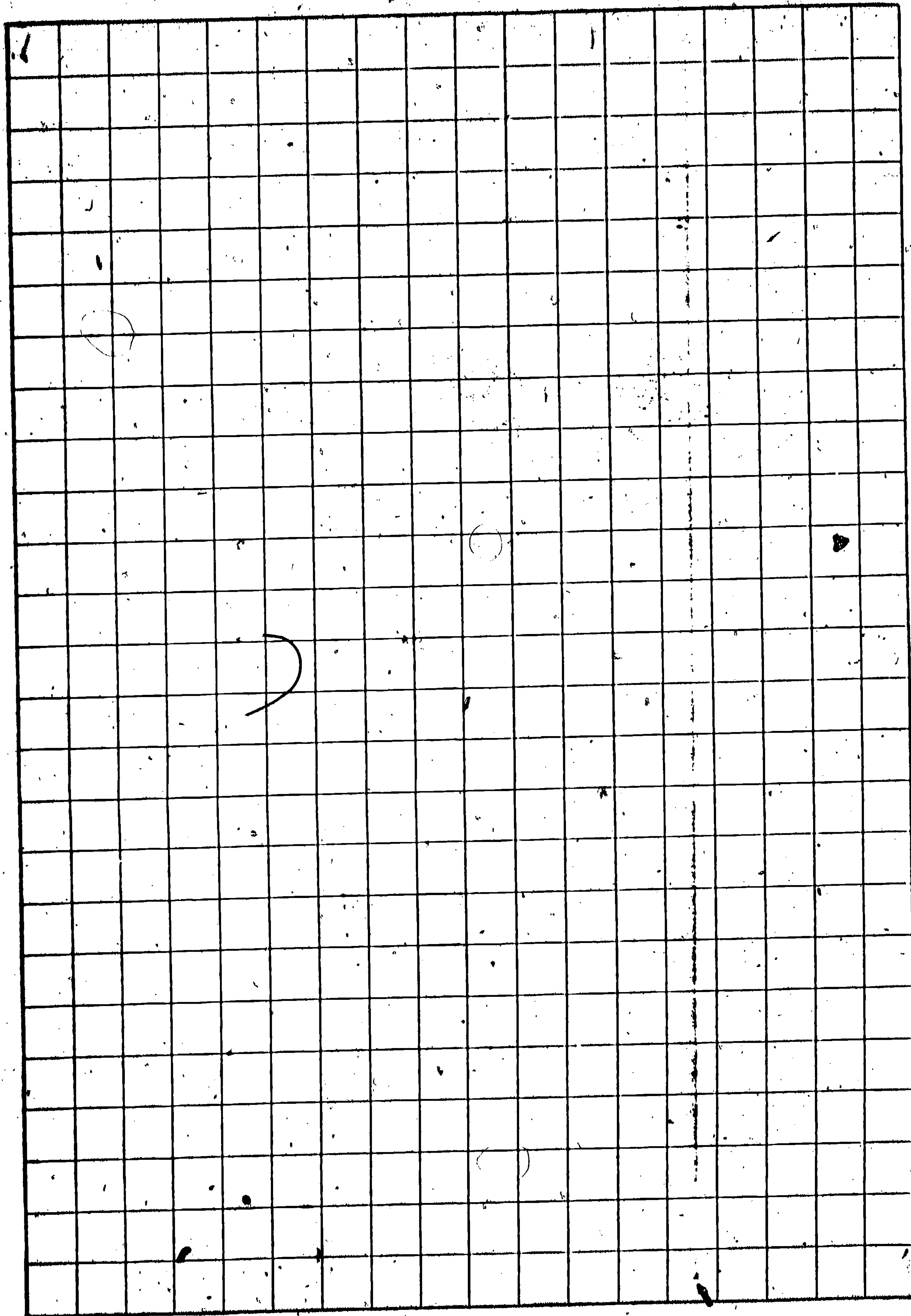


Figure 8

The Square Centimeter and Square Decimeter

Materials

1. Figure 9
2. Paper

Construction

You could make copies from Figure 9 or have the students construct squares one decimeter on a side on a piece of paper.

Activities (8, 11, 12, 13, 40)

A, B & C. 1. The activities listed under the section entitled "Centimeter Graph Paper" would apply. The objects you find the area of should be larger if you are finding the area in dm^2.

2. An excellent exercise to stress area conversions from one unit to another is to have the student find the area of an object in dm^2 and then in cm^2. If the dm^2 in Figure 9 is used, it is easy for them to understand that $1\ dm^2 = 100\ cm^2$. The next step would be for them to find the area of something in m^2 and then do it in dm^2 and finally cm^2.

Metric Geoboard (40¢ vs. $2.00)

Materials

1. Piece of plywood 20 cm x 20 cm x 1.5 cm
2. 100 nails

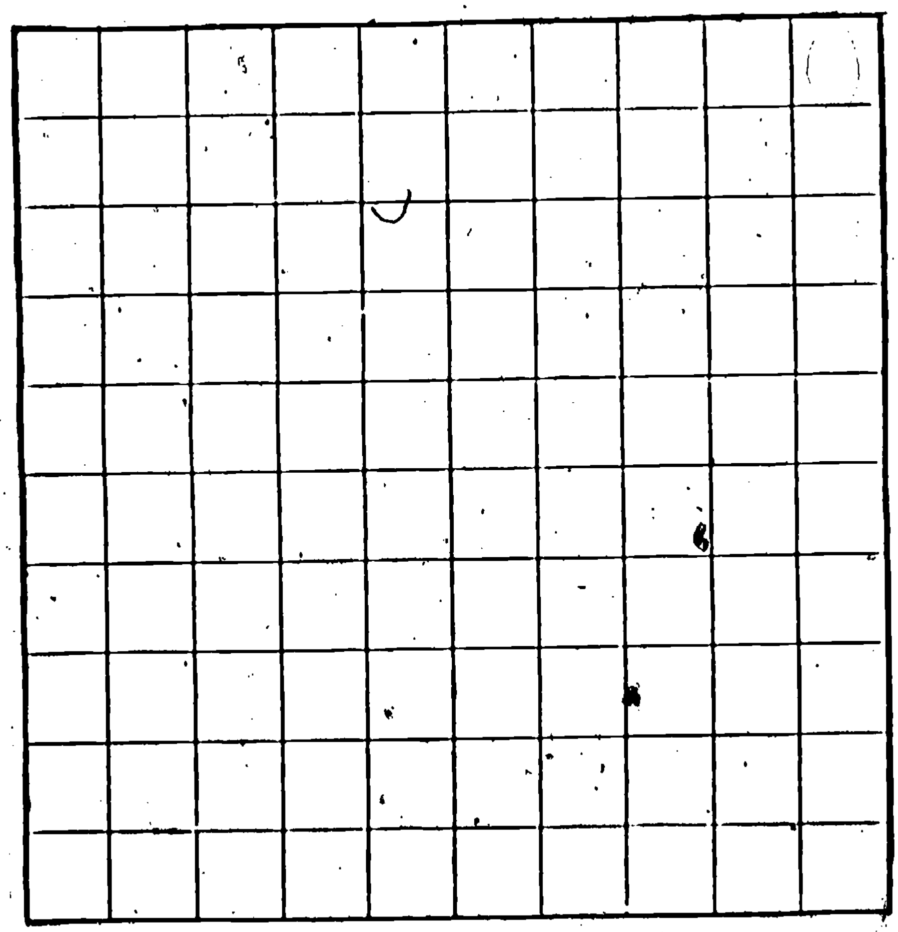
Construction (19)

Cut out a square piece of plywood 1.5 cm thick and 20 cm on a side. Now set up a grid on the geoboard so that the nail in the upper left hand corner is 1 cm in from each edge. Then put nails 1 cm from

Figure 9

1 cm^2

(A square 1 centimeter on a side)



1 dm^2

(A square 1 decimeter on a side)

the edge and 2 cm from one another as in Figure 10. You will end up with 100 nails in the board with each nail in a row 2 cm from one another. (Since there are 100 nails altogether and 10 in any one row or column, the board can also be used to teach place value with a base of 10.) The fact that the nails are 1 cm from an edge allows a child to put 2 or more boards side by side and still have 2 cm between nails.

Activities (11, 12, 19, 40)

A & B. 1. Have the students make different rectangles on the board and record their data by having them list the length, width, and the number of squares enclosed. The students should be warned that if there are 3 nails on a side, the side is only 2 "units" long. Thus, if a rectangle is formed with 5 nails along one side and 3 along another, the length and width are 4 and 2, respectively. There are 8 squares 2 cm on a side contained in the rectangle.

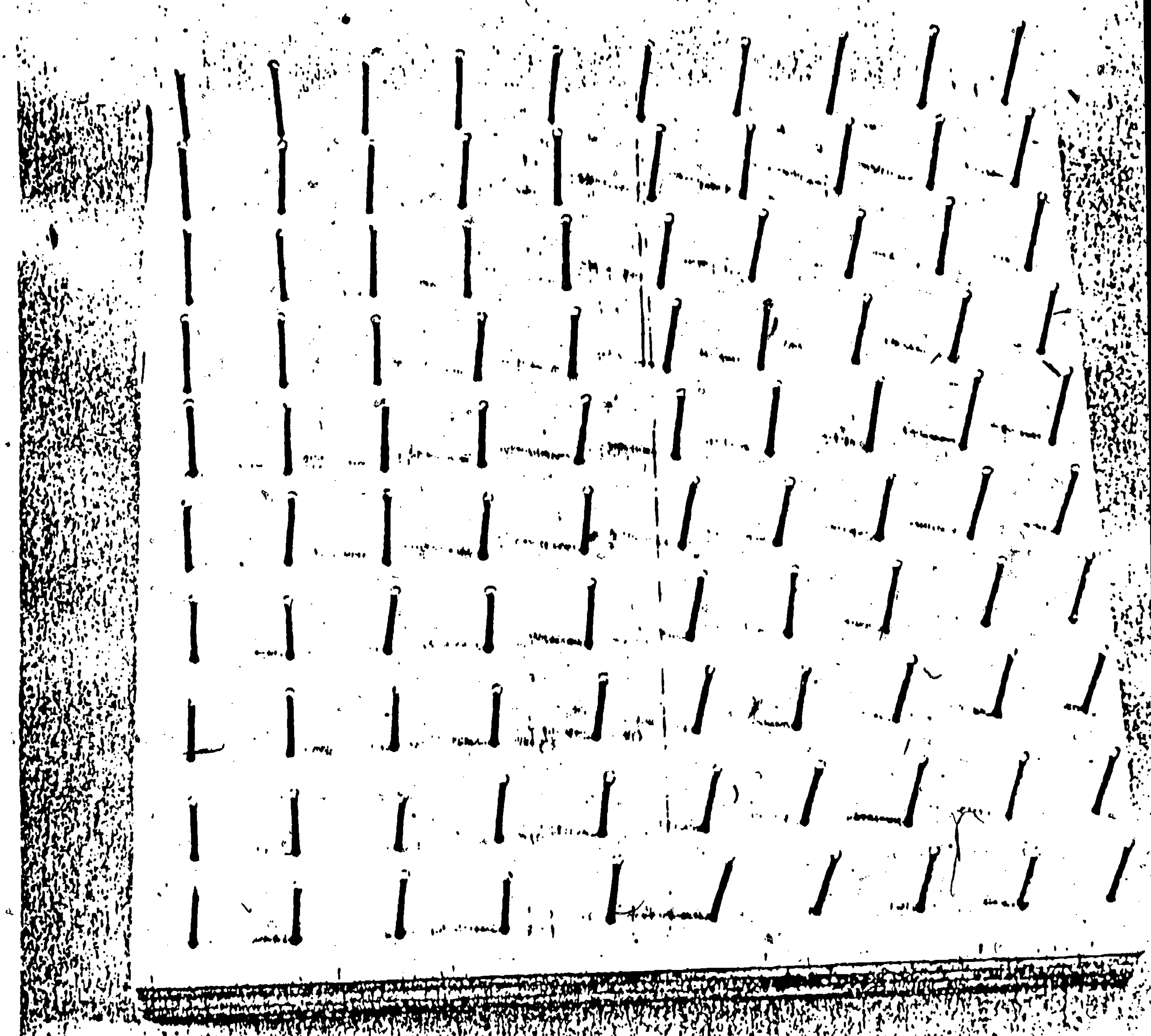
2. The same activity can be done with right triangles, non-rectangular parallelograms, and so on.

B & C. 1. Children at this age level should be able to extend the activities in Parts A & B to derive the formulas for finding the areas of many common plane figures by analyzing the data they obtain. Formulas for squares, rectangles in general, right triangles, triangles in general, parallelograms and trapezoids are a few that they should be able to derive with proper guidance.

2. Have the students make any kind of closed figure and have them compute the area by counting squares or halves of rectangles. Have them do it for both convex and concave figures.

3. Another very interesting activity is to have the students construct rectangles with a constant perimeter and then find their area.

Figure 10



What kinds of rectangles seem to have the largest area for a given perimeter?

C & D. 1. Have students construct any kind of simple polygon and record the number of nails on the boundary B, number of nails in the interior I, and the area A of the figure. A man by the name of Pick discovered a linear relationship between these three. Namely, $\frac{B}{2} + I - 1 = A$. See if your students can discover this relationship from their data.

CHAPTER IV

VOLUME

Piaget has investigated a child's understanding of volume by relating it to conservation. He investigates a child's ability to conserve "quantity" and "volume", both of which relate to volume.

Conservation of quantity refers to the child's ability to realize that the amount of a liquid or solid doesn't necessarily change just because its shape does. For example, the amount of water in a glass doesn't change just because it is poured into another glass that is narrower but taller. Children which are still in the preoperational stage will allow their perception to overwhelm them. They will probably say there is more in the taller glass because it is up higher. This same phenomenon can be observed by taking 2 balls of clay with the same volume and shape. If you flatten or lengthen one of the balls of clay, the preoperational child no longer thinks they are the same.

The conservation of volume tasks relate to building houses out of blocks. Children are asked to build different shaped houses with a certain number of blocks. They should realize that the volume of all the houses (interior volume) is constant since they used the same number of blocks for each. They should also realize that if the houses were immersed in water, then they would displace the same amount of water.

Piaget feels that most children can conserve quantity before they can conserve volume. It is felt that children will begin to conserve quantity and interior volume around age 8, but it is not until around 11 or 12 that displaced volume is conserved. Thus, volume by formulas is a topic more appropriate for junior high school students than for elementary school students. However, it is felt that elementary school students be given many readiness experiences emphasizing volume as a "filling up" process.

Liter and Milliliter Containers
(30¢ for 100 vs. $3.00)

Materials

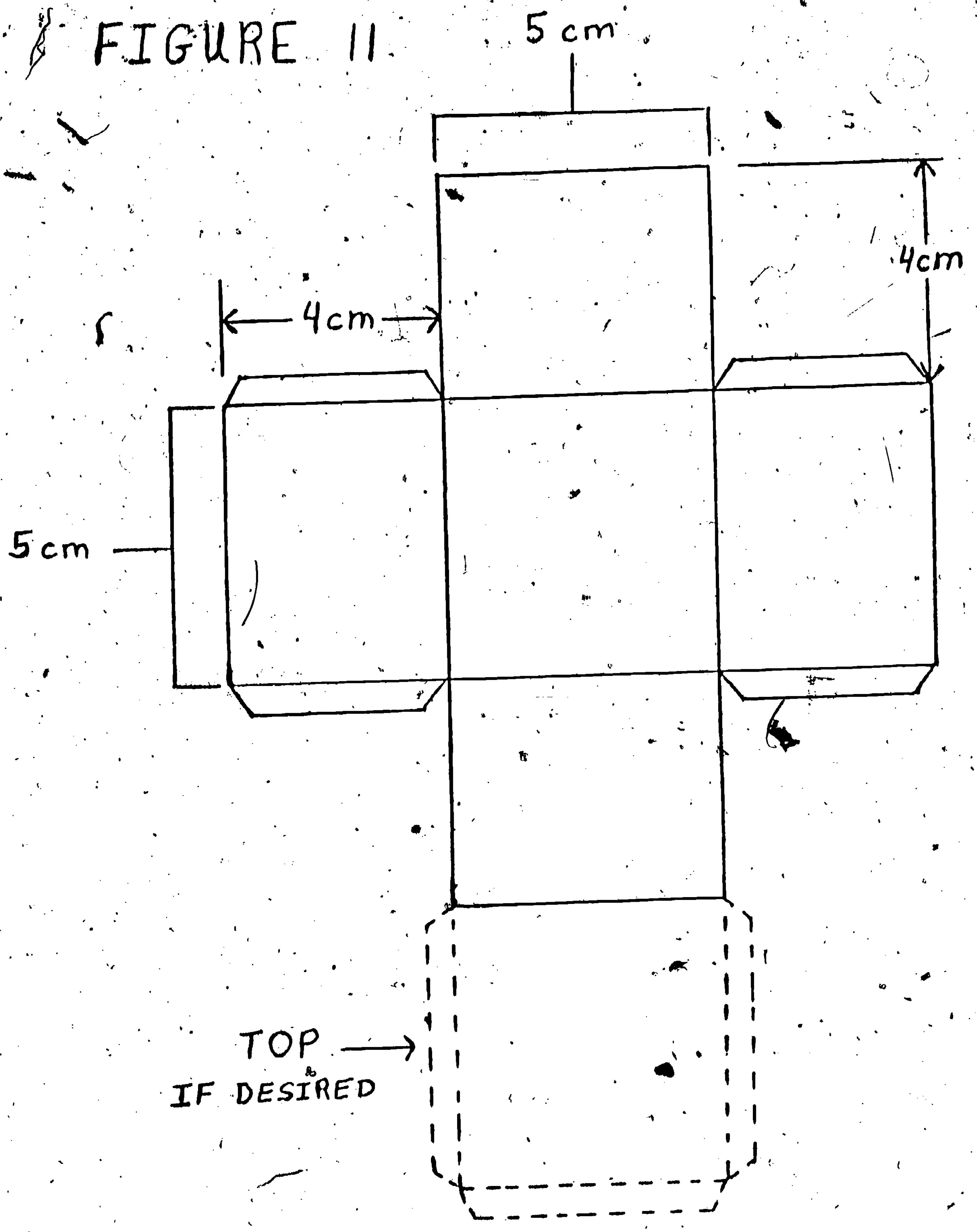
1. Access to a Thermofax "Secretary" Copier/Transparency Maker and a thermal spirit master
2. Figure 11, 12
3. Paper

Construction

Using a machine similar to a Thermofax "Secretary" Copier/Transparency Maker (or draw by hand on a regular ditto master), make a ditto of Figures 11 and 12. (A stencil could be made on a Gestetner, but it would probably be more expensive.) If these are made out of paper, they will be valuable as visual aids, but they will be worthless as far as using them as containers.

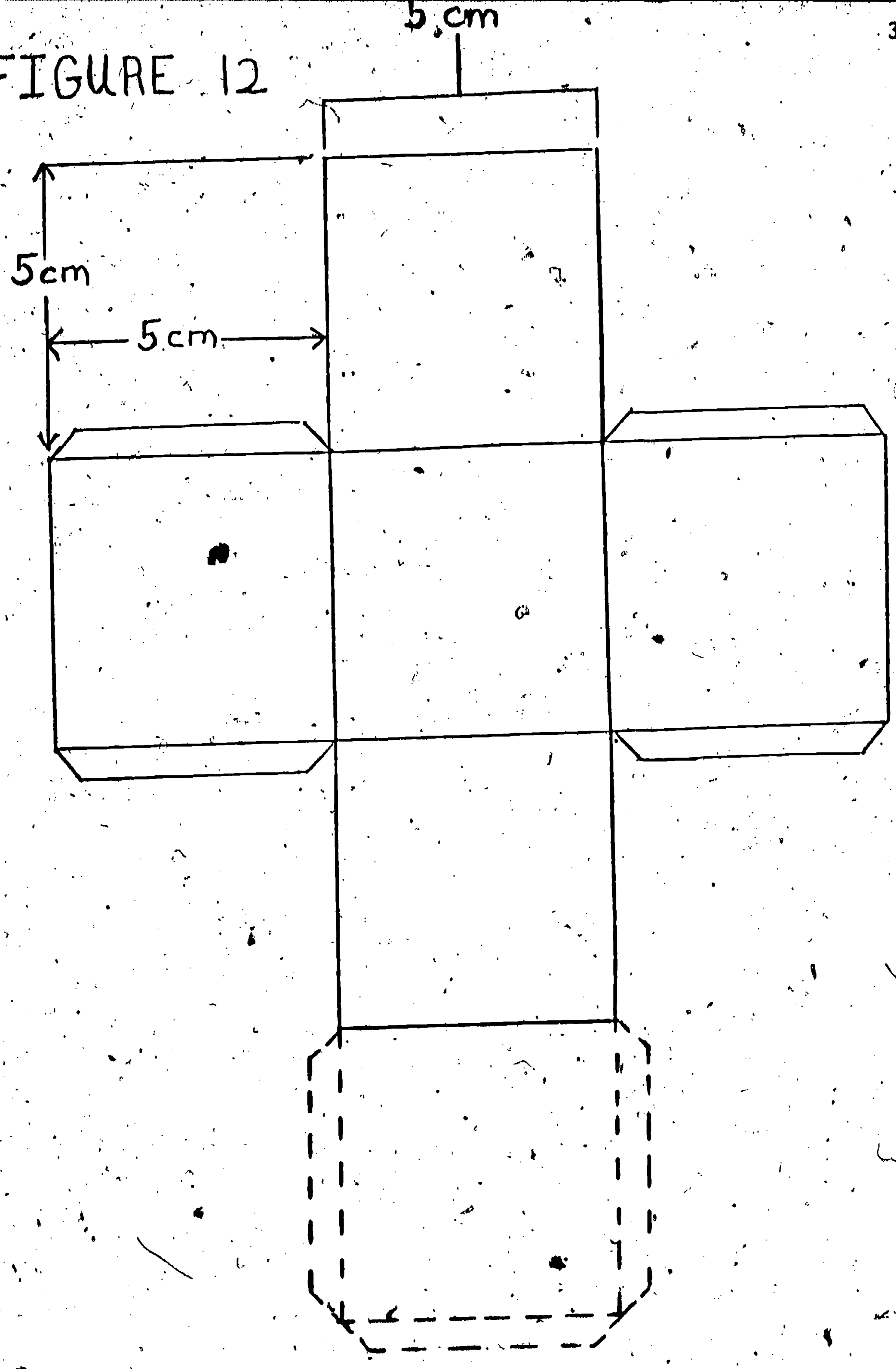
If you want every youngster to have durable containers of their own, have them bring in translucent plastic containers (not glass) like the ones used for marshmallow or sherbert and ice cream. These can be calibrated by having the students compare them to a commercial metric measuring cup. The marks can be made on the container itself or on masking tape stuck to the side of the container. These containers can be used for both liquids and dry quantities such as sand or flour. (Note: Children who understand this will be able to conserve quantity.)

FIGURE 11



100 ml = 100 cm^3 CONTAINER

FIGURE 12



125 ml = 125 cm^3 CONTAINER

The pattern used in Figure 12 can be used to construct a cubic decimeter or liter. It is strongly suggested that 125 cm^3, 1 dm^3 and 1 M^3 models be available.

<u>Activities</u> (1, 8, 9, 12, 13, 18, 22, 26)

A. 1. Durable, marked containers of various sizes should be used to see how many mℓ or cm^3 it takes to fill an unmarked container. Sand, beans, macaroni and water can be used to compare containers.

2. Have them bring in various containers such as coffee cans, oatmeal boxes and shoe boxes. Put out 3 or 4 of these and ask students to order these from smallest to largest and explain how they did it.

3. Once the child has learned to conserve quantity, then he should be encouraged to make and take home a container he has calibrated in mℓ or cm^3.

B. 1. The same as the activities in Part A.

2. Students using blocks constructed from Figures 11 and 12 and others using similar patterns, such as a dm^3, should be given problems such as: how many 125 cm^3 blocks does it take to fill a dm^3. Thus, the students will be given experiences in the "filling up" process using blocks.

3. Have them bring in containers and estimate the volume before they find it by the "filling up" process.

C. 1. The activities in Part B apply.

2. Once the students truly understand the "filling up" idea, they can be guided to discover the formula for the volume of a rectangular prism by having them list the number of blocks in the length l, width w, height h and volume v.

3. Formulas for the volume of cylinders, pyramids and so on can also be derived if you have constructed the necessary figures from durable containers. For example, if you have a pyramid with the same base and height as a prism, you can pour sand from one to the other and they can discover that it takes 3 pyramids to fill the prism.

Cubic Meter
($6.00 vs. $15.00)

<u>Materials</u>

1. 12 m x 2 cm of corner stripping 2 cm{ 
2. 8 cubes 3 cm on a side
3. Package of 2 cm screws or brads

<u>Construction</u> (21) (See Figure 13)

Cut the corner stripping into meter lengths and attach them to the 3 cm cubes. Use screws, if you want to be able to disassemble and reassemble it easily. Adjustments on the meter strips must be made so that each side is exactly 1 M. If you were to use 2 cm wide strips rather than corner strips, you could cut the construction price in half. You could also use dowels and drill holes in the blocks, which would also be considerably cheaper than $6.00. However, cubes constructed the latter two ways are not as aesthetically pleasing as the first one mentioned.

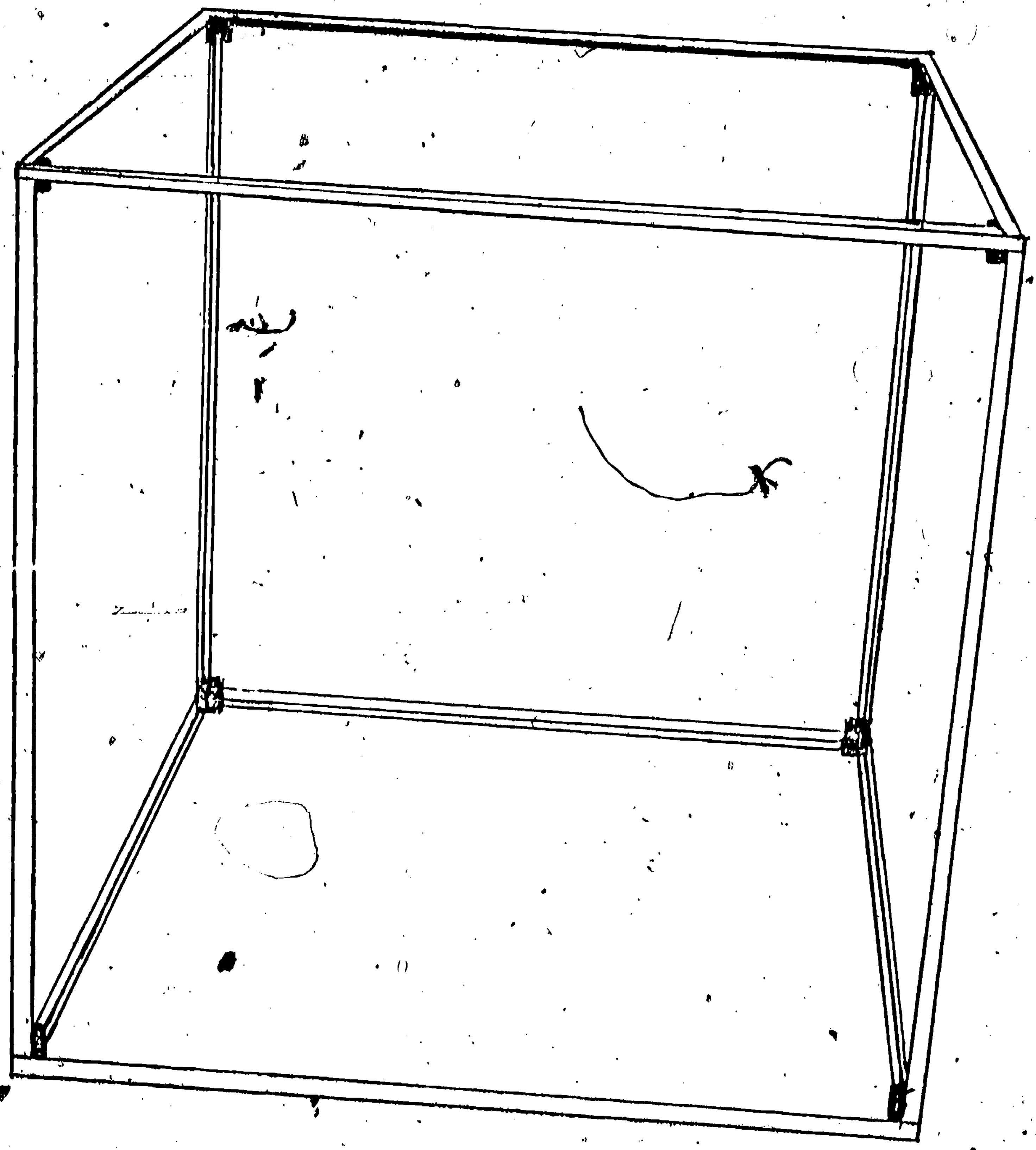
<u>Activities</u> (1, 15, 18, 22, 26)

A. None

B, C & D. 1. The main purpose of having a cubic meter is for demonstration purposes. It serves as an excellent model of 1 000 000, since 1 000 000 cm^3 = 1 M^3. It could also serve to illustrate

FIGURE 13

SIDE VIEW
OF CORNER
STRIPPING



CUBIC METER

1 000 000 000, since 1 000 000 000 mm^3 = 1 M^3. Thus, it would actually take more than 1 000 000 000 grains of sand or salt to fill a cubic meter.

2. It also is an excellent model of a kiloliter.

3. Since a liter of water "weighs" a kilogram, then a kiloliter of water "weighs" a Megagram or a metric ton.

Students can begin to appreciate the metric system, since we can relate a unit of length to a unit of volume to a unit of weight. That is, 1 dm^3 = 1 liter which weighs 1 kg if it is water. In the English system there is no correlation between an inch, a quart and a pound.

CHAPTER V

MASS

Mass and weight are two terms that are often confused. Mass refers to a measure of the amount of a substance and is constant regardless where the object is. Weight, on the other hand is a force, and varies according to its location. For example, if we were to purchase some hamburg on a space station, we would pay according to its mass and not its weight. Its weight would be zero, if we were out of the gravitational pull of the planets. Therefore, what most of us mean when we ask, "How much does it weigh?" is "What is its mass?". Consequently, we will give the mass of an object when we are asked to find its "weight". The terms "mass" and "weight" will be interchangeable in everyday usage.

The modernized metric system, called the International System of Units (SI), uses the kilogram as its basic unit of mass. (The Newton is the basic unit of force.) However, it seems more logical to think of the gram as the basic unit of weight, since one can relate the gram to the prefixes kilo, hecto and so on as we did the meter and liter. Another reason for having the students use the gram as the basic unit is that the three most widely used units of weight are the milligram, gram and kilogram.

Pan Balance (Balance Beam) and Metric Masses ("Weights")
($2.00 vs. $20.00 for both)

<u>Materials</u>

1. 2 pieces of pegboard 50 cm x 5 cm

2. Piece of plywood 30 cm x 15 cm
3. Piece of soft pine 30 cm x 4 cm x 2 cm
4. 2 plastic margerine tubs or styrofoam cups
5. String
6. A dowel which will fit the holes in the pegboard snugly.

Construction (9, 12, 19, 21, 22)

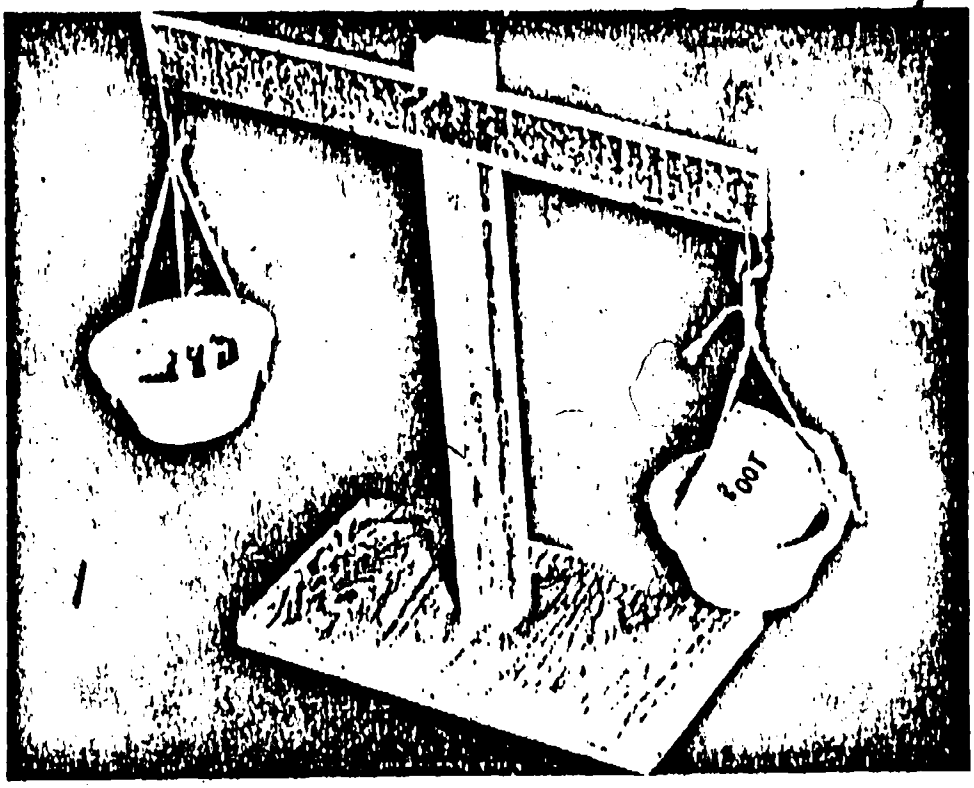
Attach the piece of soft pine to the plywood by nailing it to the bottom. Attach the pegboard to the piece of soft pine so that it easily tips from side to side as in Figure 14. Use a piece of string to tie the margerine tubs to the ends of the pegboards. If it does not balance properly, make adjustments by slipping elastic bands up and down the arms. This pan balance can also be used as a balance beam, merely by changing the pegboard arm for one similar to the arm in the lower half of Figure 14.

Activities (1, 2, 6, 12, 13, 18, 22)

A. 1. Have the students compare many objects to one another to see which is heavier. Some of the objects that they could use are rocks, tennis ball, golf ball, a pen, tin cans, jars, checkers, crayons and so on.

2. They could use something like beans and find out how many beans weigh the same as a pen, a crayon or a rock. Thus, they could use, this non-standard unit of a bean to see which is heavier, this rock or this tin can.

B. 1. Activities in Part A would be appropriate. However, you could extend Activity A1 by picking out 5 objects and asking the students to order them from heaviest to lightest. The authors have found this



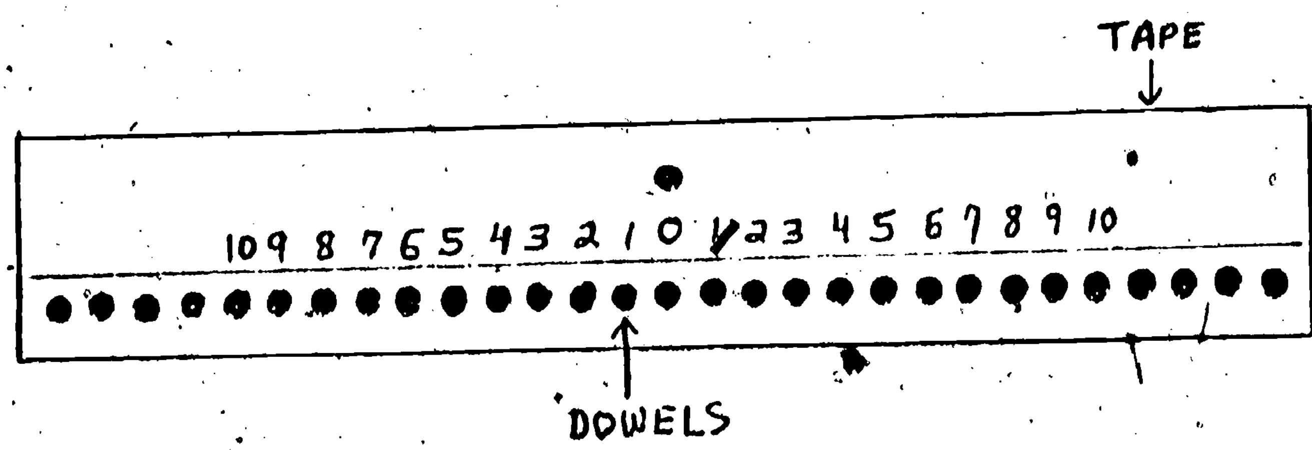


FIGURE 14

to be an extremely difficult task. For example, if you were asked to order by weight a rock, a hockey puck, a lump of clay, a jar and a quantity of sand, you would probably be very surprised with the results. Weight is very deceptive, because most people do not consider how the weight is distributed.

2. Have the students make some gram weights by comparing something like beans, macaroni or pieces of dried wood to some standard masses of 1 g, 5 g, 10 g and so on. One advantage of using wood would be that nails of various weights can be purchased and added to a piece of wood to increase its weight to the appropriate value.

3. Have them find the weights of familiar objects using the weights they constructed. Some interesting objects would be shoes, a wallet or purse, books, and so on.

C & D. 1. Activities in Part B are appropriate. A nice extension of B2 is to have the students compare the weights of objects to quantities of water, since 1 mℓ of cold water weighs 1 g. Thus, if they compensate for the weight of the water container, then they can find a very good approximation for the weight of the object by finding how many milliliters it takes to balance it off.

Bathroom Scales
($0 vs. $11.00)

Materials

1. Used English bathroom scales
2. Piece of heavy paper

Construction

If you have an old English bathroom scale which comes apart easily, then you can easily convert it to a metric scale by simply using the fact that 2.2 pounds equals 1 kg. Simply superimpose the new scale you have made over the old one.

Activities (2, 4, 12, 13, 18)

A. 1. Have the students weigh themselves, record their heights and any other information you may want at the start of the school year. At the end of the year have them find all the measurements again and compare the two.

B & C. 1. Activity A1 would apply. A good extension of this activity would be for the children to record their monthly or bi-monthly weights and make a bar graph illustrating this.

2. Students can find the weights of heavier objects like a chair, 10 math books, or a desk by subtracting their weight from the weight they obtain by holding the chair and standing on the scale.

3. If the students are not sensitive about their weight, you can have them make bar graphs illustrating the distribution of the weights of the class by 5 kg intervals. They could also find the average weight of a student in class. From this, they could compute how many students it would take to make a metric ton.

CHAPTER VI

TEMPERATURE

Temperature measured in degrees Celsius are very easy to remember and understand. Basically, you need to know the following:

1) Water freezes at 0 °C.

2) Normal room temperature is 20 °C.

3) Normal body temperature is 37 °C.

4) Water boils at 100 °C.

Thus, the construction of a cardboard Celsius thermometer as shown in Figure 15 would help students and parents relate Celsius temperatures to everyday situations.

Demonstration Cardboard Celsius Thermometer
(30¢ vs. $4.50)

Materials

1. Strips of cardboard 15 cm x 30 cm
2. String
3. Red paint or marker

Construction (13)

Construct a Celsius scale on the cardboard. If you want the scale to go from 100 °C down to -40 °C, then start the scale 1 cm up from the bottom and end it 1 cm down from the top. Thus, 1 cm will be equivalent to 10 °C and 1 mm will be 1 °C. Puncture a small hole at the top and bottom of the scales. Cut a piece of string about 66 cm and paint

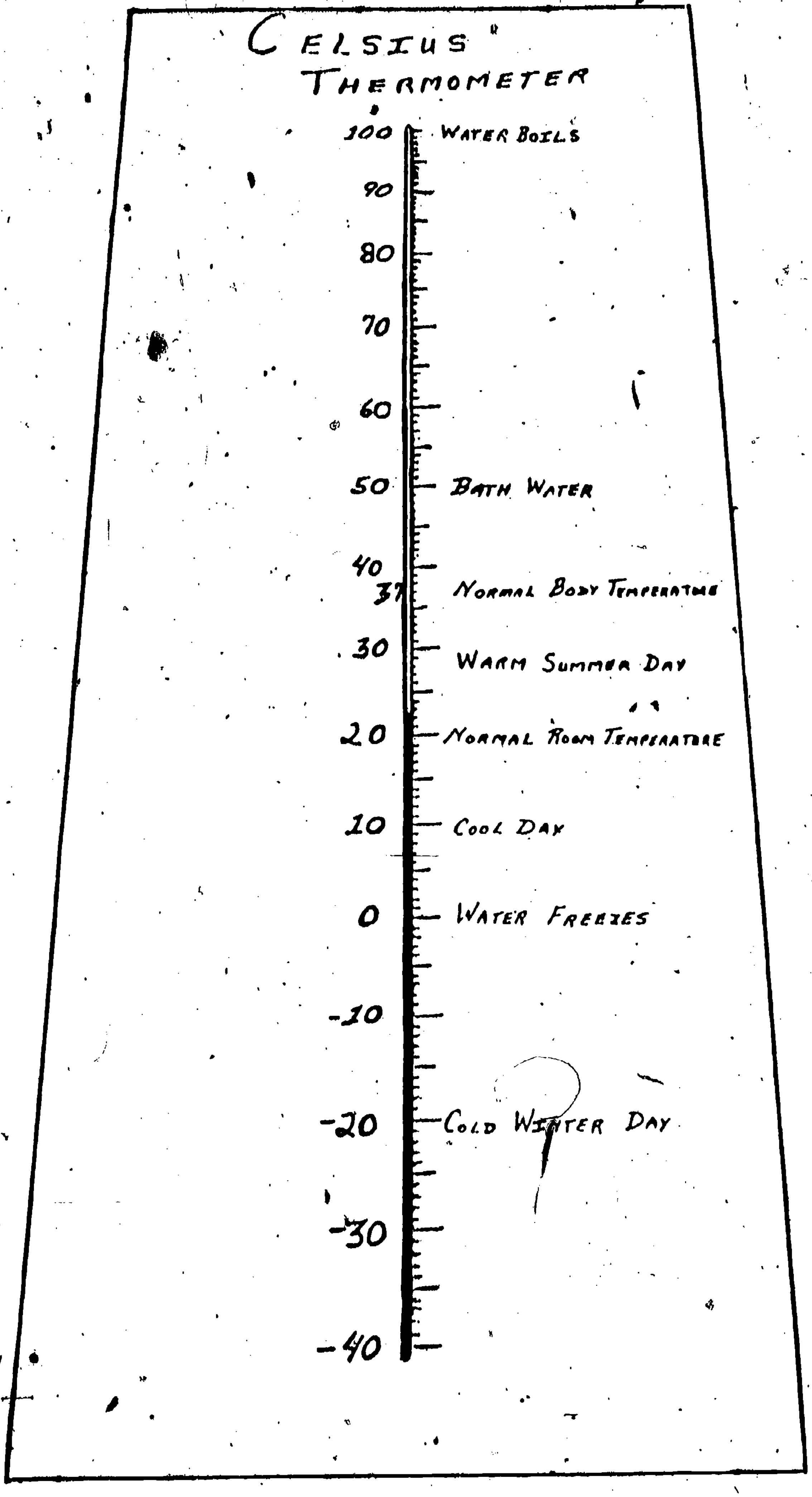

CELSIUS
THERMOMETER
100 WATER BOILS
90
80
70
60
50 BATH WATER
40
37 NORMAL BODY TEMPERATURE
30 WARM SUMMER DAY
20 NORMAL ROOM TEMPERATURE
10 COOL DAY
0 WATER FREEZES
-10
-20 COLD WINTER DAY
-30
-40

FIGURE 15

half of it red. After the paint dries, place it through the hole in the cardboard and tie it on the back side of the cardboard. Your string should now move freely up and down.

Activities (6, 13)

A & B. 1. If each child has constructed one, you could have them draw a picture next to a particular temperature (or cut and paste one out of a magazine) to indicate what that temperature is like. For example, they could draw a picture of a boiling teakettle at 100 °C, a snowflake at 0 °C, or cut out a picture of a nice cozy room with a fireplace and put it at 20 °C.

2. This thermometer can be taken home and the students can explain the Celsius thermometer to their parents.

3. Since the string can be moved, it can be used as one would use flash cards. As you move the string, ask the children to describe the kind of day it is.

Calibrating Celsius Thermometers from Fahrenheit Thermometers (0¢ vs. 40¢)

The cost of a dozen classroom thermometers is less than five dollars. Thus, to the authors it seems impractical to convert existing Fahrenheit thermometers to Celsius thermometers if your purpose is to get some Celsius thermometers. However, if your purpose is for comparison of the pros and cons of the two, then it can be done very easily. If the Fahrenheit thermometer is attached to a piece of wood or cardboard, merely put a piece of tape on one side to list the Celsius temperatures. You could use the following formulas to help you:

$F = \frac{9}{5} C + 32$ or $C = \frac{5}{9} (F - 32)$. Another way would be to mark off 20 °C = 68 °F and 0 °C = 32 °F and calibrate the rest from this information. This would be an excellent activity for junior high and senior high school students. Figure 16 shows the two scales:

Calibrating a Celsius Thermometer from an
Unmarked Thermometer (30¢ vs. 40¢)

Materials

1. An unmarked thermometer
2. Piece of cardboard or thin piece of wood

Construction (1, 21, 26)

Place an unmarked thermometer in freezing water and mark the mercury level with a piece of tape. Do the same thing with boiling water. Attach your thermometer to a piece of cardboard and mark the level of the mercury when the water was freezing 0 °C and where it was at boiling 100 °C. Subdivide the interval into 10 equal lengths and then each of those intervals into 10 equal lengths. (This construction process is recommended only for junior high and senior high students.)

Activities (1, 12, 13, 26)

A. 1. Draw a large cardboard poster with the days of the month listed across the bottom. Draw a thermometer with a Celsius scale above each day. Have a student read the thermometer at some specified time each day and color the level of the mercury in for each day. If you put the weekend and holidays on the poster, the students may find this motivating enough to try to find the temperatures for those days so that they can put them on the poster. This should help their parents become aware of the Celsius readings.

B. 1. Activity A1 would apply. Some nice extensions of this could be making a bar graph of the temperatures or finding the average

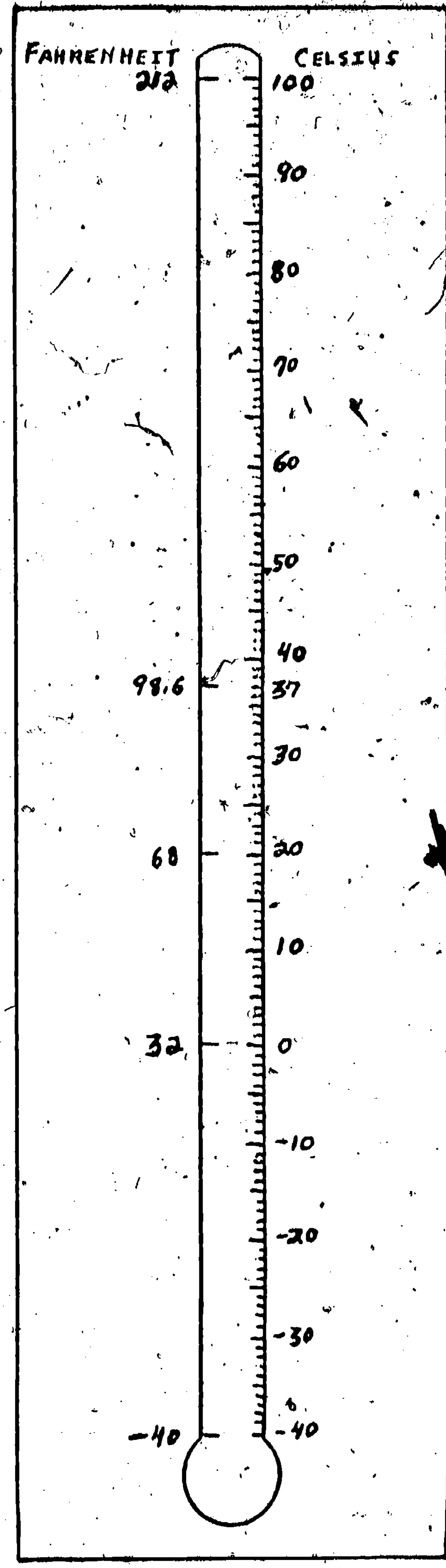

FAHRENHEIT
CELSIUS
212
100
90
80
70
60
50
40
98.6
37
30
68
20
10
32
0
-10
-20
-30
-40
-40

FIGURE 16

weekly or monthly temperature (for that specific time of day).

2. Place some containers of water of various temperatures on a table and have the students estimate their temperature. Have them estimate by using their fingers and some other part of their body like an elbow or inside of an arm. Do they think it feels the same or is one area more sensitive to temperatures than another?

3. Have students measure the freezing point of a liter of plain water, a liter of water with 50 g of dissolved salt, a liter with 100 g dissolved salt. Is there any difference?

C & D. 1. The construction process as described above.

2. The activities in Part B would apply.

CHAPTER VII

GAMES AND AIDS

Metric Flash Cards
(50¢ vs. $6.25)

Suggested Levels

B & C

Usage

These are to be used by one student, small groups, or a whole class to review concepts previously taught in class.

Materials

1. Piece of poster paper
2. Felt tip marker
3. Scissors

Construction (2, 12, 13)

Cut a piece of poster paper into rectangles 15 cm by 10 cm. Devise some short answer questions like the ones described below and put the answer on back.

(1) Cards to practice intra-metric conversions for length, area or weight could be developed. (i.e., 5m = ___ cm)

(2) Another set of cards could be developed to stress intrametric comparisons. (i.e., put >, < or = in the following: 3 dg ______ 30 g)

(3) Temperature cards could be made where the student des-

cribes the kind of day it is if the temperature is ___ °C.

(4) Many other ideas could be reinforced such as estimate the weight (or length) of a set of objects.

Follow the Metric Road
(75¢)

Suggested Levels

B and C

Usage

This game is designed for small groups (2-6) to review previously taught concepts.

Materials

1. Piece of poster paper
2. Felt tip pen
3. Spinner or die
4. 50 cards 8 cm by 4 cm made from poster paper
5. 2-6 markers

Construction

Design a curved pathway on a piece of poster paper or cardboard. Make the pathway about 3 cm wide with 50 steps each about 3 cm long. Also make up a set of at least 50 short answer questions on the metric system to be put on the 50 cards 8 cm by 4 cm. The answers to each question should be put in the lower right hand corner. The questions could vary to correspond to the level and content a teacher wishes to stress.

Directions

Spin (or roll the die) to see who goes first. The student with the highest number goes first; the person to his left is second and so on. Now if player A goes first, the player to his left draws a card from the deck and reads the question. If player A answers correctly, then he spins (rolls the die) to see how many steps he can take. He has the option of taking that many steps or none at all. For example, assume player A's question was "16 dm = _____ m?", and he answers 1.6 m. Now assume player A spins a 4. He moves those 4 spaces, and player B takes his turn.

Further, assume that during the course of the game, player A is on space 18, answers his question correctly, and spins a 3. Therefore, if he takes his 3 steps he will land on space 21, which has him move back 4 spaces to space 17. Thus, he may elect not to move at all. If player A answers the question incorrectly, player B takes his turn and the game continues. In order to win, you must land in space 50 exactly. Variations to the rules can be added. For example, you could impose a penalty for failure to answer a question, by having the person move back to the first blank space behind him.

Figure 17 is a sample game board which emphasizes some of the important historical aspects of the metric system.

Metric Concentration

Suggested Levels

A, B and C

Usage

This game is to be played by 2 players or 2 teams of 2 players.

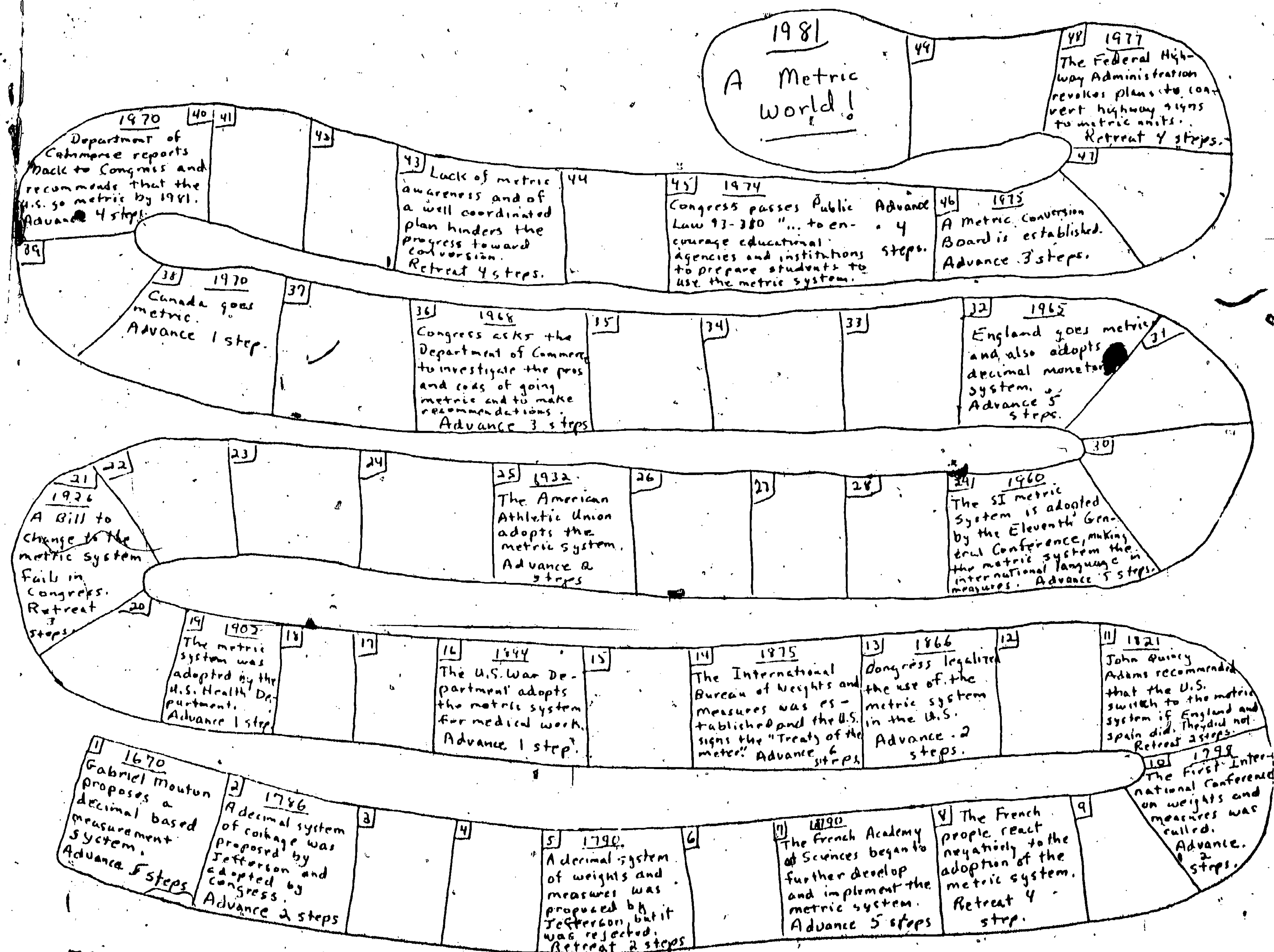

1 1670 Gabriel Mouton proposes a decimal based measurement system. Advance 5 steps
2 1786 A decimal system of coinage was proposed by Jefferson and adopted by Congress. Advance 2 steps
3
4
5 1790 A decimal system of weights and measures was proposed by Jefferson, but it was rejected. Retreat 2 steps
6
7 1790 The French Academy of Sciences began to further develop and implement the metric system. Advance 5 steps
8 The French people react negatively to the adoption of the metric system. Retreat 4 step.
9
10 1798 The First International Conference on weights and measures was called. Advance 2 steps.
11 1821 John Quincy Adams recommended that the U.S. switch to the metric system if England and Spain did. They did not. Retreat 2 steps.
12
13 1866 Congress legalized the use of the metric system in the U.S. Advance 2 steps.
14 1875 The International Bureau of Weights and Measures was established and the U.S. signs the "Treaty of the meter." Advance 6 steps
15
16 1894 The U.S. War Department adopts the metric system for medical work. Advance 1 step.
17
18
19 1902 The metric system was adopted by the U.S. Health Department. Advance 1 step
20
21 1926 A Bill to change to the metric system fails in Congress. Retreat 3 steps.
22
23
24
25 1932 The American Athletic Union adopts the metric system. Advance 2 steps
26
27
28
29 1960 The SI metric system is adopted by the Eleventh General Conference, making the metric system the international language in measures. Advance 5 steps.
30
31
32 1965 England goes metric and also adopts decimal monetary system. Advance 5 steps.
33
34
35
36 1968 Congress asks the Department of Commerce to investigate the pros and cons of going metric and to make recommendations. Advance 3 steps
37
38 1970 Canada goes metric. Advance 1 step.
39
40 1970 Department of Commerce reports back to Congress and recommends that the U.S. go metric by 1981. Advance 4 steps.
41
42
43 Lack of metric awareness and of a well coordinated plan hinders the progress toward conversion. Retreat 4 steps.
44
45 1974 Congress passes Public Law 93-380 "... to encourage educational agencies and institutions to prepare students to use the metric system. Advance 4 steps.
46 1975 A Metric Conversion Board is established. Advance 3 steps.
47
48 1977 The Federal Highway Administration revokes plans to convert highway signs to metric units. Retreat 4 steps.
49
1981 A Metric World!

Figure 17

Materials

1. 20 or more cards 8 cm by 4 cm
2. Felt tip marker

Construction

Cut up 20 or more 8 cm by 4 cm cards. Write 2 equivalent metric measures in different ways on different cards. For example, one card might have 200 dm and the other might have 20 cm. You can make them as difficult as you choose, depending on the level of student using them.

Directions

Mix the 20 cards up and place them face down between the 2 players. Flip a coin to see which player goes first. The first player flips any 2 cards in the set, and if they match he keeps them. If they do not match, the cards are turned upside down and player B flips any 2 he chooses. The game continues in a similar fashion until all the cards are gone and the winner is the one with the most cards.

"A Friend" Puzzle

Suggested Levels

A and B

Materials

1. A copy for each student of Figures 18 and 19
2. Crayons and pencil

The following is a puzzle that was made up by Mrs. Marjorie Bruner of RFD No. 7, Penacook, New Hampshire 03301. This particular version stresses conversions between cm and mm. With just a few simple adaptations, it could be used to stress many other concepts. Figures 20 and 21 show the answers to the puzzle in Figures 18 and 19.

Figure 18

A Friend

by

Marjorie Bruner
R.F.D. 7 (Canterbury)
Penacook, N.H. 03301

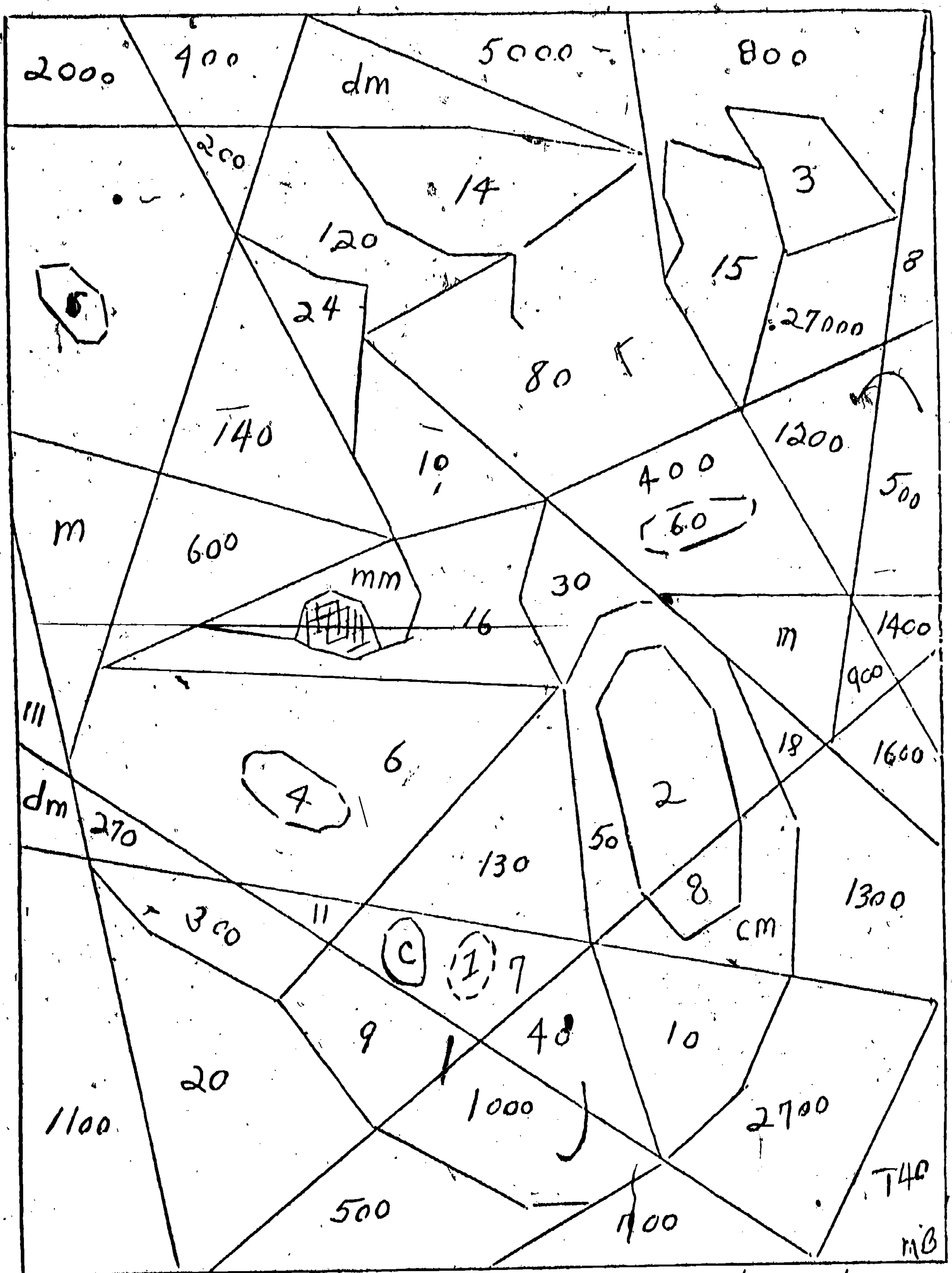
1. Fill in the blank spaces with your answers.

5 cm = ________ mm	________ cm = 150 mm
70 mm = ________ cm	30 mm = ________ cm
________ cm = 140 mm	________ mm = 1 cm
12 cm = ________ mm	________ cm = 110 mm
________ mm = 4 cm	30 cm = ________ mm
________ mm = 3 cm	60 mm = ________ cm
20 mm = 2 ________	________ mm = 27 cm
________ cm = 90 mm	100 mm = ________ cm
160 mm = ________ cm	20 cm = ________ mm
________ mm = 13 cm	100 cm = ________ mm
10 mm = ________ cm	40 mm = ________ cm

II. Shade in each area on the next sheet which contains one of your answers.

III. Who is he?

"A FRIEND"



I am hidden in the maze of geometric shapes. Clues to identify me may be found on the next page.

Figure 20

A Friend

by

Marjorie Bruner
R. F.D. 7 (Canterbury)
Penacook, N.H. 03301

1. Fill in the blank spaces with your answers.

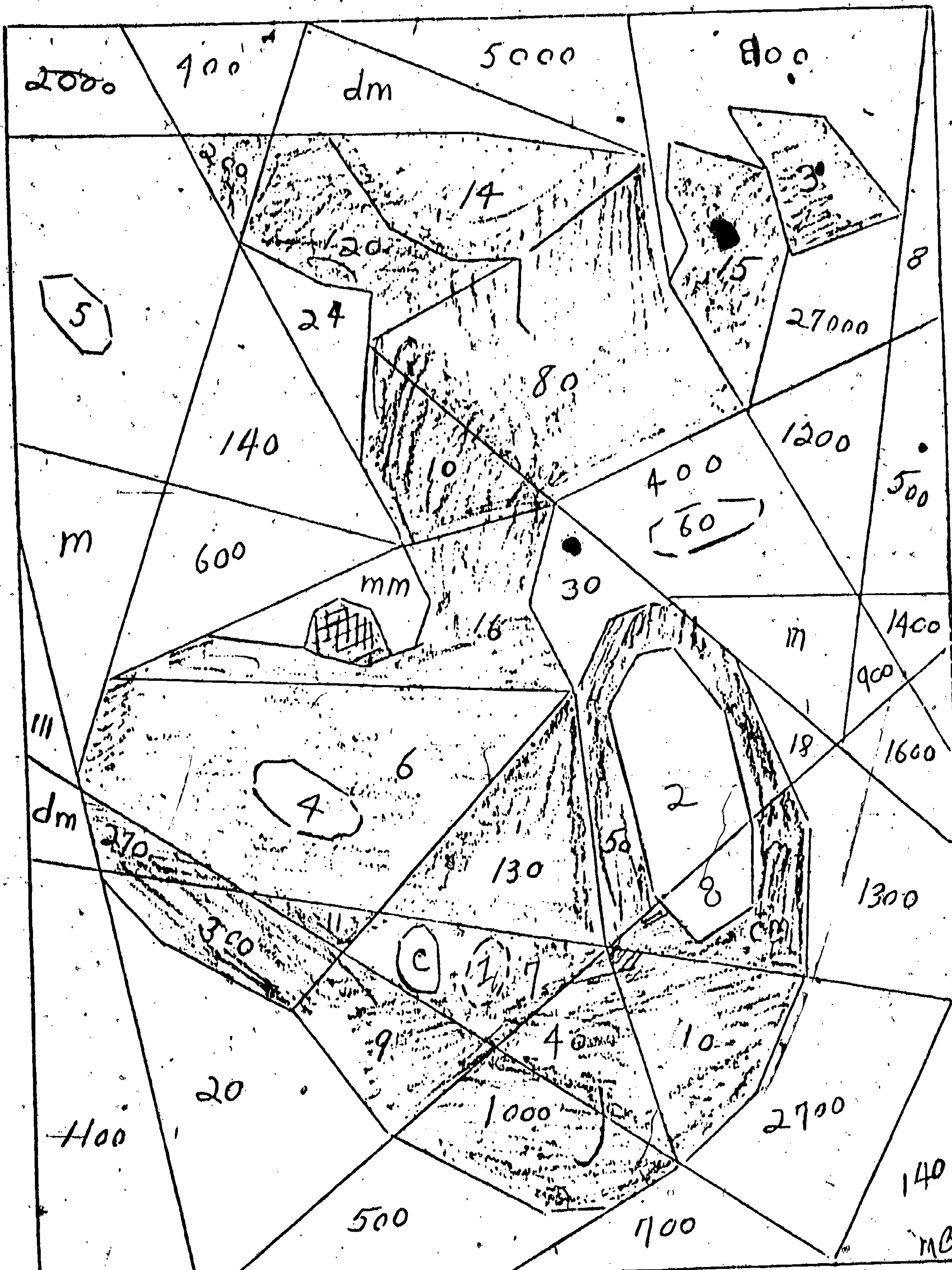
5 cm = 50 mm	15 cm = 150 mm
70 mm = 7 cm	30 mm = 3 cm
14 cm = 140 mm	10 mm = 1 cm
12 cm = 120 mm	11 cm = 110 mm
40 mm = 4 cm	30 cm = 300 mm
80 mm = 3 cm	60 mm = 6 cm
20 mm = 2 cm	270 mm = 27 cm
9 cm = 90 mm	100 mm = 10 cm
160 mm = 16 cm	20 cm = 200 mm
130 mm = 13 cm	100 cm = 1000 mm
10 mm = 1 cm	40 mm = 4 cm

II. Shade in each area on the next sheet which contains one of your answers.

III. Who is he? Snoopy

A FRIEND

Figure 21



I am hidden in the maze of geometric shapes. Clues to identify me may be found on the next page.

Metric Crossword Puzzle

Suggested Levels

D

Materials

1. Copy of the puzzle for each student (See Figure 22)
2. Pencil

A Metric Brain Teaser

Suggested Levels

B, C and D

Materials

1. A copy of the brain teaser below for each student
2. Pencil

A Metric Brain Teaser

Write down the year of your birth.	______
To this number add the number of milliliters in a liter.	+ ______
From this result, subtract the number of centimeters in a meter.	- ______
Now, to this number add your age on your birthday this year.	+ ______
From this answer subtract the number of grams in a kilogram.	- ______
To this result add the boiling temperature of water on the Celsius scale.	+ ______
Is your answer on time? Do you understand why this works?	______

Figure 22

METRIC CROSSWORD PUZZLE

Across

* 1. basic unit of length

* 6. weight changes according to location but ______ does not

8. elementary (abbrev.)

9. a direction (abbrev.)

*10. used to measure liquid capacity

12. not direct current (abbrev.)

*13. metric unit for force

*16. $\approx$ 1 000 cm^3

*18. angle measure (abbrev.)

*20. prefix for 1 000 000

22. education (abbrev.)

*23. country which developed the Metric System

*24. scale for measuring temperature

*25. centimeter (abbrev.)

* These questions are metric system oriented.

Down

1. not you, but ______

2. electricity (abbrev.)

* 3. the number conversions are based on in the metric system

4. to free from faults or errors

* 5. prefix for 1 000

6. Massachusetts Institute of Technology (abbrev.)

7. distress signal (abbrev.)

11. not out, but ______

*12. unit for measuring electric current

14. season of the year

*15. prefix for 10

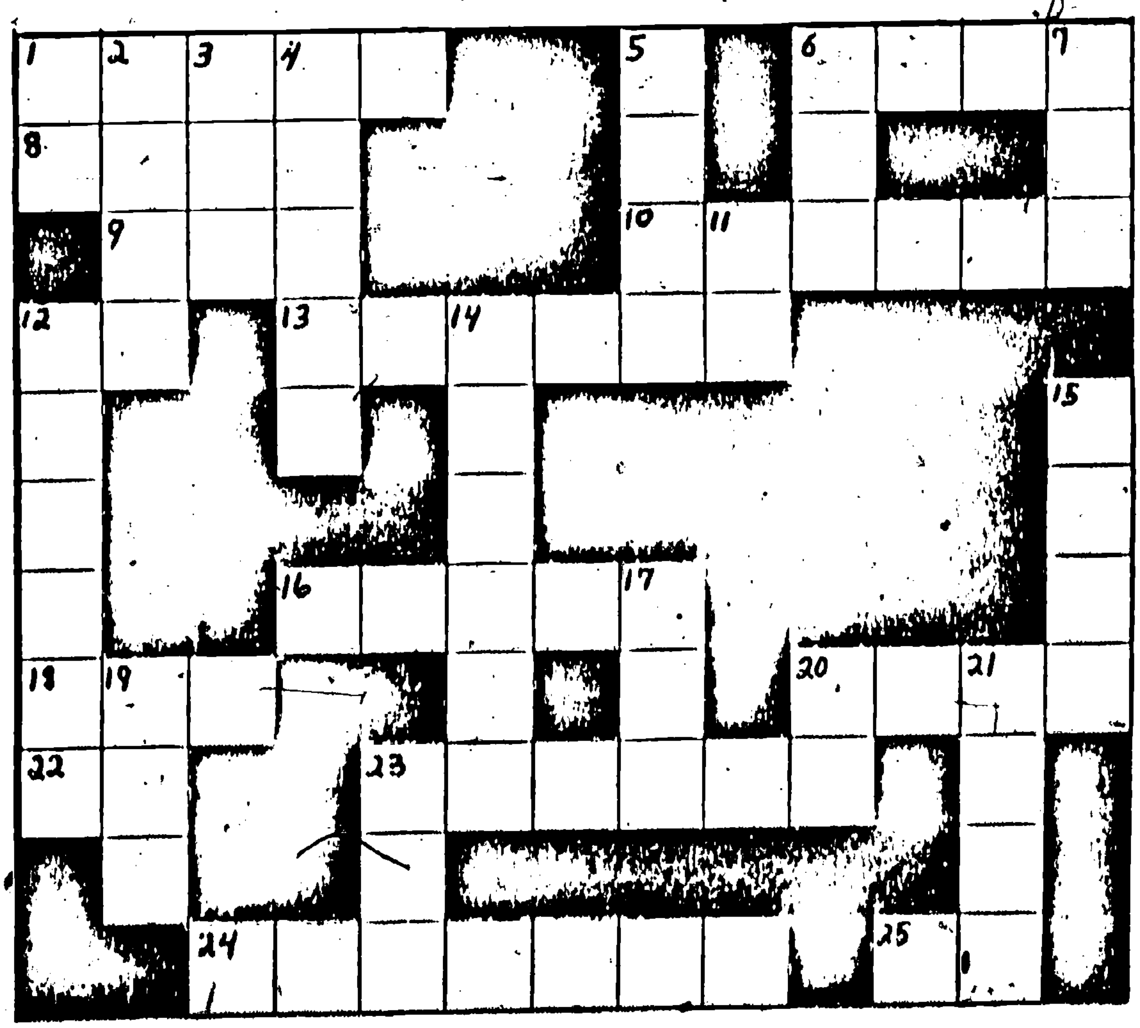
17. past tense of run

19. five ______ six equals eleven

20. Maine (abbrev.)

*21. a unit of mass (weight)

23. French Foreign Legion (abbrev.)



Intra-Metric Conversion Chart

Suggested Levels

B, C and D

Usage

The chart is designed to help those students having problems doing intra-metric conversions.

Materials

1. The Intra-Metric Conversion Chart in Figure 23

Directions

The Singular Conversion section is to be used if the students are doing conversions primarily involving length (meters), fluid capacity (liters), and weight (grams). For example, assume a student has the problem of changing 4.3 kg to grams. Here the gram is used as the base unit and not the kg. Thus, start at the "k__" space and count 3 places to the right to get to the gram spot. Therefore, in the problem move the decimal point 3 places to the right also, since every movement to the right is equivalent to multiplying by 10. Similarly, if you had 23 cm and wanted to change it to dm, move one place to the left. This is equivalent to dividing by 10. Thus, 23 cm = 2.3 dm.

The Two Dimensional section is designed to remind students that every step to the right is equivalent to multiplying by 100 and to the left is equivalent to dividing by 100. That is why 2 boxes appear over each abbreviation reminding the student to multiply and divide by 100. For example, assume you want to change 34.2 m^2 to mm^2. You move 3 places to the right, but each move is moving the decimal point 2 places. Thus,

INTRA-METRIC CONVERSION CHART

SINGULAR CONVERSIONS
METER, LITER, GRAM, ETC.

k___	h___	da___	___	d___	c___	m___
			Base Unit			

TWO DIMENSIONAL CONVERSIONS
AREA

km^2	hm^2	dam^2	m^2	dm^2	cm^2	mm^2

THREE DIMENSIONAL CONVERSIONS
VOLUME (DRY MEASURE)

km^3	hm^3	dam^3	m^3	dm^3	cm^3	mm^3

Figure 23

you move the decimal point 6 places and 34.2 m^2 = 34 200 000 mm^2.

The Three Dimensional section was designed with 3 boxes above each abbreviation to remind the students that each move is equivalent to multiplying or dividing by 1 000.

A Metric Certificate

Suggested Levels

A, B, C and D

Materials

1. Copy of a metric certificate for each student. (Figure 24)

A Metric Certificate is a good way to end a unit on the metric system. You could have the students go on a metric treasure hunt and have the treasure be a certificate and an apple. You could give out certificates similar to the one that follows, if you organized a metric field day. Here the certificate would be for winning or just participating in various events.

METRIC CERTIFICATE

THIS IS TO CERTIFY THAT

____

has completed successfully, the course entitled Measurement and the Metric System. This means that the above can hold any position which calls for a metrified (not to be confused with petrified) person.

ATTESTED TO BY:

Milli Meter

Hector Grahm ________ on ____________

Desi Liter

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