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ABSTRACT

These activity cards, developed by the Unified Science and Mathematics for Elementary Schools (USMES) Project, are divided into 18 groups. The first group of cards are Design Lab Tech Cards; the remaining groups are "How To" Cards. They include: (1) How To Construct a Sampling Histogram; (2) How To Make a Bar Graph Tally; (3) How To Make Scale Drawings and Models; (4) How To Make Triangle Drawings to Compare Fractions (or Ratios); (5) How To Find the Median of a Set of Data; (6) How To Draw Electrical Things and Electrical Circuits Quickly; (7) How To Draw Equilateral Triangles, Squares, and Regular Pentagons Using Dot Pattern Sheets; (8) How To Construct an Equilateral Triangle; (9) How To Construct a Square; (10) How To Measure Angles; (11) How To Find the Height of a Building or a Tree; (12) How To Measure Large Distances; (13) How To Use a Stopwatch; (14) How To Find the Quartile Range of a Set of Data; (15) How To Find the Average of a Set of Data; (16) How To Connect Several Things to One Source of Electricity; and (17) How To Record Data by Tallying. (MK)

Unified Science and Mathematics for Elementary Schools

DESIGN LAB TECH CARDS

CARD 1 How To Hammer Nails in Straight
CARD 2 How To Nail Two Pieces of Wood Together So They Stay Together
CARD 3 How To Put Screws in Hard-To-Get-At-Holes
CARD 4 How To Make Square Cuts With a Handsaw
CARD 5 How To Use a Hacksaw to Cut Slots in Tri-Wall
CARD 6 How To Use Hacksaw Blades To Cut Slots in Tri-Wall
CARD 7 How To Drill a Hole Straight Through a Piece of Material
CARD 8 How To Straighten Bare Wire
CARD 9 How To Put Screws into Hard Wood
CARD 10 How To Find the Right Size Drill Bit to Make Pilot Holes for Screws
CARD 11 How To Put Two Pieces of Wood or Metal Together with Bolts and Nuts
CARD 12 How To Put Two Pieces of Wood or Sheet Metal Together with Screws
CARD 13 How To Use an Electric Drill with a Screwdriver Bit
CARD 14 How To Make Varnished Wire Ready for Soldering
CARD 15 How to Solder Wires
CARD 16 How to Use "C" Clamps
CARD 17 More About "C" Clamps
CARD 18 More About "C" Clamps
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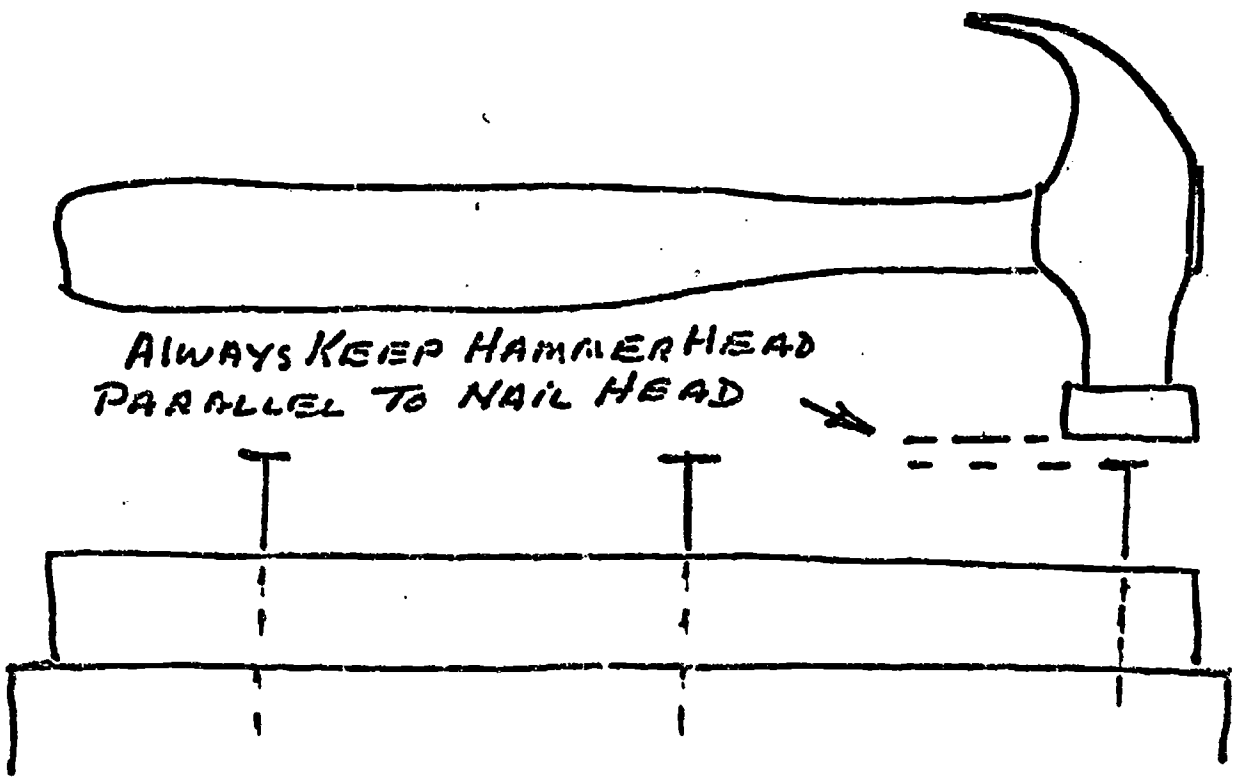
CARD 20 More About "C" Clamps
CARD 21 How To Cut Glass
CARD 22 How To Make Sheet Glass and Mirrors Safe to Use in Experiments
CARD 23 How To Cut Sheet Rock
CARD 24 How To Find the Length of a Single Layer Coil of Wire
CARD 25 How To Find the Length of a Coil of Wire With Many Layers

How To Hammer Nails In Straight

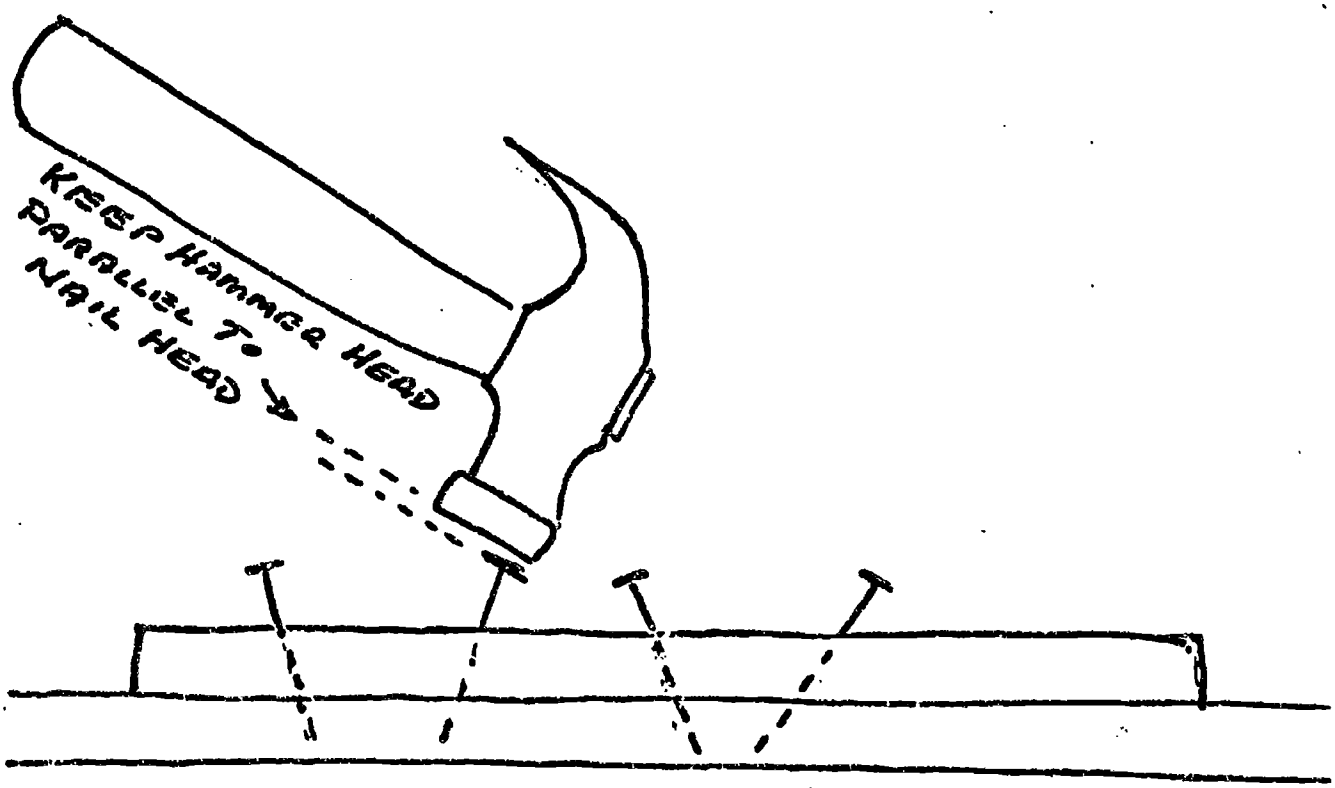
A nail will go in straight if you hit it flat on the head. Keep the head of the hammer parallel to the head of the nail, even when hammering nails in at an angle. Look at the picture.



How To Nail Two Pieces of Wood Together So They Stay Together

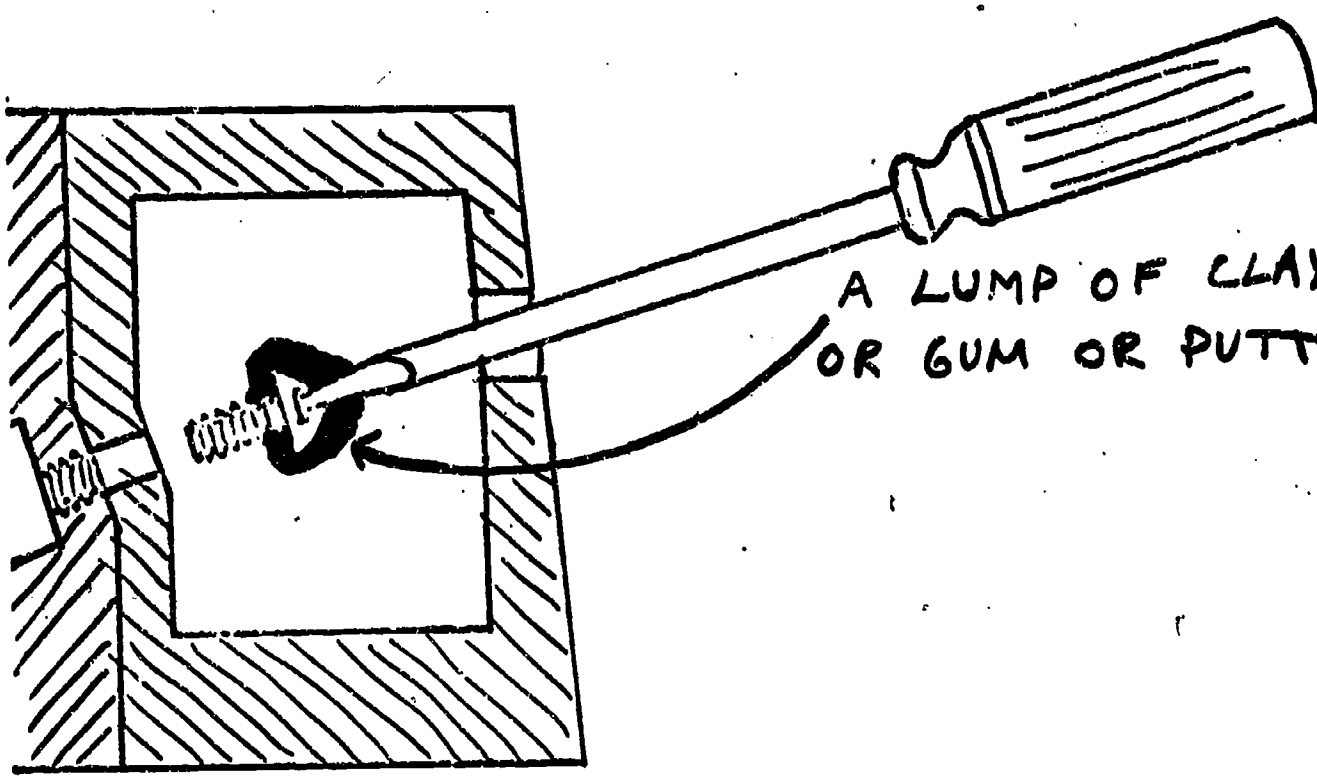
Two pieces of wood will not pull apart if you hammer the nails in at a slant instead of straight up and down. Hammer one nail in one way and the next nail in the other way. Have some nails slant one way and some nails slant the other way.

Remember to hit each nail flat on the head. Look at the picture.



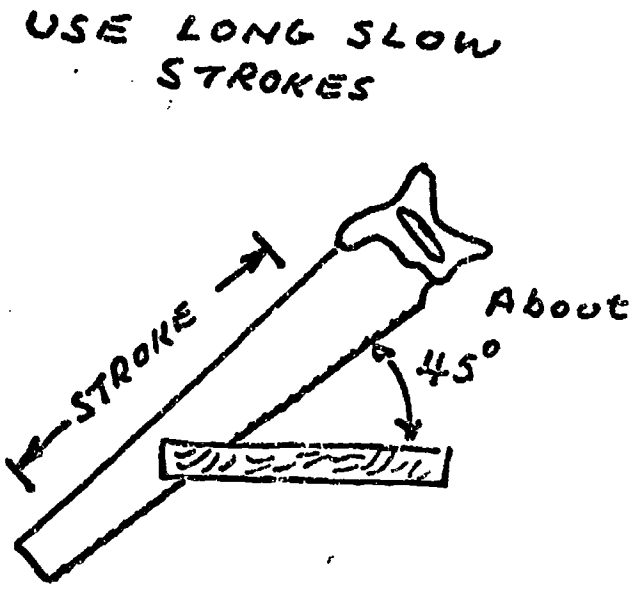
How To Put Screws in Hard-To-Get-At Holes

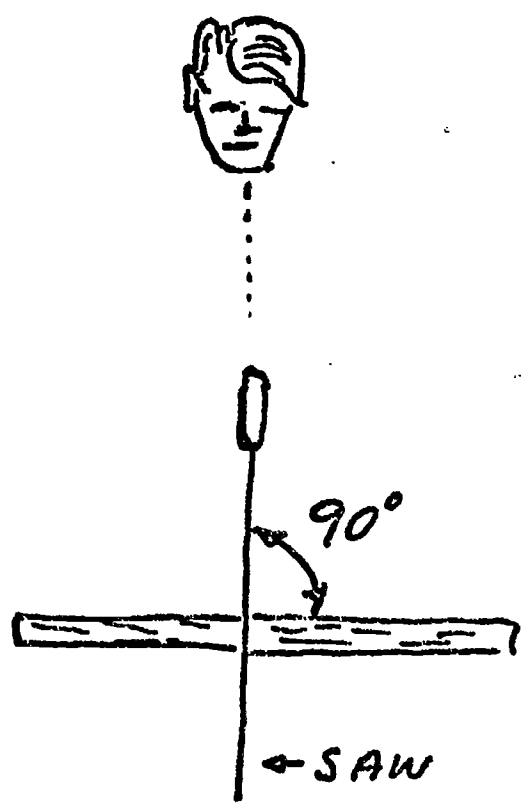
Put some clay or putty or gum on the head of the screw and stick the end of the screwdriver in it. The screwdriver will not slip off the screw. Or use a capture-head screwdriver which holds the screw just below the head. Look at the pictures.



How To Make Square Cuts with a Handsaw

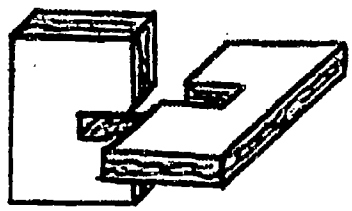
Draw straight lines to show where you want to cut. Hold the saw so it makes a 45° angle with your piece of wood. Use long, slow strokes and cut on the straight line you have drawn. Keep your eye on the line and on the back side of the saw. Never let the saw go right or left of the line. The side of the saw will stay at a 90° angle to your material as you cut. Just before you cut all the way through, be sure to have something under the piece of wood you are cutting off. This keeps the wood from being splintered. It also keeps the saw from being bent. Look at the pictures.



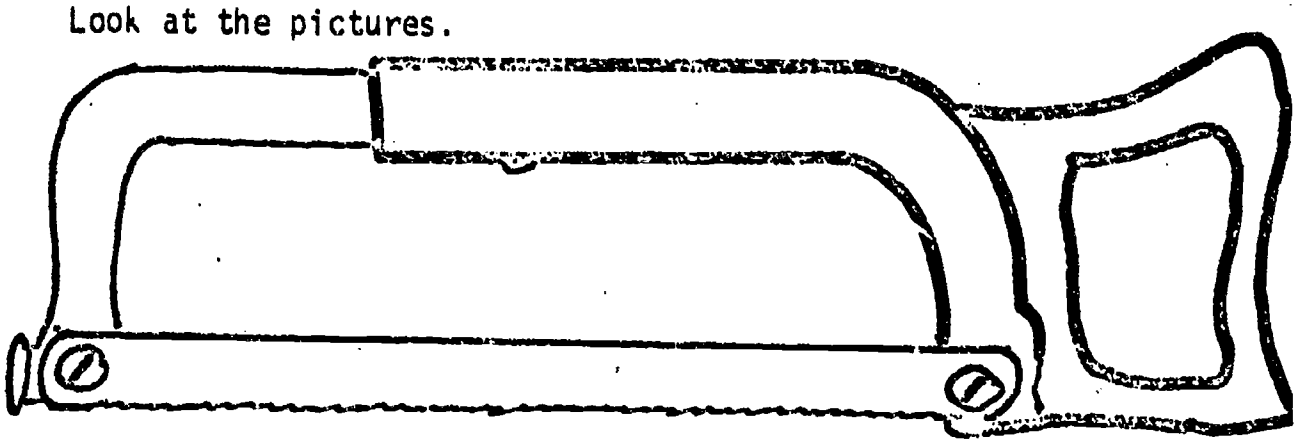


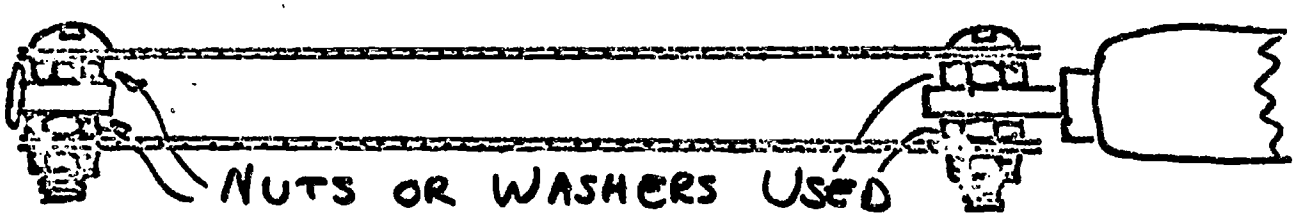
How To Use a Hacksaw to Cut Slots in Tri-Wall

One way to put two pieces of tri-wall together is to use slots. Each slot should be the same width as a piece of tri-wall. The tri-wall will then fit tightly into the slot. Look at the picture below.



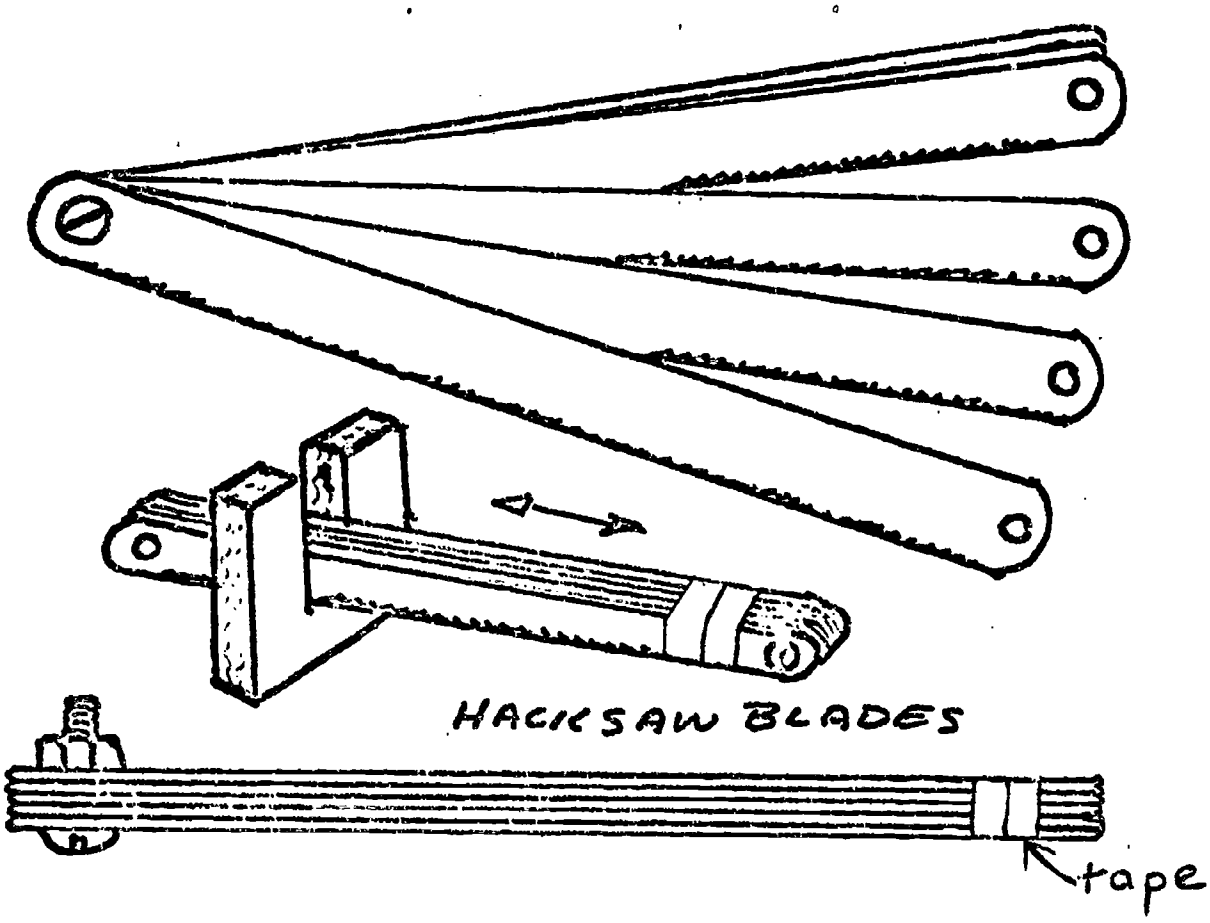
To make a hacksaw that cuts slots, use a file to take off the pins which hold the saw blade in the hacksaw frame. Then drill clearance holes for an 8-32 bolt where the pins were. Put two hacksaw blades on the bolt using washers or 8-32 nuts as spacers in between the blades. Keep putting washers or nuts in between the blades until the saw is as wide as a piece of tri-wall. Look at the pictures.





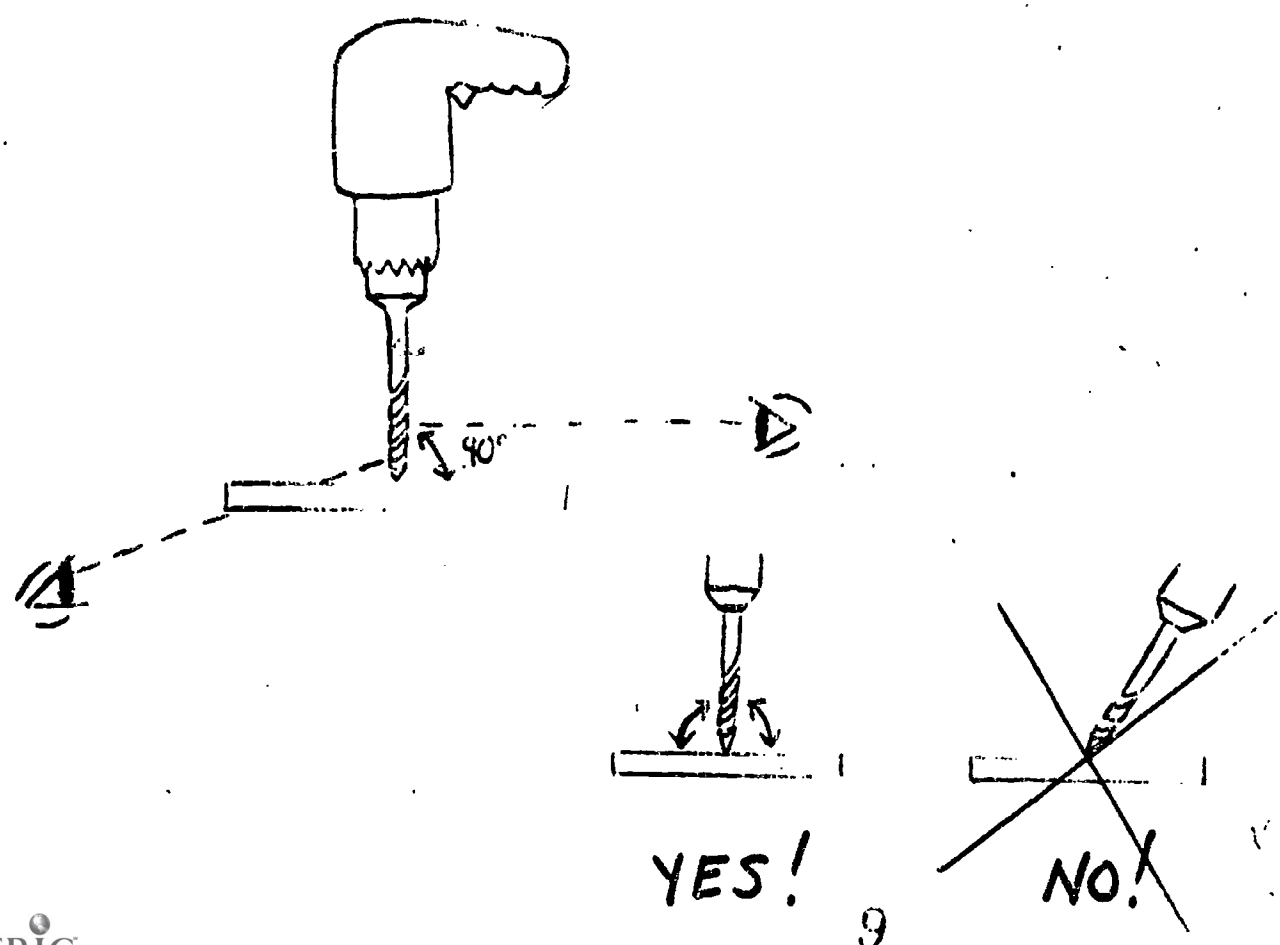
How To Use Hacksaw Blades To Cut Slots in Tri-Wall

If you do not have a slotting saw like the one described on Card 5, you can use several hacksaw blades together to cut slots. Figure out how many blades you need to make a slot the same width as a piece of tri-wall. Put the blades together at one end with a bolt and nut. Put tape around the other end so you have something to hold on to. Look at the pictures.



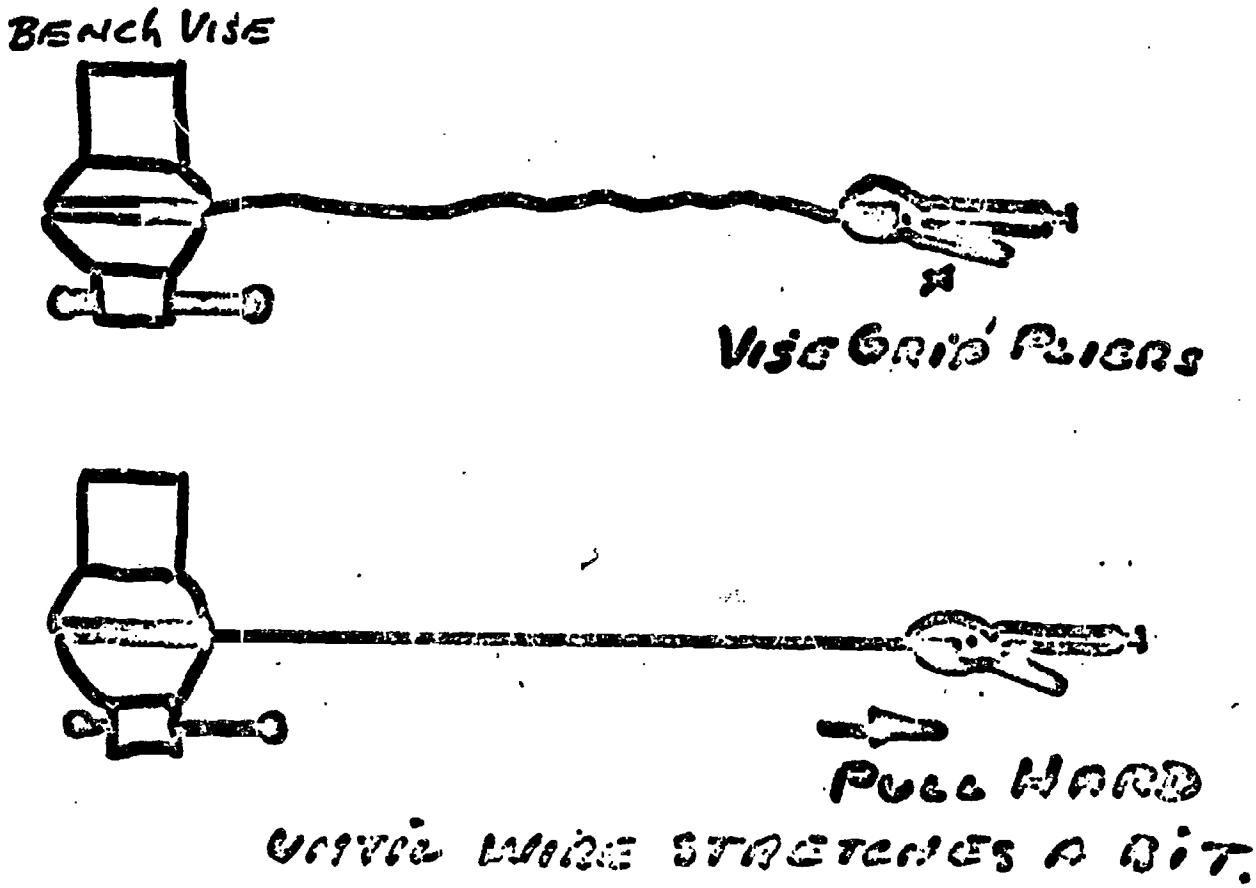
How To Drill a Hole Straight Through a Piece of Material

Put a dot where the hole should be. Start the drill and make a little hole. Then look at the drill bit from one place to see that it goes straight into the material being drilled at a 90° angle. Keep the drill steady and look at the drill bit from another place to see that it goes straight into the material from there, too. Keep looking at the drill bit from different places while you are drilling until the hole is fairly deep. After that, the drill bit will keep going in straight by itself. Look at the pictures.



How To Straighten Bare Wire

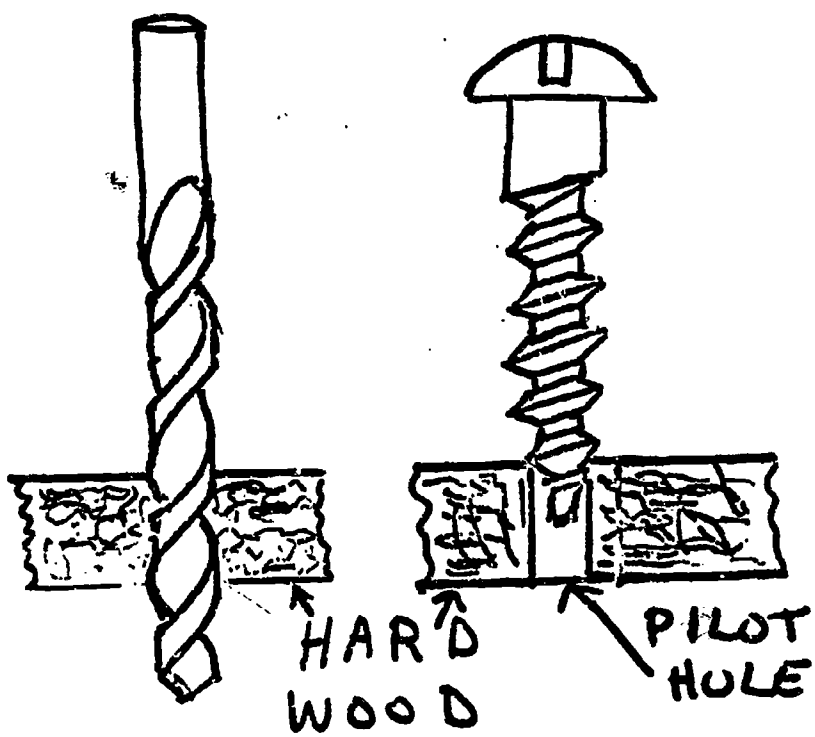
To make a piece of crooked or bent wire straight, put one end of the wire in a vise. Or, you can tie it to a doorknob, pipe, or anything that won't move easily. Then take the other end of the wire and put it into vise-grip pliers. Hold on to the pliers and pull hard until you feel the wire stretch a little. Instead of using vise-grip pliers, you can tie the end of the wire around a stick, and pull. Look at the pictures.



How To Put Screws into Hard Wood

If you put screws right into hard wood the wood may split or you may break off the screw. You should first drill holes at the spots where you want to put the screws. These holes are called "pilot holes". Read Card 10 to find the right size drill bit to use for pilot holes.

As a screw is screwed into the pilot hole, it makes grooves (or threads) in the wood. Look at the pictures.



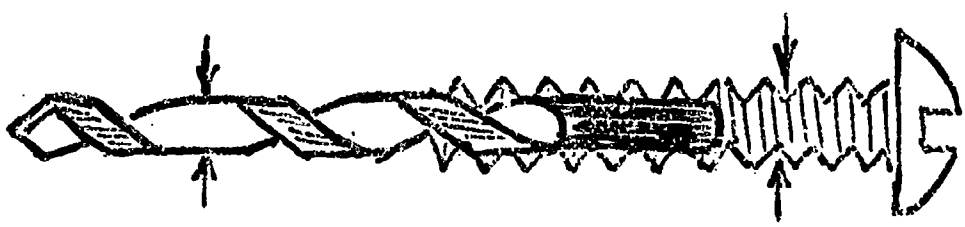
Special screws called "self-tapping screws" will make their own threads in sheet metal. You still need to drill pilot holes first.

How To Find The Right Size Drill Bit To Make Pilot Holes for Screws

Pilot holes are drilled into hard wood to keep it from splitting when screws are put in the wood. They are also drilled in sheet metal before self-tapping screws are used. See Card 9.

You can use your eye to find the right size drill bit for most pilot holes. Look at the screw you will use. Find the smallest width. This is called the "root diameter". Find a drill bit that is about the same size as the root diameter of the screw.

Hold the drill bit and the screw together to make sure the drill bit is about the right size. Look at the picture.

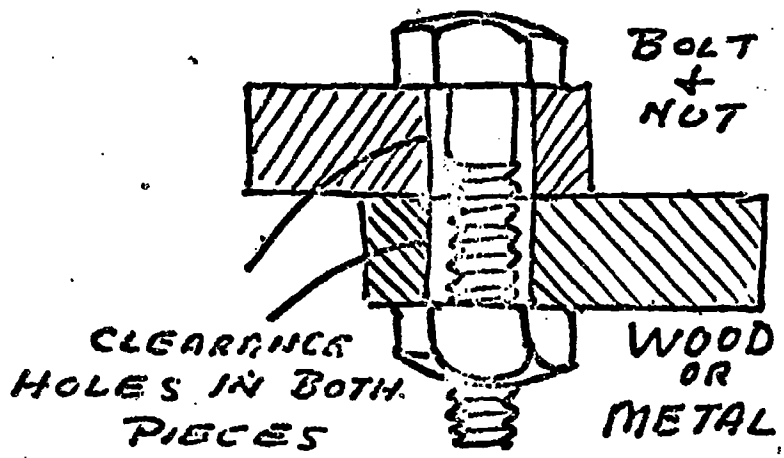


DRILL DIAMETER = SMALLEST ROOT DIAMETER OF SCREW

(OR A LITTLE LARGER)

How To Put Two Pieces of Wood or Metal Together with Bolts and Nuts

One way to put two pieces of wood together is to use a bolt and a nut. Drill holes in both pieces of wood or metal so the bolt can go through each hole easily. These holes are called "clearance holes". Put the bolt through the holes and then screw the nut onto the bolt. Look at the picture below.



You can hold the drill bit and bolt together to find the right size drill bit to use. The drill bit diameter should be larger than the bolt diameter and smaller than the diameter of the head of the bolt. Look at the picture.

DRILL DIAMETER — LARGER THAN BOLT DIAMETER AND SMALLER THAN HEAD DIAMETER

How To Put Two Pieces of Wood or Sheet Metal Together with Screws

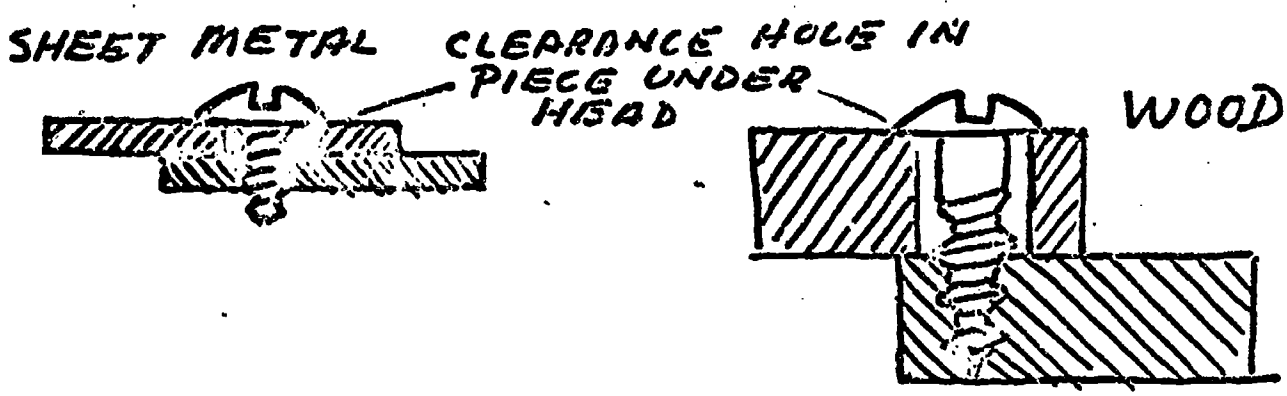
You can use screws to put two pieces of wood or sheet metal together. Screws are used if you can't reach around to put nuts on bolts. Or, you may not want nuts to show.

Drill a clearance hole in the top piece of wood or metal. Read Card 11 to find out about clearance holes.

Drill a pilot hole in the bottom piece of wood if the wood is hard. Read Card 9 to find out about pilot holes.

If you are using sheet metal, drill a pilot hole in the bottom piece of metal. Use self-tapping screws for sheet metal.

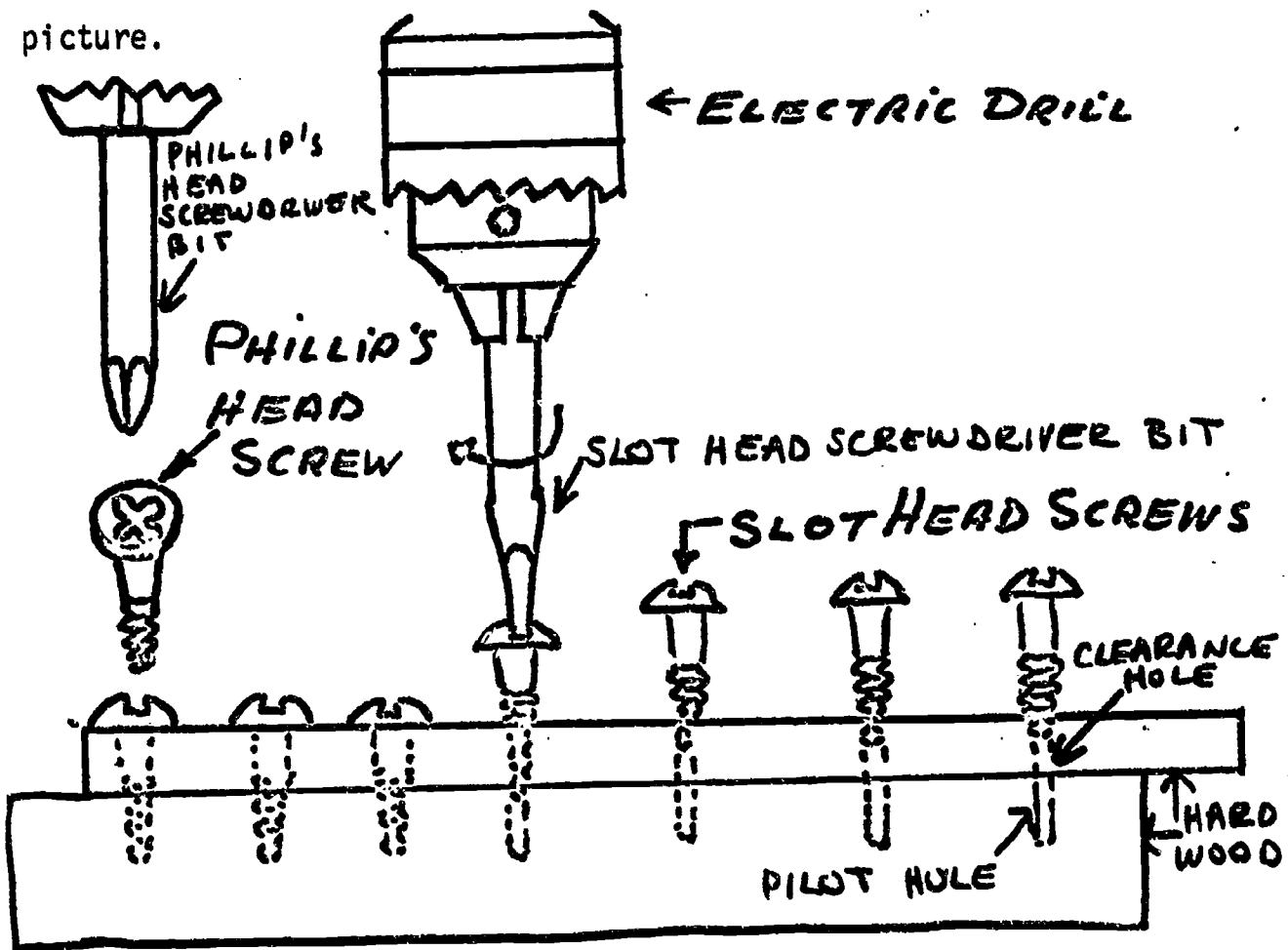
Look at the pictures.



Read Card 10 to find out how to choose the right size drill bit to use for pilot holes.

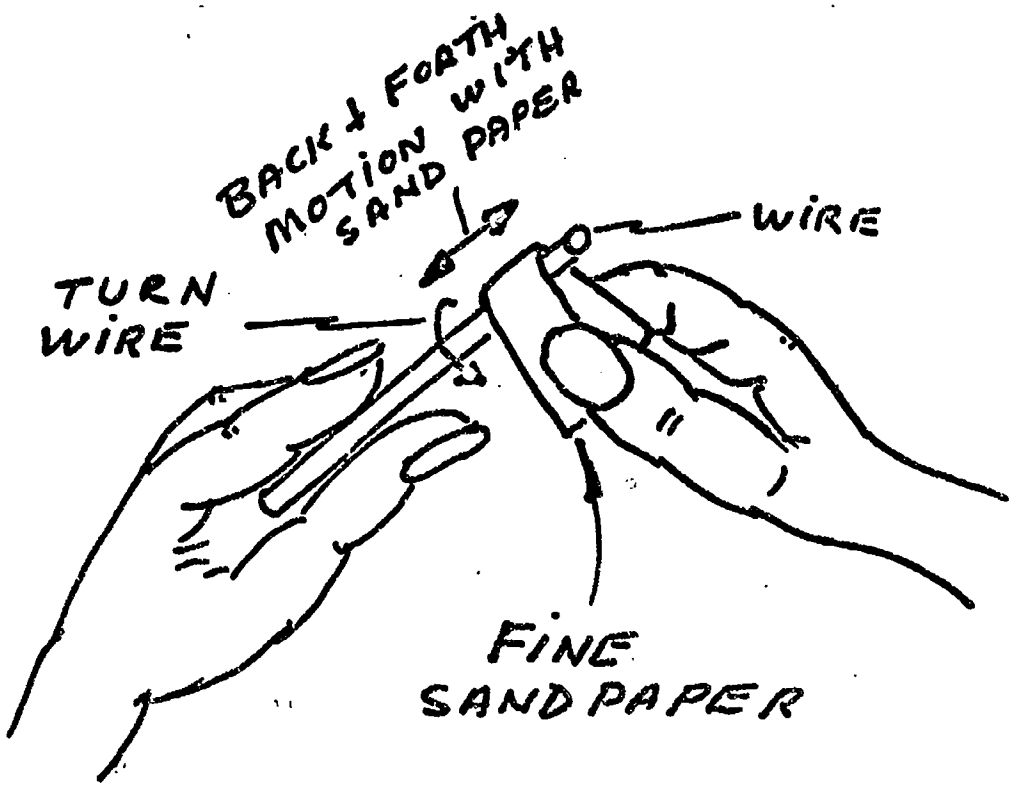
How To Use an Electric Drill with a Screwdriver Bit

Whenever you need to screw in a large number of wood screws, use a variable-speed electric drill with a screwdriver bit. If you can't find a screwdriver bit, saw off the tip of an old screwdriver and use that. Use Phillip's Head screws whenever you can, because they help keep the screwdriver tip from sliding off the head of the screw and hurting the wood. Phillip's Head screws have a slot shaped like an X on the head. Slot head screws have a single slot across the head. Look at the picture.



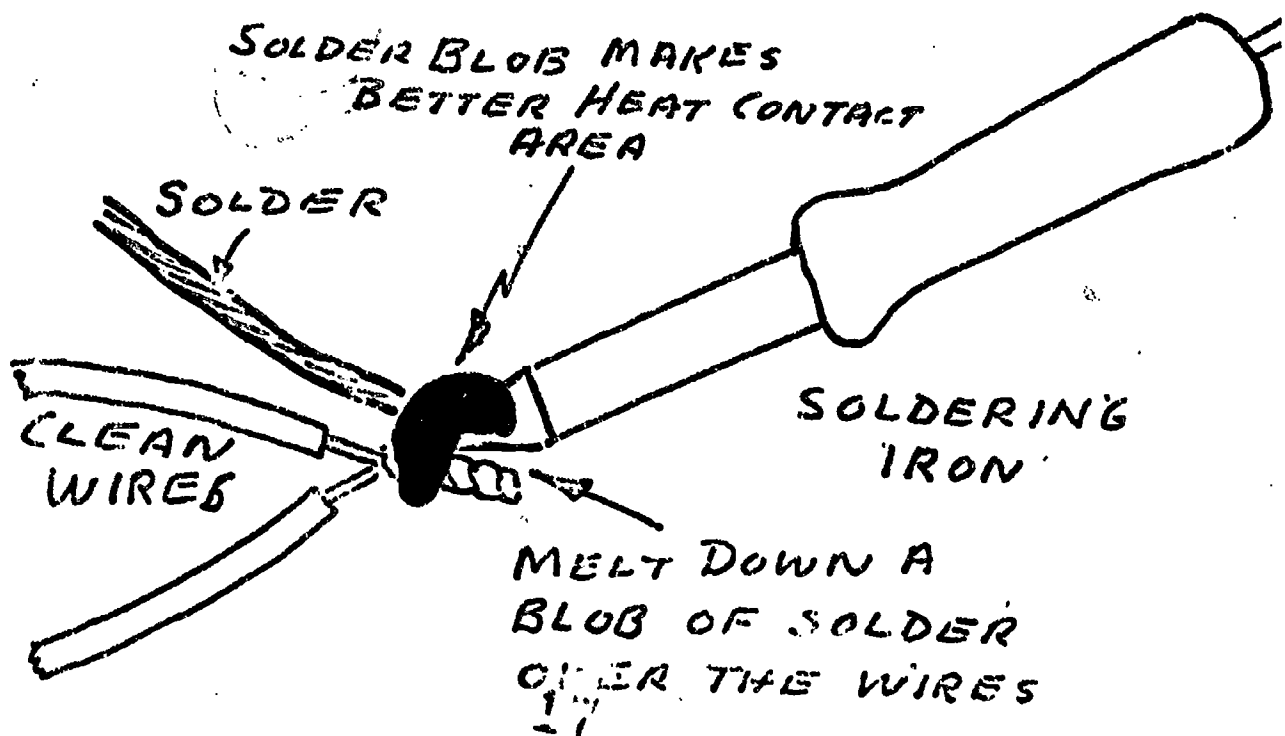
How To Make Varnished Wire Ready for Soldering

Cut a small piece of fine sandpaper. Put the sandpaper around the end of the wire as shown in the picture. Turn the wire as you rub back and forth with the sandpaper. Do this until the last inch of the wire is bright. Be sure that all the varnish is removed.



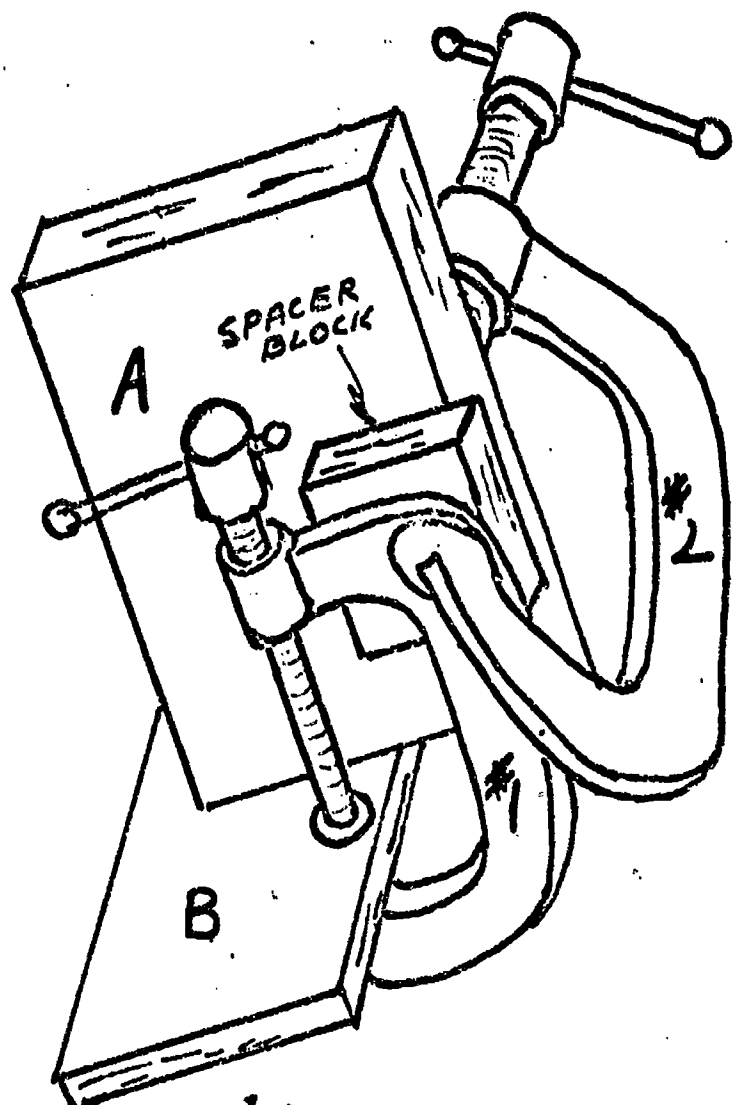
How To Solder Wires

Before you solder, be sure the ends of the wires are bright, bare metal. Take off any varnish or coating. Twist the ends of the wires together so that they will not unwind. Put the wires on a safe, clean area. Make the ends of the wires hang down a little. Take the soldering iron in one hand and a piece of solder in the other. Melt a blob of solder right over the wire. Move the soldering iron along the wires until both ends have a thin coat of solder all over them. Be sure the solder is bright and shiny. It should be smooth, not grainy. Don't leave any large blobs or sharp bits of solder on the wire. Look at the picture.



How To Use "C" Clamps

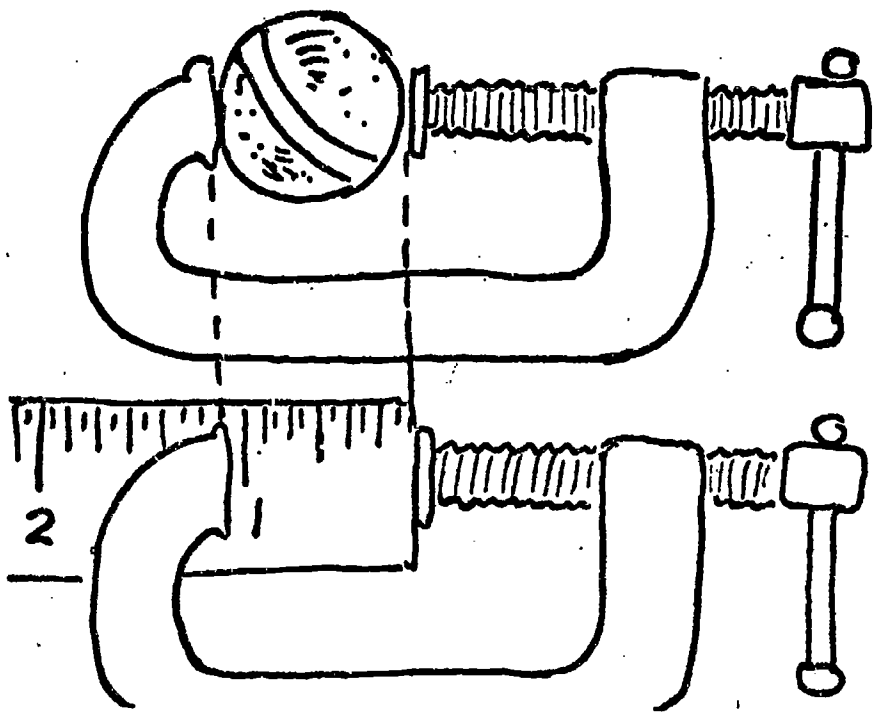
"C" clamps can be used in many ways. Look at the picture. It shows how to clamp pieces of material together at right angles to each other. If piece A is cut evenly across the bottom, you can clamp it onto piece B so it comes straight off it. Look at the picture. Put one clamp on piece B. Put the second clamp around both piece A and the first clamp. Put a spacer block in to keep piece A from hitting the first clamp. Cards 17, 18, 19 and 20 tell other ways to use "C" clamps.



Picture 1

More About "C" Clamps

Look at Picture 2. You can use a "C" clamp as a caliper to measure roughly the diameter of round things. Fit the round object into the "C" clamp so it just fits. Then slip it out and measure the space between the jaws of the "C" clamp.

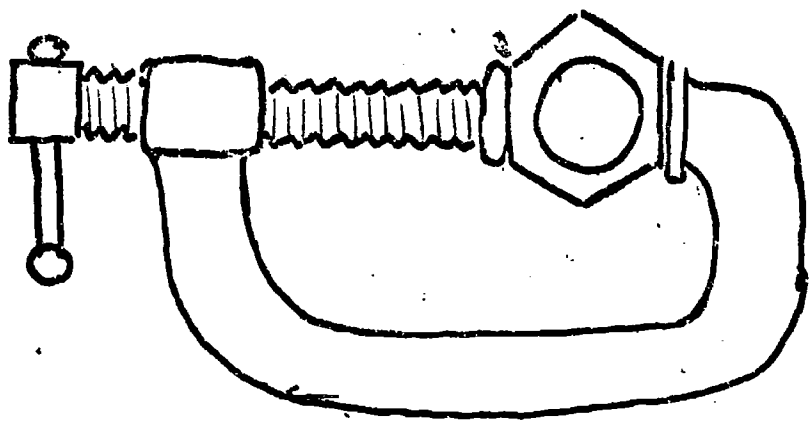


Picture 2

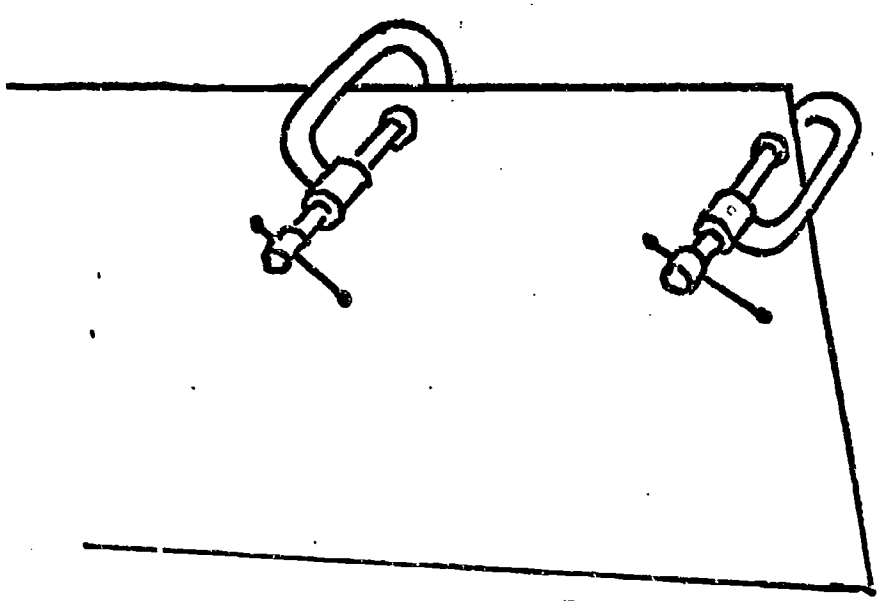
More About "C" Clamps

Look at Picture 3. You can use a "C" clamp as a wrench to turn a nut off a bolt. Fit the clamp around the nut. Tighten the clamp and turn.

Picture 3



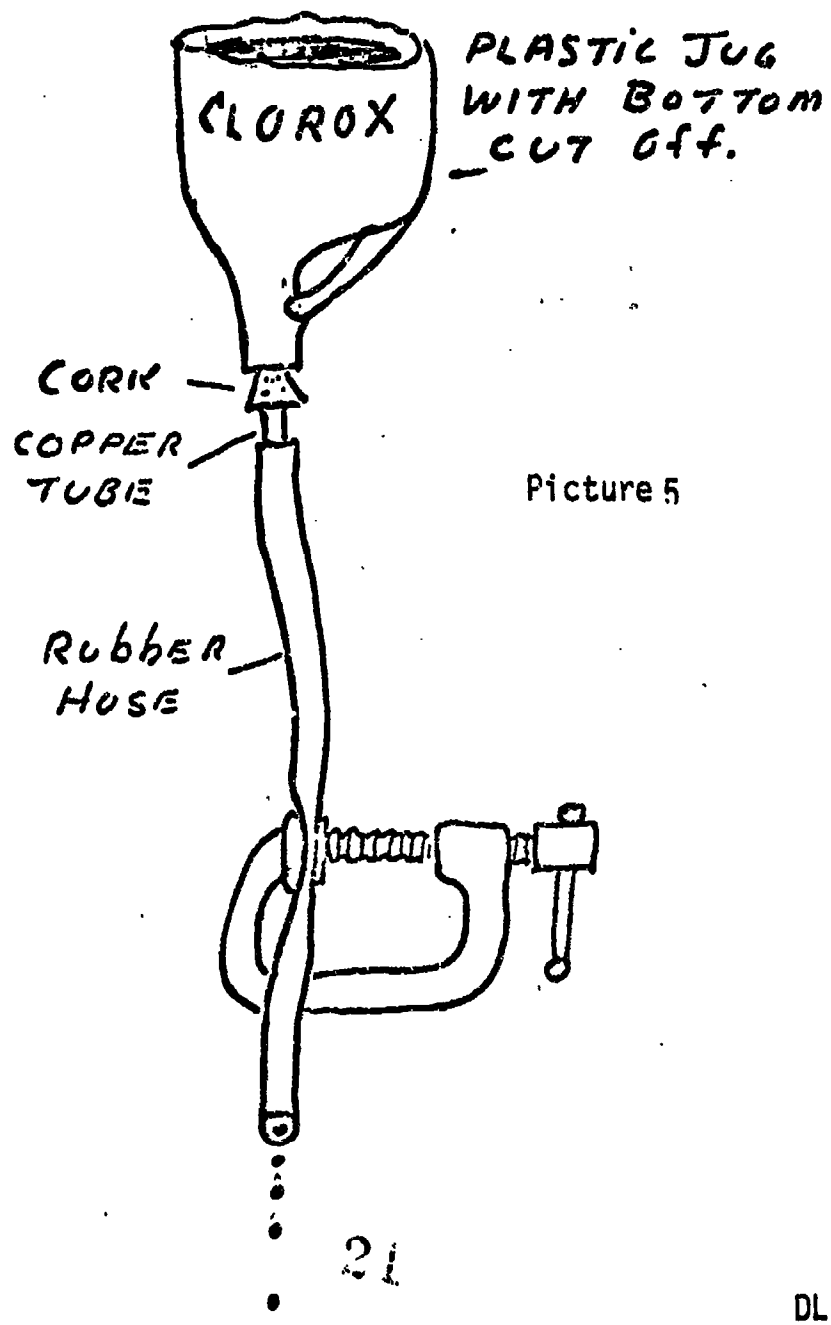
Look at Picture 4. You can use "C" clamps to lift or pull large sheets of metal. Put several clamps on the sheet and hold onto them instead of the sharp edges. It's safer.



Picture 4

More About "C" Clamps

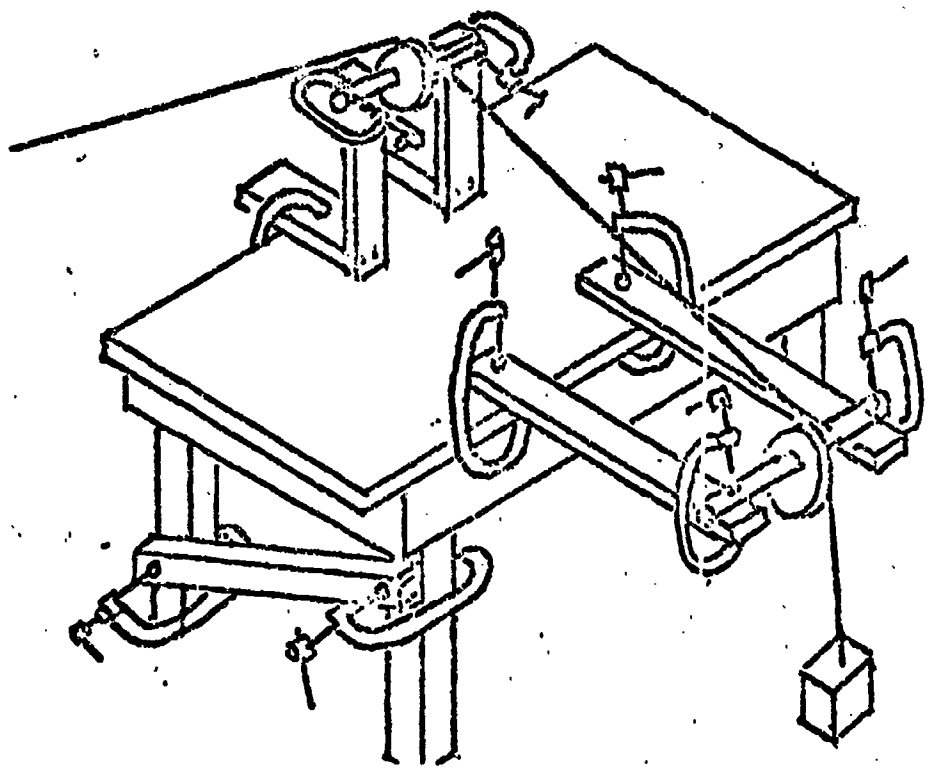
Look at Picture 5. You can use a "C" clamp as a valve on a rubber hose. Put the clamp on the hose. Tighten the clamp to hold the water back. Loosen the clamp to let the water through.



Picture 5

More About "C" Clamps

"C" clamps can be used in many ways. Look at the picture.

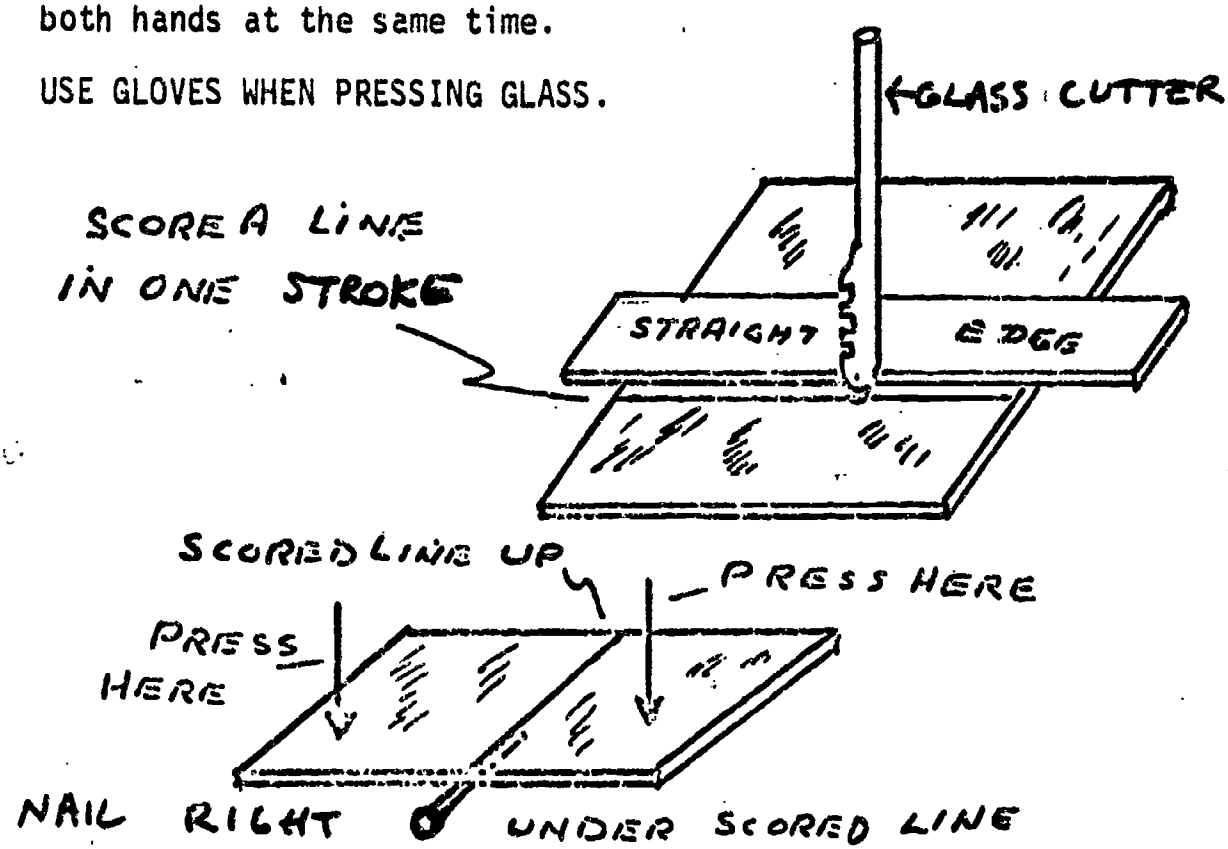


Think of two new ways to use "C" clamps.

How To Cut Glass

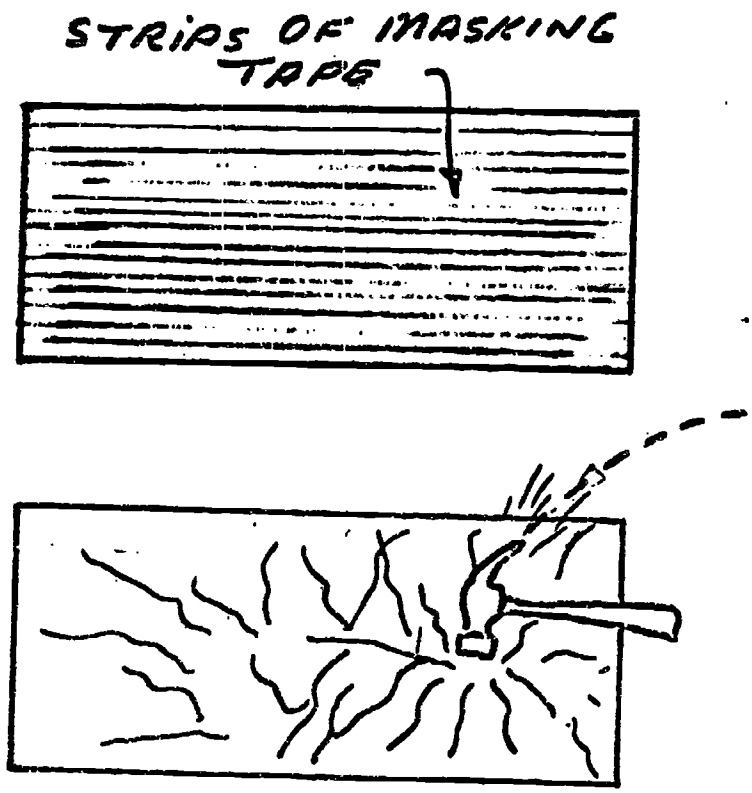
Dip the tip of a new glass cutter in kerosene. Hold it firmly against a straightedge, and score a line straight across the glass in one stroke. Do not try to score the whole line again. If you missed part of the line, carefully score only that part. To cut the glass into two parts, put it over a small nail. The nail should lie under the line at one edge of the glass. Look at the picture. Be sure the scored line is on the top side of the glass. Put gloves on your hands. Place your hands on the outside edges of the glass. Place one hand to the left and one to the right of the scored line. Now press down firmly with both hands at the same time.

USE GLOVES WHEN PRESSING GLASS.



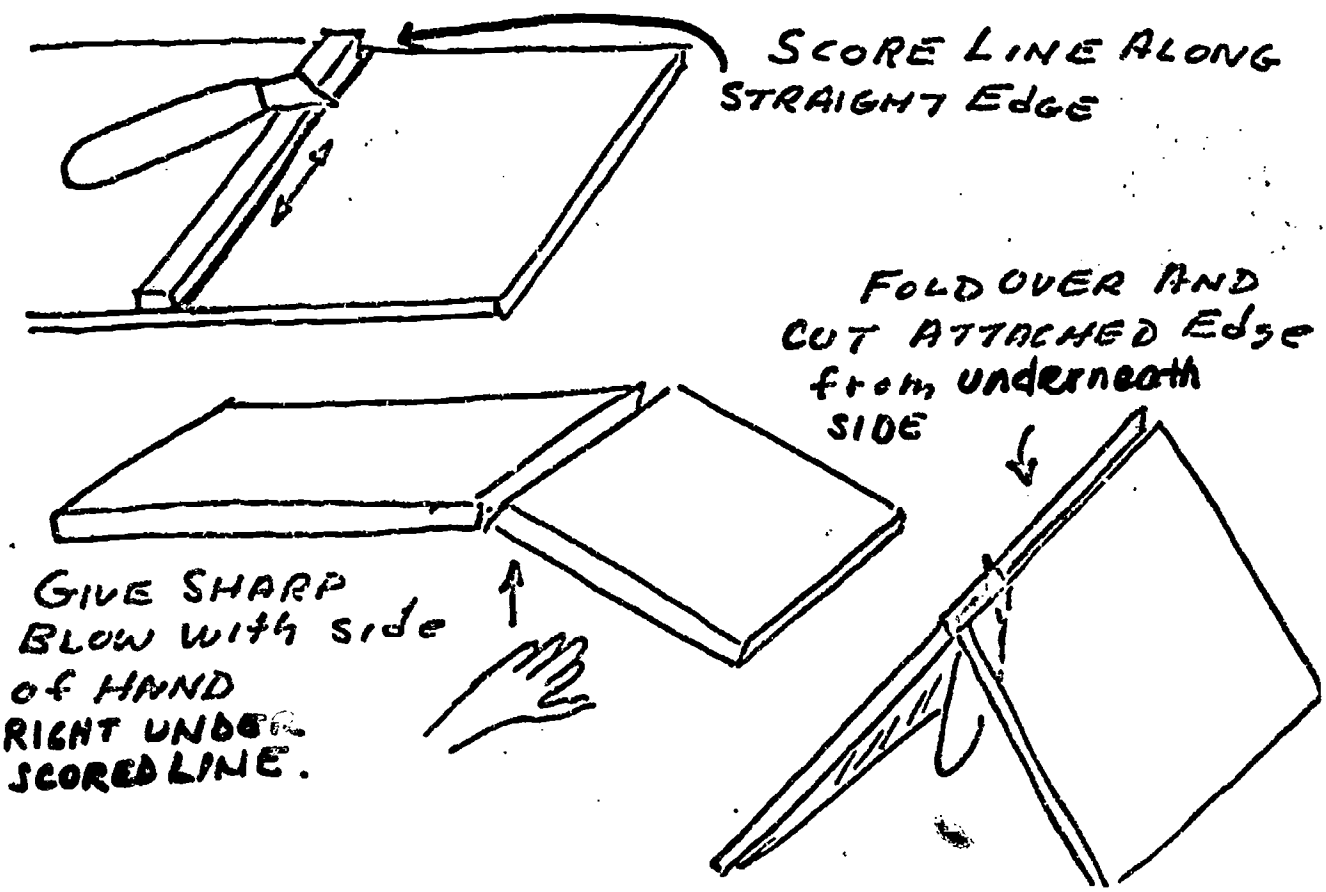
How To Make Sheet Glass and Mirrors Safe to Use in Experiments

Cover one whole side of the glass with masking tape. If the glass breaks the pieces will not fly all around. They will stick to the tape. If you need to see through the glass, use clear tape.



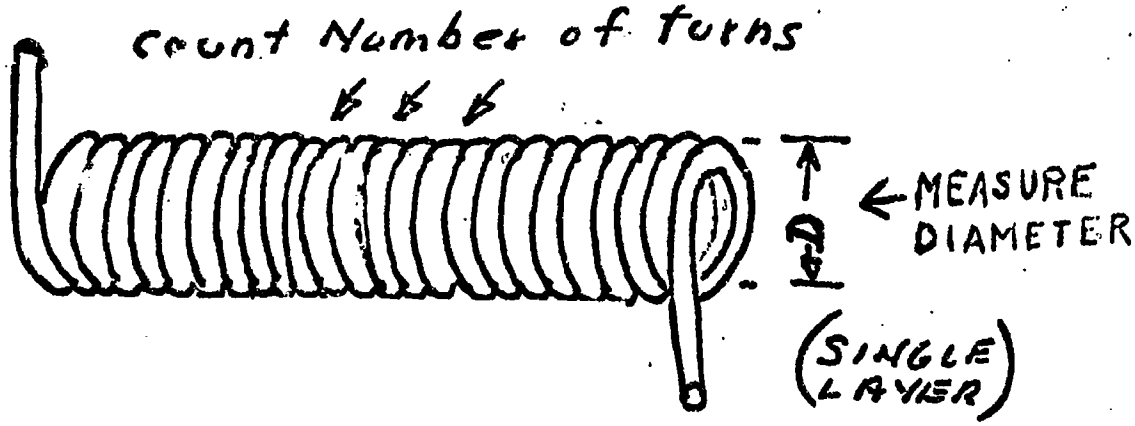
How To Cut Sheet Rock

Use a straight edge as a guide and score a line across the sheet rock with a sharp knife. You have to press hard enough on the knife to go through cardboard backing. Put your hand under the piece of sheet rock. Hit the sheet rock sharply with the side of your hand right under the scored line. The plaster will part right along the line. Now you have to cut the cardboard backing on the underneath side with the knife. Fold the piece of sheet rock and cut from underneath. Look at the pictures.



How To Find the Length of a Single Layer Coil of Wire

Measure the diameter (width) of the coil. Count the number of turns of wire. Multiply the diameter by 3. Then multiply that answer by the number of turns in the coil. Finally, find 15% of the new answer and then add it on. That answer is about how much wire is wrapped around the coil.

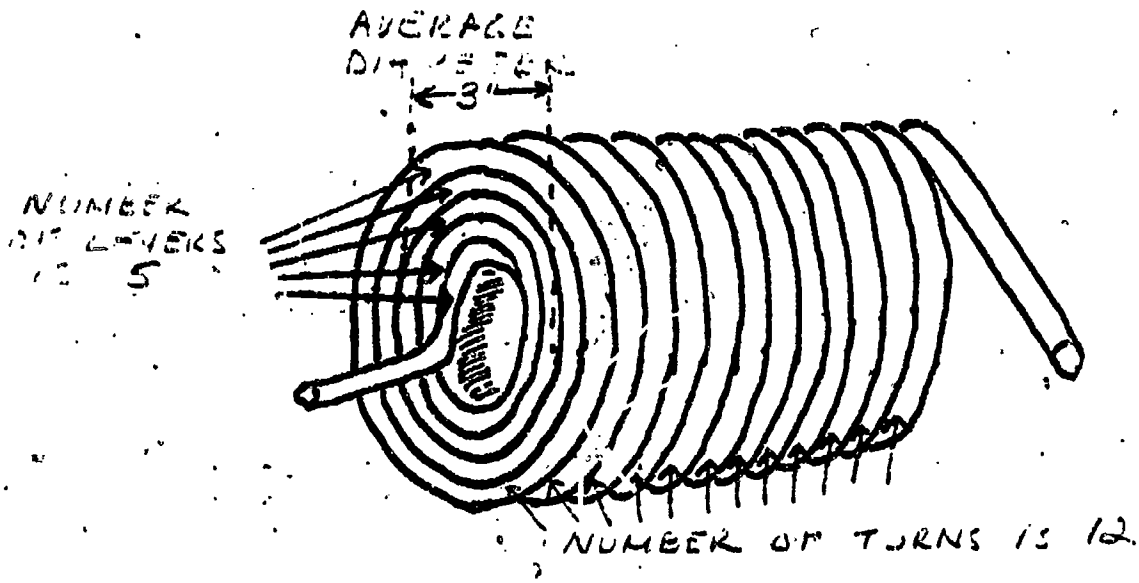


EXAMPLE: The length of 10 turns of wire on a coil with a 2" diameter is about:

1) 2" x 3 = 6"
2) 6" x 10 = 60"
3) 60" + .15 (60") = 60" + 9" = 69"

How To Find the Length of a Coil of Wire With Many Layers

Measure the diameter of the coil across the inside hole. Measure the diameter of the coil across the outside layer. Find the average diameter. Count the number of turns of wire on the top layer and count the number of layers. Multiply the average diameter of the coil by 3. Then multiply that number by the number of turns per layer. Then multiply that number by the number of layers. Find 15% of the total and then add it to the total. That answer is the approximate length of the wire.



EXAMPLE: A multilayered coil of wire has an average diameter of 3". The length of wire wound in 5 layers with 12 turns per layer is about:

1) 3 x 3" = 9"

2) 9" x 12 x 5 = 540"

3) 540" + .15 (540") = 540" + 81" = 621"

"How To" Cards

HOW TO CONSTRUCT A SAMPLING HISTOGRAM
(Revised 1972)

What a Sample Histogram Is

In an experiment you often need to count how many cars cross an intersection or how many "heads" come up when a coin is tossed. If you do the experiment again you often come up with different counts although the experiment is the same.

> For example, you may toss a coin ten times and get 8 heads and 2 tails. If you toss it ten times more you may get 4 heads and 6 tails. If you keep making ten tosses you may get the same counts for heads and tails. Or, you may get different counts. Each test or sample of ten tosses could give you a different count.

Sometimes it is important to know the distribution of the samples you take. The distribution of the samples describes how the samples turn out - how many have the same counts and how many have different counts. After taking many samples you can see the distribution. The distribution will also give you an idea about how more sample counts may turn out.

A sampling histogram is a picture of sample counts. You can use it to see the distribution of your set of samples. The histogram will show you how your sampling has turned out. It will also give you an idea about other sample counts you might take. The sampling histrogram can also help you to find the median sample in your set of samples.

Card 2 tells you how to first make a tally chart of your samples.

Making A Sampling Tally

Children from a class visited an intersection for five different days at 12:00 A.M. They counted the number of cars which passed the intersection in five minutes each day. Here is the data from the sample they took on each of the five days:

Sample	Number of cars crossing intersection in five minute samples	
Day 1	𝍸 𝍸 𝍸 ||	17
Day 2	𝍸 𝍸 |||	13
Day 3	𝍸 𝍸 𝍸 |	16
Day 4	||	2
Day 5	𝍸 𝍸 𝍸 |	16

How many cars crossed the intersection in five minutes on the first day?

On which day did the greatest number of cars cross the intersection?

On which day did the smallest number of cars cross?

Did the same number of cars cross on more than one day?

Answers: Seventeen cars crossed the intersection the first day.
The most cars crossed the first day.
The smallest number of cars crossed on the fourth day.
The same number of cars crossed on two days.
Sixteen cars crossed on those two days.

More About Making A Sampling Tally

A girl tossed a tetrahedron or four-sided solid shape 10 times. As she tossed the tetrahedron she tallied the number of times the green side landed down. After she finished this first sample of ten tosses, she did the experiment 4 more times. In each sample of ten tosses, she counted the number of times the green face landed down. Here is her tally sheet for the 5 samples of ten tosses:

	Number of times Green face landed down in samples of 10 tosses	
Sample 1	II	2
Sample 2	III	3
Sample 3	I	1
Sample 4	IIII	4
Sample 5	~~HH~~ I	6

How many times did the green face land down in the 3rd sample?

In which sample did the green face land down the most times?

What is the smallest number of times the green face landed down in any sample?

If you have trouble keeping track of samples, see Card 12 for a tally sheet.

Making a Sampling Histogram

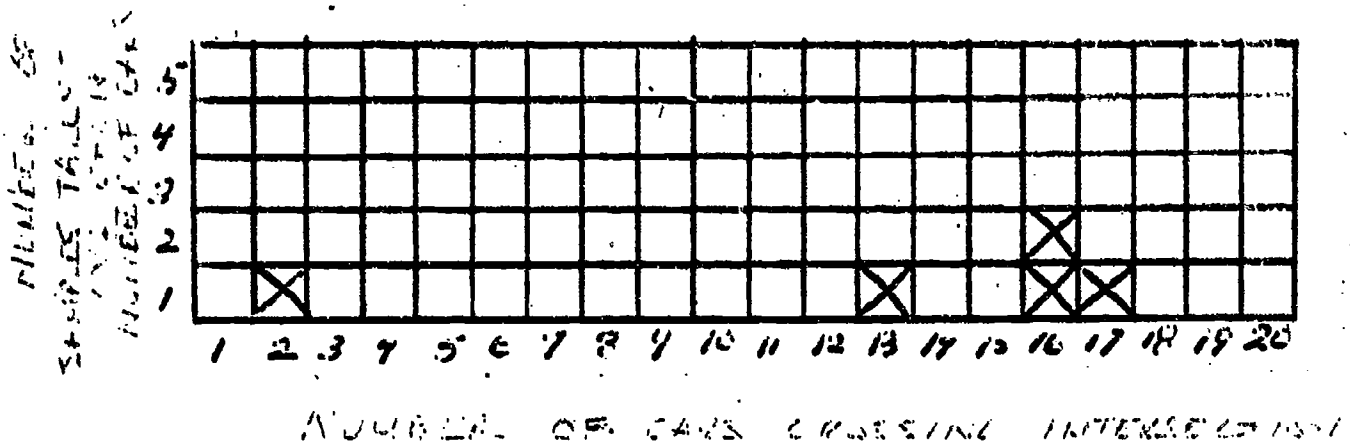
Sometimes it is important to know how each sample count you take changes or is the same. A sampling histogram is a picture of a lot of sample tallies. You can draw a sampling histogram to find out how your samples differ.

For instance, we can show the data from the tally sheet on Card 2 in a sampling histogram. On it we can show how many cars crossed the intersection in each sample. The histogram will also tell us how many samples the same number of cars crossed the intersection.

From the tally sheet on Card 2 we see that:

1 sample tallied 2 cars
1 sample tallied 13 cars
2 samples tallied 16 cars
1 sample tallied 17 cars

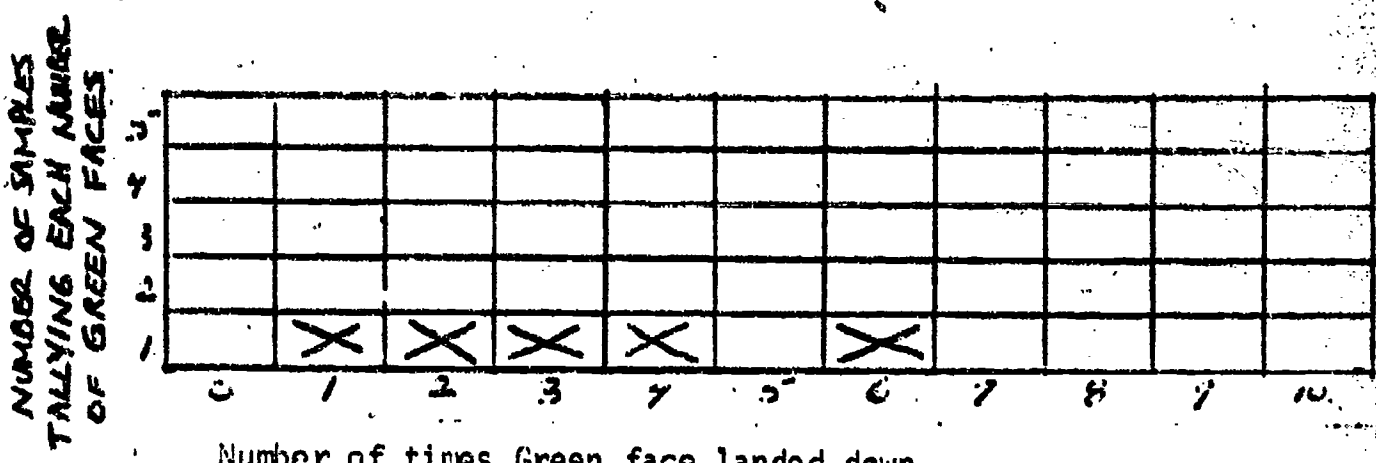
Your sampling histogram from this data looks like this:



It is hard to get a good idea about the distribution of your samples from only five samples. To see how your sample counts change or are the same you need to take many more samples. More tallies should be made on many more days. After the number of cars is counted each day, one more cross mark can be added on the sampling histogram.

More About Making a Sampling Histogram

The data from Card 3 can also be shown in a sampling histogram. On it we can show the number of times the green face landed down in each sample of ten tosses. The histogram will also tell us how many samples tallied the same number of green faces and how many tallied different numbers.



What is the largest number of times the green face landed down in any sample?

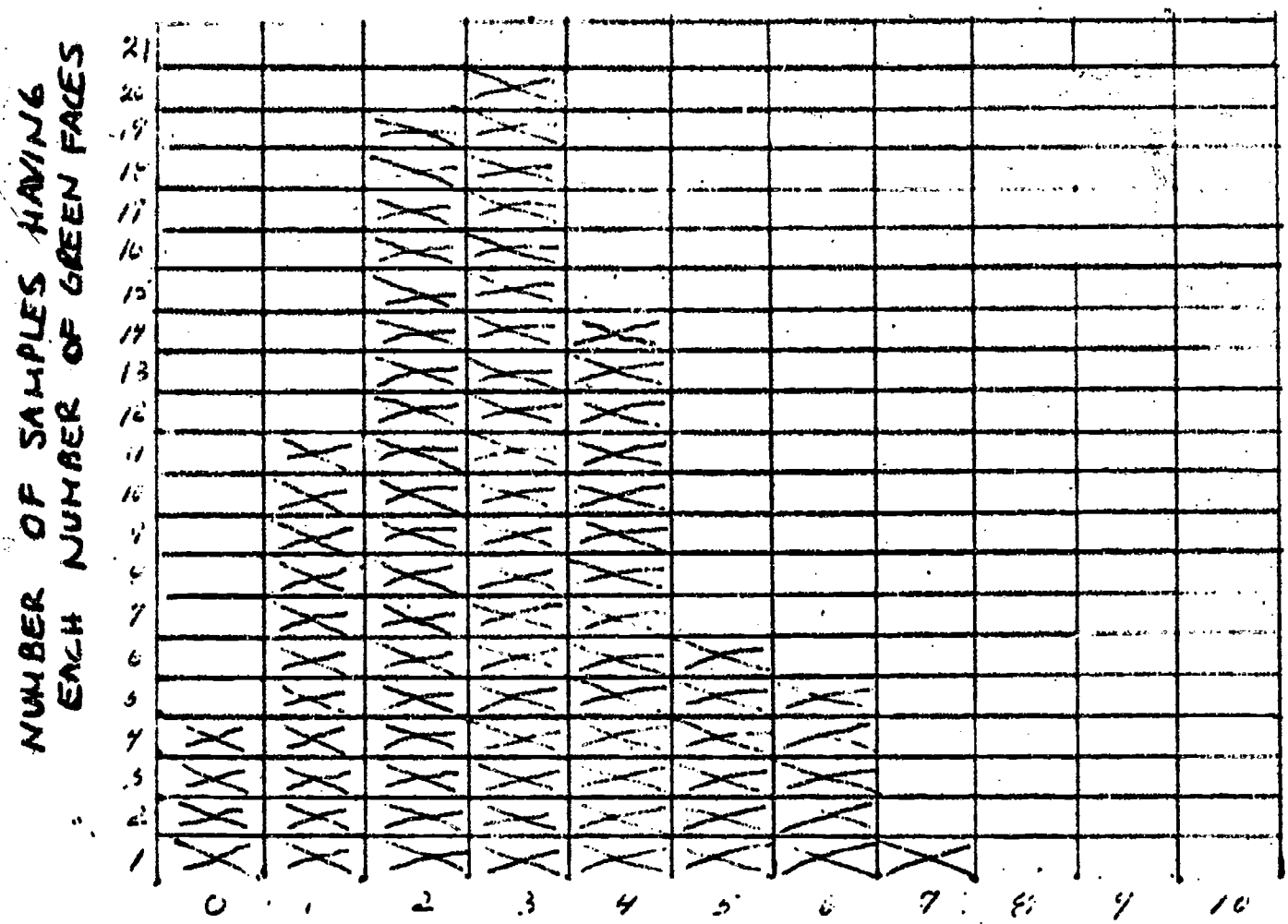
What is the smallest number of times the green face landed down in any sample?

In how many samples did the green face land down just once?

ANSWERS: The largest number of green faces is 6.
The smallest number of green faces is 1.
The green face landed down just once in one sample.

To get a good idea of the distribution of your samples you need to take many more samples. A sampling histogram of 80 samples of 10 tosses is shown on the next card.

A Sampling Histogram of 80 Samples



Number of times the Green face landed down in samples of 10 tosses.

What is the largest number of times the green faces landed down in any sample?

What is the smallest number of green faces landing down in any sample?

In how many samples did the green face not land down at all?

Did the green face land down just 5 times in more than one sample?

What is the number of times the green face landed down in most samples?

Finding the Median in a Set of Samples

The median sample is the middle sample of a group or set of samples. The median sample is found by arranging the samples of the set in order of their size - starting with the sample having the smallest tally. When the samples have been listed in order you find the middle sample in the list. This middle sample is the median sample.

The median is the number of things tallied in the median sample. You can use the median to describe the set of samples taken. The median tells you that most of the sample tallies are about the same as the median.

(See the "How To" cards on How To Find the Median in a Set of Data if you don't understand medians.)

For example, we can find the median of a set of samples using the data on Card 3. First we list our samples in order - starting with the sample having the smallest number of green faces tallied.

Sample 3	Sample 1	Sample 2	Sample 4	Sample 5
1 green	2 green	3 green	4 green	6 green

Then we find the median or middle sample. In this set of five samples the median sample is Sample 2. The median for the number of green faces tallied in Sample 2 is 3 green faces.

		median ↓		
Sample 3	Sample 1	Sample 2	Sample 4	Sample 5
1 green	2 green	3 green	4 green	6 green
		median ↓		

You can also find the median by using a sampling histogram. The median sample in a set of 5 samples is the third sample. You could count the crossmarks on the sampling histogram from left to right. The 3rd mark would be the median sample and the number of green faces or median is 3 green faces.

More About Finding the Median

Card 7 showed us that we can find the median in two ways. We can find the median by looking at the sampling tally of samples. Or we can find the median by looking at a sampling histogram.

For instance, to find the median directly from the data on Card 6 you could list all 80 samples in order of their size. The first 10 samples would be:

0, 0, 0, 0, 1, 1, 1, 1, 1, 1

If you list all 80 samples in this way you can find the median sample by choosing the middle sample in the set of 80 samples. In this set, the median sample would be the 40th sample. The median would be the number of green faces tallied in the 40th sample.

An easier way to find the median is to look at the sampling histogram. If there are 80 samples marked on the sampling histogram you know that the median sample is the 40th sample. On the sampling histogram the 40th crossmark is the median sample. You find the 40th crossmark by counting the marks - starting with the smallest sample. The 40th crossmark is the median sample. The number of green faces tallied in the 40th sample is the median.

What is the median sample in the sampling histogram on Card 6?

What is the median in the histogram on Card 6?

Answers: The median sample is the 40th sample.

The median is 3 green faces in a sample of ten tosses.

MAKING YOUR OWN HISTOGRAM

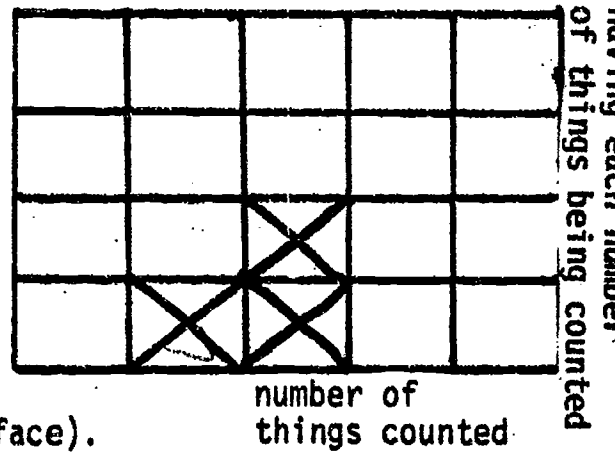
In your experiments you may want to make a sampling histogram. A sampling histogram will tell you how your sample counts from an experiment change or are the same if you repeat the experiment several times.

To make a sampling histogram you collect data about something in samples of a certain size. You may want to take five-minute samples of the number of cars crossing an intersection. Or you may want to find out the number of times a certain face of a die lands in samples of ten tosses.

As you take each sample you record your data on a sampling tally. (See Cards 2 and 3.) After you finish taking samples you find the total number of tallies for each sample.

You can draw a sampling histogram like this:

1. Draw two lines and mark them off in equal parts.
2. Notice that the bottom line shows the number of things counted (cars, faces).
3. Notice that the up and down line shows the number of samples having each number of things counted (number of samples having 1 car or 1 face).



4. You draw a crossmark for each sample in the proper square. You use your sampling tally to find out where each cross mark should go.

Sometimes it is easier to make a sampling histogram form first. Then you can record your sample counts on the histogram as you take the samples.

MORE ABOUT MAKING YOUR OWN HISTOGRAM

Does your sampling histogram give you a good idea about the distribution of your sample? Does it show you what sample size happens most often?

If not, you should continue to take samples. Record the data from each sample on your sampling tally. Then add a crossmark for each sample on the histogram. Or you can record directly on the histogram form.

After many samples you will get an idea of the distribution of your samples. You will also be able to see what sample size happens the most often. After this you can find the median sample and the median of your set of samples.

You might want to keep your sampling tallies and histograms in a safe place. The next card tells you how to make a folder to hold your work.

MAKING A FOLDER TO HOLD SAMPLING TALLIES AND HISTOGRAMS

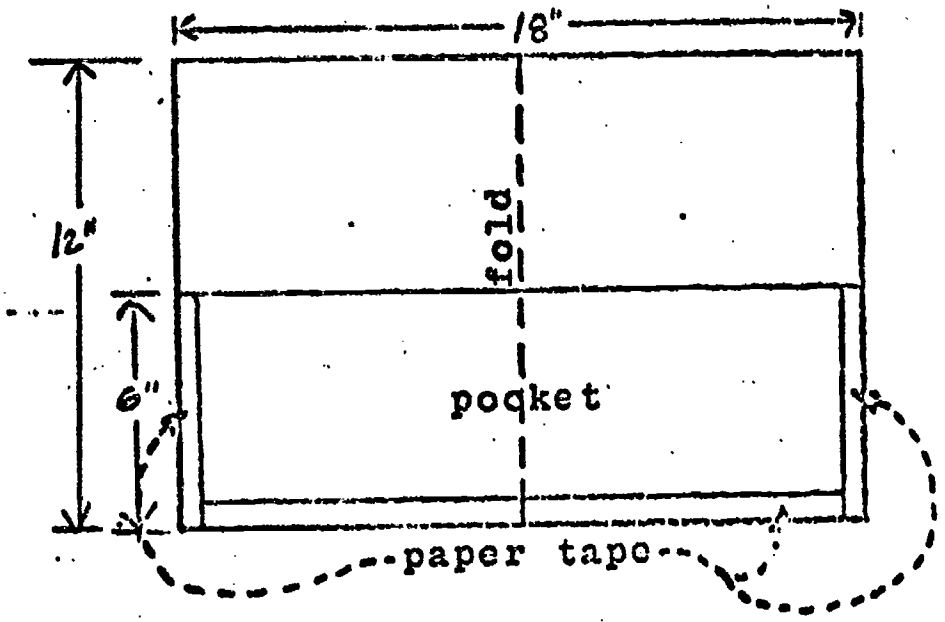
You will want to keep all your diagrams and reports in a safe place.

You can make a folder like this:

1. Cut a piece of construction paper so that it is 6 inches wide and 18 inches long.

2. Cut another piece so that it is 12 inches wide and 18 inches long.

3. Put the two pieces together with tape. Look at the picture below.



4. Fold in the middle so that the pocket is on the inside.

5. Your name and a title for your folder should be put on the front cover like this.

HOW TO KEEP TRACK OF SAMPLES

Sometimes it is hard to keep track of sample counts. A tally sheet can help you to count the number of times a thing happens in your sample.

For example, you may be tossing a tetrahedron ten times to see how many green faces land down. If you have a tally sheet you can write the results of each toss in your sample.

Here is a tally sheet of the five samples from Card 3. After each of the ten tosses in each sample a check mark is made if the green face landed down. A O is drawn if another face landed down. When ten tosses are finished the check marks in the sample are added together. This sum will tell you the total number of times a green face landed down in each sample.

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
1st toss	O	✓	O	O	✓
2nd toss	O	O	O	✓	O
3rd toss	O	O	O	✓	✓
4th toss	O	O	✓	O	✓
5th toss	✓	O	O	O	O
6th toss	O	✓	O	✓	✓
7th toss	O	O	O	O	O
8th toss	O	✓	O	O	✓
9th toss	✓	O	O	O	✓
10th toss	O	O	O	✓	O
Total number of times green face landed down	2	3	1	4	6

"How To" Cards

HOW TO MAKE A BAR GRAPH TALLY

(Revised July, 1972)

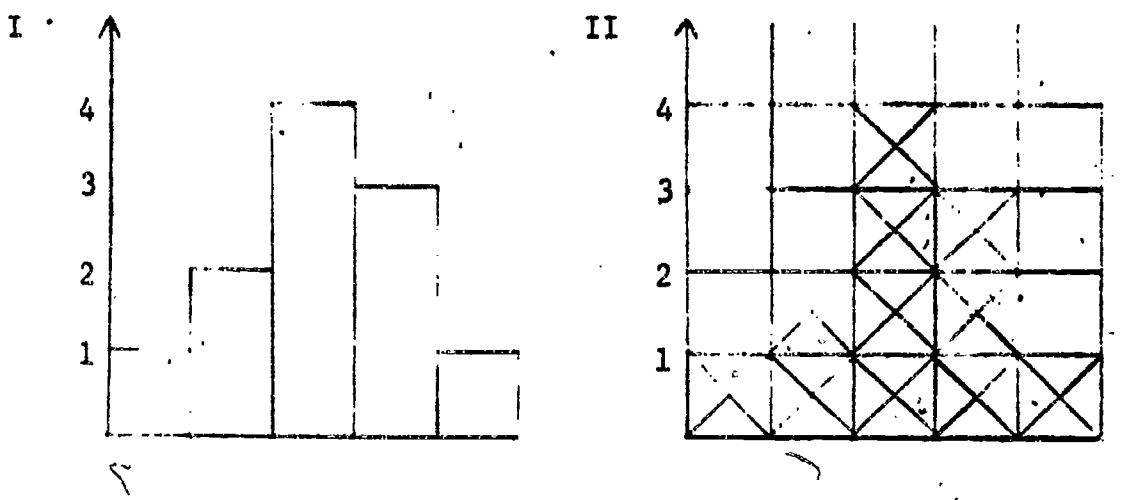
Unified Science and Mathematics for Elementary Schools

What A Bar Graph Tally Is

A bar graph tally is a picture of the data collected in an experiment.

Sometimes you can get more information about your data from a picture than from words. Sometimes, too, it is easier to describe your data to someone in a picture than in words. A bar graph tally can make your pieces of data easier to understand.

Here are two types of bar graph tallies:



Type I bar graph tally is drawn after the data from an experiment had been collected. Type II bar graph tally can be drawn during the experiment. The pieces of data in the experiment are recorded right on the graph.

Making A Bar Graph Tally - Type I

The Type I bar graph tally is made after data from an experiment has been collected.

For example, you can make the first kind of bar graph tally from the pieces of data you find in this story:

> I was watching cars at an intersection for 3 minutes. I first saw a Chevy, then a Ford, then two Buicks, then another Ford, then a Rambler, then three Fords and a Chevy.

To make a Type I bar graph tally, you first tally your data on a chart like this:

Types of Cars	Number Seen: Tally Marks	Total
Chevys	||	2
Fords	𝍸	5
Ramblers	|	1
Buicks	||	2
Chryslers		0

See the "How To" cards on How To Record Data by Tallying if you don't understand tally marks and tallying.

The next card tells you how to draw your bar graph tally using the data on this chart.

More About Making a Bar Graph Tally - Type I

To make a bar graph form for your data:

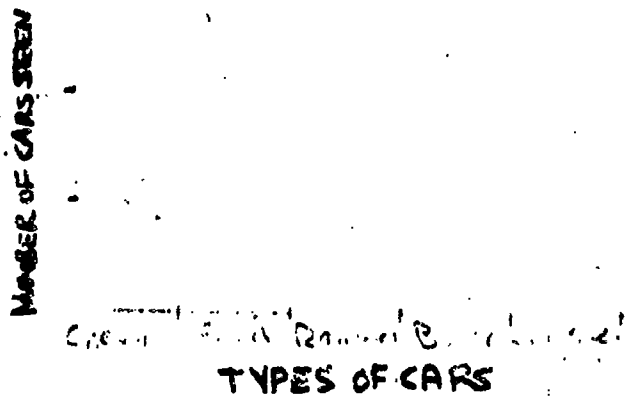
1. Draw graph form like this:

2. Notice that the bottom line is divided into five equal parts, one for each type of car.

3. Notice that the up and down line is divided into 6 equal parts.

4. Don't forget to write down the names of the cars and the words "Types of cars" under the bottom line.

5. The up and down line should be numbered 1 to 6 and titled "Number of cars seen".



To put data on your graph,

1. Look at each type of car listed on your chart. Find out how many times each was seen.

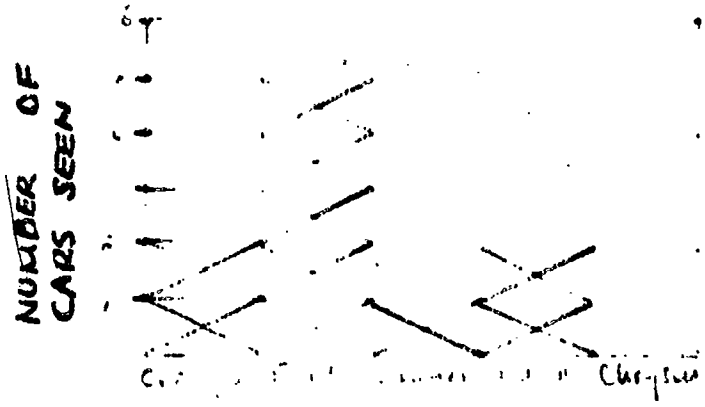
2. Above each car type draw a block which reaches to the number of times it was seen.

Making A Bar Graph Tally - Type II

The Type II bar graph tally is drawn during the experiment. The pieces of data in the experiment are recorded right on the bar graph without first tallying them.

To use a Type II bar graph tally you should figure out what you're going to record. Then you should make a bar graph form for your bar graph before you start the experiment.

For example, the cars at the intersecion described on Card 2 could have been recorded on a bar graph as they were seen. In this case, the bar graph tally would look like this:



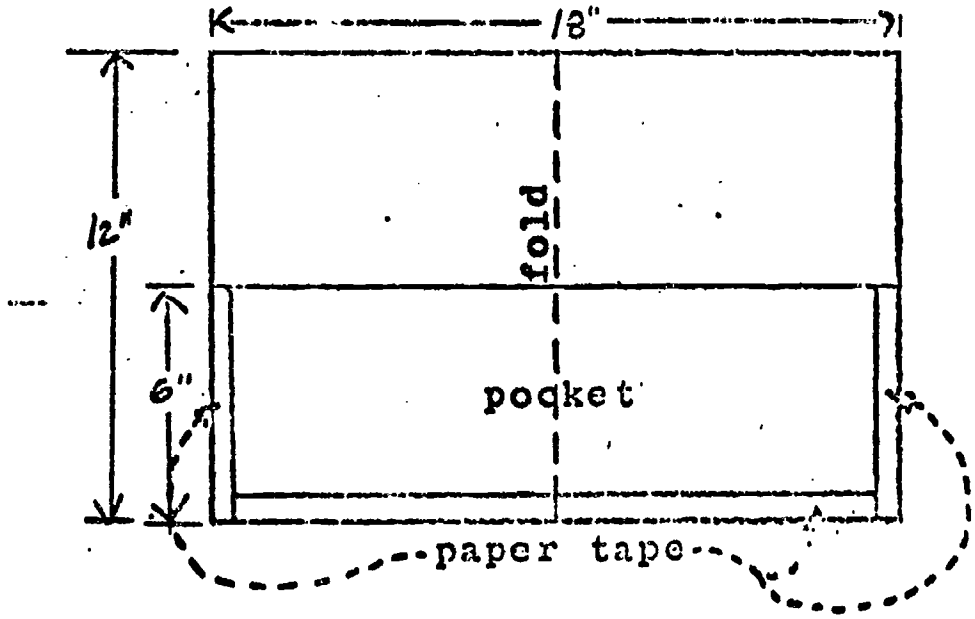
Each crossmark means that a car has been seen one time. Each time a type of car was seen another crossmark was added.

You might want to keep your bar graph tallies in a safe place. The following card tells you how to make a folder to hold your work.

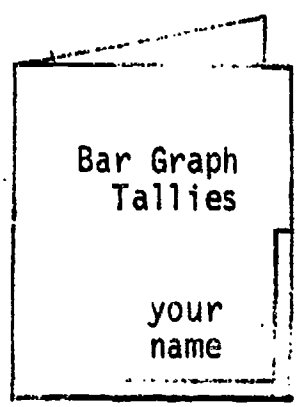
Making a Folder to Hold Bar Graph Tallies

You can make a folder like this:

1. Cut a piece of construction paper so that it is 6 inches wide and 18 inches long.
2. Cut another piece so that it is 12 inches wide and 18 inches long.
3. Put the two pieces together with tape. Look at the picture below.



4. Fold in the middle so that the pocket is on the inside.
5. Put the title and your name on the front cover. Look at the picture.



"How To" Cards

HOW TO MAKE SCALE DRAWINGS AND MODELS

(revised July, 1972)

Unified Science and Mathematics for Elementary Schools

FINDING OUT ABOUT SCALING

A scale is a rule for changing real distances to smaller or larger distances so you can make scale drawings and maps and models.

For example, the rule "one inch on paper stands for one foot in real life" is a scale.

It means that anything that measures 1 inch on paper measures 1 foot in real life. So anything that measures 5 inches on paper measures 5 feet in real life. Anything that measures 18 inches on paper measures 18 feet in real life, and so on.

This is one kind of scale you can use. You let <u>one</u> of one unit of measure stand for <u>one</u> of another unit of measure. This is the easiest kind of scale to use.

Here is a quick way to write scales. The ⟷ mark means "stands for".

1 inch ⟷ 1 foot

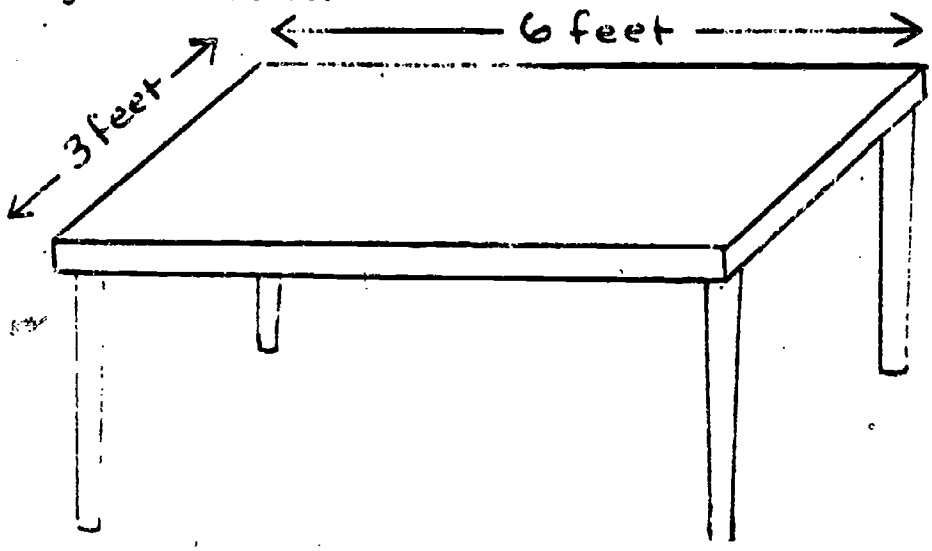
1 inch ⟷ 1 yard

1 inch ⟷ 1 mile

MAKING A SIMPLE SCALE DRAWING

Let's use the scale 1 inch↔1 foot to make a simple scale drawing.

Let's make a scale drawing of a bird's eye view of a table. Look at the picture. This is the way we might look at the table. We want the scale drawing to show what it would look like if we were looking straight down at it.



Suppose we measured the table and found that it was 6 feet long and 3 feet wide. Now we can use our scale to change real distances to scaled distances. If 1 inch↔1 foot and the table is 6 feet long in real life, it should be 6 inches long on paper. If the table is 3 feet wide in real life, it should be 3 inches wide on paper.

Draw a rectangle 6 inches long and 3 inches wide. Write under it:

Scale: 1 inch↔1 foot

That rectangle is a scale drawing of a bird's eye view of the table.

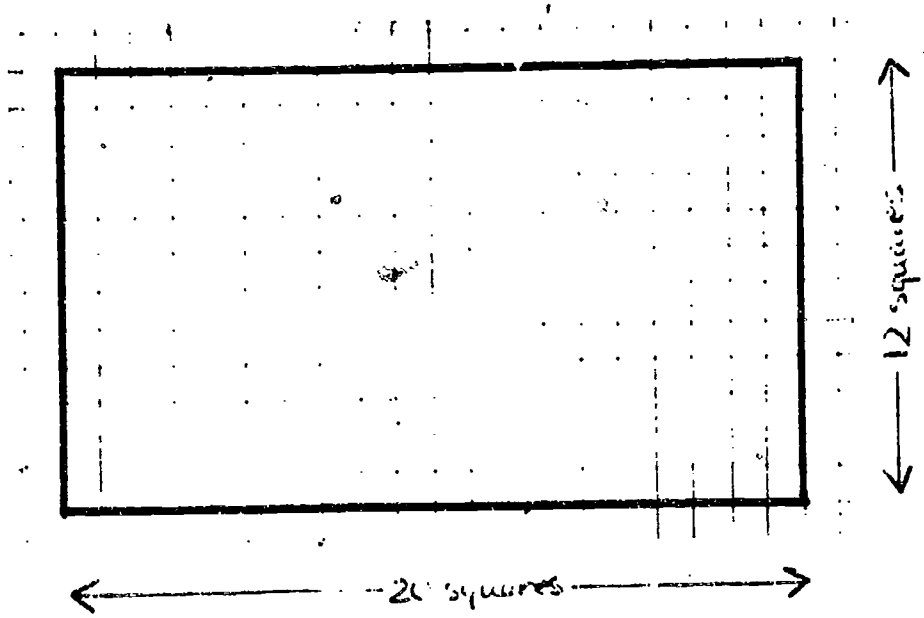
USING GRAPH PAPER TO MAKE SCALE DRAWINGS

You can use graph paper to help you make scale drawings.

Look at a piece of graph paper. Notice how it is marked off in squares. If you use graph paper for a scale drawing, you can let one square stand for some real distance.

Let's use your piece of graph paper to make another simple scale drawing. Let one square stand for one foot. Draw a bird's eye view of a room 20 feet long and 12 feet wide.

How did you do it? Did you draw a rectangle 20 squares long and 12 squares wide? Look at the picture.



Scale: 1 square ↔ 1 foot

MAKING SCALE DRAWINGS BIGGER

Did you know that you can get graph paper with different size squares? Some kinds have large squares. Some have small squares. If your paper has small squares your scale drawing of the room is small like the picture on Card 3. Suppose you want to make a bigger scale drawing so you can draw furniture inside the room? How can you make your scale drawing of the room bigger? Do you know? Can you guess?

Suppose you want to make a scale drawing of the room bigger than the drawing on Card 3. How can you do it? You can let 2 squares stand for 1 foot.

How do you use this scale? If the room is 20 feet long and 12 feet wide and 2 squares ↔ 1 foot:

20 feet X 2 squares per foot = 40 squares

12 feet X 2 squares per foot = 24 squares

So the scale drawing of the room will be 40 squares long and 24 squares wide.

How is this scale different from the other scales we have talked about so far?

2 squares ↔ 1 foot

Several of one thing stand for one of another thing.

Remember: When you are using a scale to make a drawing bigger:

real distance X scale = distance to use in scale drawing.

CHOOSING SCALES AND PAPER

Suppose you want to make a scale drawing of a bird's eye view of your playground. First you have to measure the length and width of the playground.

Suppose you measure and find the playground is 100 yards long and 50 yards wide.

Now you have to pick the scale and the paper you will use to make the scale drawing.

Think of easy scales to use. One easy scale to use would be 1 inch ⟷ 1 yard.

How long will your paper have to be to use this scale? How wide? Can you find a piece of paper at least 100 inches long and 50 inches wide?

Here is a way to find out how big that is. Use chalk to draw a rectangle 100 inches long and 50 inches wide on the blackboard or the floor.

How can you make your scale drawing of the playground smaller? Think of other easy scales to use.

Figure out what size paper you need for each scale you think of. Try to find the right size paper or paper which can be cut down to the right size.

MAKING SCALE DRAWINGS SMALLER

What other easy scales did you think of?

Did you think of using 1 square ⟷ 1 yard? Did you find a piece of graph paper at least 100 squares long and 50 squares wide?

Did you think of using 1 inch ⟷ 5 yards?

How do you use this scale? How do you figure out what size paper you need?

If the playground is 100 yards long and 50 yards wide and 1 inch ⟷ 5 yards:

100 yards ÷ 5 yards per inch = 20 inches

50 yards ÷ 5 yards per inch = 10 inches

So the scale drawing will be 20 inches long and 10 inches wide. You will have to use paper at least 20 inches long and 10 inches wide.

How is this scale different from other scales we have talked about?

1 inch ⟷ 5 yards

<u>One</u> of one unit of measure stands for <u>several</u> of another unit of measure.

Remember: When you are using a scale to make a drawing smaller:

real distance ÷ scale = distance to use in scale drawing.

USING DIFFERENT UNITS OF MEASURE

Yards and feet and inches are three different units of measure. You use one or two or even all three when you measure things.

You can change measurements from one unit of measure to another. You probably know that:

1 foot = 12 inches

1 yard = 3 feet = 36 inches

These are the rules you use to change from one unit of measure to another.

You also know now that you use different units of measure when you make up scales.

Sometimes when you are making scale drawings and models you have to change some of your measurements from one unit of measure to another so you can use your scale. Card 8 tells you more about this.

WORKING WITH MEASUREMENTS

Think about the scale 1 inch ⟷ 1 yard. In order to use the scale you will want all your measurements to be in yards.

What will you do if you measure things in yards but have feet and inches left over?

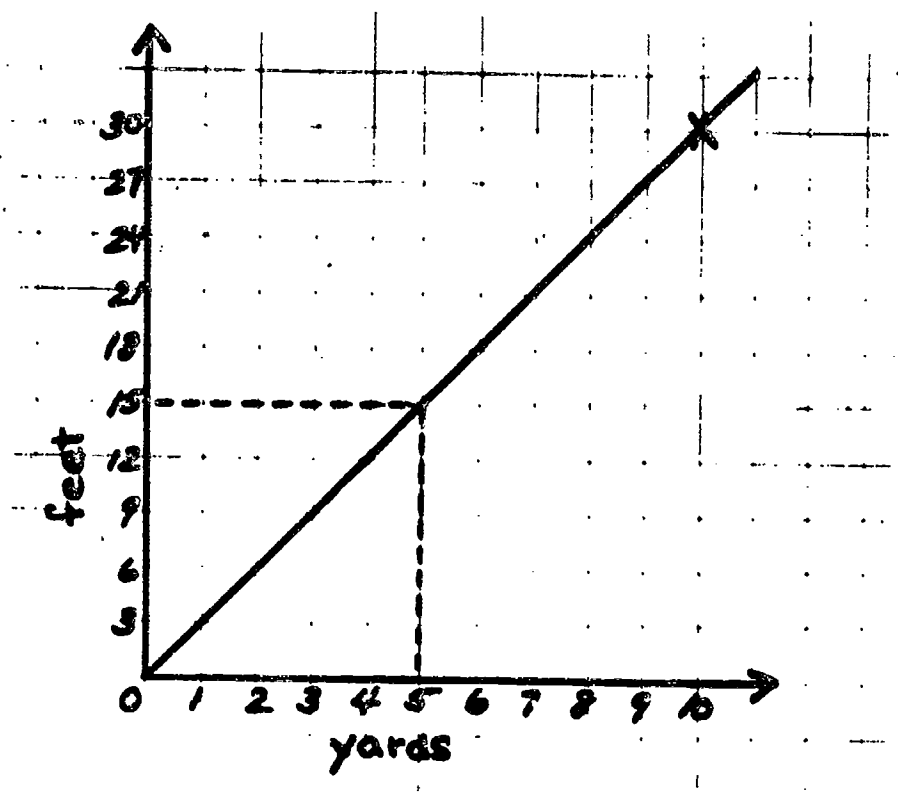
One easy answer is to measure to the nearest yard and forget about what is left over. Or you can change the feet and inches left over to fractions of yards. Then put the fractions of yards on the scale drawing as fractions of inches.

Think about the scale 1 inch ⟷ 4 yards. What will you do if you are using that scale and have feet and inches left over? You have the same two choices, but now if you try to put in the feet and inches left over, they will go on the scale drawing as very small fractions of inches. Because each inch now stands for 4 yards, each fraction of a yard will be less than 1/4 inch. It will hardly show up. So in this case it would make sense to measure to the nearest yard and forget about what is left over.

Think about this after you choose your scale and before you do all your measuring. Your scale will help you decide whether you should measure to the nearest yard or foot or inch and forget about what is left over or whether you should try to put what is left over in the drawing.

CONVERSION GRAPHS

Think about the scale 1 inch ⟷ 1 yard again. Suppose some of your measurements are in feet or inches or both instead of yards. You will have to change them to yards to use the scale. You will have to use the rules to change them. You can use the rules to make a conversion graph. A conversion graph is a straight line graph that can be used to change from one unit of measure to another. Look at the picture. You can use this graph to change from yards to feet or from feet to yards.



Card 10 tells you how to make and use a conversion graph.

MAKING AND USING CONVERSION GRAPHS

This is how to make a conversion graph. Look at the picture on Card 9.

Draw a graph form like the one in the picture. Divide each line into equal parts. Label the bottom line "yards" and number each part counting by 1's. Label the side line "feet" and number each part counting by 3's. You count by 1's and 3's because 1 yard = 3 feet.

Using the rule 1 yard = 3 feet, put an easy point on your graph. For example, draw a light line straight up from 10 yards and another light line straight over from 30 feet. Put an "X" where the two lines meet. Draw a dark straight line from that "X" to the zero corner of the graph form.

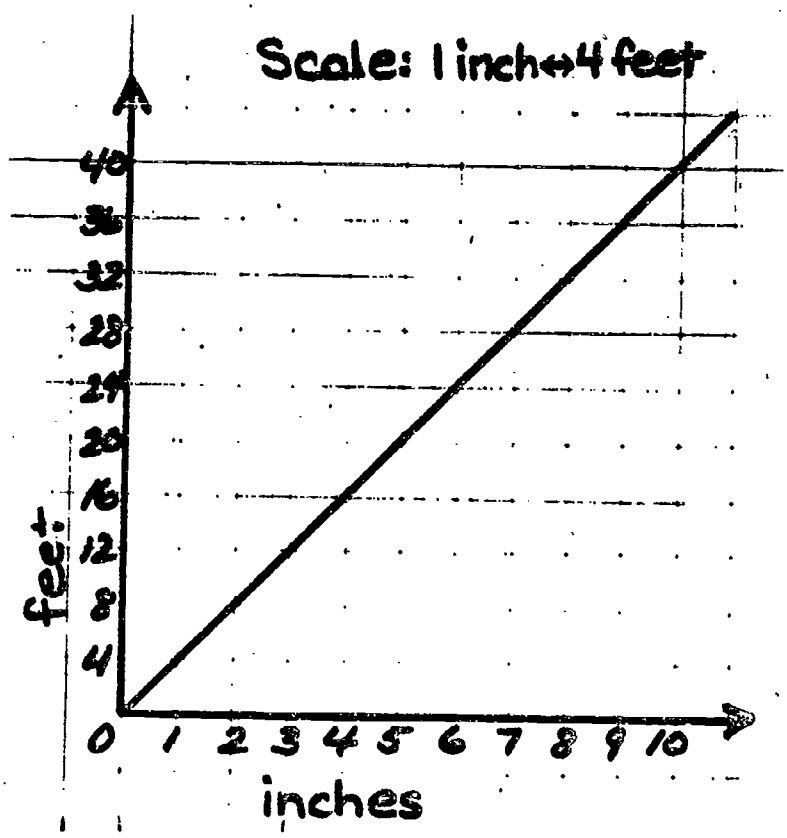
Now you can use the graph to change from yards to feet or from feet to yards. You trace a line up from a number on the yard line until you reach the dark line. Then you change direction and trace a line over to the feet line. The number of yards you begin with equals the number of feet you end with. You go the other way to change from feet to yards. Look at the dotted lines on the picture. They show how to change from 5 yards to 15 feet or from 15 feet to 5 yards.

You can make other conversion graphs to change from yards to inches and back again or from feet to inches and back again.

USING CONVERSION GRAPHS FOR SCALES

You can also make a conversion graph for a scale. Instead of setting it up to change from one unit of measure to another, you set it up to change from real distances to scaled distances using a scale.

Look at the picture. It shows a conversion graph for the scale 1 inch ↔ 4 feet.



You use this graph the same way you use the other conversion graph. See Card 10.

Make a conversion graph for your own scale.

MAKING A SCALE DRAWING

To make a scale drawing:

1. Measure the length and width of the area you want to make the scale drawing of.
2. Choose your scale and your paper.
3. Decide what tools to use to measure all the things you want to put in the drawing. Your scale will help you decide what tool to use. See the "How To" cards on choosing measuring tools for more about this.
4. Use your chosen tools to measure the things you want to put in.
5. Use your scale to change the real distances you have measured to the smaller or larger distances you will use in the drawing.
6. Draw or cut out the things you want to put in using the scaled measurements.

MAKING SCALE MODELS

There is one big difference between making scale drawings and making scale models. When you make scale drawings you work with lengths and widths. When you make scale models you work with lengths and widths and heights.

Sometimes when you make scale models you need to know the height of tall objects which you can't measure straight up because they are too tall or hard to get at. If you need help finding the heights of things like that, see the "How To" cards on finding the height of a building or a tree.

Once you get your measurements you work with heights the same as you work with lengths and widths. You use your scale to figure out how long and wide and tall to make things and where to place them. Then you build them and place them.

"How To" Cards

HOW TO MAKE TRIANGLE DRAWINGS TO COMPARE FRACTIONS (OR RATIOS)

An Outline of the Problem

A ratio compares two numbers or measurements. It is a fraction. Sometimes you need to compare two or more fractions or ratios.

For example you may need to know if a person is long-legged or short-legged. You have to be careful because a person can be tall and have long legs. But he may not look long-legged because the rest of his body is also long.

To find out if a person is long or short-legged you need to do 3 things.

1. Make two measurements on each person, leg length and trunk length (distance from shoulders to top of legs).
2. For each person make a ratio

$$\frac{\text{trunk length}}{\text{leg length}}$$

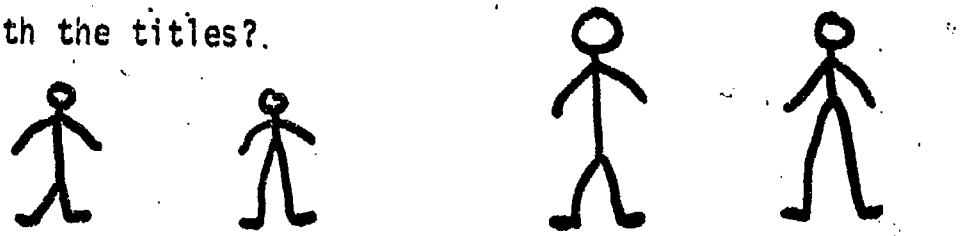
3. Compare each person's ratio with one another.

Other ratios can be compared in this way. If you made a ratio $\frac{\text{dollars}}{\text{pounds}}$ for each food item in the food store you could compare the ratios for the different food items in the store.

This set of cards tells you how to make triangle drawings to compare ratios.

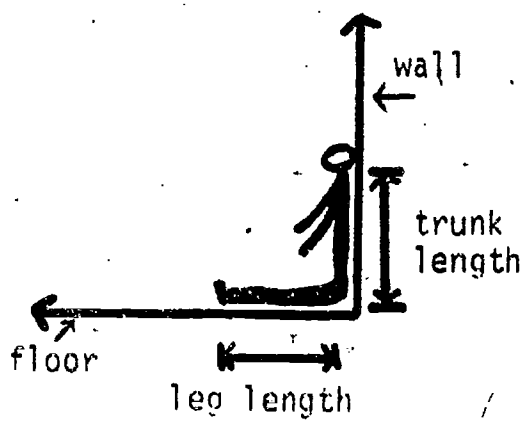
Picturing Two Measurements

How do you decide a person was short-legged or long-legged? One way is to look at the person to see how long his legs are compared to the rest of his body. Look at the stick people below. Do you agree with the titles?



short-legged child | long-legged child | short-legged adult | long-legged adult

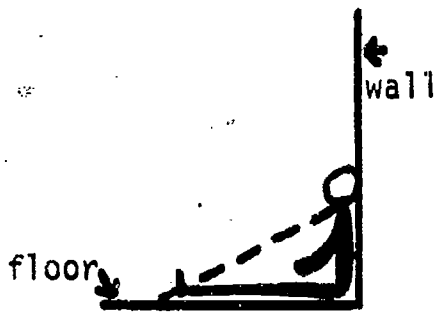
A better way to find out if a person is short-legged or long-legged, would be to measure both the leg length and the length of a person's trunk (distance from shoulders to top of legs). An easy way to measure is to have him sit on the floor with his back against a wall. Look at the picture below.



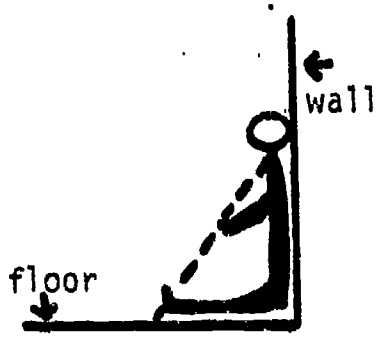
You can measure the two distances with a ruler or a yardstick. Put all your measurements and drawings in a folder. (Card 12 tells you how to make a folder.)

Comparing People's Measurements

To tell if a person is long or short-legged pretend there is a line drawn between his shoulders and his feet. Look at the dotted lines in the pictures below. The dotted line makes a triangle. How steep it is tells you whether he is short-legged or long-legged.



long-legged person



short-legged person

Which dotted line is steeper...the one for the long-legged person or the one for the short-legged person?

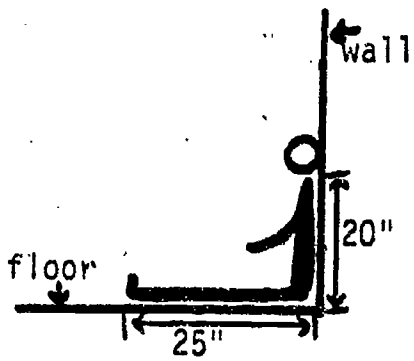
Would the line between shoulders and feet for a very short-legged person go up steeper, or be less steep?

Measure the trunk length and leg length of several friends as they sit against a wall. Do you think they are short-legged or long-legged?

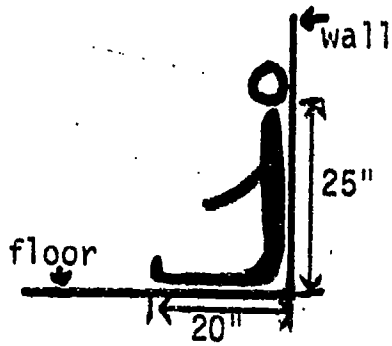
Comparing People's Measurements by Making Scale Drawings

You can compare people's measurements by making scale drawings. Let's say we have three people's measurements. Look at the pictures below.

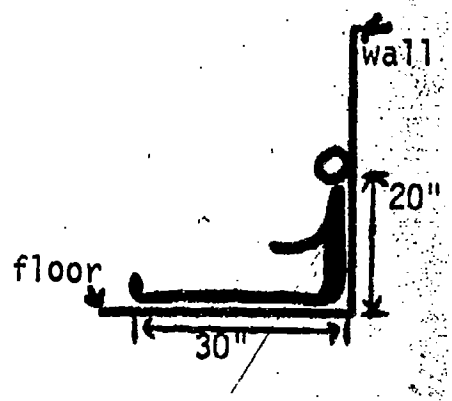
1st child



2nd child



3rd child



To make a scale drawing:

1. Get some graph paper.
2. Decide on a scale for your drawing. For example, let's say the scale of one square on the paper stands for 2" on the real measurements. If you need help deciding on a scale, see "How to Make Scale Drawings or Models."
3. Draw the leg length of the 1st child on a line at the bottom of the paper. Use your scale (1 square stands for 2"). Is your line 12 1/2 squares long?

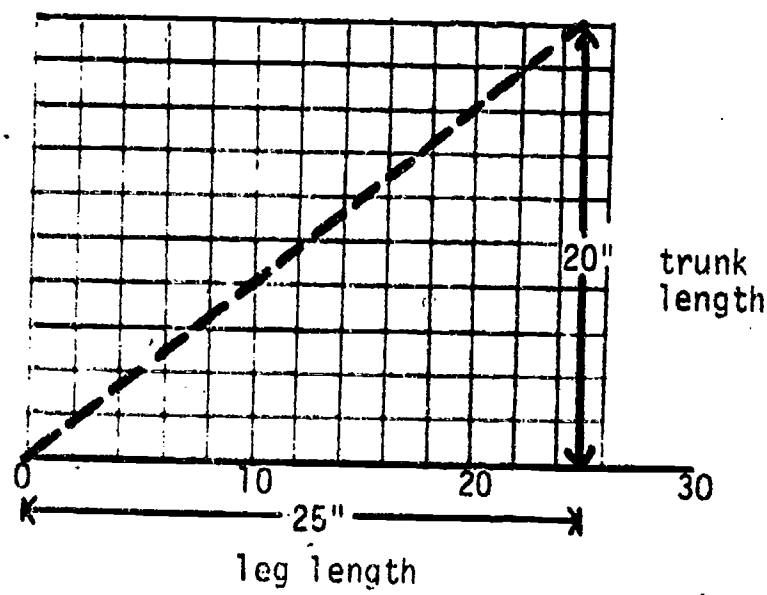
Go on to Card 5.

More About Making a Scale Drawing

4. At the right end of the leg length line draw the trunk length line up and down. Don't forget your scale (1 square stands for 2"). Is your line 10 squares high?

5. Now make a triangle by drawing a dotted line from the top of the trunk length line to the left end of the leg length line.

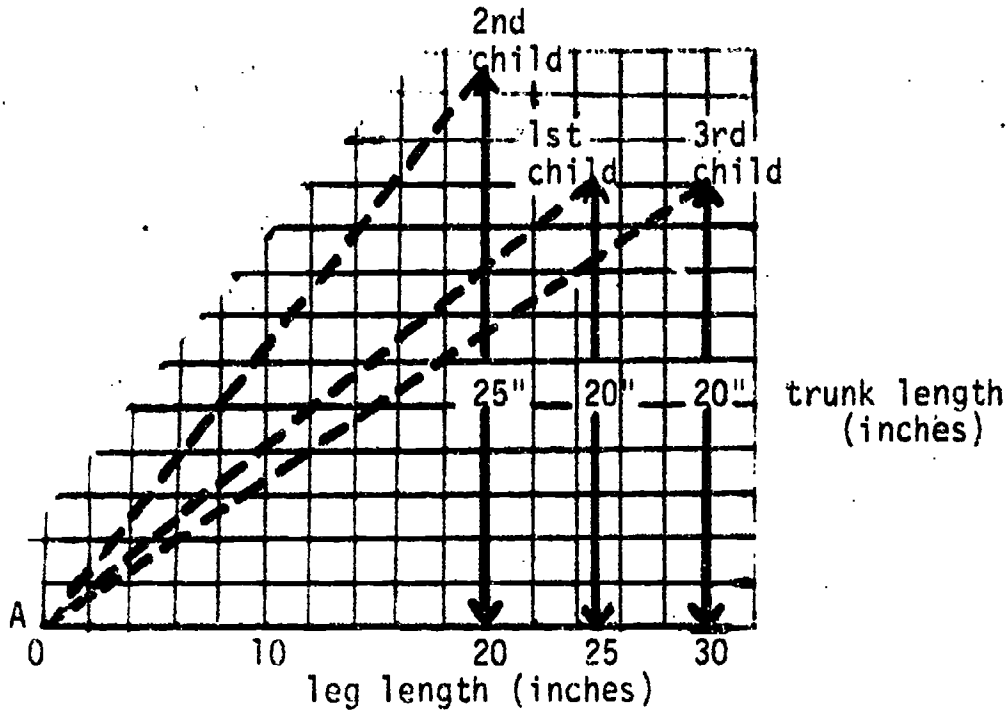
Look at the picture below. It shows the 1st child's measurements. The steepness of the dotted line in the triangle shows you if the person is long-legged or short-legged.



Can you tell if the 1st child is short-legged or long-legged?

Finding Comparisons from Scale Drawings

Sometimes it is hard to tell if a person is short-legged or long-legged. You need to compare the measurements of several people to decide if a person is long-legged or short-legged. The other two children's measurements can be added to your drawing on Card 5. Look at the triangles in the pictures below.



In each triangle how steep the dotted line is shows you if a person is long-legged or short-legged. Which child could be called short-legged? Which child could be called long-legged? Look at the pictures on Card 3 if you are not sure.

Ratios

The triangles you have been drawing for each person show his measurements as a ratio.

A ratio is a fraction. It compares two numbers. The top part of the fraction is called the numerator. The bottom part is called the denominator.

$$\frac{\text{numerator}}{\text{denominator}}$$

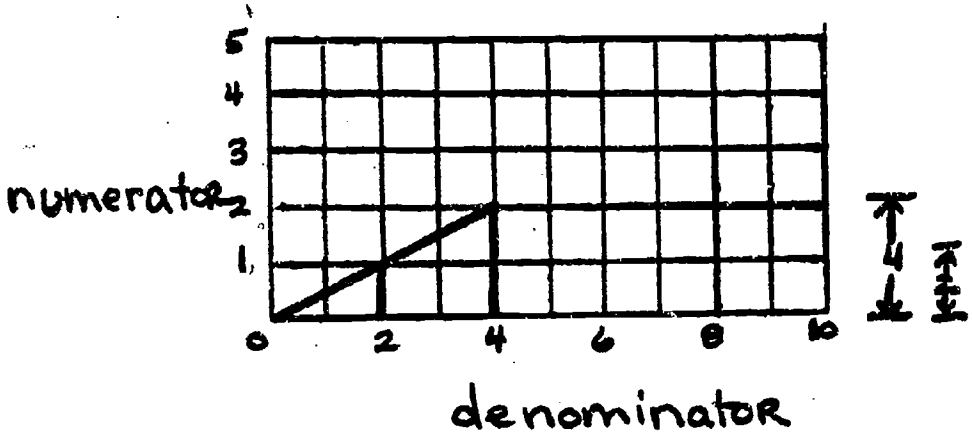
A ratio compares two measurements. The ratio on your drawings can also be shown this way: $\frac{\text{trunk length}}{\text{leg length}}$

The 1st child's $\frac{\text{trunk length}}{\text{leg length}}$ ratio is $\frac{20"}{25"}$. (See the drawing on Card 6.)

What would the 2nd and 3rd child's $\frac{\text{trunk length}}{\text{leg length}}$ ratio be?

Finding Equal Ratios

Ratios can be equal even if the numerators and denominators are different. By drawing ratios you can tell if they are equal. Let's take the two ratios 1/2 and 2/4. The drawing below shows both ratios.



How can you tell if the ratios are equal?

Hint: Does the line making each a triangle have the same steepness?

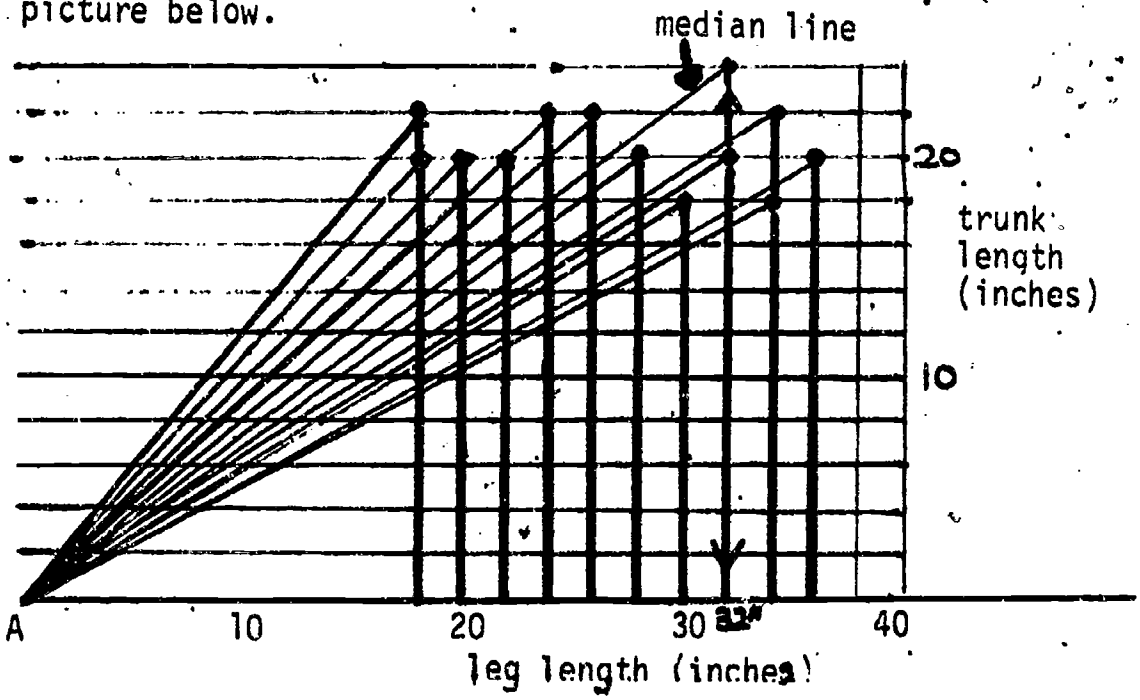
Look at the drawing again. Can you find other ratios that are equal to 1/2? See if you can make triangle drawings of other ratios you know are equal.

Finding the Median Ratio

If you have measured trunk length and leg length for several children, you may want to find the median ratio.

This would help you pick one size of clothing which would fit the "average" child.

You can make triangle drawings showing the ratios of your measurements of the different children. Thirteen ratios are shown in the picture below.



Can you find the median ratio? The middle or seventh line would be the median line. The median ratio is $\frac{24 \text{ inches}}{32 \text{ inches}}$. See the "How To" cards on medians if you need help finding the median.

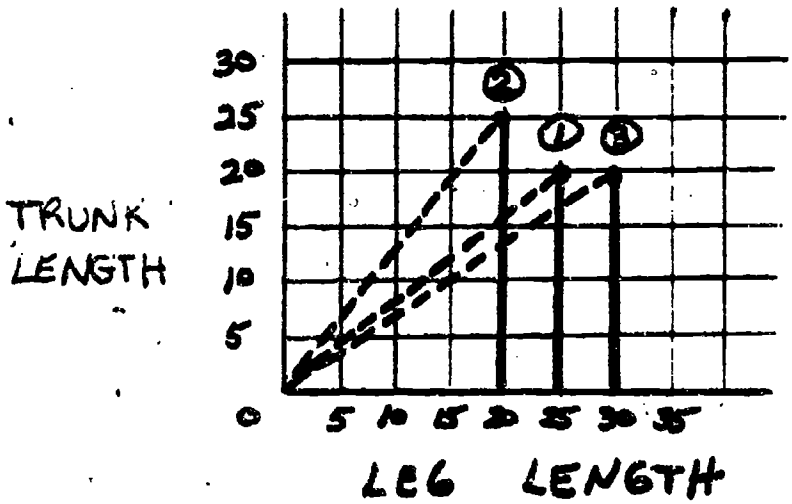
Children with lines steeper than the median could be called short-legged and children with lines less steep could be called long-legged.

Comparing Ratios

When you make triangle drawings of two or more ratios it is important that they are pictured the same way.

For example, the children's $\frac{\text{trunk length}}{\text{leg length}}$ ratios can be compared if they are all written like this: $\frac{\text{trunk length}}{\text{leg length}}$

The triangle drawings would look like this.



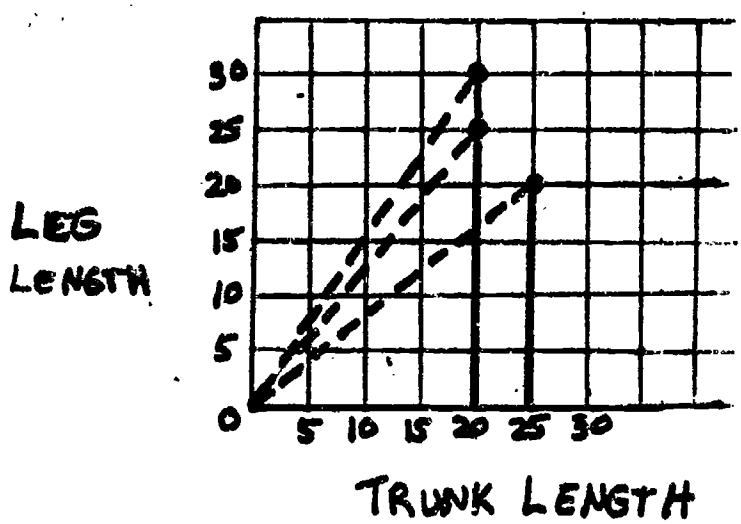
A steep line would show a short-legged person because the trunk length measurement is shown on the up and down line.

Now compare this drawing with the drawing on Card 11.

More On Comparing Ratios

The children's $\frac{\text{trunk length}}{\text{leg length}}$ ratios can also be compared if they are all written like this: $\frac{\text{leg length}}{\text{trunk length}}$

When the ratios are written like this, the triangle drawings would look like this.



How is this drawing different from the one on Card 10?

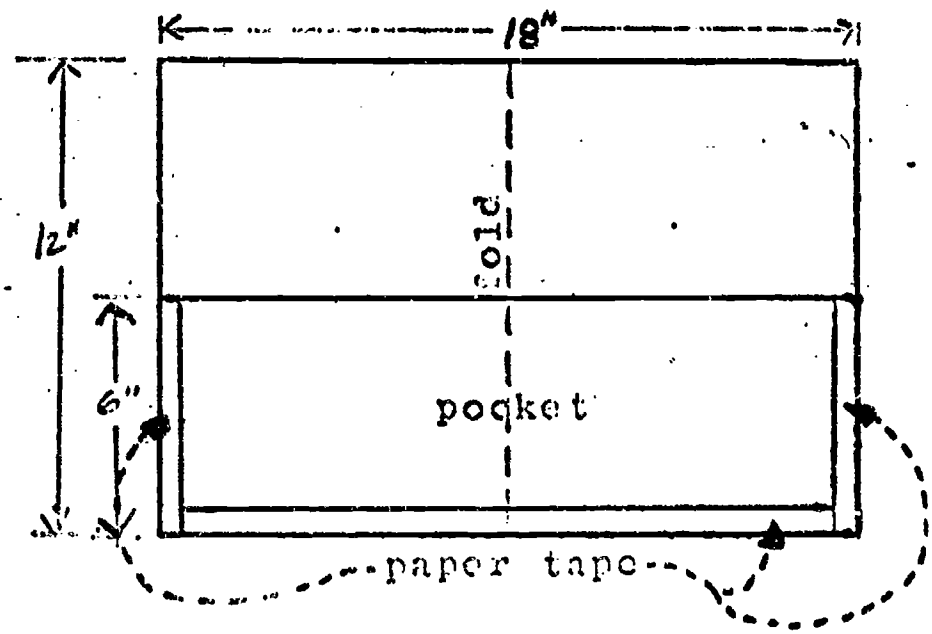
In this drawing a steep line would show a long-legged person because the leg length measurement is shown on the up and down line.

Making a Folder to Hold Drawings and Recorded Measurements

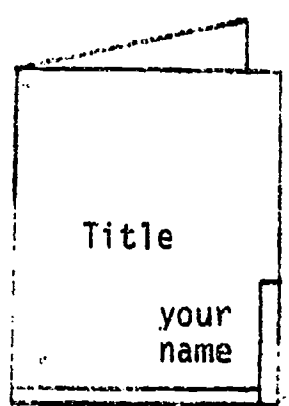
You will want to keep all your drawings and recorded measurements in a safe place.

You can make a folder by doing what it tells you below.

1. Cut a piece of construction paper so that it is 6 inches wide and 18 inches long.
2. Cut another piece so that it is 12 inches wide and 18 inches long.
3. Put the two pieces together with tape. Look at the picture below.



4. Fold in the middle so that the pocket is on the inside.
5. Put the title and your name on the front cover. Look at the picture.



"How To" Cards

HOW TO FIND THE MEDIAN OF A SET OF DATA

(revised July, 1972)

What the Median Is

(If you don't understand averages yet, see the "How To" cards on How to Find the Average of a Set of Data.)

If someone says the average height of a group of people in a class is 4 feet, 6 inches, you have an idea about the heights of people. Four feet 6 inches describes the height of the group. People in the group are about 4 feet, 6 inches tall.

If you think this way, you can sometimes be wrong. For example, if the teacher was included in the group, the heights might have been:

6 ft. 2 in.
4 ft. 3 in.
4 ft. 2 in. average height = 4 ft. 6 in.
4 ft. 0 in.
3 ft. 9 in.

One person in the group is much taller than the average height of 4 ft. 6 in. Four people are shorter than the average height. People in the group are not about 4 ft. 6 in. tall.

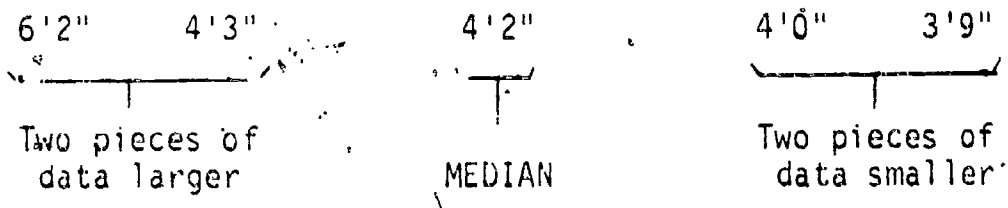
In this example, the data is off-center. The average does not describe the set very well. We can use the median to describe the set of heights instead of the average. The median is the middle piece of data in a set. Here the median will describe the heights of the group better than the average does.

Finding the Median

The median is the middle piece of data. There are as many pieces of data larger than the median piece as there are smaller than the median.

For example, on Card 1 the median height is 4 feet, 2 inches.

One way of finding the median is to list the pieces of data in order of size -- either the largest or the smallest first. Then find the middle piece of data. In the example we would make the list as follows:



The median height is 4 feet, 2 inches. The median 4 ft. 2 in. describes the set of heights.

What is the median in the following example? Attendance in class last week was:

Monday - 25 students
Tuesday - 20 students
Wednesday - 24 students
Thursday - 23 students
Friday - 3 students (it snowed on Friday)

Find the median attendance. Why is the median better than the mean in this case if you are planning school activities?

More About Finding the Median

You may have an even number of pieces of data such as:

4 sec., 9 sec., 13 sec., 16 sec., 17 sec., 22 sec.

In this example, there is no single piece of data in the middle, but 13 sec. and 16 sec. are the two middle pieces.

4 sec. 9 sec.	13 sec. 16 sec.	17 sec. 22 sec.
2 pieces smaller	2 middle pieces	2 pieces larger

To find the median add these two middle numbers together and then divide by two:

13 + 16 = 29

29 ÷ 2 = 14 1/2

The median is 14 1/2 seconds

For some sets of data, the two middle numbers may be equal or nearly equal. Then you don't need to find their average. Can you figure out why?

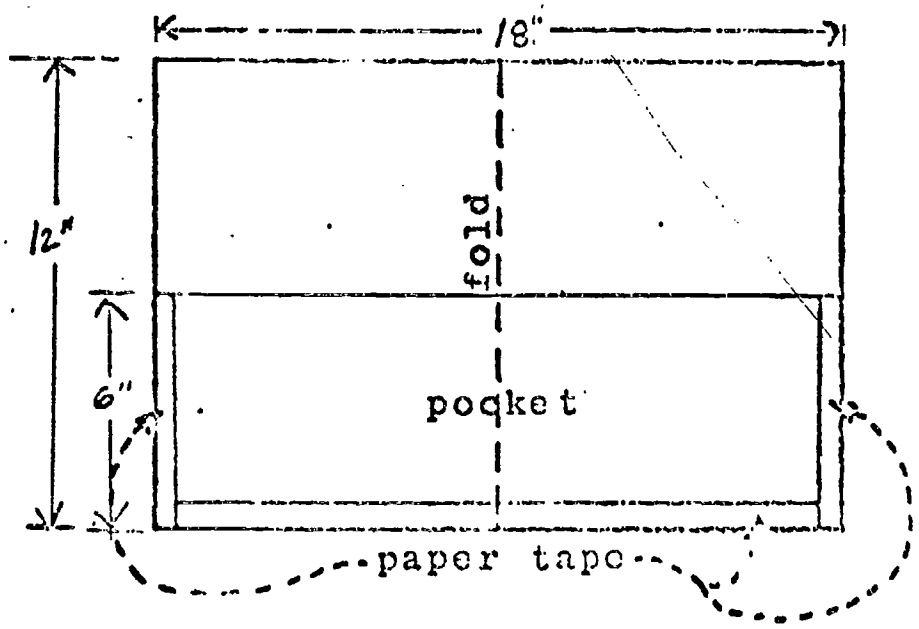
List your data in order of size and find the median piece of data.

You might want to keep the list of your data and the medians in a safe place. Card 4 tells you how to make a folder to hold your work.

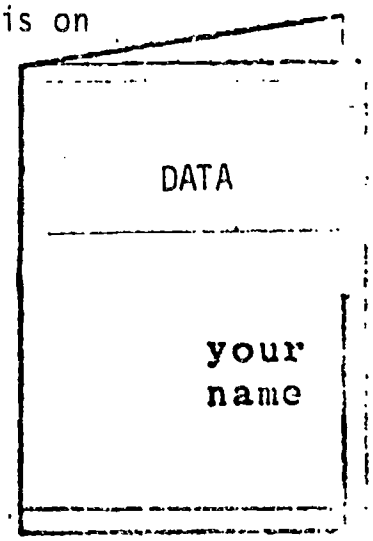
Making a Folder to Hold your Data

You can make a folder like this:

1. Cut a piece of construction paper so that it is 6 inches wide and 18 inches long.
2. Cut another piece so that it is 12 inches wide and 18 inches long.
3. Put the two pieces together with tape. Look at the picture below.



4. Fold in the middle so that the pocket is on the inside.
5. Your name and a title for your folder should be put on the front cover like this.



Comparing the Median and the Average

In the example on card 2, the data on attendance was:

Monday - 25 students

Tuesday - 20 students

Wednesday - 24 students

Thursday - 23 students

Friday - 3 students

The median is 23 students.

3 students, 20 students, 23 students, 24 students, 25 students

median

The mean is $\frac{3 + 20 + 23 + 24 + 25}{5} = \frac{95}{5} = 19$ students

Which number of students, 23 or 19, would you use to plan a bus trip, or seating in a lunch room? Would you ask for a bus that has exactly the median number of seats? Exactly the mean number of seats?

"How To" Cards

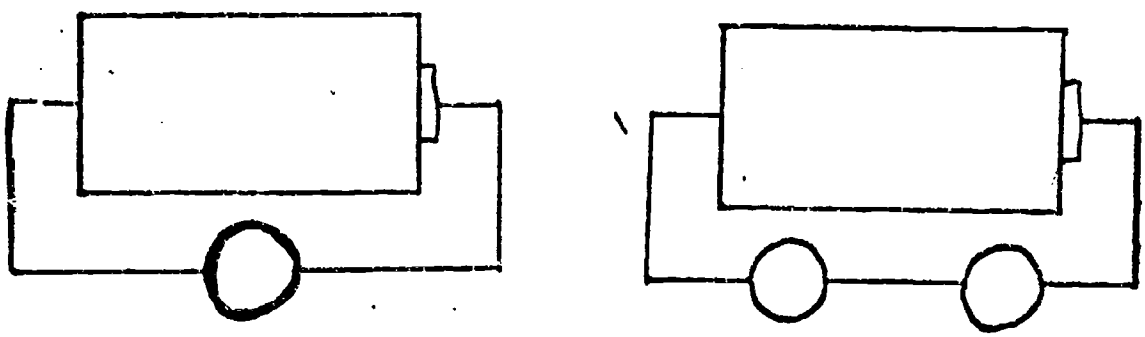
HOW TO CONNECT SEVERAL THINGS TO ONE SOURCE OF ELECTRICITY

(Revised July 1972)

Adding a Second Bulb in Series

You may want to add a second bulb or a buzzer to your circuit. These cards will show you several ways of doing it.

Build the two circuits in the pictures.* The second picture shows the bulbs connected in series.



Bulbs Connected in Series

What happens to the brightness of one bulb when a second bulb is added?

Can you think of a reason why this happens?

Find a way to connect the two bulbs so that they do not get dimmer.

Draw a schematic picture showing how you did it. (Card 2 tells you how to make a folder to hold your drawings.)

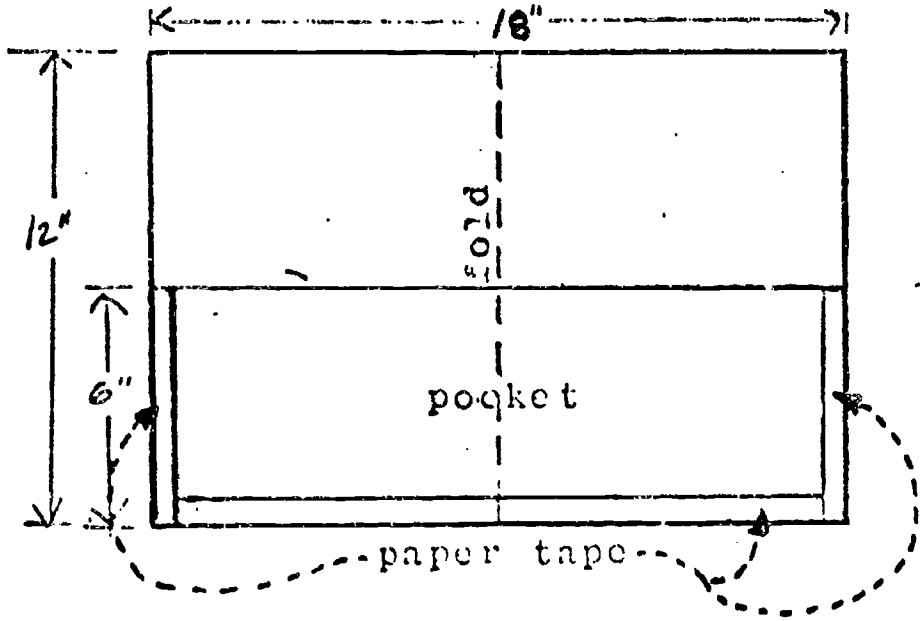
* In this set of cards schematics are used. See "How to Draw Electrical Things and Electric Circuits Quickly".

Making a Folder to Hold Drawings and Reports

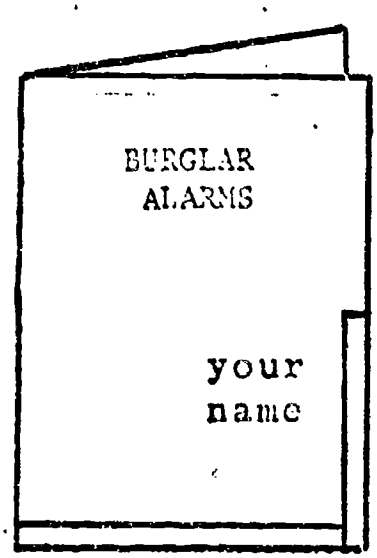
You will want to keep all your drawings and reports in a safe place.

You can make a folder by doing what it tells you below.

1. Cut a piece of construction paper so that it is 6 inches wide and 18 inches long.
2. Cut another piece so that it is 12 inches wide and 18 inches long.
3. Put the two pieces together with tape. Look at the picture below.

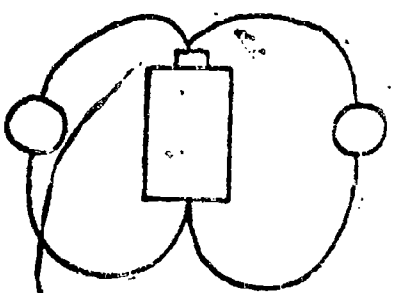


4. Fold in the middle so that the pocket is on the inside.
5. Put the title and your name on the front cover. Look at the picture.

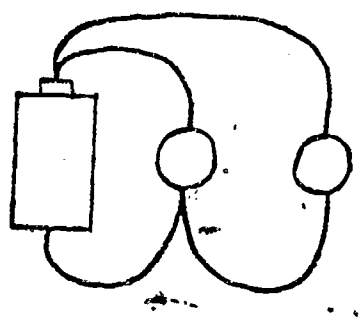


Adding a Second Bulb in Parallel

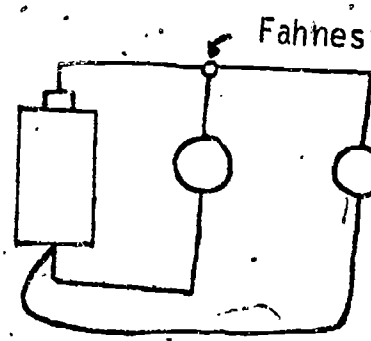
Does your drawing look like one of the pictures below? All the pictures show the bulbs connected in parallel.



Bulbs Connected in Parallel



Bulbs Connected in Parallel



Bulbs Connected in Parallel

Draw arrows in your picture to show how the electricity flows through one bulb.

Does the electricity have to go through one bulb to get to the second bulb?

Draw arrows on a picture of a circuit with bulbs connected in series (Card 1) to show how the electricity flows.

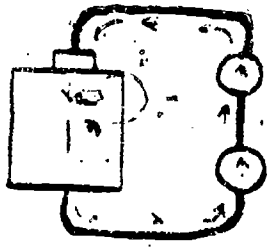
How are all the parallel connections the same? How are they different from the series connections?

Draw a second set of arrows to show how the electricity can go through the second bulb when two bulbs are connected in parallel.

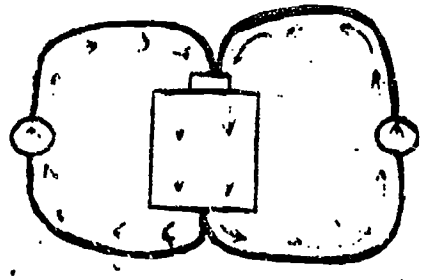
The Amount of Flow of Electricity through Circuits

Does your drawing (from Card 3) show several arrow paths through the battery?

Look at the pictures to see how the electricity flows in a series connection and in a parallel connection.



Bulbs Connected in Series



Bulbs Connected in Parallel

Any electrical gadget (bulb, buzzer, bell) reduces the amount of electricity in its path. The more gadgets in one path the less the amount of electricity. When two bulbs are in one path, they will be dim. They take only half the electricity from the battery as a one bulb circuit.

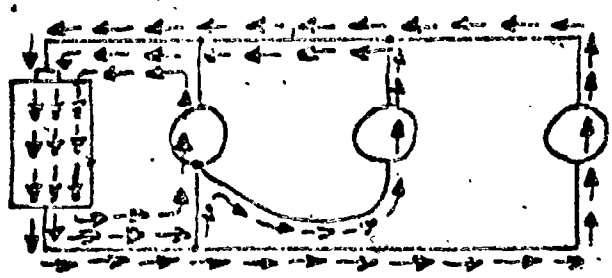
When two bulbs each have their own path (connected in parallel) they will be as bright as in a one bulb circuit. They take twice as much electricity from the battery as a one bulb circuit.

Putting Three Bulbs in Parallel

Can you connect three bulbs in a circuit with one battery so that they are all bright?

Draw a schematic picture that shows how you did it.

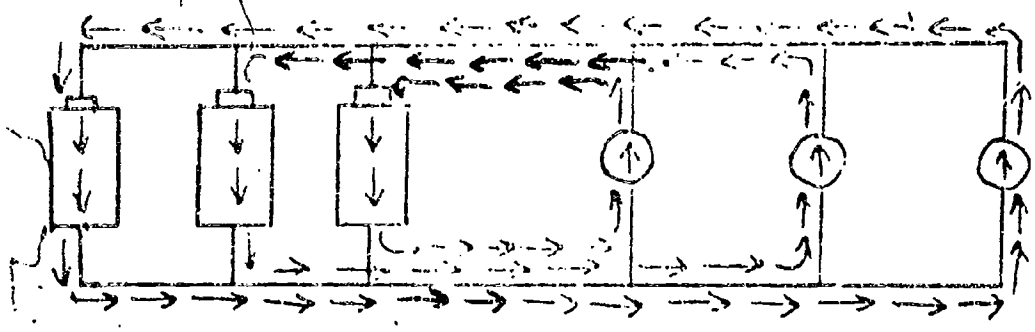
The picture below shows one way of doing it.



Electricity Paths from One Battery for Bulbs in Parallel

The bulbs may become dim quickly. The battery is using its electricity three times faster for three paths of electricity than for one path. (1 bulb circuit.)

You can connect three batteries in parallel as in the picture below to make extra electricity.



Electricity Paths from Batteries for Bulbs in Parallel

How would you add more batteries to make the bulbs even brighter?

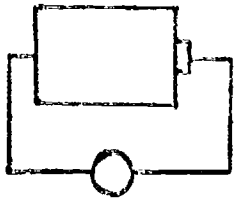
Making a Bulb Burn Brighter

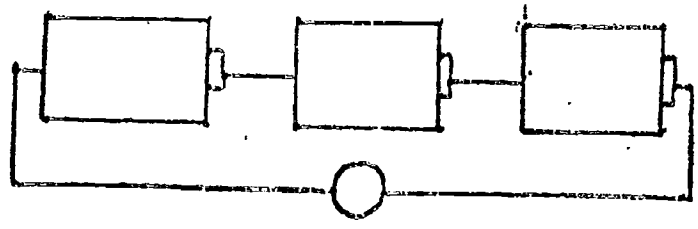
Sometimes if you have many electrical things in your circuit, they will not work right. The bulbs will be dim or the buzzer won't work.

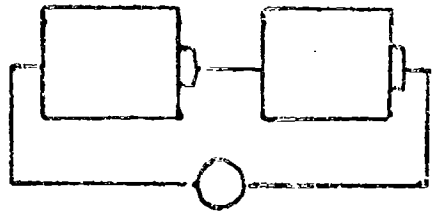
Can you think of a way to put more electricity in the circuit?

Look at the pictures below.

1. Which circuit will make a dim light?
2. Which will make a brighter light?
3. which will make the brightest light?







Build the circuits and find out if you were right.

When the same path of electricity goes through several batteries, they are connected in series. Draw arrow paths through your circuits to see if the batteries are connected in series. Caution: Too many batteries in series will burn out bulbs and other things.

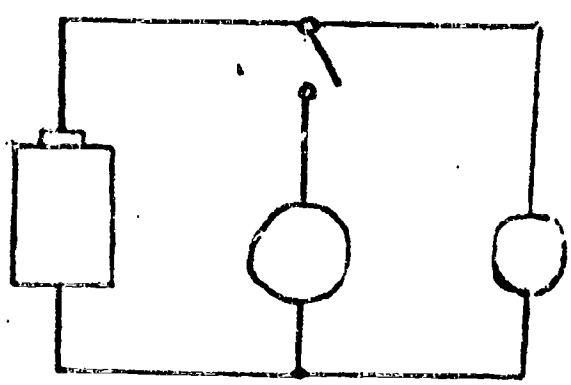
Working Two Bulbs One at a Time

Sometimes you may want to turn one bulb (or buzzer) on and off but have the other bulb stay on.

Connect a switch in a circuit with two bulbs and a battery so that it turns only one bulb off and on.

Draw a schematic picture that shows how you did it.

The picture below shows one way to do it.



On-Off Switch for Only One Bulb

Can you connect another switch in the circuit to turn the other bulb on and off?

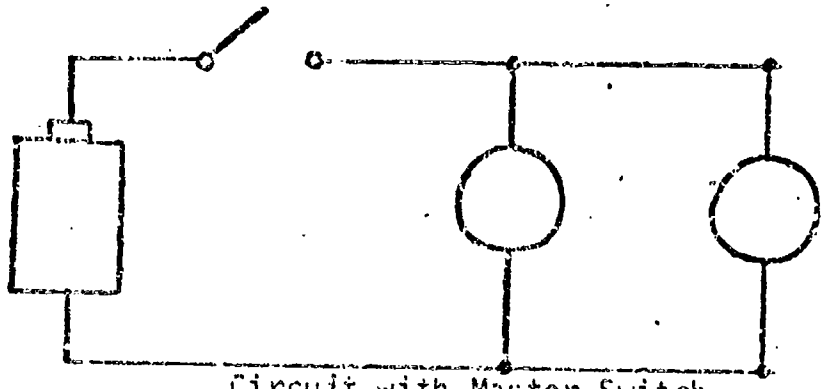
Using a Master Switch

A master switch turns all the bulbs in a circuit on and off.

Connect a switch to your circuit so that it turns both bulbs on and off.

Draw a schematic picture that shows how you did it.

The picture below shows one way to do it.



Circuit with Master Switch

Can you use some of the ideas from these cards in your burglar alarms?

"How To" Cards

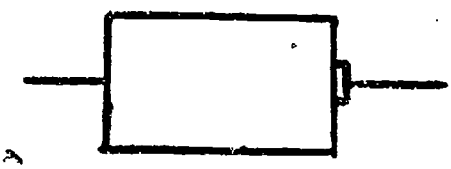
HOW TO DRAW ELECTRICAL THINGS AND ELECTRIC CIRCUITS QUICKLY

(revised July, 1972)

Unified Science and Mathematics for Elementary Schools

Schematics

It takes too much time to draw a bulb or a bell every time. Short quick pictures can be used instead to stand for the real thing. These quick pictures are called schematics. Look at the pictures below. They are schematic drawings.

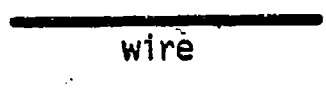


battery (in holder)

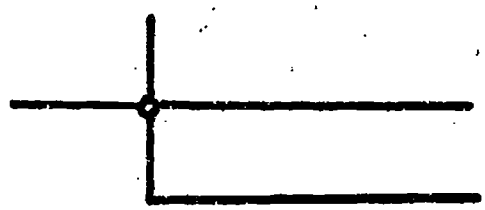
bulb (in socket)

bell or buzzer

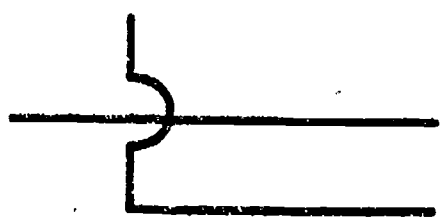
switch (open)



wire



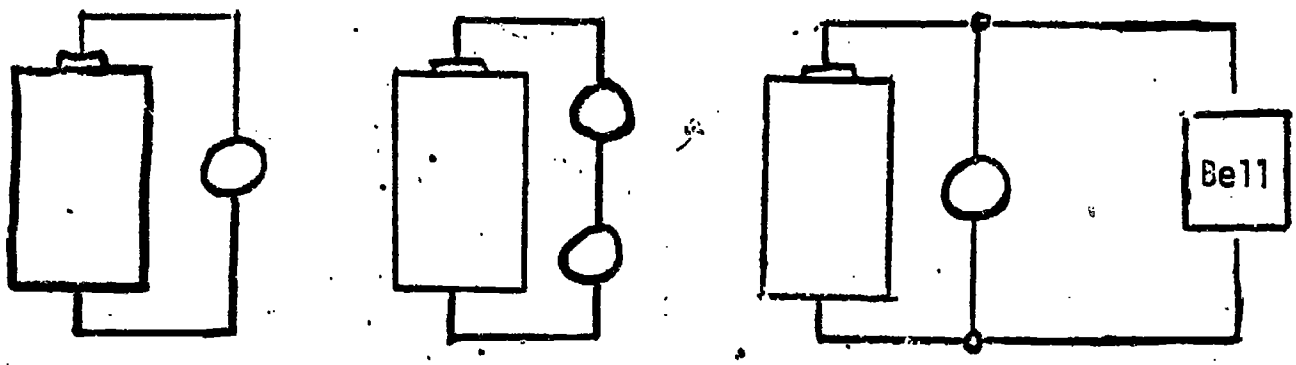
two wires connecting



two wires not connecting

Using Schematic Drawings to Design and Build Circuits

The pictures below are schematic drawings of three circuits.



Design and build a circuit of your own.

Can you design a circuit that could be a burglar alarm? See "How to Make a Simple Burglar Alarm."

Draw a picture of it using circuit schematics.

See Card 2 in "How to Make a Simple Burglar Alarm" to make a folder to keep your drawing in.

Dice Design Unit

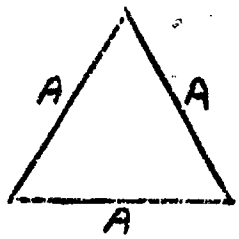
"How To" Cards

HOW TO DRAW EQUILATERAL TRIANGLES, SQUARES, AND REGULAR PENTAGONS USING DOT PATTERN SHEETS

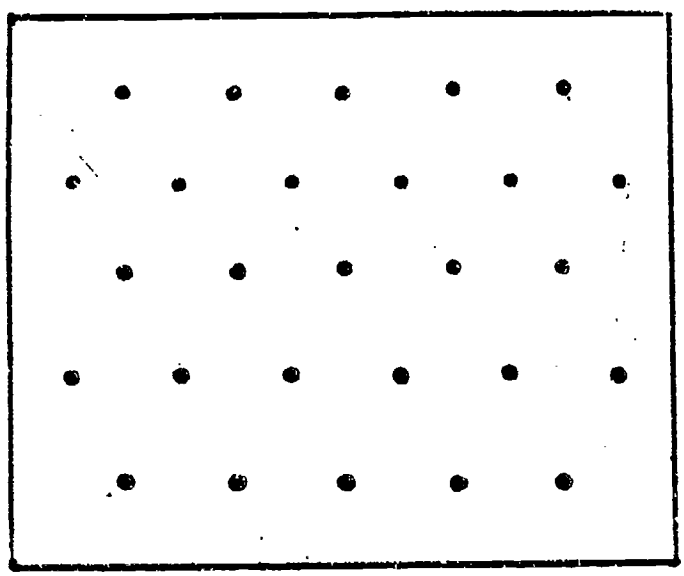
(revised July, 1972)

Drawing Equilateral Triangles

An equilateral triangle is a figure with three equal straight sides and three equal angles.



Ask your teacher for a large sheet of heavy paper which has dots on it like this:



Use a pencil and a ruler to draw straight lines between the dots so that equilateral triangles are formed.

Cut out one of the triangles. Can you fold it to check whether the angles are equal? If the angles are not equal maybe you have the wrong sheet. Or, maybe you connected the wrong dots.

Making Dice from Equilateral Triangles

Cut out some equilateral triangles and tape the edges together to form a solid shape. This solid shape is one kind of polyhedron.

Can you make different polyhedrons by making a different number of triangles meet at a corner?

Can you draw a pattern of several triangles on your dot sheet? Cut out your whole pattern. Make a polyhedron by folding some edges between the triangles. Tape the other edges together.

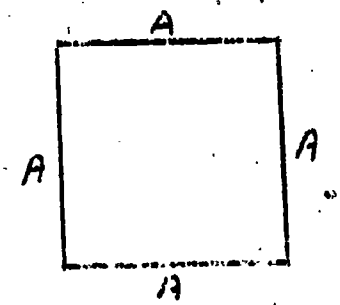
How many different polyhedrons for dice can you make using equilateral triangles for faces?

Can you connect the dots to make a figure that is not an equilaterial triangle?

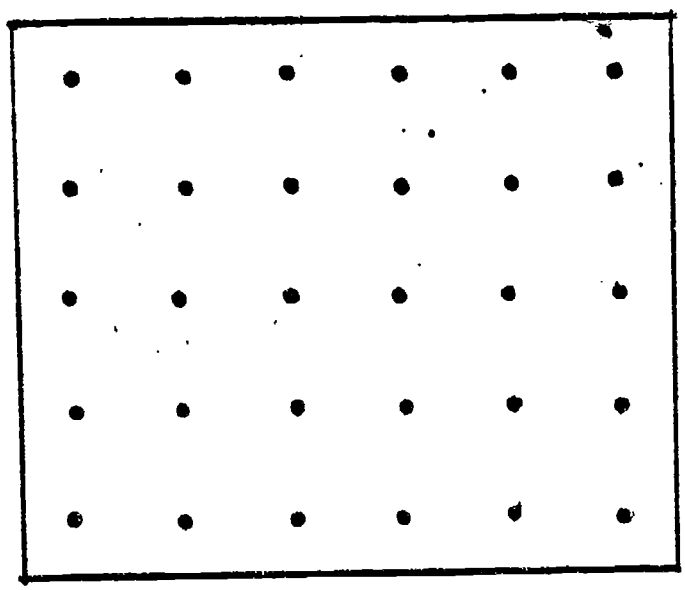
Can you make polyhedrons from this figure?

Drawing Squares

A square is a figure with four equal sides and four equal angles.



Ask your teacher for a large sheet of heavy paper which has dots on it like this:



Use a pencil and a ruler to draw straight lines between the dots so that squares are formed.

Cut out one of the squares. Can you fold it to check whether the angles are equal?

Making Dice from Squares

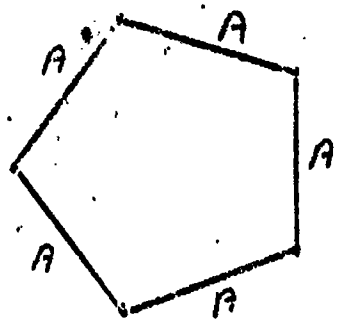
Cut out some squares and tape the edges together to form a solid shape. This is another kind of polyhedron.

Can you draw a pattern of several squares on your dot pattern sheet? Cut out your whole pattern. Make a solid shape by folding some edges between the squares. Tape the other edges together.

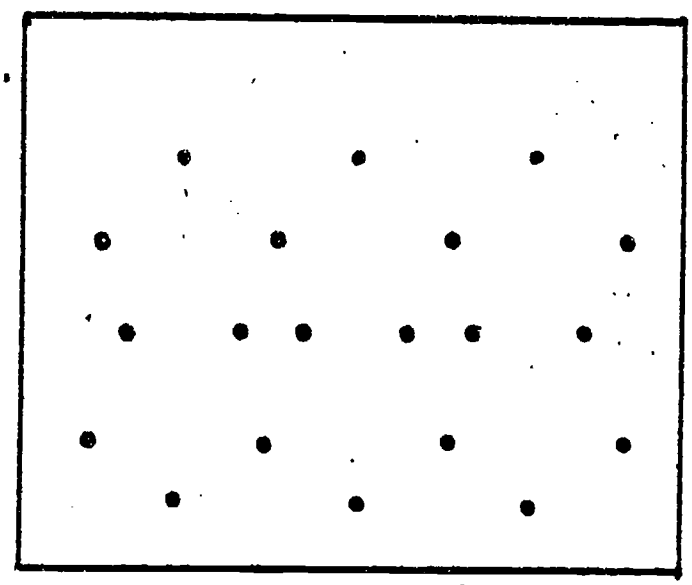
Can you make different polyhedrons for dice using squares as faces?

Drawing Regular Pentagons

A regular pentagon is a figure with five equal sides and five equal angles.



Ask your teacher for a large sheet of heavy paper which has dots on it like this:



Use a pencil and ruler to draw straight lines between the dots so that pentagons are formed.

Cut out one of the pentagons. Can you fold it to check whether the angles are equal? Can you use two pentagons to check if the angles are equal?

Making Dice from Regular Pentagons

Cut out some regular pentagons and tape the edges together to form a solid shape. This is another kind of polyhedron.

Can you draw a pattern of several pentagons on your dot pattern sheet? Cut out your whole pattern. Make a polyhedron by folding some edges between the pentagon. Tape the other edges together.

Can you make different polyhedrons for dice using pentagons as faces?

Making Dice from a Mixture of Triangles, Squares and Pentagons

Try making different polyhedrons by using a mixture of your figures.

Do you think that these polyhedrons could be used for fair dice in games?

"How To" Cards

HOW TO CONSTRUCT AN EQUILATERAL TRIANGLE

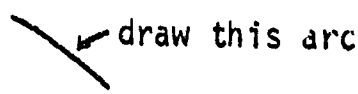
Unified Science and Mathematics for Elementary Schools

An equilateral triangle has three equal sides and three equal angles.

Needed: pencil
paper
ruler
pencil compass
old magazine

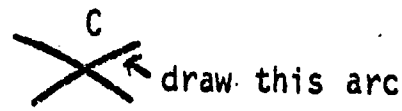
Place a magazine under the paper. With a ruler you can draw a line segment AB 2 inches long*.

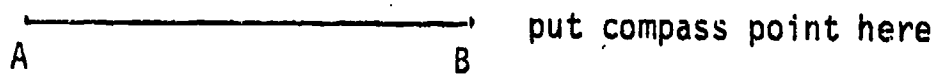
Using a pencil compass place the compass point at A and the pencil point at B. Being careful not to change the distance between the compass point and the pencil point, draw a curve (arc) above the middle of the line.



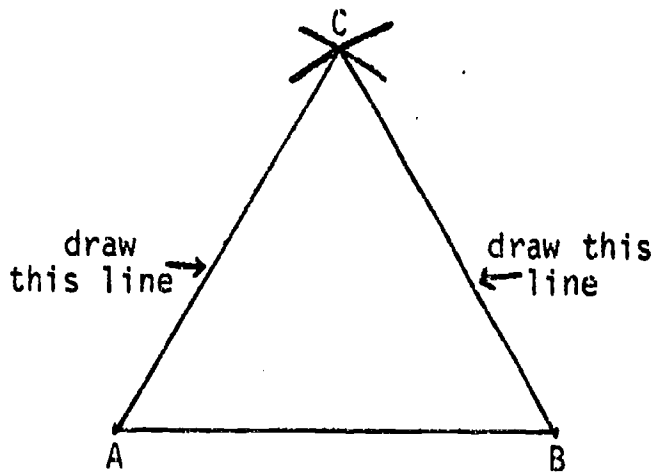
*The segment should be the length you want for a side of the triangle. The length of side should be the same for all polygons.

Without changing the way the compass is set, place the compass point on B and draw a second arc crossing the first one. Label the crossing point C.





With a ruler draw a line from A to C and a line from B to C.



How many sides does an equilateral triangle have? Are the sides equal? How many angles does it have? Are the angles equal? Check the sides and angles by cutting out the triangle and folding it in different ways.

"How To" Cards

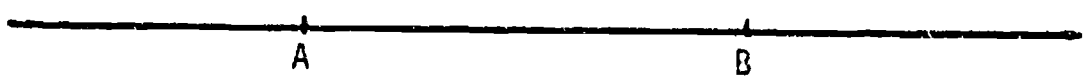
HOW TO CONSTRUCT A SQUARE

A square has four equal sides and four equal angles.

Needed: pencil
paper
ruler
pencil compass
old magazine

Place the magazine under the paper. With a ruler draw a line across the paper.

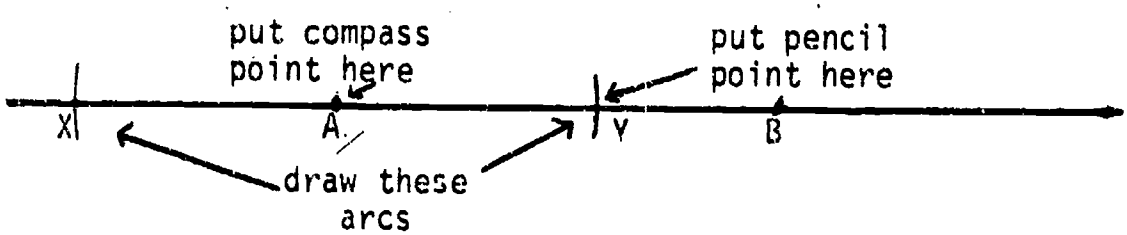
Mark off, near the center of the line, a line segment AB 2" long*.



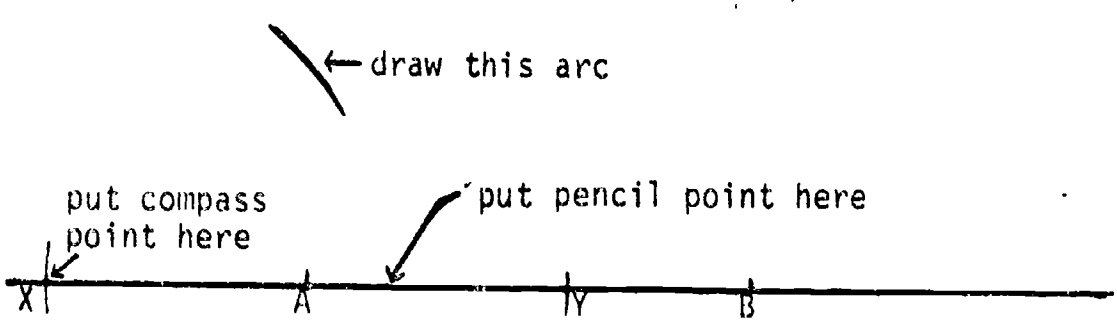
*The segment should be the length you want for a side of the square. The length of side should be the same for all polygons.

To construct a right angle at A, do what cards 2 and 3 tell you. (If you already know how to construct a right angle, skip to card 4.)

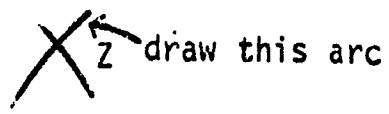
Using a pencil compass, put the compass point on A and the pencil point at any other point on the line between A and B. Draw two arcs which cross the line and label the crossing points X and Y.

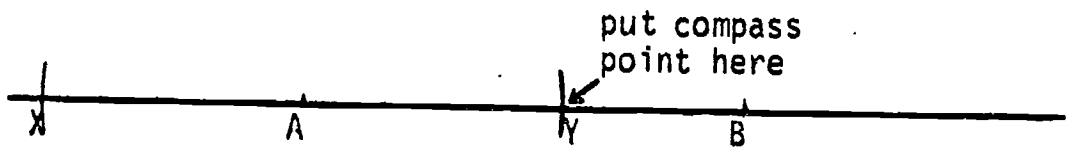


Now put the compass point on X and the pencil point on any point between A and Y and draw an arc above point A.

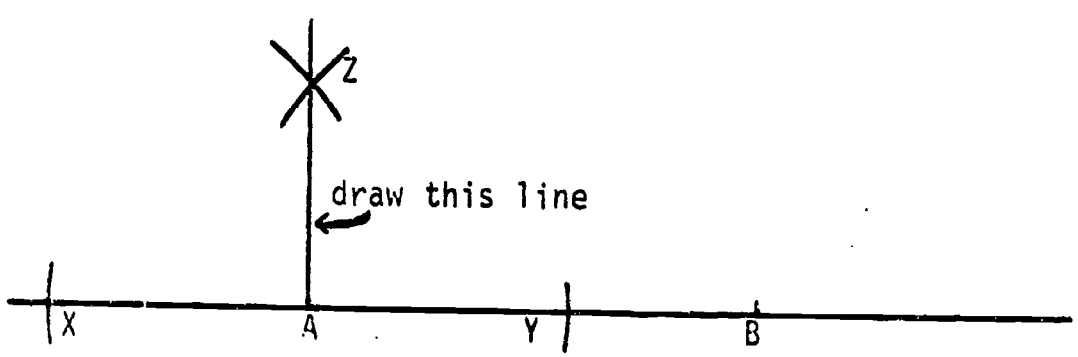


Keeping the same setting on the compass, put the compass point on Y and draw an arc which crosses the first arc. Label the crossing point Z.



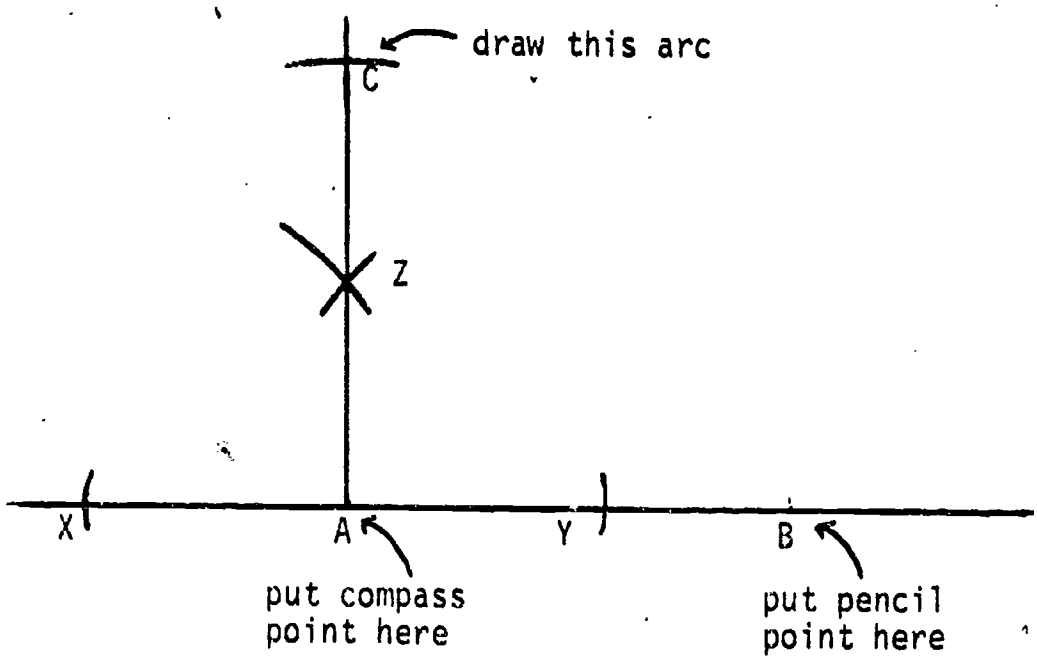


With a ruler draw a line from A through Z. This line makes a right angle with line AB.

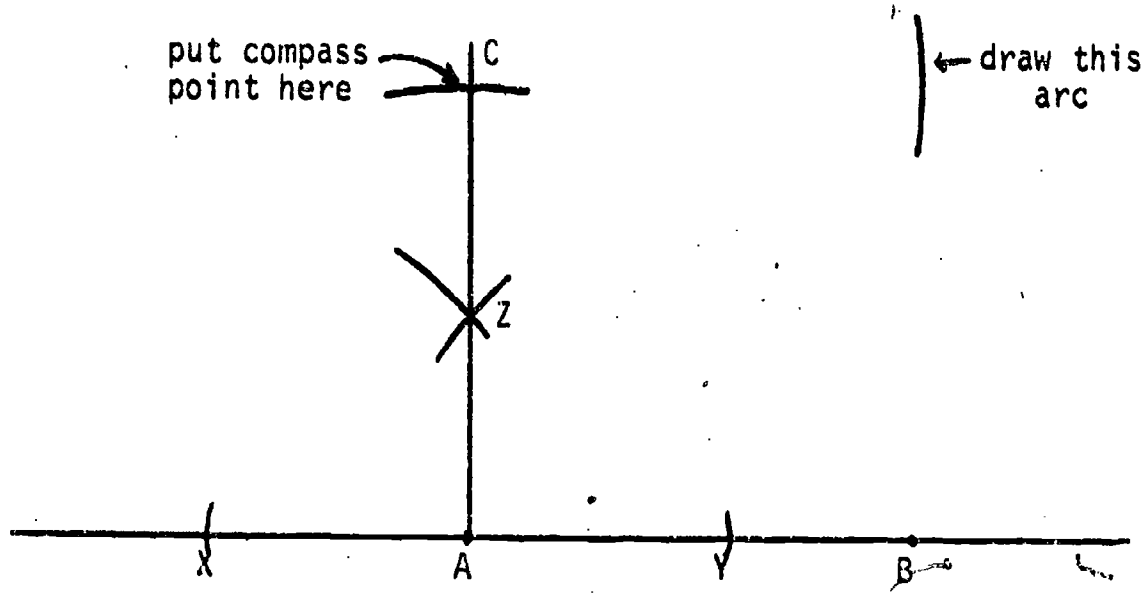


Using the compass, put the compass point on A and the pencil point on B.

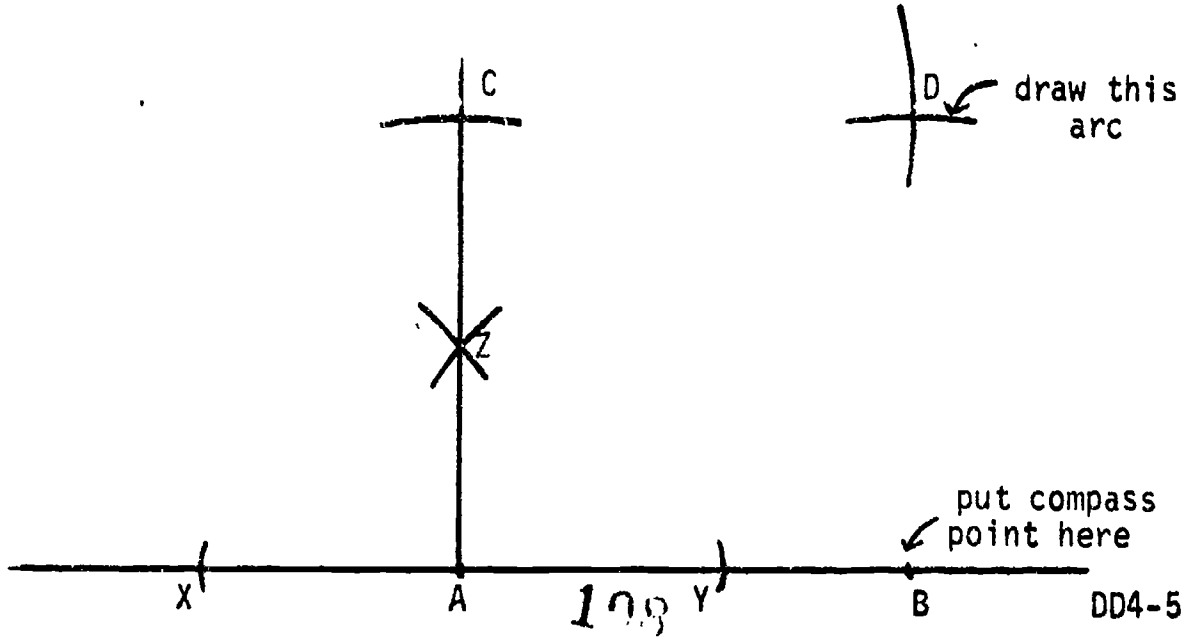
Draw an arc crossing line AZ. Label the crossing point C.



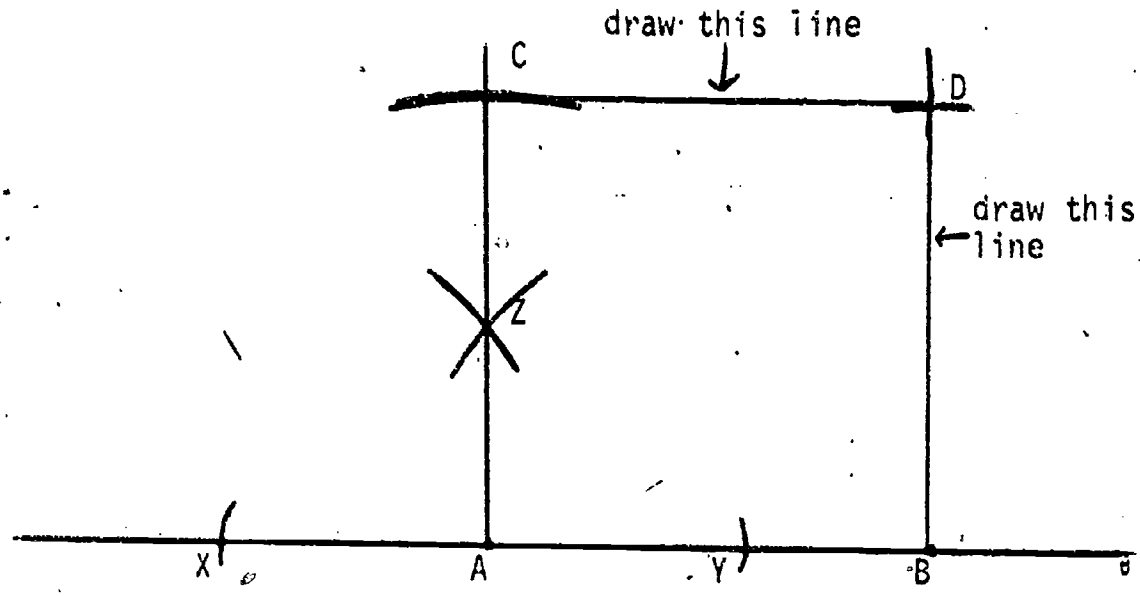
Keeping the compass set the same way, put the compass point on C and draw an arc above B.



Without changing the way the compass is set, put the compass point on B and draw an arc crossing the last arc. Label the crossing point D.



With a ruler draw lines from C to D and from D to B.



How many sides does a square have? Are the sides equal?

How many angles does a square have? Are the angles equal?

Check the sides and angles by cutting out the square and folding it in different ways.

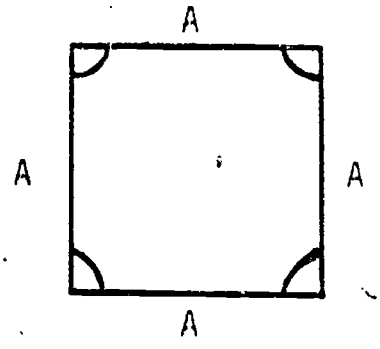
"How To" Cards

HOW TO MEASURE ANGLES
(Revised July 1972)

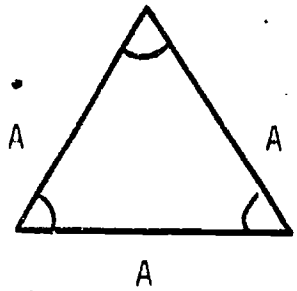
Angles Measure the "Corners" of Figures

A good way to describe the shape of a figure is to tell about its "corners" or angles.

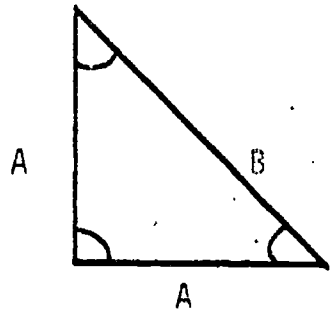
Look at the figures in the picture.



Square



Equilateral Triangle



Right Isosceles Triangle

Squares have four equal sides. Equilateral triangles have three equal sides. Isosceles triangles have two equal sides.

What can you say about the angles of the figures?
Use some precut figures to compare the angles. If you don't have precut figures, you can make your own figures. You can use "How To" Cards to find out how to draw squares and equilateral triangles. How can you make a right isosceles triangle from a square?

111

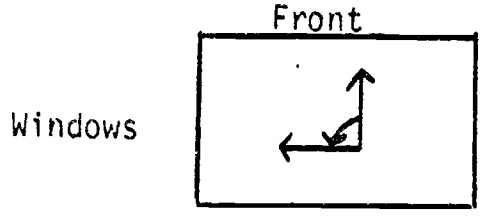
Which angles in the figures in the pictures are the largest? Which are the smallest? Which are in between in size?

Angles Measure the Amount of Turn

An angle is a measure of the amount of turn a pointer makes when the end of it moves from one point to another.

For example:

Point your arm toward the front of the classroom. Now move your arm until it points toward the windows. The angle between the two positions is a measure of the amount of turn. Look at the picture.



Measuring Angles

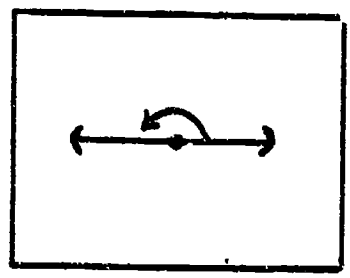
How can you make an instrument which measures angles?

Draw a sketch of your idea and construct your instrument in the Design Lab.

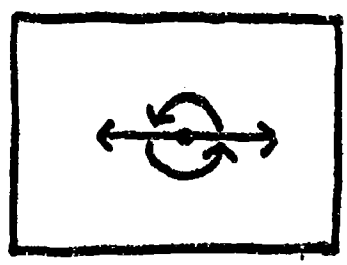
If you need help in designing an instrument, see Card 4.

The Straight Line Angle

Point your arm toward one wall. Now move your arm until it is pointing toward the opposite wall. The two spots you pointed at are on the same straight line. Look at the picture.



If you move your arm around so it points toward the first wall again you make a complete circle. Look at the picture.



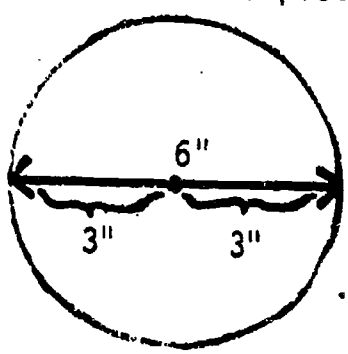
What part of a whole turn is the angle of a straight line?

How many half turns are in a whole turn?

Marking Right Angles on a Protractor

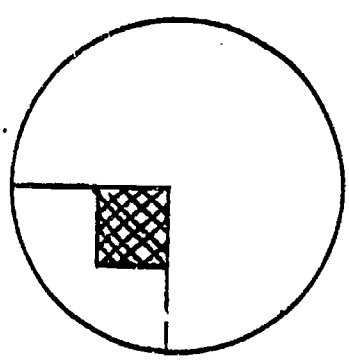
One instrument which will help you measure angles is called a protractor. The next few cards explain how to make a protractor.

First, cut out a circle about 6" in diameter. Put a dot in the center of the circle. Look at the picture.



Then find some squares or rectangles - shapes that have 4 equal angles. Make sure that the angles are equal.

Place the tip of one square at the center of the circle. Look at the picture.



Place the tips of other squares at the center of the circle, so the squares just touch each other. Do not put the squares on top of each other.

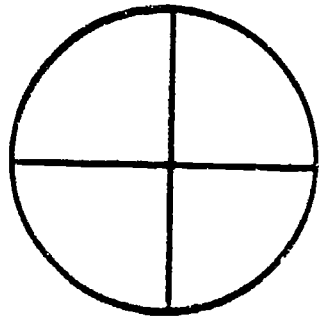
How many corners of squares fit together at the center of the circle?

Draw lines on the circle along the edges of all the squares. Draw the lines all the way out to the edge of the circle.

Understanding Right Angles

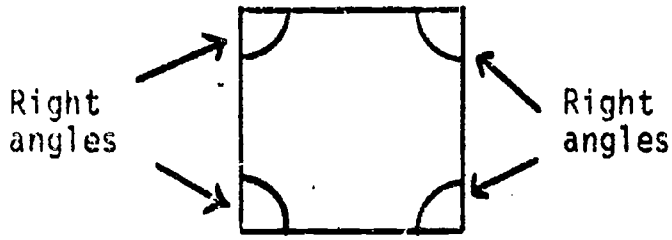
Look at the picture.

Your protractor should look like that now. The tips of four squares meet at the center of the circle.



The angle at the corner of a square is called a <u>right angle</u>.

Look at the picture of a square.



How many right angles have you marked on your protractor?

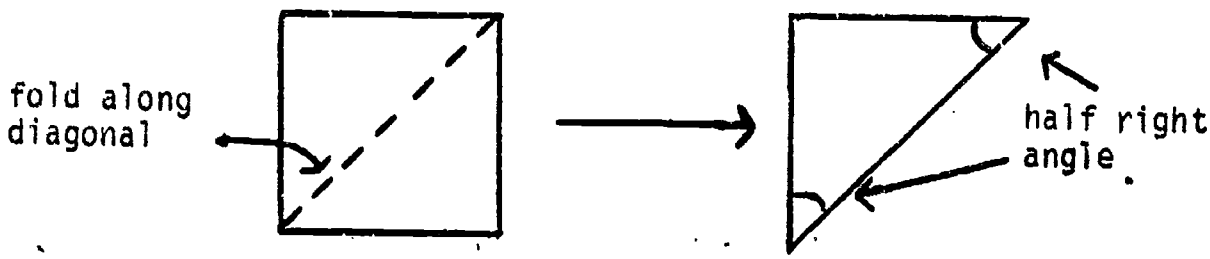
What fraction of a circle (a complete turn) is one right angle?

Marking Half Right Angles

How can you make a half right angle?

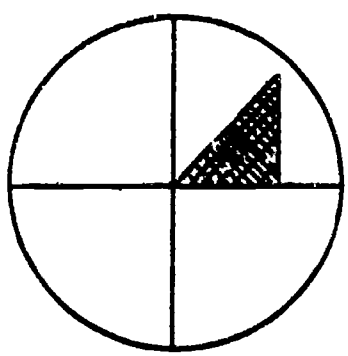
One way to make a half right angle is to fold a square crosswise.

Look at the picture.



Why is the triangle you have made called a right isosceles triangle? (See Card 1 for more about isosceles triangles.)

Place your half right angle on your protractor with the tip at the center and one edge along one of the lines.



Move the half right angle around the circle, keeping one edge on a line.

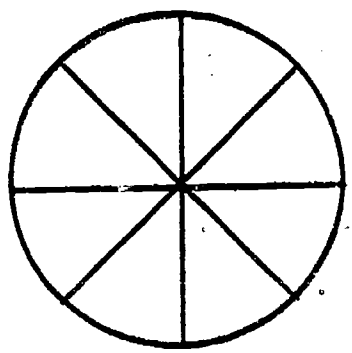
How many half right angles can you fit around the center of your protractor?

Draw lines on your protractor along the edge of the half right angle as you move it around. Draw the line from the center to the edge of the circle.

Understanding Half Right Angles

Look at the picture.

Your protractor should now look like that now.



There are 8 half right angles on your protractor. What fraction of a circle (a complete turn) is a half right angle?

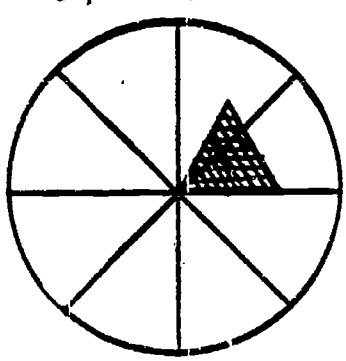
Can you think of another way to make a half right angle?

Can you think of a way to mark other angles?

Marking Smaller Angles

One way to mark smaller angles on your protractor is to use the "corner" of an equilateral triangle. An equilateral triangle has three equal sides and three equal angles. (See Card 1).

Place the tip of an equilateral triangle at the center of your protractor with one edge along a line.



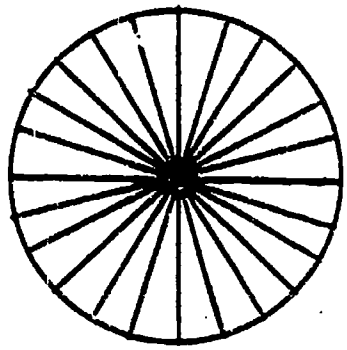
Move the triangle around the circle, keeping one edge on a line. How many corners of equilateral triangles can you fit around the center of your protractor?

Draw lines on your protractor along the edges of the triangle, as you move it around. Draw the lines from the center to the edge of the circle.

Understanding Small Angles

Look at the picture.

Your protractor should look like that now.



There are 24 small angles on your protractor.

What fraction of a circle (a complete turn) is one small angle?

Understanding Degrees

Many years ago the Egyptians thought that the sun took a year to go around the earth. They also thought that there were 360 days in a year. So, they divided circles into 360 angles and called each angle a degree.

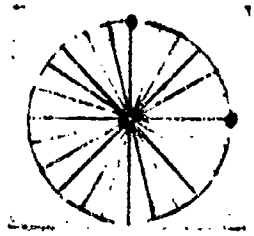
If a circle or one complete turn has 360 degrees, how many degrees does a right angle have? Remember a right angle is 1/4 of a circle.

How many degrees does a half right angle have? Remember a half right angle is 1/8 of a circle.

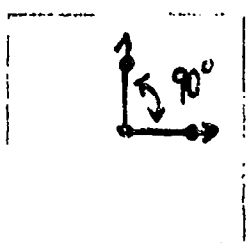
How many degrees does your small angle have?
Remember your small angle is 1/24 of a circle.
How many degrees does a straight line angle have?
Remember, a straight line angle is 1/2 of a circle.

Using Your Protractor to Draw Angles

You can use your protractor to draw angles in this way. Make a small hole in the center of your protractor. Make it just big enough to put the point of your pencil through. Put your protractor on a piece of paper and hold it firmly in one place. Put a dot on the paper through the hole in the protractor. Then pick out which lines on the protractor mark off the angle you want to draw. Put a dot on the paper at the end of each line. Look at the picture. It shows how to make the dots for a 90° angle (1/4 of a circle.)



After you make the dots, take away the protractor and use a ruler to connect the dot in the center with the two other dots.

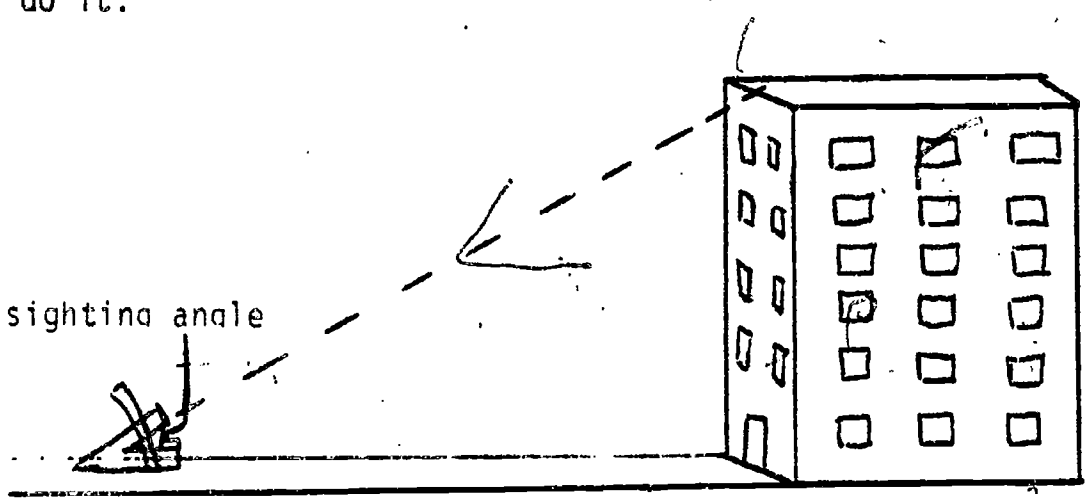


Make another angle which is equal to 1/8 of a circle (45°).

Make another angle which is equal to 1/6 of a circle (60°).

Using Your Protractor to Find the Height of Tall Objects

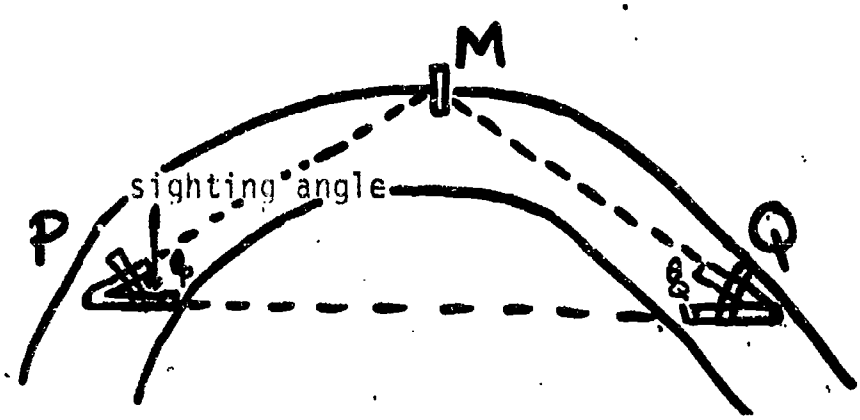
If you want to find the height of a building or a tree or a hill, you will need to measure a sighting angle as shown in the picture. A set of "How To" Cards tells you how to do it.



Measuring the Height of a Tall Building with Open, Level Ground Beside it

Using Your Protractor to Find How Much a Road Curves

If you want to find how much a road curves, you will need to measure sighting angles as shown in the picture. A set of "How To" cards tells you how to do it.



Measuring How Much a Road Curves

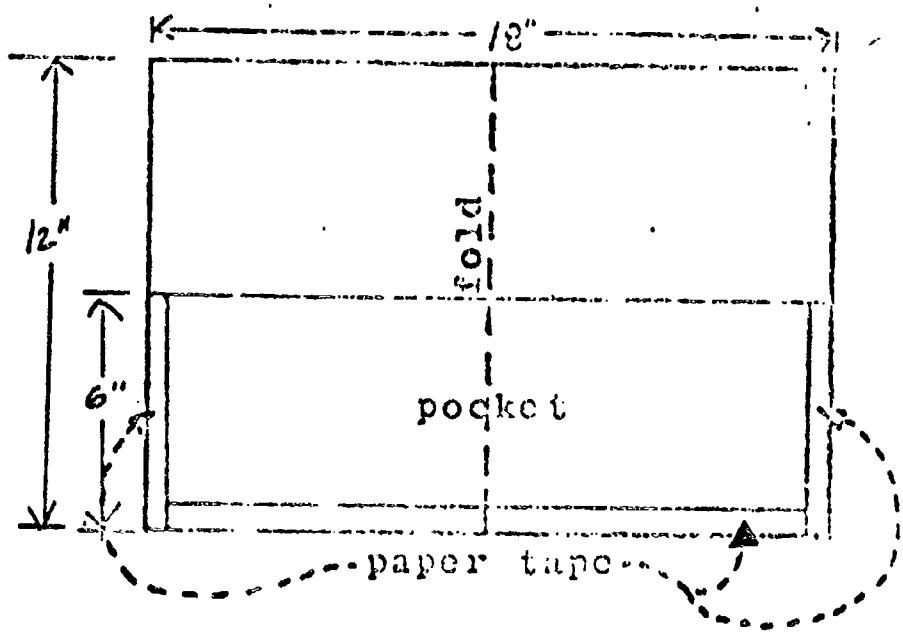
Card 15 tells you how to make a folder to hold your data sheets, pictures, and reports.

Making a Folder to Hold Data Sheets, Pictures, and Reports

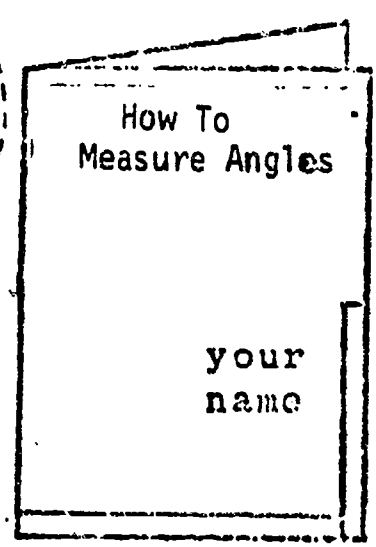
You will want to keep all your data sheets, pictures, and reports in a safe place.

You can make a folder like this.

1. Cut a piece of construction paper so that it is 6 inches wide and 18 inches long.
2. Cut another piece so that it is 12 inches wide and 18 inches long.
3. Put the two pieces together with tape. Look at the picture below.



4. Fold in the middle so that the pocket is on the inside.
5. Put the title and your name on the front cover. Look at the picture.



"How To" Cards

HOW TO FIND THE HEIGHT OF A BUILDING OR A TREE

(revised July, 1972)

Unified Science and Mathematics for Elementary Schools

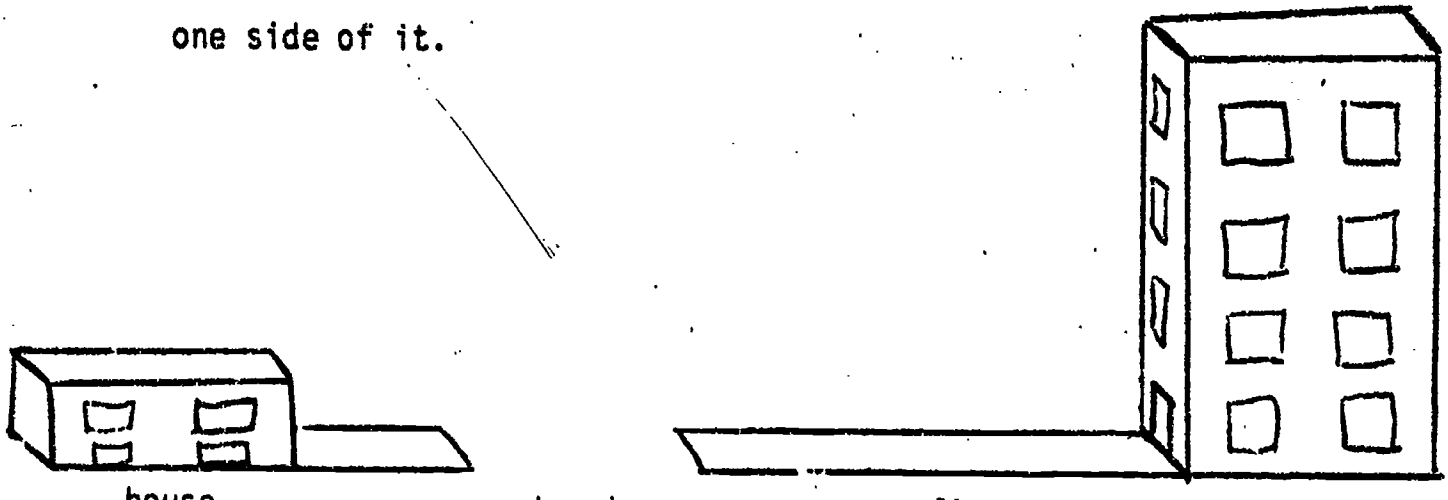
Thinking About Measurements

When you are making scale models you may want to put in trees, buildings, or other tall objects which are hard to measure. Or you may need to know the height of a building or tree for some other reason.

These cards tell about a way to find the height of a building or a tree even if you can't measure it directly.

Draw a rough picture of the building or tree you want to measure. Show the ground on one side of it. Pick the side that is most level and open.

Look at the picture below. It shows a building and the ground on one side of it.



Can you think of any measurements you could make? Make a picture like the one on this card and mark the measurements you could make on your picture.

Card 11 tells you how to make a folder to hold your pictures and any measurements you make, later.

CARD 2

Finding Possible Measurements

Did you mark any large distances?

Did you mark any angles?

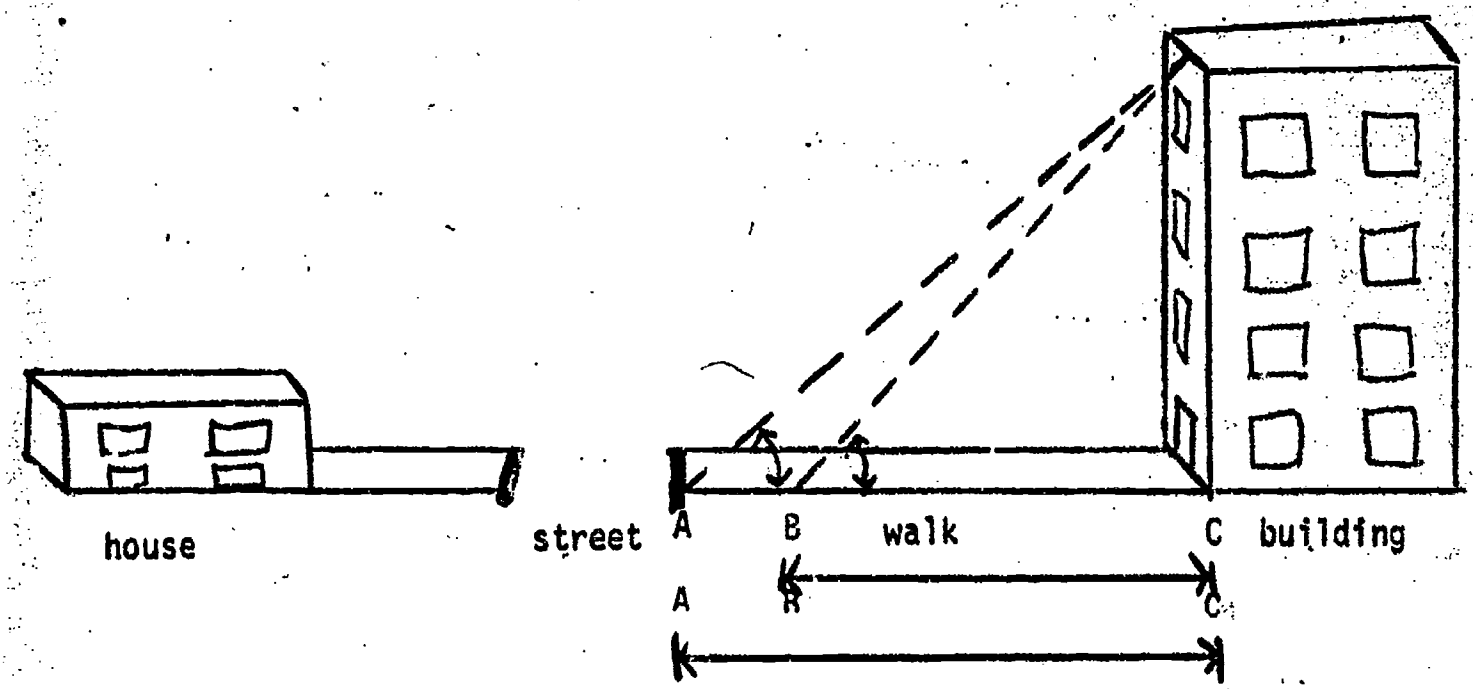
Have you ever measured large distances?

Have you ever measured angles?

If you haven't measured large distances or angles, there are "How To" cards you can use that explain how to measure both.

Can you think how measuring distances and angles might help you find the height of a building?

Some distances and angles you could measure are marked on the picture.



Which of the distances measured on the ground would be the same as the height of a building?

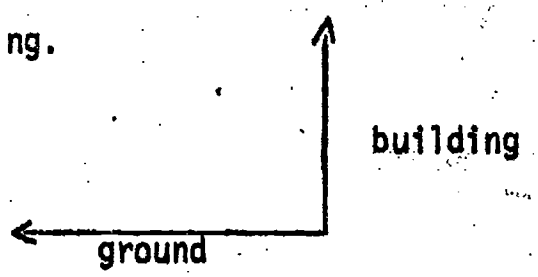
What is the angle between that distance and an imaginary line drawn to the top of the building?

MT3-2

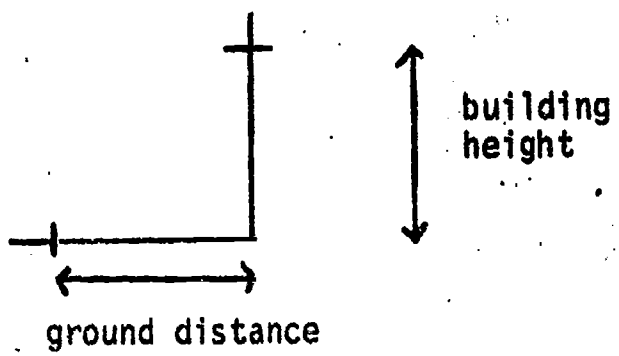
Thinking About Ground Distance and Building Height

Draw a line across the bottom of a piece of paper to stand for the ground.

At one end of the "ground" line draw another line going straight up to stand for the building.



Mark off an equal distance on both lines. Start at the corner where they meet. Measure up to show building height and measure across to show ground distance.



If the two distances are the same, then

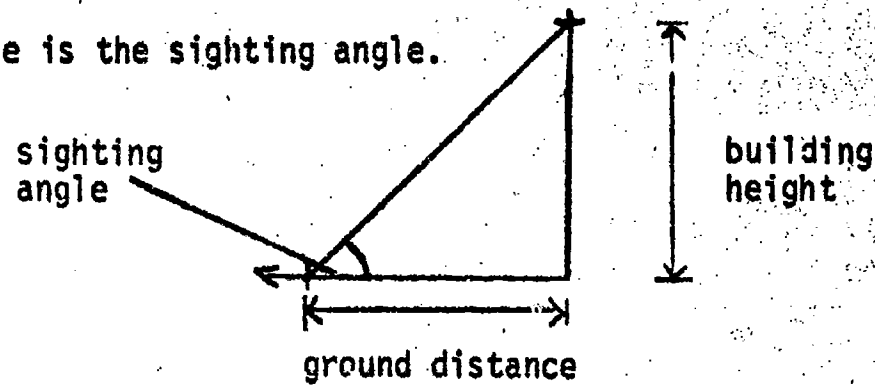
building height = ground distance

Go to the next card for more about this.

Using Triangles to Find the Height of a Building

Draw a triangle by connecting the end points of the two distances.

Use a protractor to measure the angle on the ground away from the building. This angle is the sighting angle.



Do you need help making a protractor or measuring the angle? See the set of "How To" cards on measuring angles if you do.

What did the sighting angle on your picture measure?

The sighting angle is always 45° when the building height and the ground distance are the same.

So an easy way to find the height of a tall object is to make an imaginary triangle with a sighting angle of 45°. Then when you measure the ground distance, you also find the height of the object.

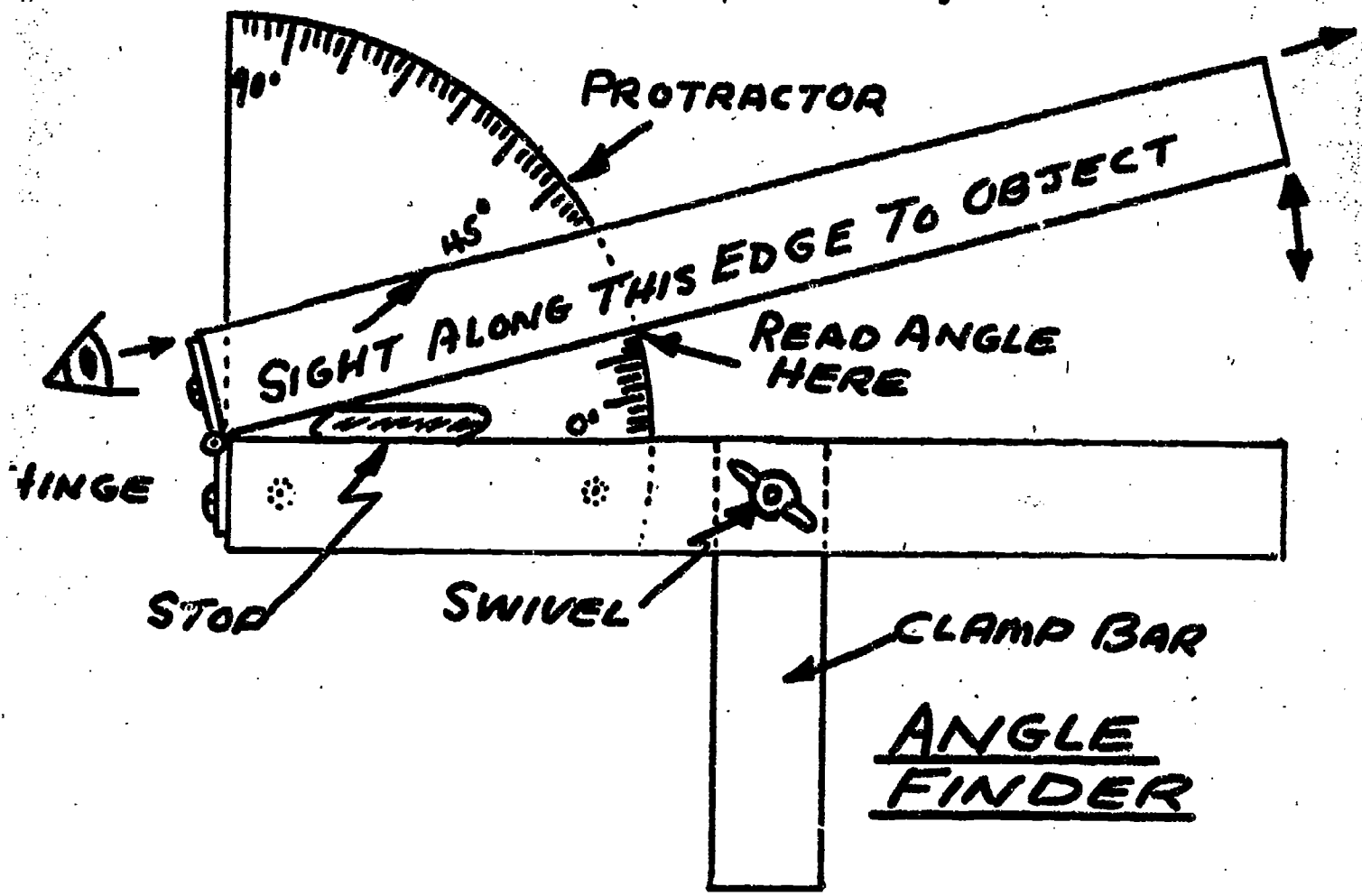
Now think about the real building or the real tree you want to measure.

What measurements should you make?

Designing and Constructing Measuring Tools

Design a tool to help you measure large distances. If you need help, see the "How To" cards on measuring large distances.

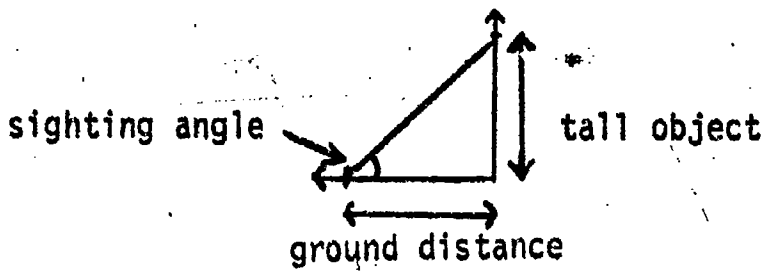
Design a tool to help you measure angles outside so you can make imaginary triangles. This is one possible design.



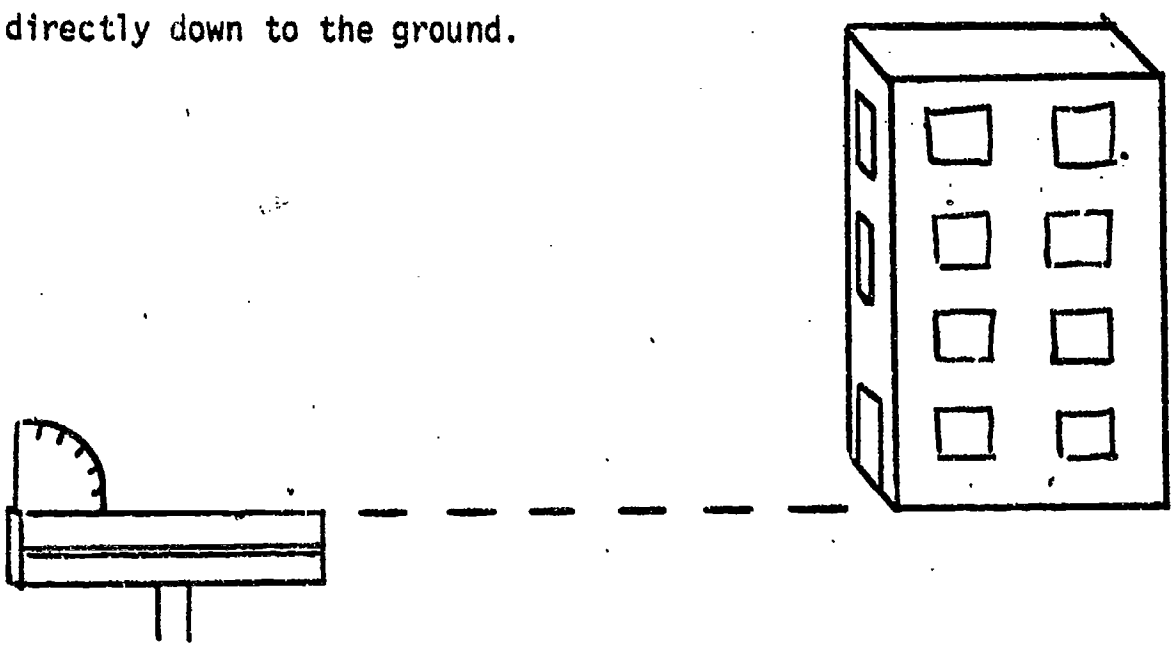
You sight along the top of the arm but read the angle along the bottom of the arm. This difference is not important if the building or tree is tall.

Making Measurements to Find Heights

Now you can use your tools to make sighting angle measurements and ground distance measurements outside.



Here is how to make an imaginary triangle so you can find the height of a building. Take your angle finder outside. Keep both arms of the angle finder together. Point the top arm toward the base of the building and adjust the clamping bar so that it points directly down to the ground.

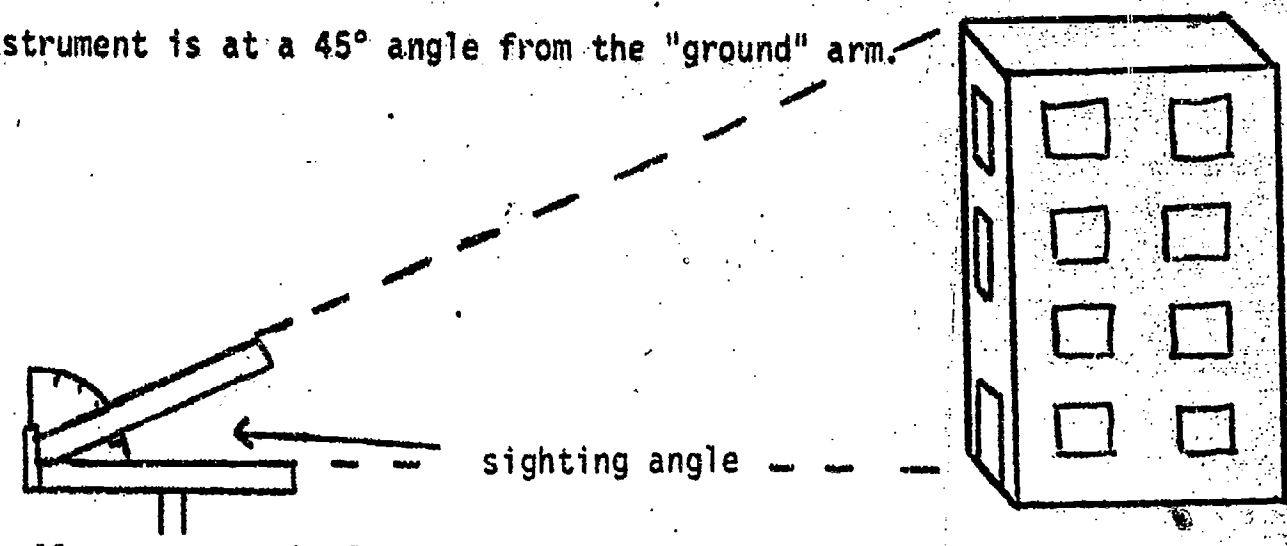


Go right on to the next card.

More About Making Measurements to Find Heights

Now point the top arm of the angle finder toward the top of the building.

Move toward or away from the building until the sighting arm of your instrument is at a 45° angle from the "ground" arm.



Finally, measure the level distance to the building from that point. If the sighting angle is 45°, the building height is equal to the ground distance.

What if you can't move far enough away from the building to get a 45° sighting angle?

Can you find other angles that would make triangles that are easy to work with?

Try making small triangles with sides of different lengths so the ratio $\left(\frac{\text{building height}}{\text{ground distance}}\right)$ is an "easy" fraction or whole number. Then measure the sighting angle on the triangle.

Finding Heights When the Sighting Angle Is Not 45°

You can use the ground distance measurement to find the height of the building even if the sighting angle is not 45°.

If the sighting angle is 45° the height equals the ground distance.

If you use another sighting angle, then the height equals the ground distance times the ratio $\left(\frac{\text{building height}}{\text{ground distance}}\right)$ you found when you made small triangles with other angles.

$$\text{Height} = \text{ground distance} \times \left(\frac{\text{building height}}{\text{ground distance}}\right)$$

↓

found using other angles

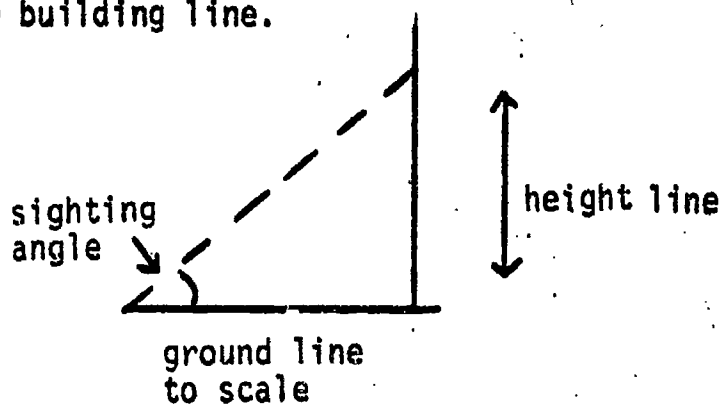
For example, suppose you made a triangle with the building height twice as long as the ground distance and you found that the sighting angle was about 60°. You can then use a 60° sighting angle outside and multiply the ground distance by 2 to get the building height.

If you have trouble with this way for figuring the height, see card 9 for another way.

Using Triangles to Scale to Figure the Height of Tall Objects

Another way to figure the height of the building is to:

1. Decide on a sighting angle, use your angle finder, and measure the ground distance.
2. Draw the ground line to scale across a piece of paper. If you need help see "How To" cards on scaling.
3. Draw another line up and down at one end of the ground line to show the building.
4. Mark off your sighting angle at the other end of the ground line.
5. Make a triangle by drawing the angle line long enough to touch the building line.



6. Measure the length of the height line from the ground line up to the sighting angle line.
7. Calculate the actual height of the building by using your scale.

Can you think of other ways to find the height of the building? Is your way easier? Try out your way, if you think it is easier.

Finding Heights When the Ground Distance is Hard to Measure

Some buildings may be placed so you can not measure the ground distance right up to the foot of the building.

The ground around the building may not be level or open.

The building may be on a hill or near a stream.

Draw a sketch of the building and the ground on one side of it.

Pick the side that is most level and open.

See Card 1.

Look for measurements you can make and ways to use them to figure the height of the building.

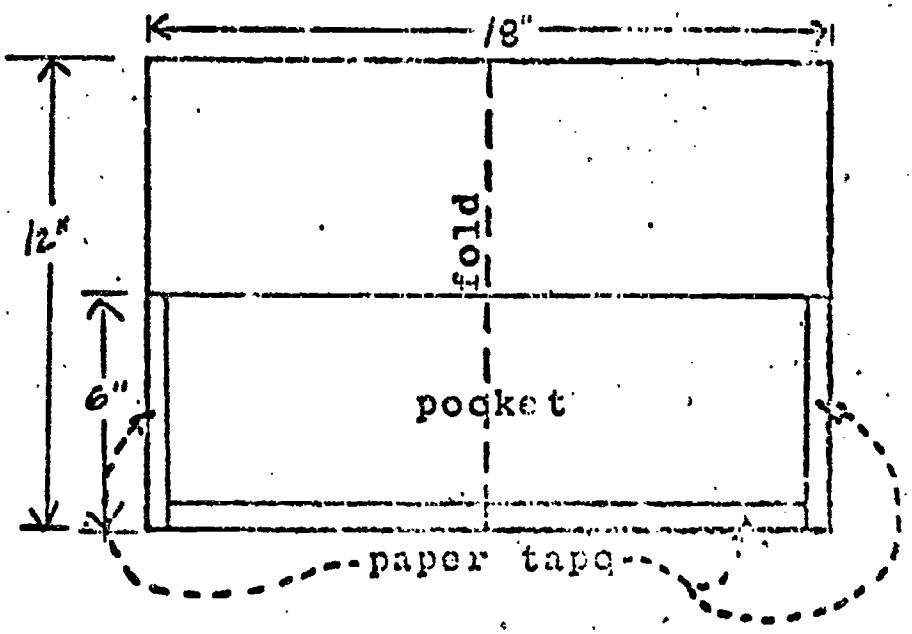
Ask your teacher for help if you need it.

Making a Folder to Hold Data Sheets, Pictures and Reports

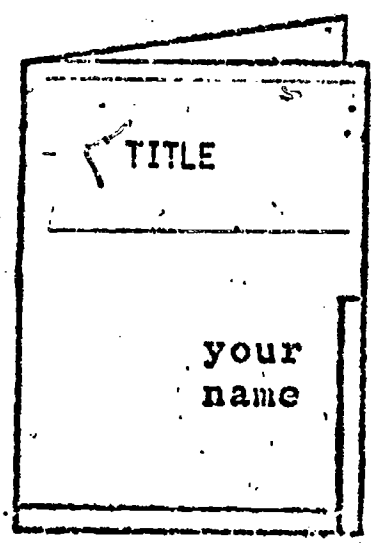
You will want to keep all your data sheets, pictures, and reports in a safe place.

You can make a folder like this.

1. Cut a piece of construction paper so that it is 6 inches wide and 18 inches long.
2. Cut another piece so that it is 12 inches wide and 18 inches long.
3. Put the two pieces together with tape. Look at the picture below.



4. Fold in the middle so that the pocket is on the inside.
5. Put the title and your name on the front cover. Look at the picture.



MT3-11

"How To" Cards

HOW TO MEASURE LARGE DISTANCES

(revised July, 1972)

Different Ways to Measure

There are many different ways to measure. There are many different tools to measure with. Always ask yourself, "What is the best tool to use to measure this?"

Here are some questions for you to think about.

1. How can we measure large distances - the width of a street or the length of a football field?
2. How can we measure small distances - the width of your desk, or the height of a door?
3. How can we measure very small distances - the thickness of a pad of paper?
4. How can we measure long periods of time - the time you spend in school?
5. How can we measure short periods of time - the time it takes you to cross the street?

This set of cards shows you how to measure large distances. Other sets show you how to measure other things.

Measuring Distance Along Lines

Let's look at lines - a short straight line, a long straight line, and a curved line.

A. The Short Straight Line

What kind of measuring tool would you use to measure the width of your desk? What other tools could you use?

B. The Long Straight Line

What kind of tool would you use to measure the length of a football field? What other tools could you use?

C. The Curved Line

What kind of tool would you use to measure the distance around a circle?

Did you suggest using the same tools for all three things? Did you suggest using different ones? Would you use a ruler to measure your desk? Would you use a ruler to measure a football field? Would you use a ruler to measure a circle? Why are some tools better for measuring some things and other tools better for measuring other things?

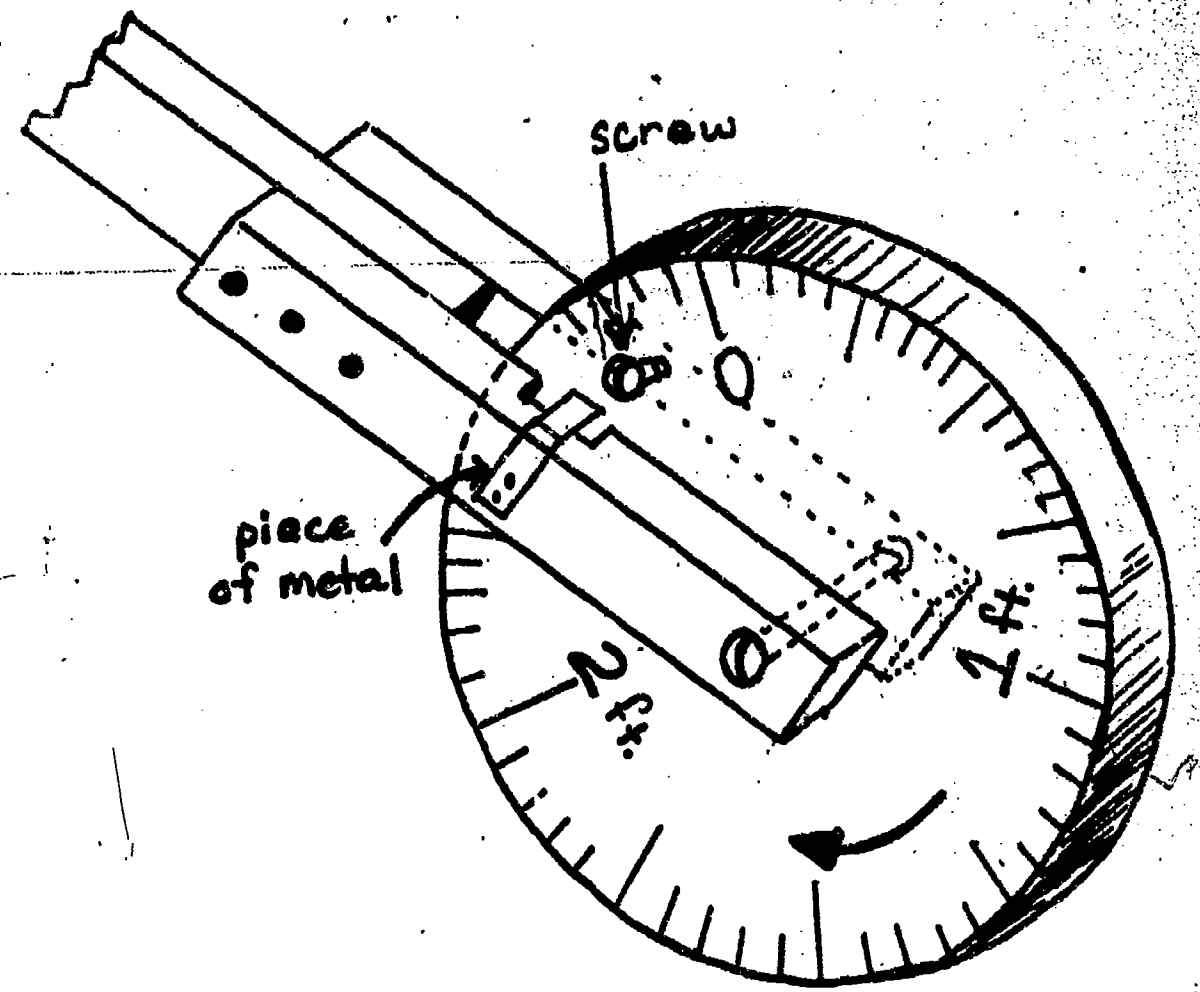
Some tools used to measure distance along lines are listed below. Can you name more?

ruler, rope, string, yardstick, tape measure, trundlewheel

See the next card to find out about trundlewheels.

What is a Trundlewheel?

Look at a trundlewheel or the following sketch of a trundlewheel.



What could you use the trundlewheel for?

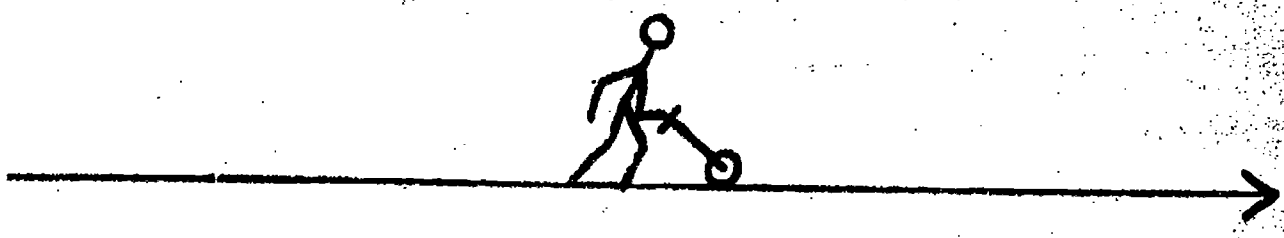
How do you use a trundlewheel?

Do you think it gives an accurate measurement?

If you are sure you know how to use a trundlewheel, then go right ahead and use it. If you want to know more about it, see the next card.

How Does a Trundlewheel Work?

The trundlewheel is a tool used to measure large distances. You push it along the distance you want to measure.



A trundlewheel has three main parts:

- handle
- wheel
- clicker

Find these parts on your trundlewheel or on the sketch.

Push your trundlewheel across the room.

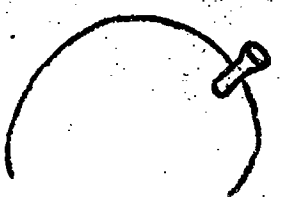
Do you hear it click?

Why does it click?

What do the clicks mean?

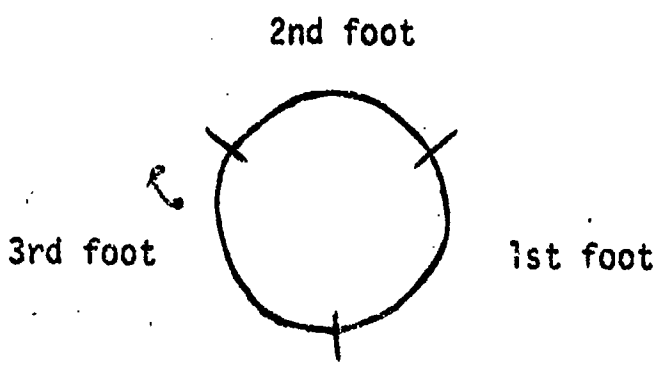
How Does a Trundlewheel Measure?

There is a screw on the wheel of the trundlewheel.

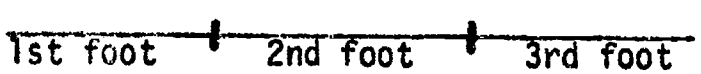


When the wheel turns, the screw hits a piece of metal on the handle. Look at the picture on card 3. Each time the screw hits the metal piece, it makes a click. Each time there is a click, the wheel has made one complete turn.

The distance around the outside of some trundlewheels is three feet. So everytime we hear a click, the trundlewheel has moved three feet, or one yard, because three feet equals one yard.



If we flattened the wheel, it would look like a yardstick. Look at the pictures.



A trundlewheel does not have to measure exactly three feet. All you need to know is the distance it does measure. How can you find this out?

Using a Trundlewheel

Let's use the trundlewheel to measure a large distance.

Before you start, make sure that the screw on the wheel touches the metal piece on the handle when the wheel turns. You want to be sure that there is a click every time the wheel makes a complete turn.

Measure the length or width of a room.

1. Start your trundlewheel at one side of the room.
2. Roll it to the opposite side of the room. Be sure to count the clicks!
3. Write down the number of clicks. This is the distance in whole yards. If you want a more accurate measurement, start your trundlewheel with the zero mark on the floor. Push the trundlewheel across the room and then write down the mark that is on the floor when you finish. This is the number of inches left over. Add the number of inches to the number of whole yards.

If your trundlewheel does not measure a yard in each turn you will have to make a correction. Card 7 shows you how to do it.

Using Larger or Smaller Trundlewheels

Your trundlewheel may measure more than one yard in one turn. It may measure less than one yard in one turn. Here is one way to figure out the distance when you know the number of turns.

Multiply the number of turns by the distance each turn measures.

Example: Your trundlewheel measures 30 inches in each turn. It turns 10 times going across a room.

distance across room = 30 inches per turn x 10 turns
= 300 inches

There is another way to figure out the distance when your trundlewheel measures more or less than one yard. If you want to know more about it, see Card 8.

Another Way To Use Larger or Smaller Trundlewheels

Write down the number of clicks. This is the distance in "whole yards". Figure out how many inches more or less than one yard your trundlewheel measures.

Multiply the number of clicks by that number of inches.

If your trundlewheel measures more than a yard, add this amount to the number of "whole yards".

If your trundlewheel measures less than a yard, subtract this amount from the number of "whole yards".

Example: Your trundlewheel measures 2 inches less than a yard. It makes 48 clicks going across a street. Because it measures less than a yard, the trundlewheel takes more turns to get across the street. Therefore the distance in number of "whole yards" is too great.

distance in "whole yards" = 48 yards

distance too great = 2 inches per turn x 48 turns = 96 inches

distance across street = 48 yards - 96 inches
= 48 yards - 2 yards 24 inches
= 46 yards and 2 feet

Be sure you write down your measurements and keep them, so you'll have them when you want to use them.

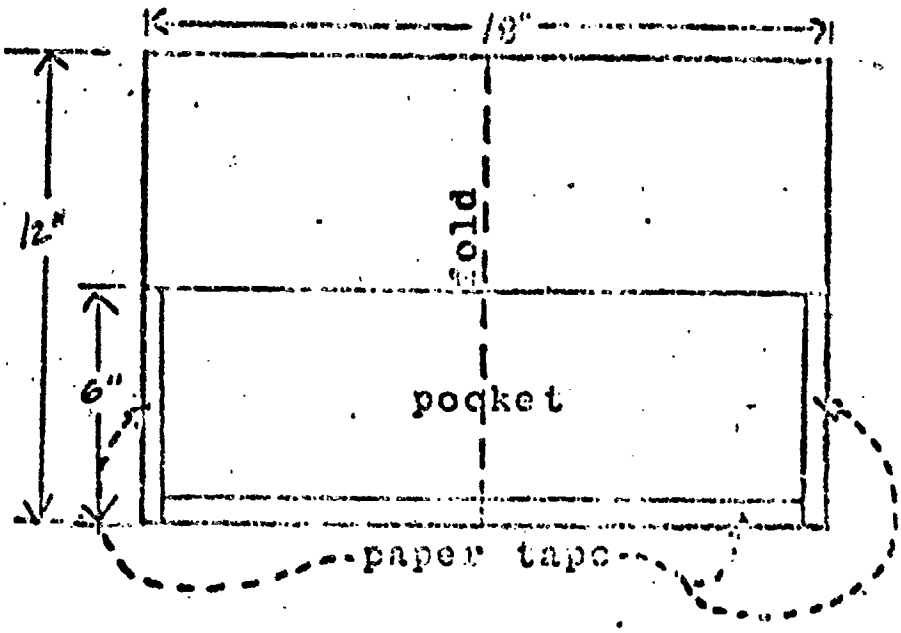
The next card tells you how to make a folder for your data sheets and reports.

Making a Folder to Hold Data Sheets, Diagrams and Reports

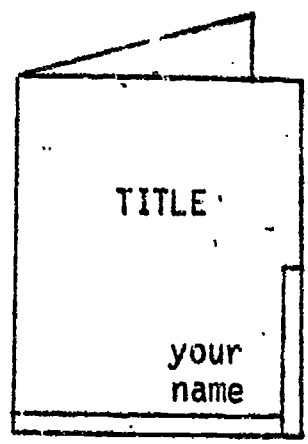
You will want to keep all your data and reports in a safe place.

You can make a folder like this.

1. Cut a piece of construction paper so that it is 6 inches wide and 18 inches long.
2. Cut another piece so that it is 12 inches wide and 18 inches long.
3. Put the two pieces together with tape. Look at the picture below.



4. Fold in the middle so that the pocket is on the inside.
5. Put the title and your name on the front cover. Look at the picture.



MT2-9

"How To" Cards

HOW TO USE A STOPWATCH

(revised July, 1972)

Unified Science and Mathematics for Elementary Schools

CARD 1

HOW TO WORK A STOPWATCH

First, let's learn to work the stopwatch.

Look at it, try it, and answer the questions.

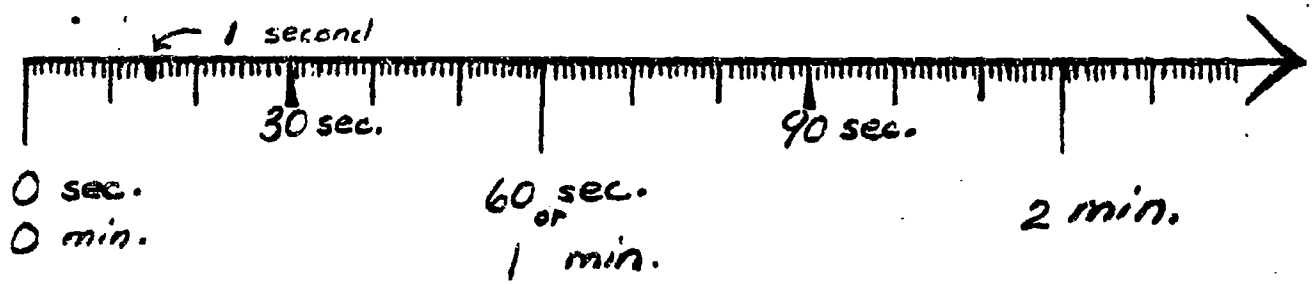
1. How many buttons are on your stopwatch?
2. How do you start the watch?
3. How do you stop the watch?
4. How do you start the watch on zero again?
5. You have to wind a stopwatch just like you wind some other clocks and watches. How do you wind the stopwatch?

Now, let's learn what the stopwatch does.

A STOPWATCH MEASURES TIME

A stopwatch is a measuring tool; it measures something. A ruler measures distance. A scale measures weight. What does a stopwatch measure?

Let's talk about time. Look at the drawing of the time line.



1. How many seconds are in one minute?
2. How many seconds are in 1 1/2 minutes?
3. How many seconds are in 2 minutes?

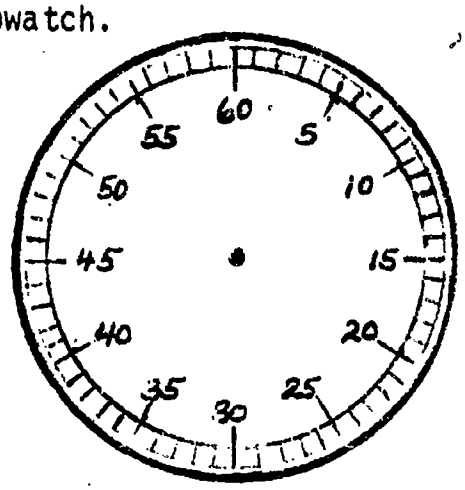
Do you know that there are 3,600 seconds in 1 hour?

Let's think about seconds.

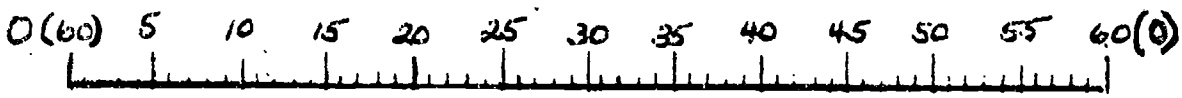
How long is a second? Not very long at all because you can blink your eyes open and shut once in about a second.

THE STOPWATCH AND THE TIME LINE

A stopwatch is like a time line rolled into a circle. Let's look at a 60-second stopwatch.



Now let's stretch it out.

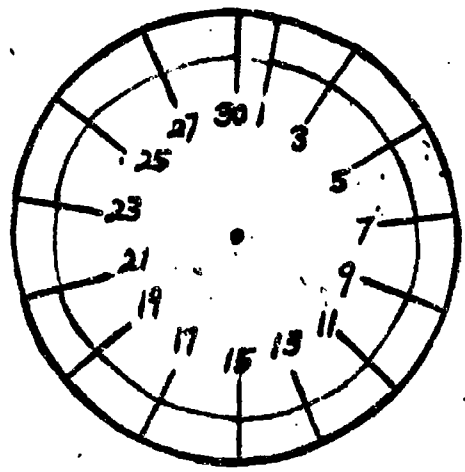


Answer the questions.

1. The biggest lines are counting by _____ 's.
2. The next biggest lines are counting by _____ 's.
3. How many seconds in all are there on the time line?
4. Put your finger on the line for:
   a) 10 seconds
   b) 45 seconds
   c) 7 seconds
   d) 33 seconds

DIFFERENT STOPWATCHES USE DIFFERENT TIME LINES

Let's look at another stopwatch.



Answer the questions.

1. The biggest lines are counting by _____ 's.
2. The littlest lines are counting by _____ 's.
3. How many seconds in all are there on this stopwatch?

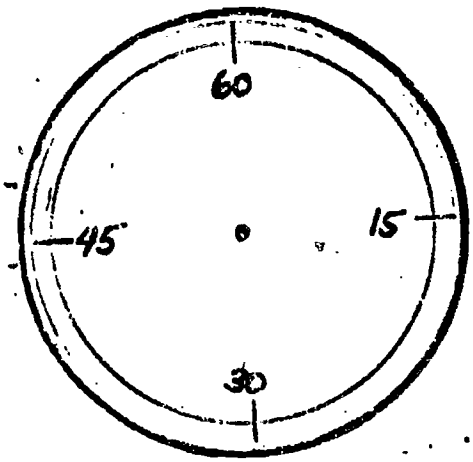
Different stopwatches use different time lines. Sometimes they have 60 seconds in all and sometimes they have 30 seconds in all. You have to figure out what kind of time line your stopwatch has.

DRAWING A PICTURE OF YOUR STOPWATCH

Look at the drawings.

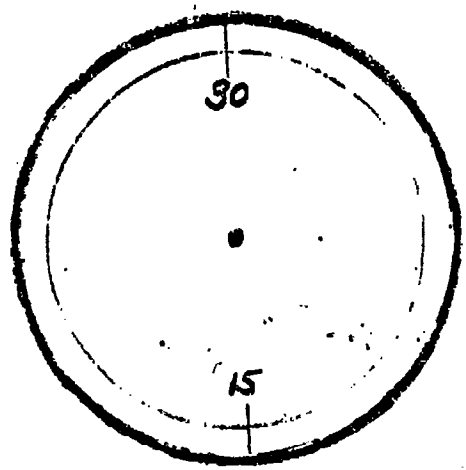
Does your stopwatch look like

this?



or

this?



Draw your stopwatch on a piece of paper. Show all the lines, numbers, and buttons.

Draw your watch's time line.

What are the lines counting by?

Some stopwatches have two hands. One hand is a fast hand. The other hand is a slow hand.

How many hands does your stopwatch have?

TELLING SECONDS ON A STOPWATCH

Set the stopwatch at zero. Start it running.

Look at the fast hand moving around the watch.

- Do you think that it measures hours? Why not?
- Do you think it measures minutes? Why not?
- Can you guess what part of time it measures?
- How many lines does the fast hand cover in the time it takes to blink your eyes? Try it!
- Has the hand moved from one line to the next line? ___
  If your answer is yes, your stopwatch shows whole seconds.
- Has the hand moved past several lines? ___
  If the answer is yes, your stopwatch shows parts of seconds.
- It takes the second hand 1 second to move from one line to another line of the same kind on a stopwatch. Which lines on your watch show 1 second?

Parts of seconds are shown by a different kind of line - lighter, darker, longer or shorter than the kind of line used for seconds.

If the fast hand goes all around the watch once, how many seconds have passed? (Count each second as it passes if you are not sure.)

TELLING MINUTES ON A STOPWATCH

If your watch has two hands, answer the questions:

1. Do both hands move at the same speed?
2. Which hand moves faster?
3. When the fast hand goes all around the watch once, how far does the slow hand move?
4. How many times does the fast hand have to go around the watch to make the slow hand move 1? Why?

   (How many seconds are in one minute?)
5. What does the slow hand measure?
6. How many minutes in all are shown on your stopwatch?
7. How does your stopwatch show minutes?
   a) Do minutes have a little dial of their own on the watch?
   b) Do they use the same numbers and lines the seconds do?

USING A STOPWATCH

Make a list of the things you think or know people use stopwatches for. Why is it better to use a stopwatch to time something instead of an ordinary clock?

Pick something to time with the stopwatch. Some ideas are listed below. Record your data on paper.

a. walking all the way around a room

b. walking the length of a corridor or hall

c. walking up 1 flight of stairs

d. walking up 2 flights of stairs

e. walking up 3 flights of stairs

f. reading one page of a book

g. reading one paragraph of a book

h. reading one line of a book

i. spinning a penny until it stops

j. tossing a penny from hand to air to hand

Always record your data and keep it so you will have it to look back at when you need it. The next card tells how to make a folder to hold your data sheets, diagrams, and reports.

Making a Folder to Hold Data Sheets, Diagrams, and Reports

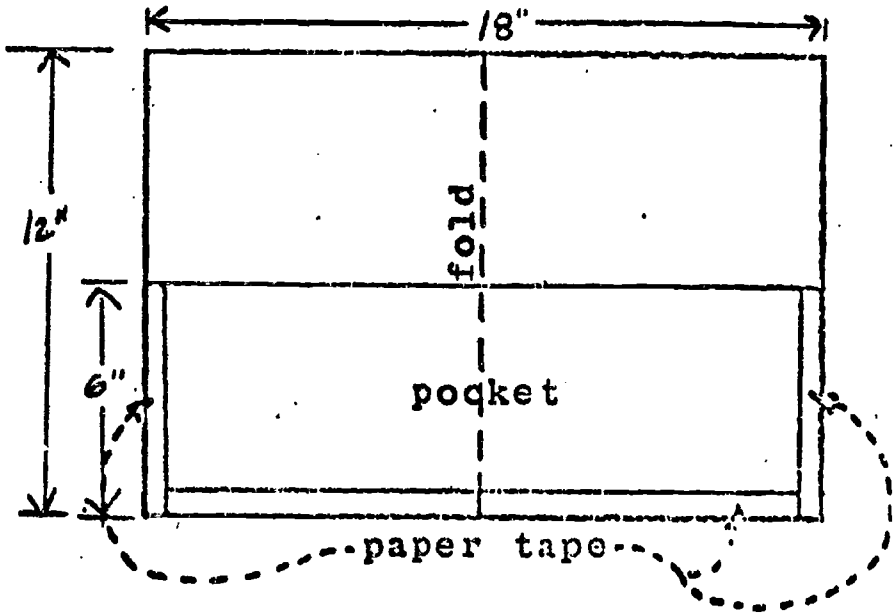
You will want to keep all your data and reports in a safe place.

You can make a folder like this.

1. Cut a piece of construction paper so that it is 6 inches wide and 18 inches long.

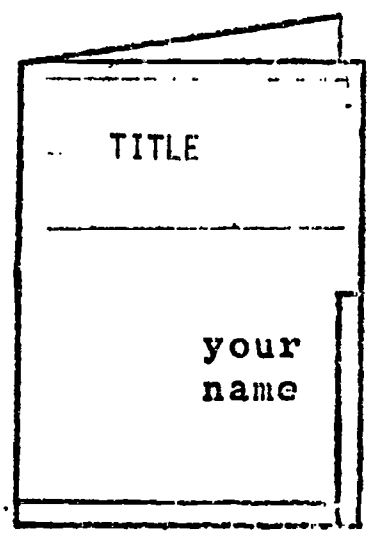
2. Cut another piece so that it is 12 inches wide and 18 inches long.

3. Put the two pieces together with tape. Look at the picture below.



4. Fold in the middle so that the pocket is on the inside.

5. Put the title and your name on the front cover. Look at the picture.



"How To" Cards

HOW TO FIND THE QUARTILE RANGE OF A SET OF DATA

(revised July, 1972)

Unified Science and Mathematics for Elementary Schools

WHAT THE QUARTILE RANGE IS

The median piece of data is used to describe a set of data. See the "How To" cards on How to Find the Median if you don't understand medians.

Sometimes we also need to know how wide the pieces of data in a set spread. You can do this by finding the range of the set. The range or spread of a set is found by subtracting the smallest piece of data in the set from the largest piece in the set.

Often we may just want to find the range of several pieces of data in the set. One way to do this is to find the quartile range.

The quartile range covers the half of the data around the median. It tells you the range of those pieces of data. It can be found by first finding the piece of data called the first quartile and subtracting it from the piece of data called the third quartile.

The next card will tell you how to find the first quartile and third quartile pieces of data.

WHAT THE FIRST AND THIRD QUARTILES ARE

The median is the middle piece of data in a set when the pieces are listed in order of size

The first quartile piece is the quarter-way piece of data. You find the first quartile piece by first listing the pieces of data starting with the smallest piece. Then you find the quarter-way piece of data. The third quartile piece is the three quarter-way piece of data.

Example 1: Some boys counted the number of cars which passed through an intersection. They spent 5 minutes each day for 20 days counting cars. This set of 20 pieces of data shows the number of cars which passed through the intersection in 5 minutes each day.

9, 1, 2, 4, 8, 6, 7, 6, 8, 4, 5, 9, 1, 7, 5, 6, 4, 8, 9, 8

The median is the middle piece of data when the data is listed in order of size. The median in this set of 20 pieces is the 10th piece or 6 cars.

10th piece
1, 1, 2, 4, 4, 4, 5, 5, 6, 6, 6, 7, 7, 8, 8, 8, 8, 9, 9, 9
median

The first quartile is the quarter-way piece of data. In this set of 20 pieces of data for the first quartile piece is the 5th piece of data. The first quartile or the 5th piece of data is 4 cars.

5th piece 10th piece
1, 1, 2, 4, 4, 4, 5, 5, 6, 6, 6, 7, 7, 8, 8, 8, 8, 9, 9, 9
first quartile median

The third quartile is the three quarter-way piece of data. In this set of 20 pieces of data the third quarter piece is the 15th piece of data. The third quartile or 15th piece of data is 8 cars.

5th piece 10th piece 15th piece
1, 1, 2, 4, 4, 4, 5, 5, 6, 6, 6, 7, 7, 8, 8, 8, 8, 9, 9, 9
first quartile median third quartile

FINDING THE FIRST AND THIRD QUARTILES

The first quartile is the quarter-way piece of data. In Example 1 on Card 2 the first quartile is the 5th piece of data in the set of 20 pieces. The first quartile piece was found by dividing the total number of pieces in the set by 4.

$$\frac{\text{total number of piece in set}}{4} = \frac{20 \text{ pieces}}{4} = 5\text{th piece} = \text{1st quartile piece}$$

The 5th piece of data is the first quartile piece. Then the first quartile is 4 cars.

5th piece 10th piece
1, 1, 2, 4, 4, 4, 5, 5, 6, 6, 6, 7, 7, 8, 8, 8, 8, 9, 9, 9
↓ ↓
1st quartile median

The third quartile is the three quarter-way piece of data. In Example 1 on Card 2 the third quartile is the 15th piece of data. The third quartile piece was found by multiplying the first quartile piece by 3.

first quartile piece X 3 = 5th piece X 3 = 15th piece = third quartile piece

The 15th piece of data is the third quartile piece. Then the third quartile is 8 cars.

5th piece 10th piece 15th piece
1, 1, 2, 4, 4, 4, 5, 5, 6, 6, 6, 7, 7, 8, 8, 8, 8, 9, 9, 9
↓ ↓ ↓
1st quartile median 3rd quartile

MORE ABOUT FINDING THE FIRST AND THIRD QUARTILES

Example 2: One class polled 14 other classes in a school to find out how many people in each class wanted to have a school fair. This set of 14 pieces of data tells how many people in each class wanted to have the fair:

4, 7, 9, 3, 4, 17, 11, 12, 8, 10, 4, 14, 16, 8

The median is the 7th piece of data or 8 votes.

7th piece
3, 4, 4, 5, 7, 8, 8, 9, 10, 11, 12, 14, 16, 17
median

The first quartile piece is:

$\frac{\text{total number of pieces in set}}{4} = \frac{14 \text{ pieces}}{4}$ = 3-1/4 pieces = first quartile piece

Here the division does not give a whole number. We can use the average of the 3rd and 4th pieces of data to find the first quartile.

$\frac{4 \text{ votes} + 5 \text{ votes}}{2} = \frac{9 \text{ votes}}{2}$ = 4-1/2 votes = first quartile

The third quartile piece is:

first quartile piece X 3 = 3-1/4 pieces X 3 = 9-3/4 pieces = 3rd quartile piece

The third quartile piece is not a whole number. We can take the average of the 9th and 10th pieces of data to find the third quartile.

$\frac{10 \text{ votes} + 11 \text{ votes}}{2} = \frac{21 \text{ votes}}{2}$ = 10-1/2 votes = third quartile

3rd & 4th / 2 — 7th piece — 9th & 10th / 2

3, 4, 4, 5, 7, 8, 8, 9, 10, 11, 12, 14, 16, 17

1st quartile (4 1/2 votes) — median — 3rd quartile (10 1/2 votes)

FINDING THE QUARTILE RANGE

On Card 2 we found the first and third quartiles for the set of car tallies.

5th piece 10th piece 15th piece
1, 1, 2, 4, 4, 4, 5, 5, 6, 6, 6, 7, 7, 8, 8, 8, 8, 9, 9, 9
first quartile median third quartile

The first quartile is 4 cars. The third quartile is 8 cars.

The quartile range describes the half of the data around the median. This half of the data includes all the data pieces from the first quartile to the third quartile.

5th piece 10th piece 15th piece
1, 1, 2, 4, 4, 4, 5, 5, 6, 6, 6, 7, 7, 8, 8, 8, 8, 9, 9, 9
first quartile median third quartile

half the data

The quartile range tells you how wide is the spread of this half of the data around the median. You find the quartile range by subtracting the first quartile from the third quartile.

third quartile − first quartile = quartile range
8 cars − 4 cars = 4 cars

In this example the quartile range is 4 cars. This tells you that the spread of half the data around the median is 4 cars wide.

5th piece 10 piece 15th piece
1, 1, 2, 4, 4, 4, 5, 5, 6, 6, 6, 7, 7, 8, 8, 8, 8, 9, 9, 9
first quartile median third quartile

half the data

spread = quartile range = 4 cars

MORE ABOUT FINDING THE QUARTILE RANGE

In Example 2 on Card 4 we found the first and third quartiles in the set of class votes.

$$\frac{3\text{rd} + 4\text{th}}{2} \qquad 7\text{th piece} \qquad \frac{9\text{th} + 10\text{th}}{2}$$

3, 4, 4, 5, 7, 8, 8, 9, 10, 11, 12, 14, 16, 17

median

first quartile (4-1/2 votes)

third quartile (10-1/2 votes)

What is the quartile range of this set? The quartile range is found by subtracting the third quartile from the first quartile. The quartile range tells you how wide the half of data around the median spread.

third quartile - first quartile = quartile range

10-1/2 votes - 4-1/2 votes = 6 votes

The quartile range is 6 votes. This means that the spread of the half of data around the median is 6 votes.

$$\frac{3\text{rd} \,\&\, 4\text{th}}{2} \qquad 7\text{th piece} \qquad \frac{9\text{th} \,\&\, 10\text{th}}{2}$$

3, 4, 4, 5, 7, 8, 8, 9, 10, 11, 12, 14, 16

median

first quartile (4-1/2 votes)

third quartile (10-1/2 votes)

half the data

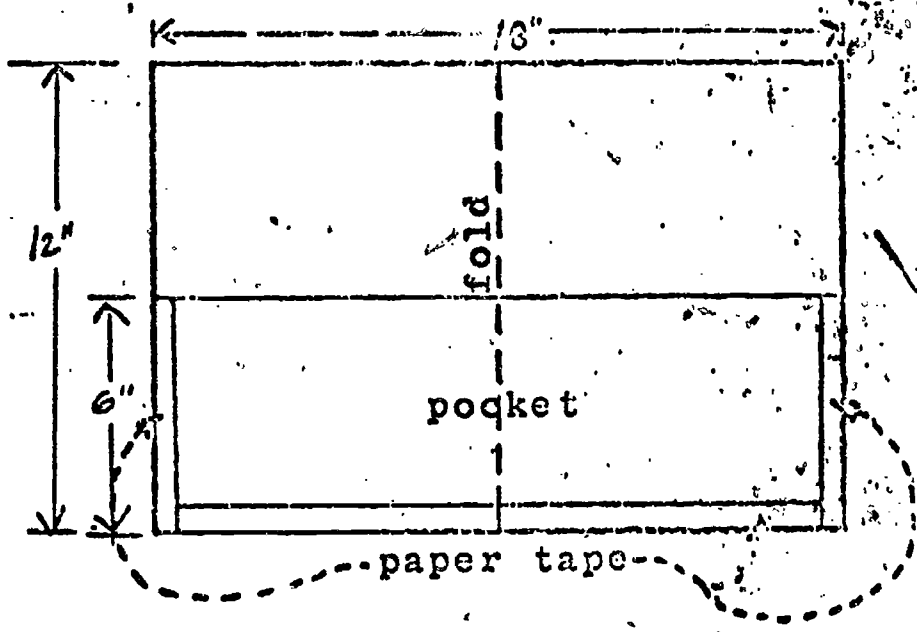
spread = quartile range = 6 votes

You may want to keep your data in a safe place. Card 7 tells you how to make a folder for your data.

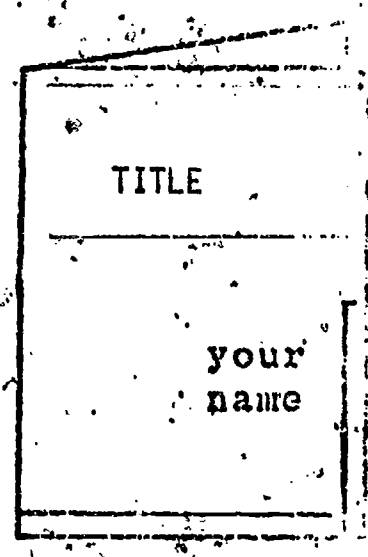
MAKING A FOLDER TO HOLD DATA

You can make a folder like this:

1. Cut a piece of construction paper so that it is 6 inches wide and 18 inches long.
2. Cut another piece so that it is 12 inches wide and 18 inches long.
3. Put the two pieces together with tape. Look at the picture below.



4. Fold in the middle so that the pocket is on the inside.
5. Your name and a title for your folder should be put on the front cover like this.



"How To" Cards

HOW TO RECORD DATA BY TALLYING

(Revised July 1972)

CARD 1

Using Tally Marks

In your experiments you need to count or tally the number of times you see something or something happens. If there are a lot of things to tally, it is helpful to use tally marks. Tally marks help you to count a lot of pieces of data.

Tally marks look like this:

One piece of data	:	/
Two pieces	:	//
Three pieces	:	///
Four pieces	:	////
Five pieces	:	𝍸
Six pieces	:	𝍸 /
Seven pieces	:	𝍸 //
Eight pieces	:	𝍸 ///
Nine pieces	:	𝍸 ////
Ten pieces	:	𝍸 𝍸

The fifth tally mark bundles four marks together. This bundle helps you to see sets of five. Bundles of five marks also make it easier to count the total number of marks you have made.

Recording Data with Tally Marks

Your data from an experiment can be recorded in a table like this:

(Name of Pieces)	Tally Marks	Total

Example: Number of different types of cars counted from 1:00 p.m. to 1:05 p.m.

Type	Tally Marks	Total
Chevys	𝍸 ||	7
Fords	||	2
Ramblers	𝍸 𝍸	10

Record your data from an experiment in a chart using tally marks.

You might want to keep your chart in a safe place. Card 3 tells you how to make a folder to hold your chart.

See set of cards on "How to Make a Bar Graph Tally" to find out how to tally directly on a graph.

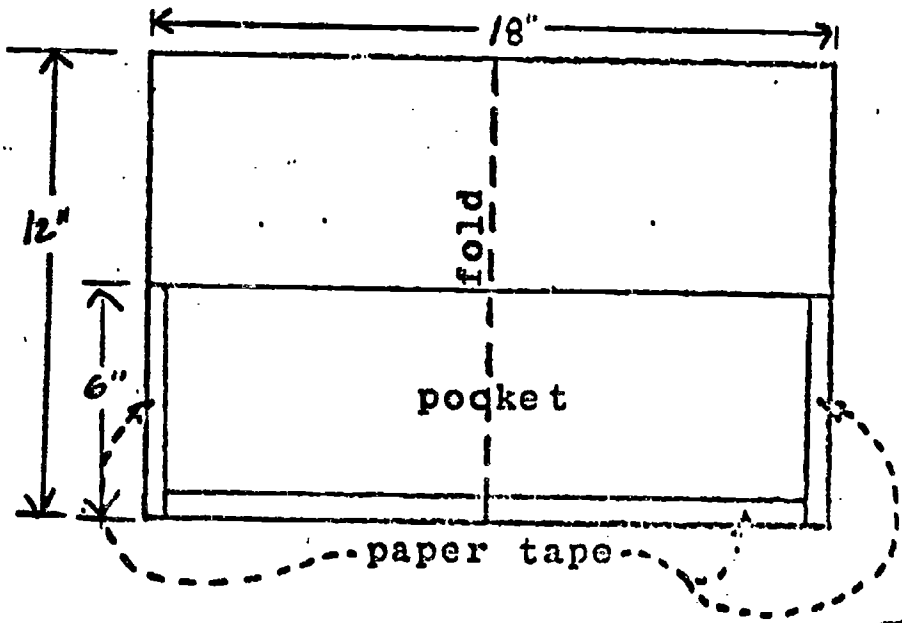
Making a Folder to Hold Charts of Data

You can make a folder like this.

1. Cut a piece of construction paper so that it is 6 inches wide and 18 inches long.

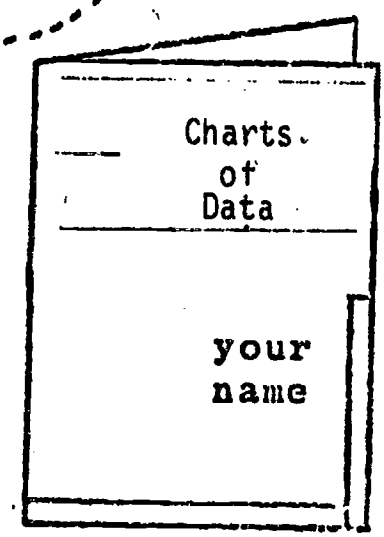
2. Cut another piece so that it is 12 inches wide and 18 inches long.

3. Put the two pieces together with tape. Look at the picture below.



4. Fold the middle so that the pocket is on the inside.

5. Your name and a title for your folder should be put on the front cover like this.



SQ3-3

"How To" Cards

HOW TO FIND THE AVERAGE OF A SET OF DATA

(Revised July 1972)

Unified Science and Mathematics for Elementary Schools

What the Average Is

In your experiments you collect many kinds of information. Each kind of information can be called a piece of data. When you group together several pieces of data about the same thing, you make a set of data.

Often you may want to find a way of describing a set of data. If this set is a group of numbers, you can use the average to describe it. The average is a single number which describes a set of numbers.

Example: You want to prove that it is hard to cross the street at a certain corner. You spend five minutes each day counting the number of cars that pass the corner. Your set of data is:

Monday	16 cars
Tuesday	28 cars
Wednesday	40 cars
Thursday	32 cars
Friday	19 cars

The average of this set of data is 27 cars. The average 27 describes the set. It means that on each day about 27 cars pass the corner in five minutes.

Finding the Average

To find the average of a set of data, we add up the pieces of data and divide by the number of pieces in the set.

$$\text{Average} = \frac{\text{sum of pieces of data}}{\text{number of pieces of data}}$$

Example 1: What is the average of the heights of the children in my class?

	name	height
1.	John	60 inches
2.	Mary	58 inches
3.	Eleanor	62 inches
4.	William	61 inches
5.	Jane	59 inches
		sum = 300 inches

$$\text{The average} = \frac{\text{sum of pieces of data}}{\text{number of pieces of data}} = \frac{300 \text{ inches}}{5} = 60 \text{ inches}$$

The average 60 inches describes this set of heights. It means that most people in the class are about 60 inches tall.

In this example, the average height in the set is the same as John's height.

Finding the Average

In example 1 the average was the same as one of the pieces of data. However, it does not always turn out that way.

Example 2: What is the average number of tickets to the class play sold by each student?

	name	tickets sold
1.	Jane	10
2.	John	9
3.	Mary	11
4.	Roger	15
5.	Bill	10
6.	Eleanor	0

The average = $\frac{10 + 9 + 11 + 15 + 10 + 0}{6} = \frac{55}{6}$ = 9 1/6 tickets

Notice that Eleanor counts even though the number of tickets she sold was 0.

The average number of tickets sold is 9 1/6 tickets. There isn't any real way to sell 9 1/6 tickets, but the number 9 1/6 still gives you an idea about how many tickets were sold by each student.

Finding the Average of your Own Data

Now you are ready to find the average of your own data. First, make sure all the pieces measure the same thing (heights, number of heads, numbers of cars).

1. Count the number of pieces of data and write it down after the "equals" sign.

   N =

2. Add up the numbers and write the sum after the "equals" sign.

   S =

3. Divide the number for S by that for N. The answer is the average of your data.

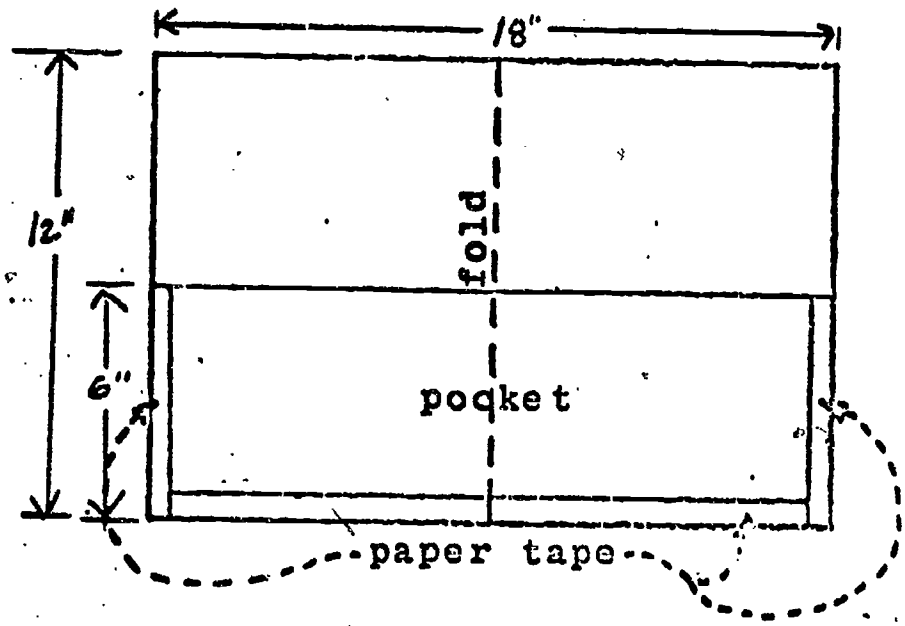
   Mean = S ÷ N

You might want to make sure that your data is kept in a safe place. The following card tells you how to make a folder to hold your work.

Making a Folder to Hold your Data

You can make a folder like this.

1. Cut a piece of construction paper so that it is 6 inches wide and 18 inches long.
2. Cut another piece so that it is 12 inches wide and 18 inches long.
3. Put the two pieces together with tape. Look at the picture below.



4. Fold in the middle so that the pocket is on the inside.
5. Your name and a title for your folder should be put on the front cover like this.