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METRIC GEOMETRY LINEAR MEASURE.

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THIS BOOKLET, ONE OF A SERIES, HAS BEEN DEVELOPED FOR THE PROJECT, A PROGRAM FOR MATHEMATICALLY UNDERDEVELOPED PUPILS. A PROJECT TEAM, INCLUDING INSERVICE TEACHERS, IS BEING USED TO WRITE AND DEVELOP THE MATERIALS FOR THIS PROGRAM. THE MATERIALS DEVELOPED IN THIS BOOKLET INCLUDE (1) THE HISTORY AND MEANING OF LINEAR MEASURE, (2) FINDING THE APPROXIMATE PERIMETER OF CIRCLES, TRIANGLES, AND RECTANGLES, AND (3) USE OF THE MICROMETER FOR MEASURING LINEAR DISTANCES. ACCOMPANYING THESE BOOKLETS WILL BE A "TEACHING STRATEGY BOOKLET" WHICH WILL INCLUDE A DESCRIPTION OF TEACHER TECHNIQUES, METHODS, SUGGESTED SEQUENCES, ACADEMIC GAMES, AND SUGGESTED VISUAL MATERIALS. (RP)

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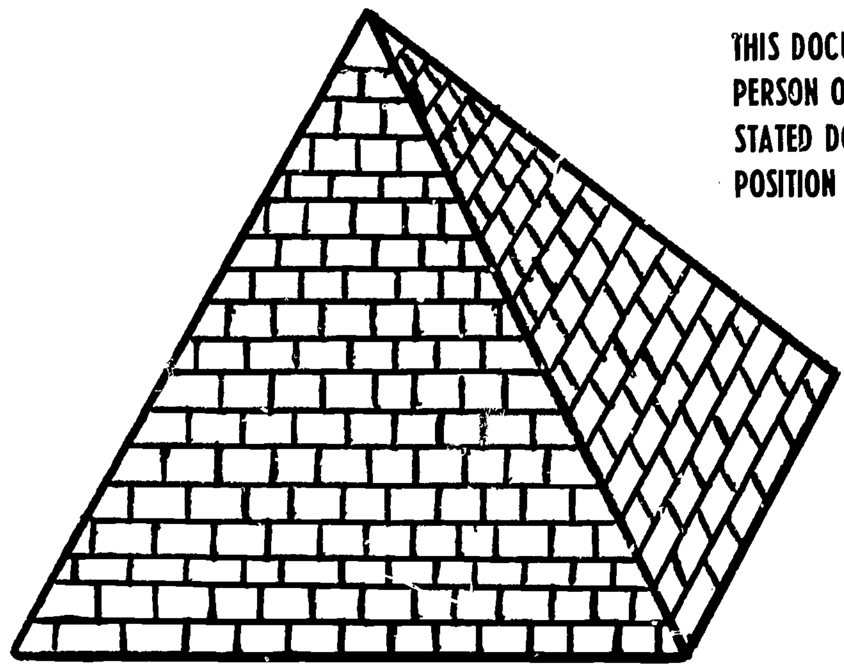

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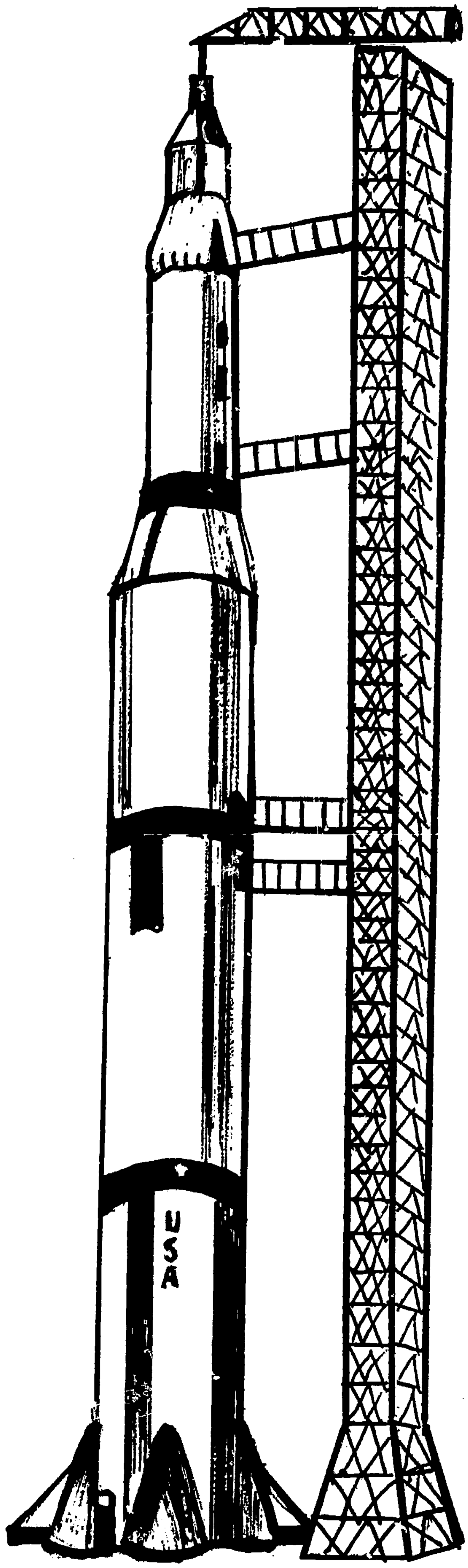

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ESEA Title III

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CONCEPTS OF LINEAR MEASURE

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INTRODUCTION

Measurement is very important in your everyday activities. There is seldom a day when you do not perform some measurement or think about a measurement. How far is it from your home to your school? What was the high, or low, temperature yesterday? How fast will your car go, or how quickly can you bring it to a stop? How many yards did that pass play cover? How long did it take you to complete your homework assignment? It goes on and on.

Without measurement our highly industrialized society would be nonexistent. As men learned to measure more accurately, to within a thousandth of an inch, the assembly line technique was born. With this technique it was no longer necessary for a man to be an expert at making one part of a piece of equipment. Since one part could be manufactured to within a thousandth of an inch, it would fit into another part without the tedious process of comparing and making readjustments with the first part. Thus articles manufactured by the assembly line technique were superior in quality and less costly. This technique also created many new jobs which could be done by almost anyone with a small amount of training.

There are several different types of measurements. Consider the distance from your home to your school. This is a <u>linear</u> measure. A measure of <u>area</u> for instance would be the number of acres of sugar cane planted in the Glades. The number of gallons of water in Lake Okeechobee is a <u>volume</u> measure. The number of degrees in an angle is an <u>angular</u> measure. Each of these, and indeed any measure, involves a number.

HISTORY AND THE MEANING OF LINEAR MEASURE

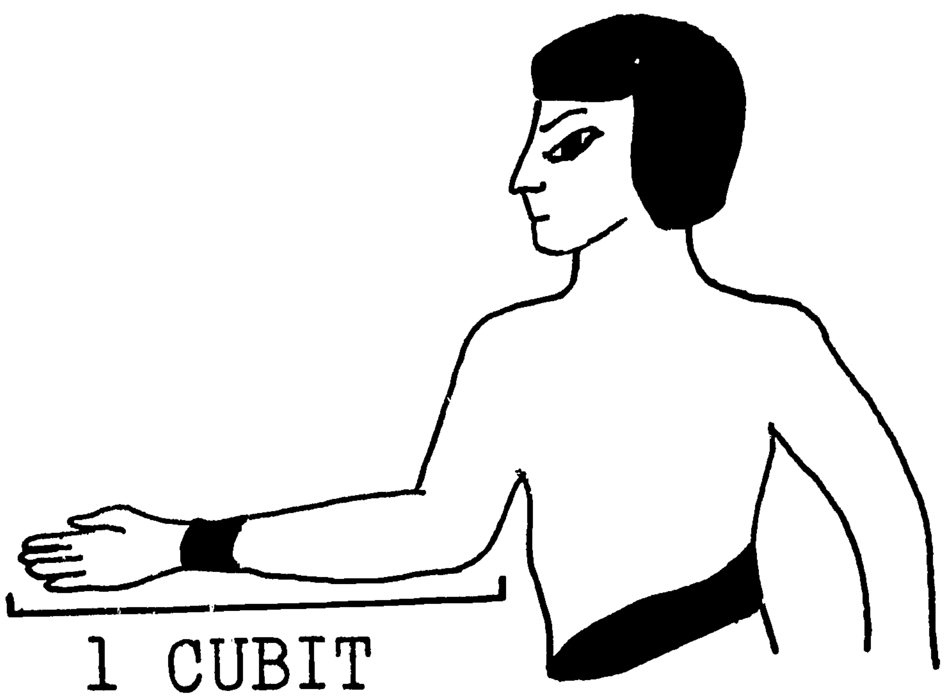
Suppose we begin our study of measurement by finding the length of the top of your desk and the length of your math textbook. First, select a unit of measure. For our purposes here, let us select two different units: the length of your pencil and the length of your thumb. Record your results in the following table.

Description of the Unit of Measure	Name of the Unit	Book Length (measure)	Desk Length (measure)
Length of pencil	pencils		
Length of thumb	thumbs		

Do you see the difficulty created by using these two units in our measuring? Did every student find the length of his textbook and desk top in pencils and thumbs to be the same? ______________

Egyptians

There is historical evidence to support the claim that 6,000 years ago the Egyptians were aware of linear measures. They selected a unit with which to measure length called the meh (cubit). It was described as the distance from the point of the elbow to the tip of the middle finger of an outstretched hand. Of course this distance would vary, according to the size of the person, but in terms of our present-day measures it was usually between 18 and 19 inches.



The cubit eventually became a standard unit in Egypt and was given a fixed length (18.24 inches compared to our present measurements). This measurement was used in the construction of the pyramids. The cubit was also used in the construction of King Solomon's temple. In the Old Testament (I Kings 7:23) you will find mention of a circular basin which was 10 cubits from brim to brim and 30 cubits around. Noah's Ark is described as 300 cubits long, 50 cubits wide, and 30 cubits high. (This was using the length of Noah's cubit. We do not know its exact measure but as stated above it was probably around 18 or 19 inches.)

Activities

1. Find the length in inches of your cubit. Give your answer to the nearest inch.

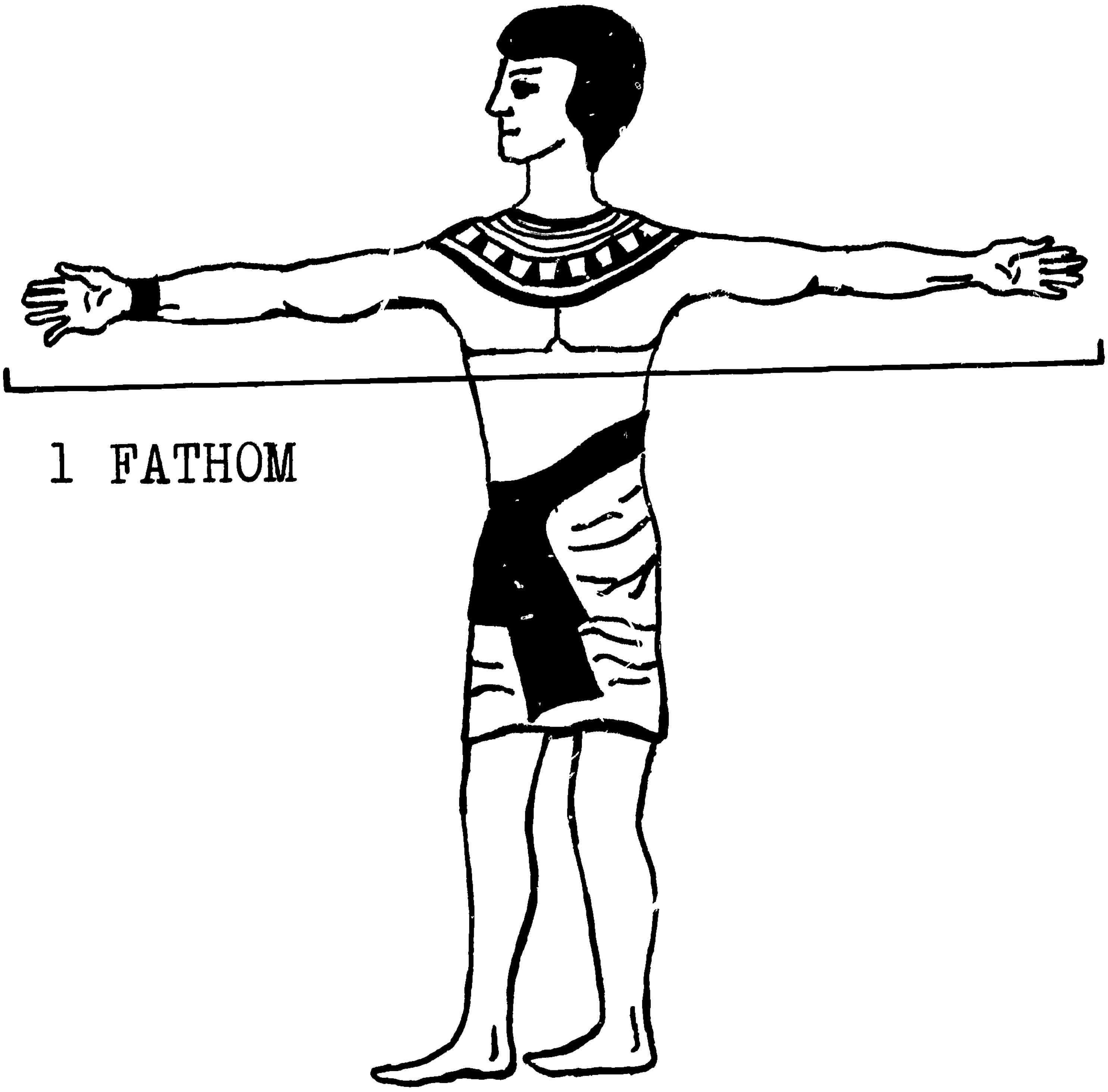
   ____

2. Using 18 inches as the length of Noah's cubit, determine the dimensions, in inches, of his ark. (The ark's dimensions were: length = 300 cubits, width = 50 cubits, and height = 30 cubits. ________________
3. Determine the dimensions of the ark in feet. ________________
4. Find the number of cubits in the length and width of your classroom. (Hint: using 18 inches as one cubit, how many cubits are in one yard? ____________)

Like the cubit, most of the units selected by the early Egyptians were based on parts of the human body. The span, one-half a cubit, was the distance between the tip of the little finger and the tip of the thumb when the hand was outstretched. The fathom was the length between one finger tip to the opposite finger tip of the extended arms. The palm was the width of the hand; a digit was the width of the middle finger. A meridian mile was given as 4,000 cubits.

The following list shows how some of the Egyptian units were related:

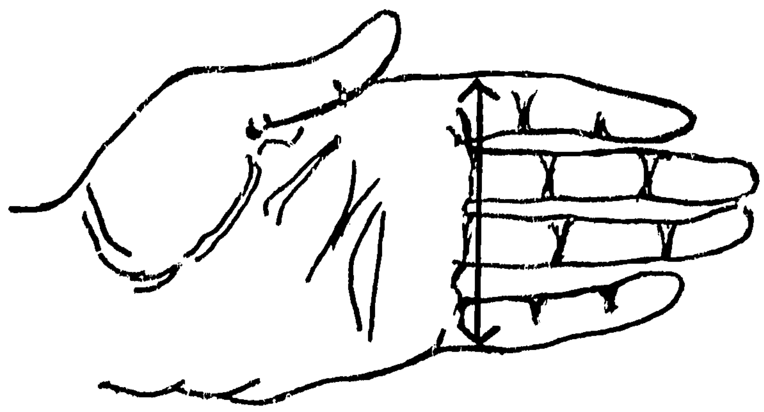
1 digit	=	width of the middle finger
4 digits	=	1 palm
3 palms	=	1 span
2 spans	=	1 cubit (meh)
4 cubits	=	1 fathom
10 cubits	=	1 rod (khet or log)
4,000 cubits	=	1 meridian mile



Activities

1. By placing your hand on a sheet of paper and marking with your pencil determine the width of your middle finger. This unit is known as ___________.
2. With your ruler draw a segment about 6 inches long. With your compass mark off on this segment 4 of the units of problem 1. This larger unit which is composed of 4 of the smaller units is called a ___________.
3. With your ruler draw a segment about 11 inches long. (Draw the segment diagonally from the upper left corner to the lower right corner of your paper.) Using your compass, mark off 3 palms. A segment which is 3 palms in length is equal to 1 ___________ in length.

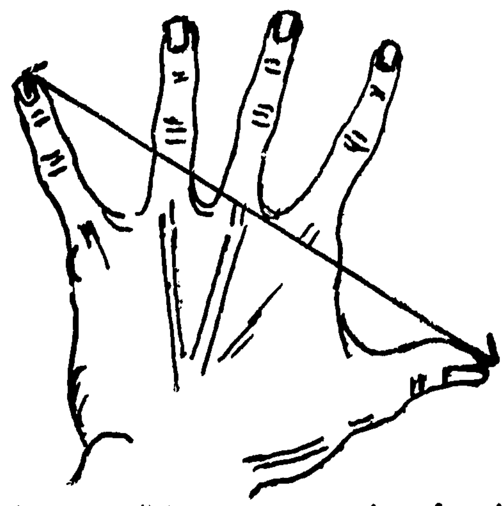
4. Measure the width of your hand as in the following illustration.



4 digits = 1 palm

Is the length of <u>your</u> palm about four times the length of your digit?

5. Measure from the tip of your little finger to the tip of your thumb of your outstretched hand. This is illustrated.



1 span

6. Give the lengths of these line segments in terms of the length of your digit:

(a) ______________

(b) ____________________________

(c) _________________ _______________________________________

(d) ____________________________________

7. Give the lengths of these line segments in terms of the length of your palm:

(a) ____

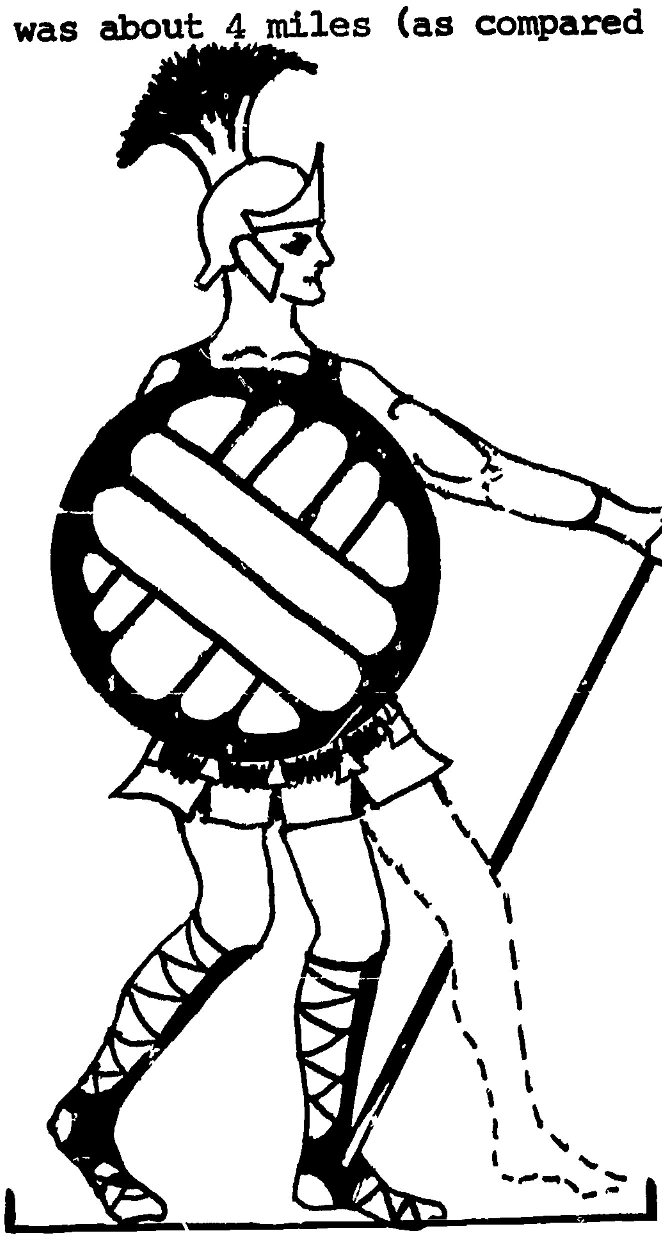
(b) _____________________________

Romans

Rome, at one time, was the greatest city in the world. It was the capital of the Roman Empire and also the center of learning and culture for the world. When the Roman armies conquered new territories, they imposed their customs on other peoples. The early Roman system of measures was made up of their own units of measures plus units borrowed from the Greeks, Chaldeans, Egyptians, and other people.

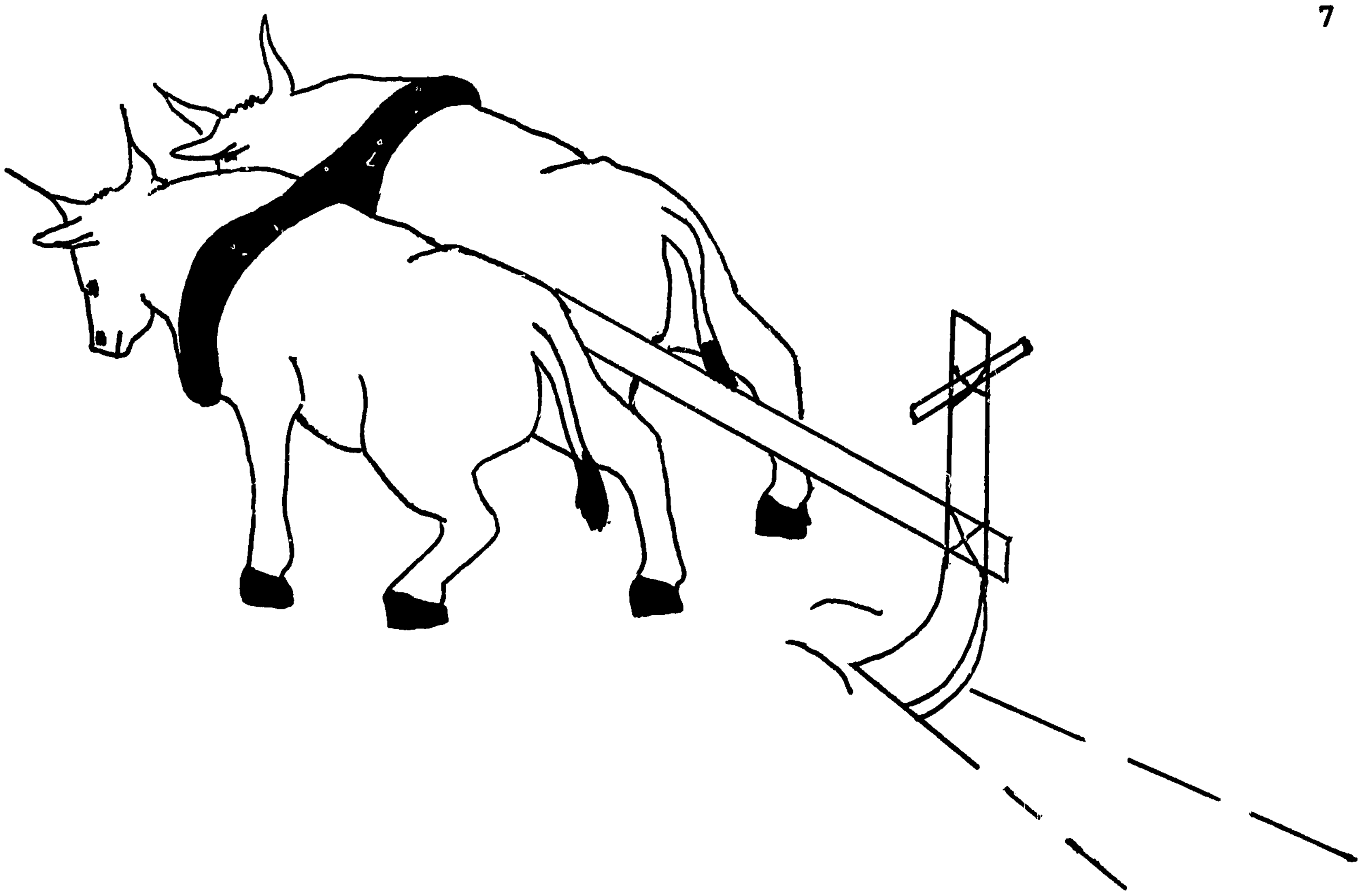
The inch was first invented by the Romans. This unit was described as the width of the thumb. A foot represented 12 inches. This idea—12 inches in one foot—has carried over until the present time.

The Roman pace was a double step and was approximately 5 feet. The mille or mile, also used by the Romans, was described as 1,000 paces. A longer unit known as the parasang, was about 4 miles (as compared to our measurements).



1 PACE

A unit used in land measurement and also in the construction of buildings was the actus. The actus was 120 feet long and was defined as the distance that a yolk of oxen could plough without rest.



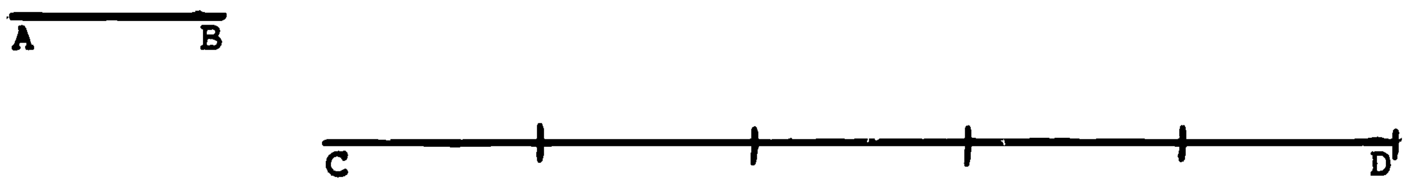
The stadia was a unit often used by both the Romans and Greeks. It represented about 600 feet, although the length of this unit varied considerably. It is possible that the stadia was the first unit used in calculating the distance around the earth. Perhaps you would be interested in reading more about the first person to give a very accurate measure of this distance. He lived in Alexandria, a city named after Alexander the Great. His name was Eratosthenes. Eratosthenes was librarian at the University of Alexandria. At the time, this university was the most famous in the world - the intellectual center for Greek scholars. Eratosthenes used very little mathematics in computing the distance around the earth, and it was amazingly close to the figure we know today.

Below are some Roman units and their approximate relationships.

1 inch	=	thumbs width
12 inches	=	1 foot
5 feet	=	1 pace
1,000 paces	=	1 mille (mile)
4 miles	=	1 parasang
1 actus	=	120 feet
1 stadia (stode)	=	varied considerably (at times around 500 feet and at other times about 600 feet.)

You have already seen the consequences of selecting an arbitrary unit of length, such as the length of a pencil, for your measurements. An object which has a certain length when measured in inches, for instance, has several different "lengths" when measured in pencils.

This difficulty is eliminated by agreeing on a "standard" unit. For instance, measure the length of the following line segment CD, using AB as your standard unit. (AB is the symbol for the length of the line segment whose end points are A and B.)



Using your compass, the number of units AB in length contained in the line segment can be determined by beginning at one end of the segment and marking off as many $\overline{AB}$'s as possible. In this example the line segment has a length of 5 units.

Activities

In each of the following problems find the length of the given segment using the indicated unit.

Unit   Segment To Be Measured

1. 

2.

3.

4. Is the length of the segment to be measured in problem three nearer 3 units or 4 units? ____________

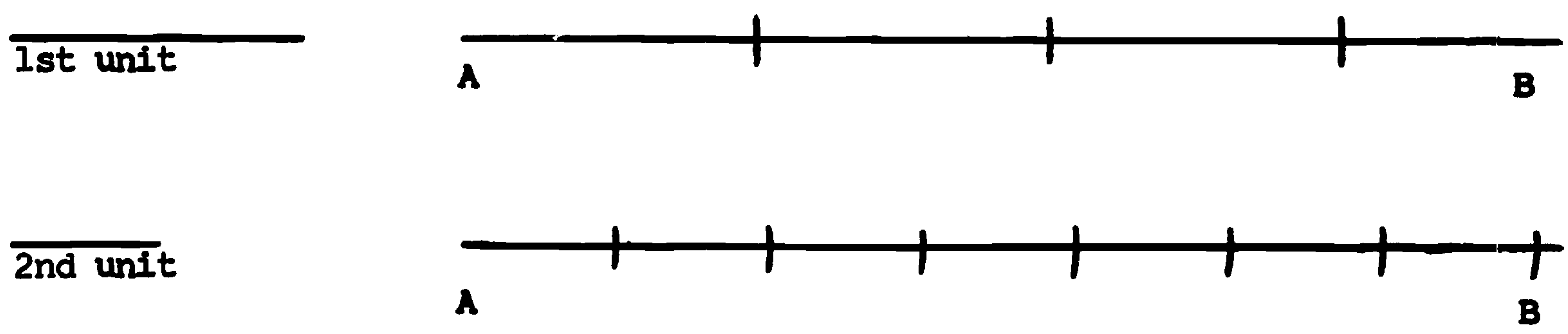
5. Is the length of the segment in problem one less than the length of the segment in problem two? ____________

6. Compare the lengths of the cubits of three different students.

Do you see that in order to know how the lengths of two line segments compare you must know the unit of measure as well as the number representing the length of the line segment.

In problem three we had a segment which when measured with our unit did not have a length which could be represented by a whole number. This will occur most of the time. You probably gave 3 as the length of this segment. You know that this is not exactly correct. There is some error in stating that the length of this segment is 3 units. While we can never eliminate the error completely, we can cut down the amount of error by making a new unit of measure which is $\frac{1}{2}$ the first unit.

If the line segment AB is measured first with a given unit, then a second time with $\frac{1}{2}$ our unit the second measurement has less error.



It can be seen that the first measuring gives an answer of 3 or 4, whichever you believe is nearer the correct length. As a result of the second measuring you would probably choose 7 as the number representing the length of $\overline{AB}$. To compare the two numbers we found in measuring $\overline{AB}$ with the two different units, multiply the second measurement, 7, by $\frac{1}{2}$.

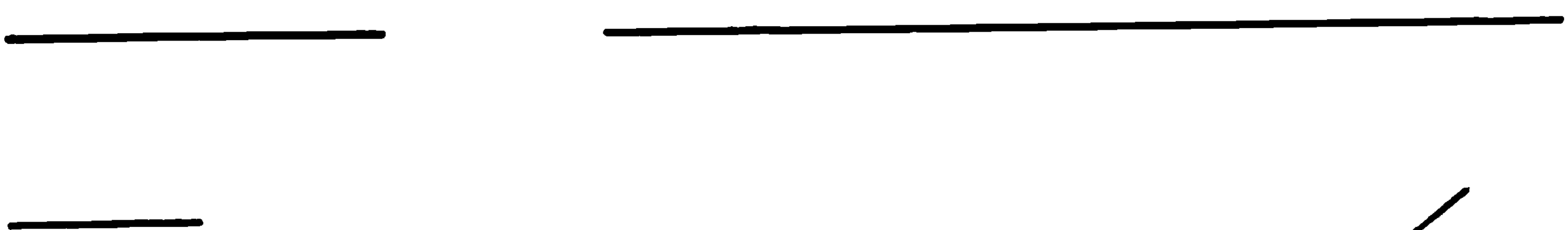
$$\frac{1}{2} \times 7 = 3\frac{1}{2}$$

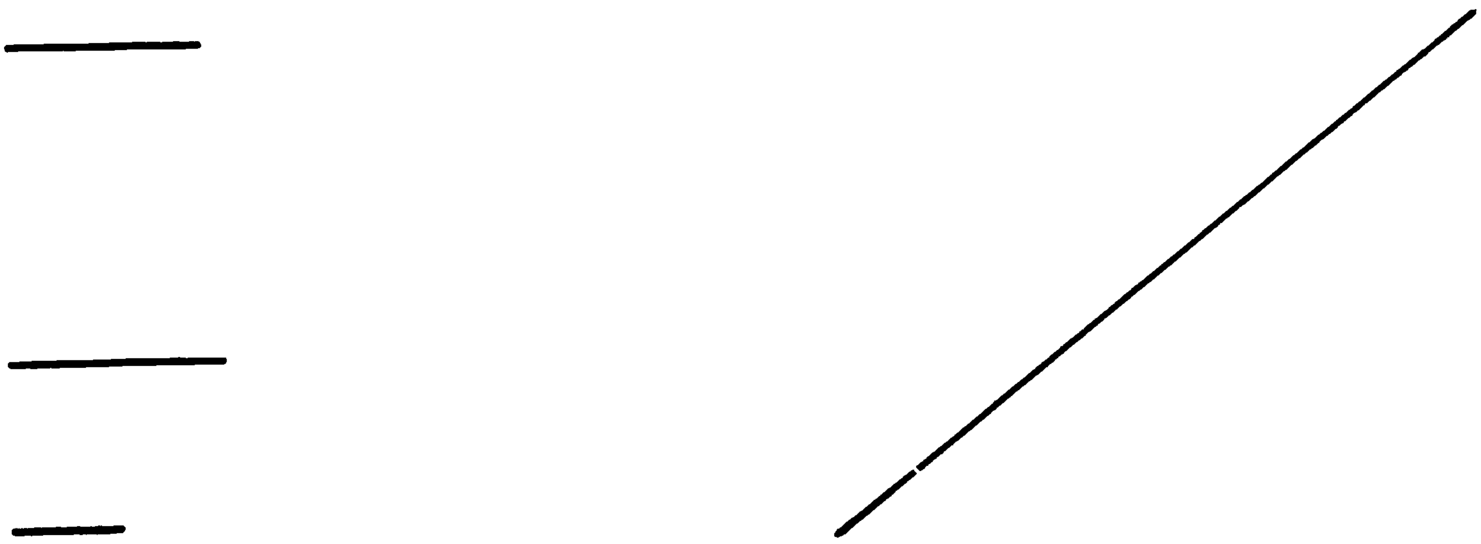
As can be seen from the illustration $3\frac{1}{2}$ is nearer the length of $\overline{AB}$ than 3 or 4.

Activities

Using the given units find the length of each of the line segments and state which answer is more nearly correct. The second unit is $\frac{1}{2}$ the first unit in each problem.

1. 

2. 

3. 

Precision

The word precision relates to the size of a unit of measure. The smaller the unit, the more precise the measurement. The following questions relate to the units below. Answer by writing yes or no.

A. ____________________

B. ______________

C. ________

D. __________________

E. _____

1. A is more precise than B. ____________
2. D is less precise than C. ____________
3. C is more precise than E. ____________
4. B is the least precise of all. ____________
5. E is the most precise of all. ____________
6. Which of the following units of linear measure is most precise?

   (a) foot
   (b) inch
   (c) pace
   (d) mile

7. Which of these units of measure is most precise?

   (a) cubit
   (b) pace
   (c) fathom
   (d) span

8. A tunnel has this statement printed above the entrance: vertical clearance 15 feet 0 inches. If you were driving a truck which needed a vertical clearance of 15 feet 3 inches would you attempt to travel through the tunnel? __________
9. If a tunnel gave the vertical clearance as 15 feet would you attempt to drive the same truck, as in problem 8, through the tunnel? ____________
10. Which of the following measurements is most precise?

    (a) 2 feet 5 inches
    (b) 2 feet
    (c) 1 pace 2 feet
    (d) 4 miles 3 paces

The units of measure used in some of the preceding problems could hardly be termed standard units of linear measure (pencils, thumbs). They were agreed upon only by those of us in this class. They are not agreed upon by all the people in the United States, not even all the students in this school.

Can you think of some standard units of linear measure which are <u>really</u> standard? "Standard" means that a large group of people know and understand this unit of measure. What about the inch, foot, yard and mile?

The ruler is an instrument for making linear measures in inches. The ruler, which has a length of one foot, is subdivided into 12 units each with the same length. These twelve units, as you know, are called inches. Most rulers subdivide each inch into smaller units, in most instances into 16 equal parts. Thus the smallest unit of division on most rulers is 1/16 of an inch.

Activities

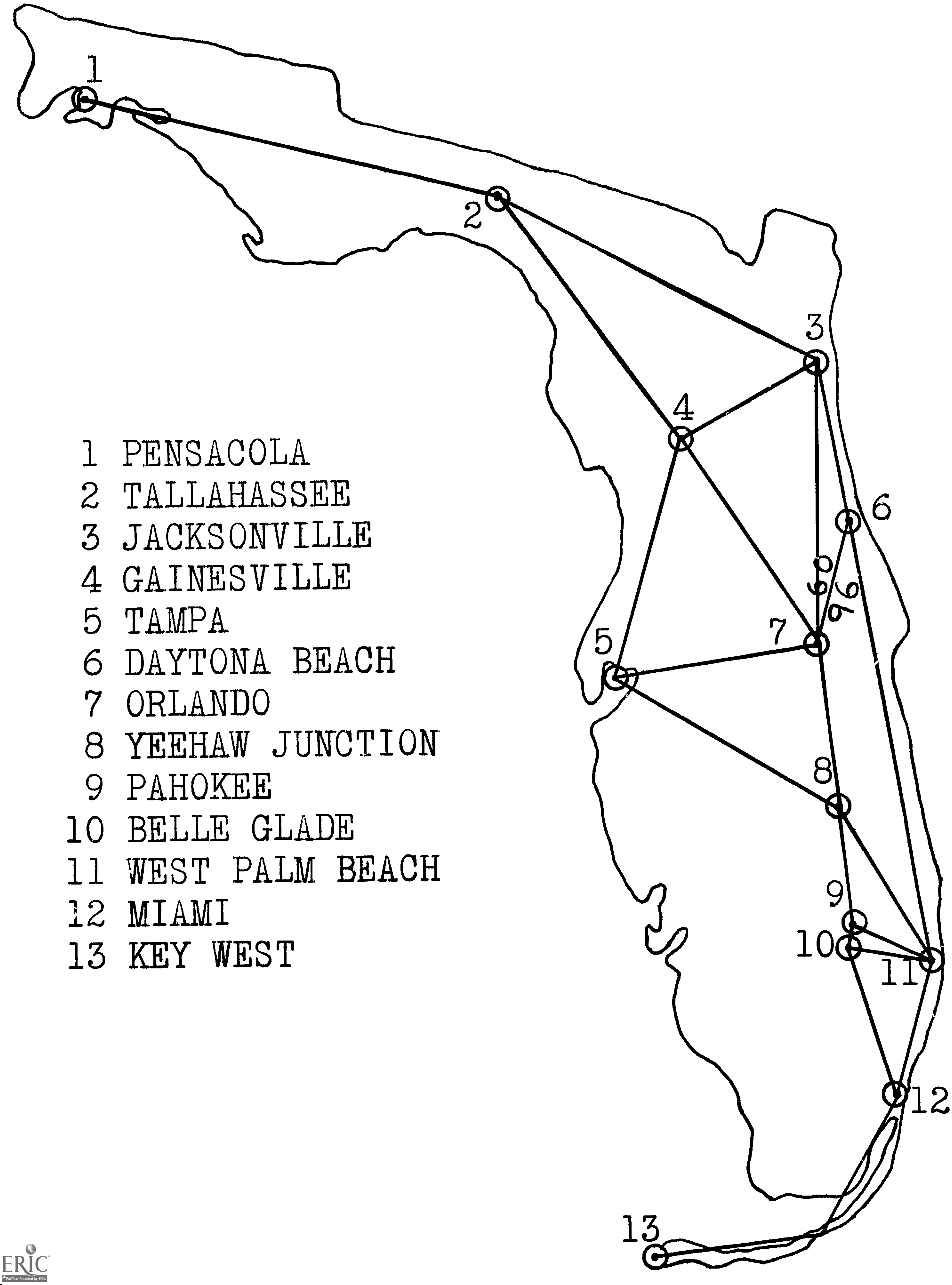
Using your ruler find the number of inches, to the nearest 1/16 of an inch, between the names of the following "cities". Use the map on page 14 of your book and measure along the lines on your map.

1. Pensacola - Tallahassee ____________________
2. Tallahassee - Jacksonville ____________________
3. Tallahassee - Gainesville ____________________
4. Gainesville - Tampa ____________________
5. Tampa - Orlando ____________________
6. Tampa - Yeehaw Junction ____________________
7. Jacksonville - Orlando ____________________
8. Orlando - Yeehaw Junction ____________________
9. Yeehaw Junction - Pahokee ____________________
10. Pahokee - Belle Glade ____________________
11. Belle Glade - Miami ____________________
12. Miami - Key West ____________________
13. West Palm Beach - Miami ____________________
14. West Palm Beach - Pahokee ____________________
15. West Palm Beach - Belle Glade ____________________
16. Jacksonville - Gainesville ____________________
17. Jacksonville - West Palm Beach ____________________
18. West Palm Beach - Yeehaw Junction ____________________
19. Tampa - Jacksonville ____________________
20. Miami - Belle Glade ____________________

Most maps are drawn to a scale. This means that a certain linear measure represents another linear measure. For instance, 1 inch might represent 10 miles. If the names of two cities on this map are three inches apart, these cities are in reality 3 x 10 or 30 miles apart. If the names of two cities are ½ inch apart, then the cities are ½ x 10 or 5 miles apart.

Activities

1. Determine the scale of the map on page 14. (Hint: The distance from Orlando to Daytona is 60 miles.) The distance between the names of Orlando and Daytona on the map is 1 inch. Thus the scale of __________ inch represents __________ miles.
2. Check your solution to problem 1 by finding the map distance between Orlando and Gainesville. (See page 15)
3. Use the scale that you found to complete the mileage chart.


1
2
3
4
5
6
7
8
9
10
11
12
13
1 PENSACOLA
2 TALLAHASSEE
3 JACKSONVILLE
4 GAINESVILLE
5 TAMPA
6 DAYTONA BEACH
7 ORLANDO
8 YEEHAW JUNCTION
9 PAHOKEE
10 BELLE GLADE
11 WEST PALM BEACH
12 MIAMI
13 KEY WEST

MILEAGE CHART

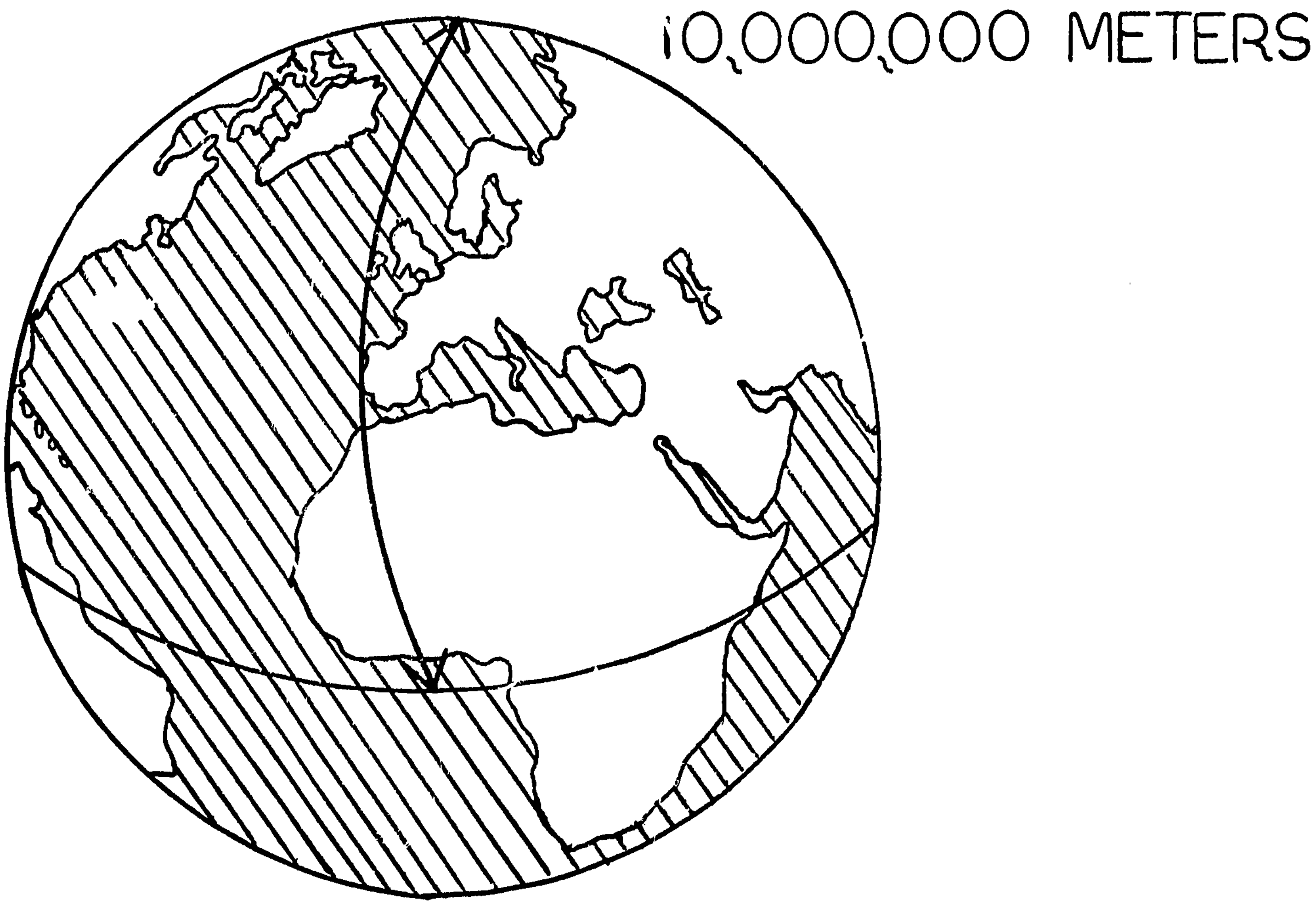
	BELLE GLADE	GAINESVILLE	JACKSONVILLE	KEY WEST	MIAMI	ORLANDO	PAHOKEE	PENSACOLA	TALLAHASSEE	TAMPA	WEST PALM BEACH
ELLE GLADE		266	281	232				611	409	195	
AINESVILLE	266			498	341	120	255				285
ACKSONVILLE	281			516	359		270				292
EY WEST	232	498	516			389	243	843	641	427	
IAMI		341	359			232		686	484	270	67
RLANDO		120		389	232			465			
AHOKEE		255	270	243				600	398		
ENSACOLA	611			843	686	465	600			465	630
ALLAHASSEE	409			641	484		398				428
AMPA	195			427	270			465			
EST PALM BEACH		285	292		67			630	428		

To determine the distance between two cities, find the name of one city on the horizontal row and the name of the other city on the vertical column. The numeral at the intersection gives the mileage. Example: the distance from West Palm Beach to Miami is 67 miles.

Metric Measurements

The work that we have done in linear measure up to this time has included some of the units of the English system of measure, the inch and the mile. A system of measurement with which you may not be familiar is the metric system.

One of the standard units of linear measure in the metric system is the meter. The meter is one ten-millionth of the distance along a great circle as measured from the north pole to the equator. Compared to a measure we commonly use, this is about 39.37 inches.



In the metric or meter system of measures, we use a "prefix" before our unit to tell us "how many". An easy way to explain this is to give the prefixes of linear measure. We use the meter as our basic unit.

Below are some of the prefixes commonly used and their meanings.

Prefix	Meaning
kilo	thousand
hecto	hundred
deca	ten
deci	tenth
centi	hundredth
milli	thousandth

You can see below how useful the above prefixes are in learning the metric system.

Compare

Place value of our numeration system	Place value of the metric system (prefixes)	Metric System Unit
thousands	kilo unit	kilometer
hundreds	hecto unit	hectometer
tens	deca unit	decameter
ones	unit	meter
tenths	deci unit	decimeter
hundredths	centi unit	centimeter
thousandths	milli unit	millimeter

The metric system was adopted by the French in 1837. From that time until about 1960 the official standard was a platinum--iridium bar which was kept at Sevres, France. Shortly after 1960, the meter was officially defined as 1,650,763.73 times the wavelength of orange light emitted by the isotope krypton 86.

The distances between Orlando and Daytona is indicated on the map on page 14 by two numerals. The smaller number gives the distance in miles and the larger one in kilometers. The term kilo means a thousand, and therefore a kilometer is one thousand meters.

A kilometer is very nearly equivalent to 0.62 miles. This can be seen from the map we have been using. The distance between Orlando and Daytona is given as 60 and 96, 60 miles and 96 kilometers. This means, for practical purposes, that:

$$60 \text{ miles} = 96 \text{ kilometers}$$

or

$$\frac{60}{96} \text{ mile} = \frac{96}{96} \text{ kilometer}$$

$$0.62 \text{ mile} = 1 \text{ kilometer}$$

How would you determine the number of kilometers in a mile? Begin with the same information as in the previous problem:

$$60 \text{ miles} = 96 \text{ kilometers}$$

Since the distance from Orlando and Daytona is 60 miles, 1/60 of that distance would be 1 mile. But 1/60 of this distance would also be 1/60 x 96 kilometers. The solution to this problem is 1.6 kilometers. Thus we see that:

$$0.62 \text{ miles} = 1 \text{ kilometer}$$

and

$$1.6 \text{ kilometers} = 1 \text{ mile}$$

Activities

1. Using your completed mileage table on page 15, fill in the kilometer table on page 18. (You'll have to change miles to kilometers.)
2. Determine the distance in miles from Daytona Beach to West Palm Beach by changing kilometers to miles. (It is 329 kilometers from Daytona Beach to West Palm Beach.)
3. Check the answer to problem 2 by determining the distance on the map between the names of Daytona Beach and West Palm Beach, and then multiply by the appropriate number.
4. Mr. Harkless took a European tour. Since he wanted to drive around to each place he visited, he took his American made automobile. While he was traveling in Germany he saw a sign that stated the maximum speed was 80 kilometers per hour. Mr. Harkless was doing 60 mph. Was he speeding?

KILOMETER CHART

	BELLE GLADE	GAINESVILLE	JACKSONVILLE	KEY WEST	MIAMI	ORLANDO	PAHOKEE	PENSACOLA	TALLAHASSEE	TAMPA	WEST PALM BEACH
ELLE GLADE		426	450	371				978	654	312	
AINESVILLE	426			797	546	192	408				456
ACKSONVILLE	450			826	574		432				467
EY WEST	371	797	826			622	389	1349	1026	683	
IAMI		546	574			371		1098	174	432	107
RLANDO		192		622	371			744			
AHOKEE		408	432	389				960	637		
ENSACOLA	978			1349	1098	744	960			744	1008
ALLAHASSEE	654			1026	774		637				685
AMPA	312			683	432			744			
EST PALM BEACH		456	467		107			1008	685		

Converting Measures

Suppose we wanted to change the following measure to inches: 4 yards 2 feet 6 inches.

1 yard = 36 inches and 4 yards = 144 inches
1 foot = 12 inches and 2 feet = 24 inches

4 yards 2 feet 6 inches = 144 inches + 24 inches + 6 inches = 174 inches

A similiar conversion in the metric system may be to change the following measure to centimeters: 4 meters 2 decimeters 6 centimeters.

We know already that it is 426 centimeters since:

1 meter = 100 centimeters and 4 meters = 400 centimeters
1 decimeter = 10 centimeters and 2 decimeters = 20 centimeters

4 meters 2 decimeters 6 centimeters = 400 centimeters + 20 centimeters + 6 centimeters = 426 centimeters

Which do you think is easier to change and which involves the least to remember? Let's add and subtract some measures and look at regrouping of the English and metric linear measures.

Addition

ENGLISH

5 yards	2 feet	9 inches
+ 8 yards	2 feet	8 inches
13 yards	4 feet	17 inches
13 yards	5 feet	5 inches
14 yards	2 feet	5 inches

Must Remember: 1 foot = 12 inches
3 feet = 1 yard

METRIC

5 meters	2 decimeters	9 centimeters
+ 8 meters	2 decimeters	8 centimeters
13 meters	4 decimeters	17 centimeters
13 meters	5 decimeters	7 centimeters

Must Remember: Just add as we do in our numeration system since,
10 centimeters = 1 decimeter
10 decimeters = 1 meter

Now how would we convert the English answer to inches and the metric answer to centimeters?

14 yards	= 14 x 36 inches =	504 inches
2 feet	= 2 x 12 inches =	24 inches
5 inches		5 inches
		533 inches

13 meters	= 1300 centimeters
5 decimeters	= 50 centimeters
7 centimeters	= 7 centimeters
	1357 centimeters

(You could have arrived at the answer without computing.)

Subtraction

	3	
8	$\cancel{4}$	15
$\cancel{9}$ yards	$\cancel{1}$ foot	$\cancel{3}$ inches
− 2 yards	2 feet	9 inches
6 yards	1 foot	6 inches

Must Remember: Change 9 yards to 8 yards and increase the 1 foot to 4 feet, then change that to 3 feet and make the 3 inches 15 inches and then subtract.

8	10	13
$\cancel{9}$ meters	$\cancel{1}$ decimeters	$\cancel{3}$ centimeters
− 2 meters	2 decimeters	9 centimeters
6 meters	8 decimeters	4 centimeters

Must Remember: Just subtract as we do in our numeration system.

Activities

1. Change the answer of the first subtraction problem above to inches. ________

2. Change the answer of the second subtraction problem above to centimeters.

   ____

In each of the problems 3 - 5 change to centimeters (cm.).

3. 5 meters 6 decimeters 4 centimeters. ________

4. 2 meters 4 decimeters 9 centimeters. ________

5. 7 decimeters 5 centimeters. ________

Change to millimeters (mm.):

6. 2 meters 5 decimeters 9 centimeters 6 millimeters. ________

7. 7 meters 3 decimeters 0 centimeters 2 millimeters. ________

8. 7 meters 3 decimeters 2 millimeters. ________

9. 5 meters. ________________

10. Change 256 kilometers to meters. ________________

11. Change 7 meters to millimeters. ________________

12. Change 4 meters to centimeters. ________________

13. Change 2 meters 5 decimeters to centimeters. ________________

14. To measure the distance from Belle Glade to West Palm Beach, you would most likely use which one of the following units of measure?

(a) millimeter

(b) centimeter

(c) kilometer

(d) decimeter

15. To measure the depth of Lake Okeechobee, you would most likely use which one of the following units of measure?

(a) millimeter

(b) centimeter

(c) meter

(d) kilometer

16. To measure the diameter of a ball point pen, you would most likely use which one of these units of measure?

(a) meter

(b) kilometer

(c) centimeter

(d) millimeter

17. 5 yards 1 foot 5 inches
− 3 yards 2 feet 6 inches

18. 5 meters 1 decimeter 5 centimeters
− 3 meters 2 decimeters 6 centimeters

19. 6 yards 2 inches
− 3 yards 1 foot 4 inches

20. 6 meters 2 centimeters
− 3 meters 1 decimeter 4 centimeters

Two tables for converting units are given below. These corresponding values are approximate.

Metric	English	English	Metric
1 kilometer	.62 miles	1 mile	1.6 kilometers
1 kilometer	1091 yards	1 mile	1600 meters
1 meter	1.09 yards	1 yard	.9144 meters
1 meter	3.28 feet	1 foot	.3048 meters
1 meter	39.37 inches	1 foot	30.48 centimeters
1 centimeter	.3937 inches	1 inch	2.54 centimeters

Convert expressions in English measures to metric and those in metric to English.

1. A mile a minute is __________ kilometers a minute.

2. Driving 30 miles per hour is __________ kilometers per hour.

3. If a person travels 100 miles, he travels __________ kilometers.

4. At one place the Pacific Ocean is 10,863 meters deep. The ocean is __________ feet deep at this location.

5. In Oklahoma City a TV tower is 479 meters tall or __________ feet tall.

6. Arctic Terns migrate about 6,820 kilometers each way every year. These birds travel __________ miles each way.

7. The shoreline of the Dead Sea located between Israel and Jordan is 1,286 feet below sea level. This is the distance of __________ centimeters.

8. The 100 yard dash would be a __________ meter dash.

9. The longest snake on record, a 37.5 foot Anaconda in South America, is how many meters long? __________ meters

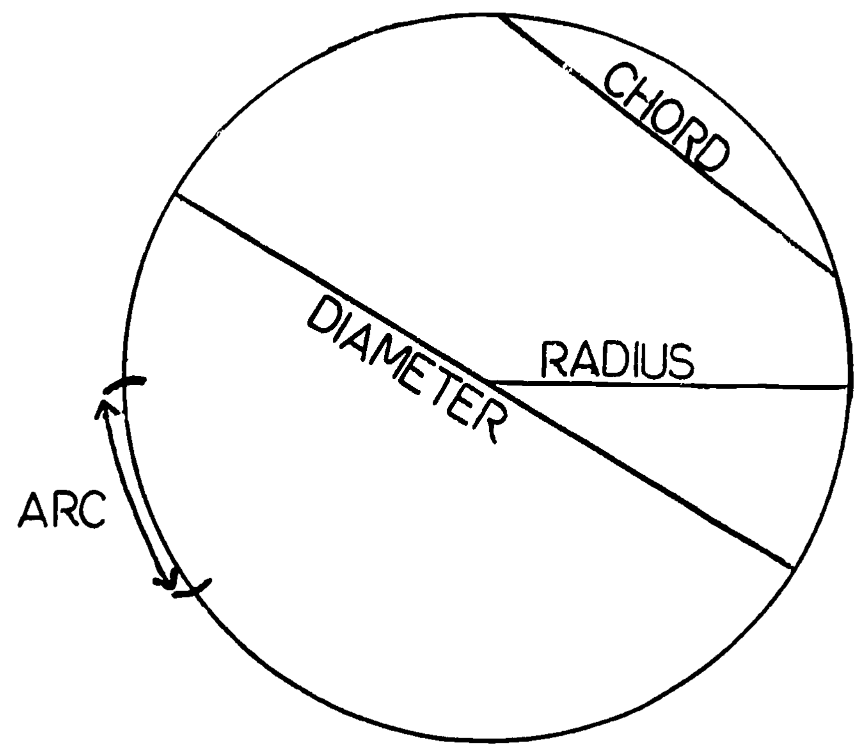
10. The Mississippi River is 2,350 miles or __________ kilometers long.

PERIMETER—THE DISTANCE AROUND

Linear measure is used to find the distance around plane geometric figures. Usually you are not told to find the distance around, but to find the perimeter. This word perimeter, is made up of two words, the Greek work peri meaning around and meter which refers to metric or measure. We see then that perimeter means the measure around.

Circles

This illustration will give you the vocabulary which is necessary in a discussion of the circle.



A diameter is a line segment through the center of the circle with endpoints on the circle.

A radius is a line segment which has the center of the circle and one point of the circle as endpoints.

A chord is a line segment with two points of the circle as endpoints.

An arc is part of the circle.

One of the more interesting perimeters is that of the circle. To determine the perimeter, called the circumference of a circle, take a piece of string and wrap it around the circular object and then measure the length of the string. This length will be the circumference of the circle.

Activities

Three circular objects will be needed for this activity.

1. Find the circumference of two circular objects (a cup, a coin, a wheel, a tin can, etc.) by measuring the length of string necessary to wrap around the objects.
2. Find the circumference of the third circular object by making one complete revolution of the object. Mark the beginning and the completion of the revolution on a sheet of paper. Measure the straight line segment between these two points. This is the circumference.
3. Measure the diameter of each of the three objects used in activities 1 and 2, and complete the following table.

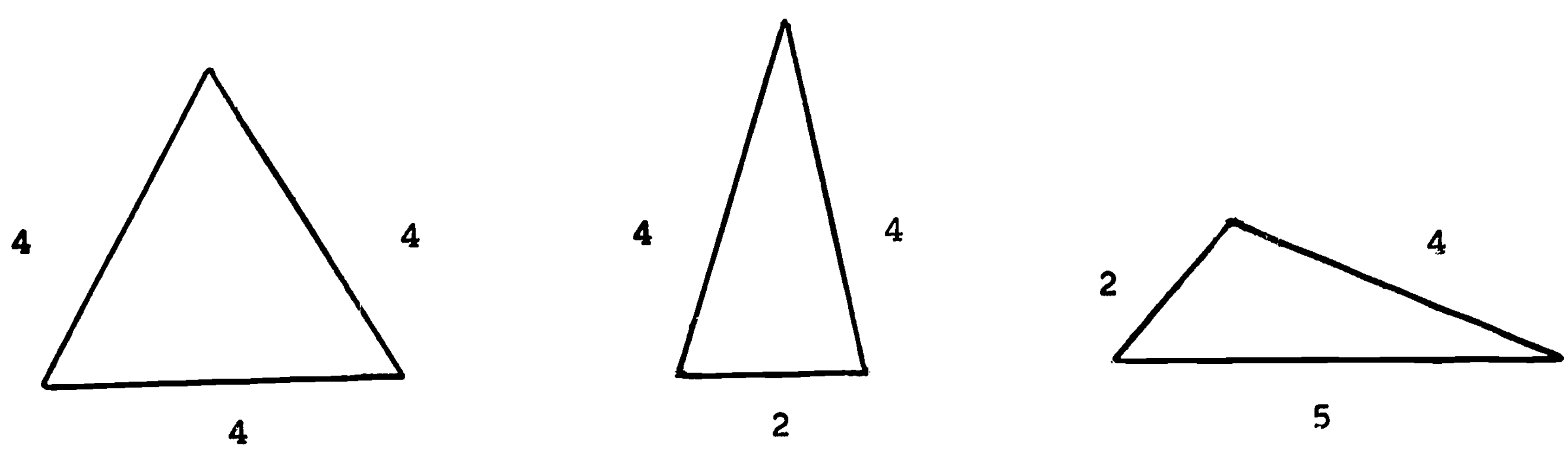
Object	Circumference	Diameter	Circumference ÷ Diameter
1.			
2.			
3.			

4. Find the average of the last column. ________________

Do you see that regardless of the size of the circle, the circumference divided by the length of the diameter is always just about the same number. If it were not for the error involved in measurement, this would always be the same number. This number, circumference divided by diameter, is designated by the symbol π, the Greek letter pi. If c represents the circumference and d the length of the diameter, then our result is written as $c/d = \pi$. The exact value of the number π cannot be written as a common fraction. This also means that it cannot be written as a terminating decimal fraction. We will use the value 3.14 or 22/7 as an approximate value of π. The relationship of the diameter to the circumference shows that there are about 3.14 diameters in the circumference of the circle ($c = 3.14 \times d$).

Triangles

An equilateral triangle is one with the lengths of all three sides equal. Again the name tells us what the triangle is like. The word lateral means side. A lateral in a football game means a pass to the side, not a forward pass. So equilateral means equal sides. An isosceles triangle has the lengths of at least two of its sides equal and a scalene triangle has none of its sides the same length.



The perimeter of the equilateral triangle whose sides are each four centimeters is 4 + 4 + 4 or 12 centimeters. What is the perimeter of an equilateral triangle if one side measures 6 inches in length? ____________

Did you obtain the answer by adding 6, 6, and 6 or did you multiply 3 times 6? ____________

The perimeter of an isosceles triangle can be obtained by adding the lengths of all three sides, of course. The perimeter of the isosceles triangle pictured above is 4 + 4 + 2 or 10 centimeters. This result could have been obtained by multiplying 2 times 4 and adding 2. What is the perimeter of an isosceles triangle when one of the two sides of equal length is 10 inches and the other side is 5 inches.

Solution: 2 x __________ + 5 = __________.

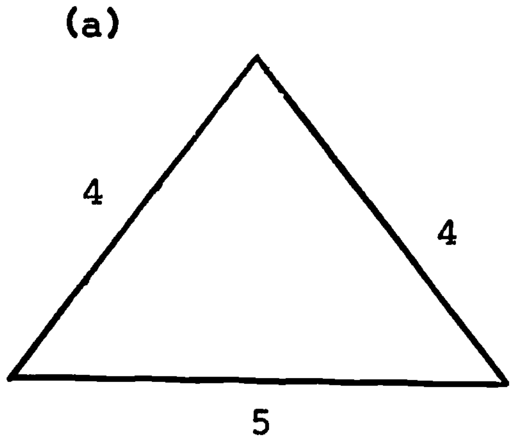
Activities

1. Find the perimeter of an equilateral triangle with a side of length:
   (a) 7 inches ____________
   (b) 15 inches ____________
   (c) 2.7 feet ____________
   (d) 3 2/3 inches ____________

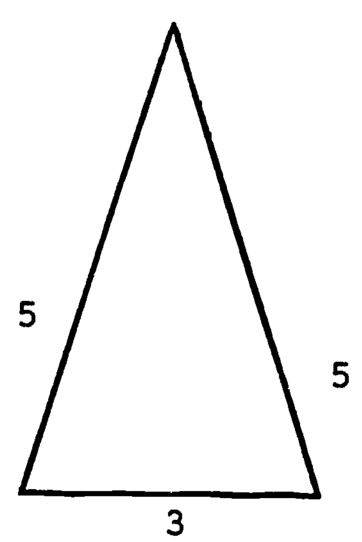
2. Find the perimeter of a scalene triangle with sides of lengths:
   (a) 3, 5, and 7 inches ____________
   (b) 22.5, 15.05, and 39.37 centimeters ____________
   (c) 17 1/2, 43 1/3, and 27 1/4 inches ____________

3. Find the perimeter of the following isosceles triangles:

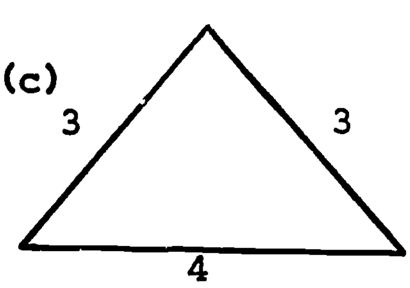
(a)



(b)

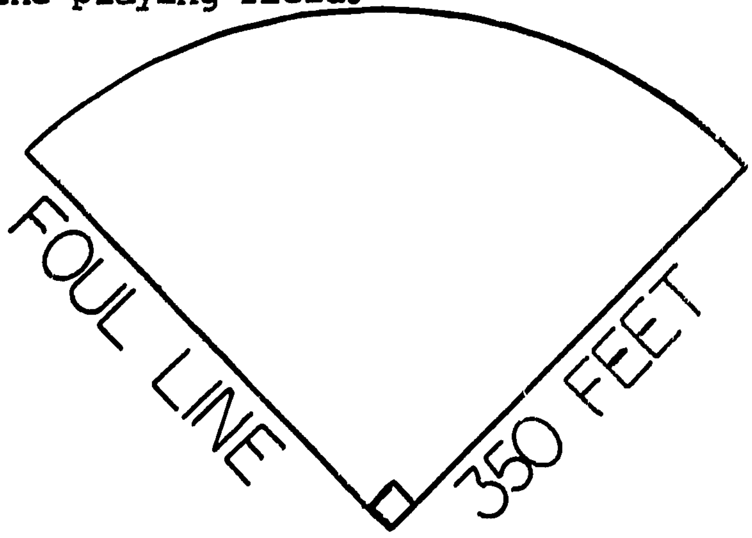


(c)

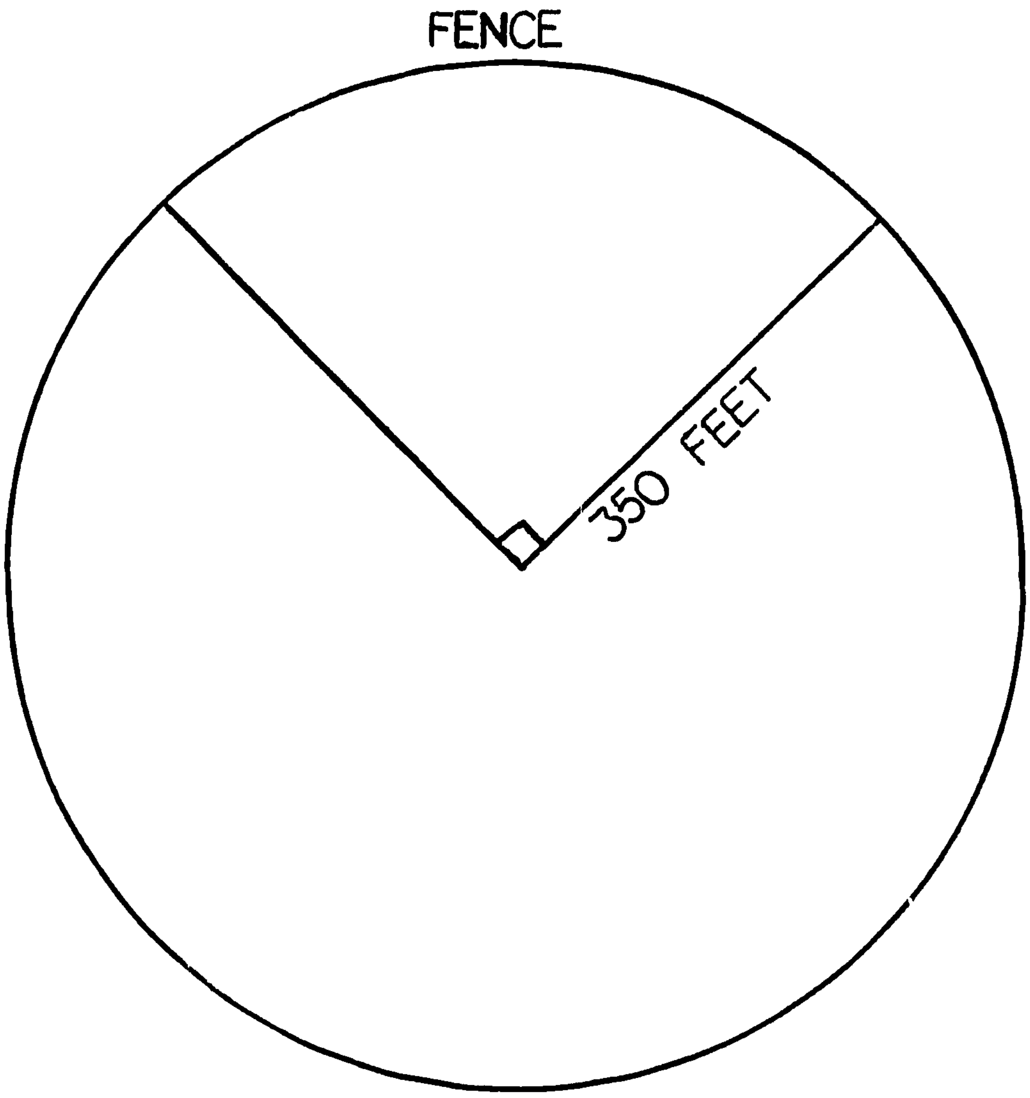


a) ____________ b) ____________ c) ____________

4. Find the perimeter of the baseball field pictured below. This will give you the distance around the playing field.

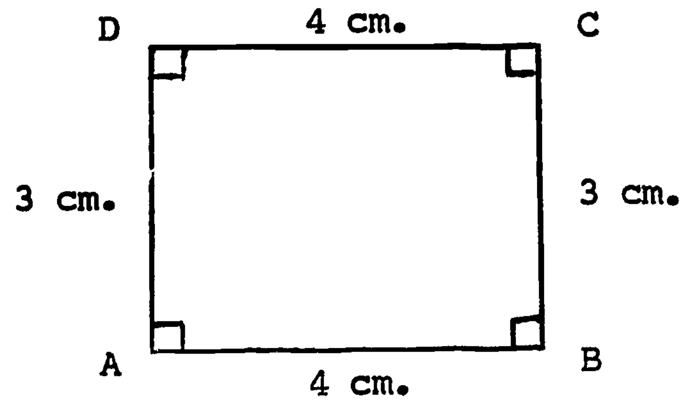


(Hint: The length of the fence is one-fourth the circumference of the circle with a radius of length 350 feet. See the following drawing.)



Rectangles

A rectangle is a four sided plane geometric figure with four 90° angles and the lengths of the opposite sides equal.



In the preceding figure DC and AB equal 4 centimeters, AD and BC equal 3 centimeters and the measure of angles A, B, C, and D is 90. This then is a picture of a rectangle.

The perimeter of this rectangle is determined as follows: (Let P represent the perimeter.)

$$
\begin{aligned}
P &= (3 + 4) + (3 + 4) \\
&= 7 + 7 \\
&= 14
\end{aligned}
$$

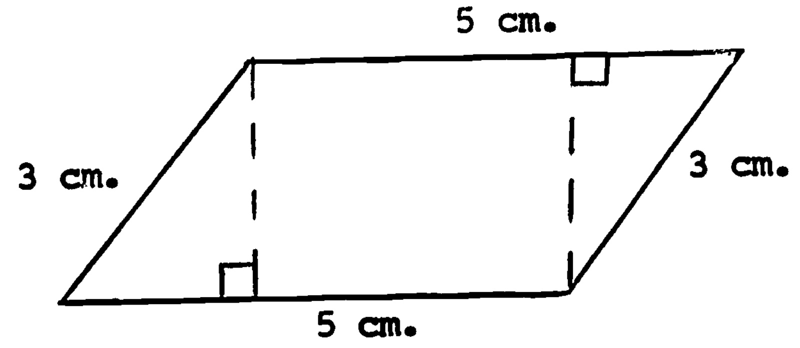
The perimeter of this rectangle is 14 centimeters. Do you see that the perimeter could also be determined in this manner?

$$
\begin{aligned}
P &= (3 + 4) + (3 + 4) \\
&= 2\ (3 + 4) \\
&= (2 \times 3) + (2 \times 4) \\
&= 6 + 8 \\
&= 14
\end{aligned}
$$

This method makes use of the distributive principle.

If the rectangle has a base b inches in length and a height of h inches, then the perimeter is 2 (b + h).

How would you find the perimeter of a parallelogram? Would it be twice the sum of the base and the height? ____________ If you said yes, you are incorrect. Look at the figure on the following page.



Do you see that the perimeter is 2 (3 + 5), or 16 centimeters?

Activities

Find the perimeter of the following:

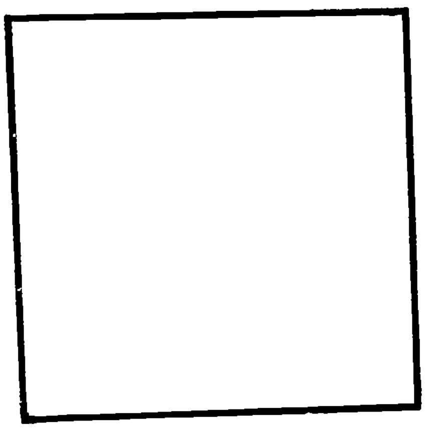
1. Parallelogram with two sides of 6 and 19 inches. ______________
2. A rectangle with the base and height of 9.7 centimeters and 4.45 centimeters respectively. ______________
3. A billboard with base and height of 12 feet and 6 feet respectively. __________
4. A parallelogram with two sides of 5 and 10 inches. ______________

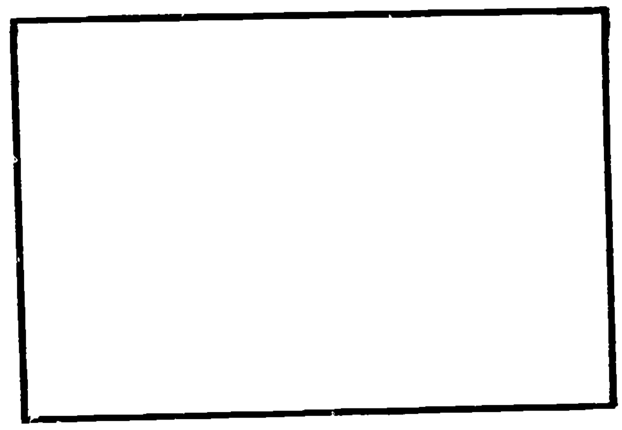
In problems 5 - 10 estimate the perimeter of each:

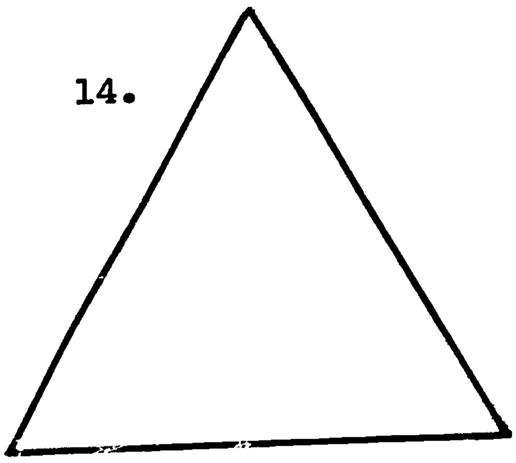
5. Your desk top. ____________ centimeters
6. A piece of notebook paper. ____________ inches
7. Your ruler. ____________ centimeters ____________ inches
8. A textbook. ____________ inches
9. Your notebook. ____________ centimeters
10. This booklet. ____________ inches

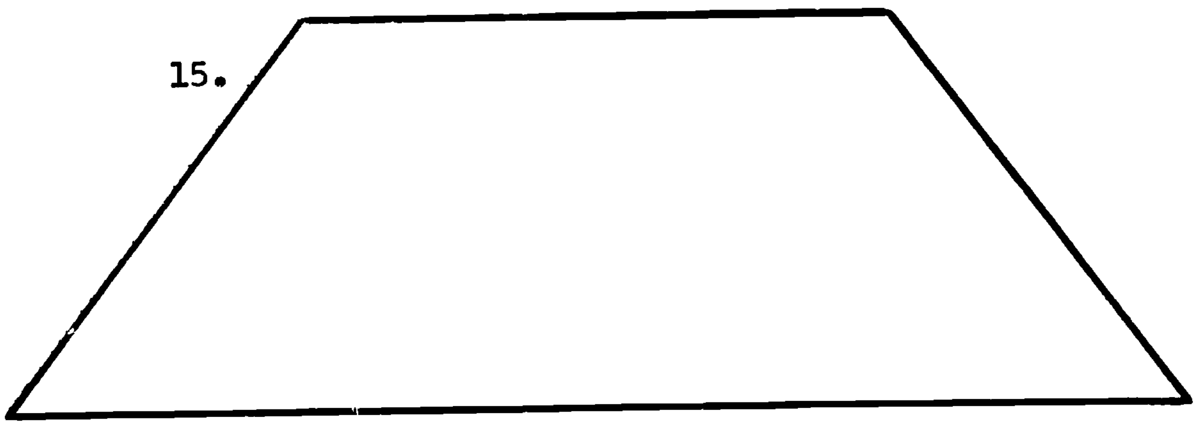
11. Measure, using your ruler, the perimeters of problems 5 - 10.

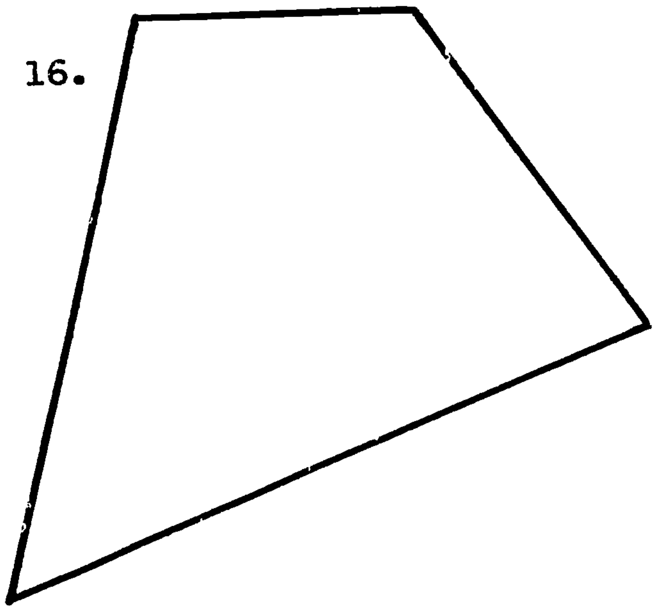
Use your ruler to find the perimeter in centimeters of the following:

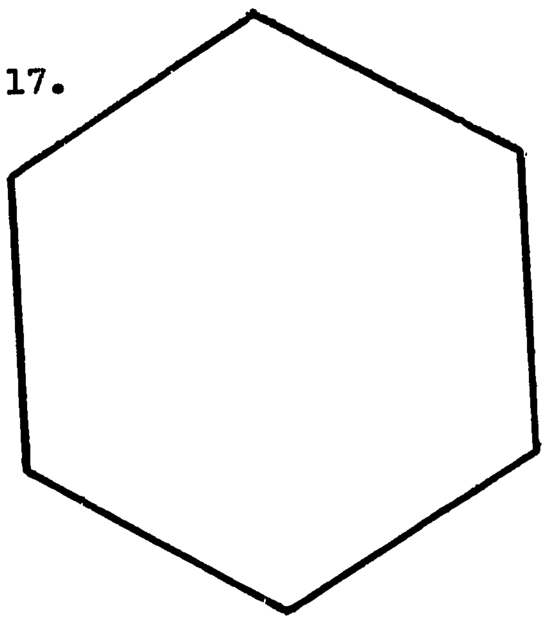
12. 

13. 

14. 

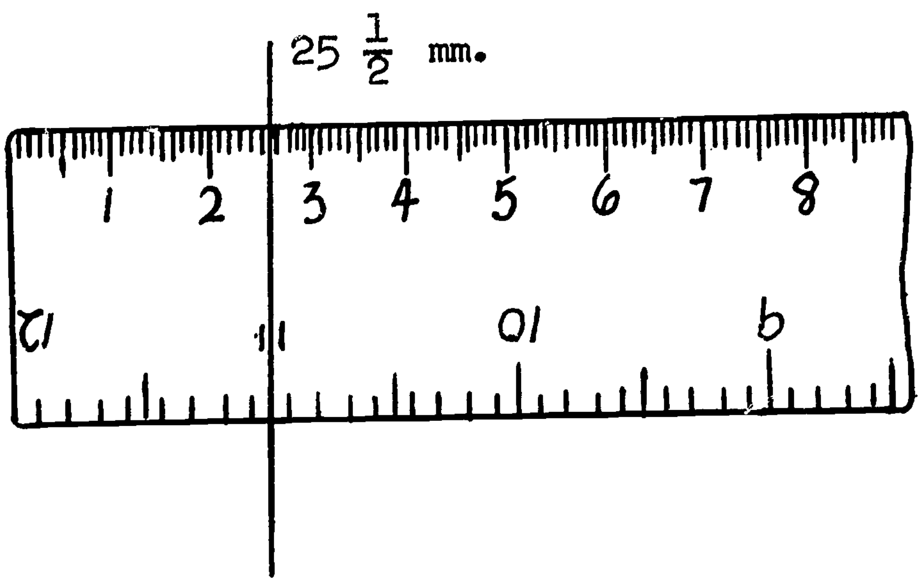
15. 

16. 

17. 

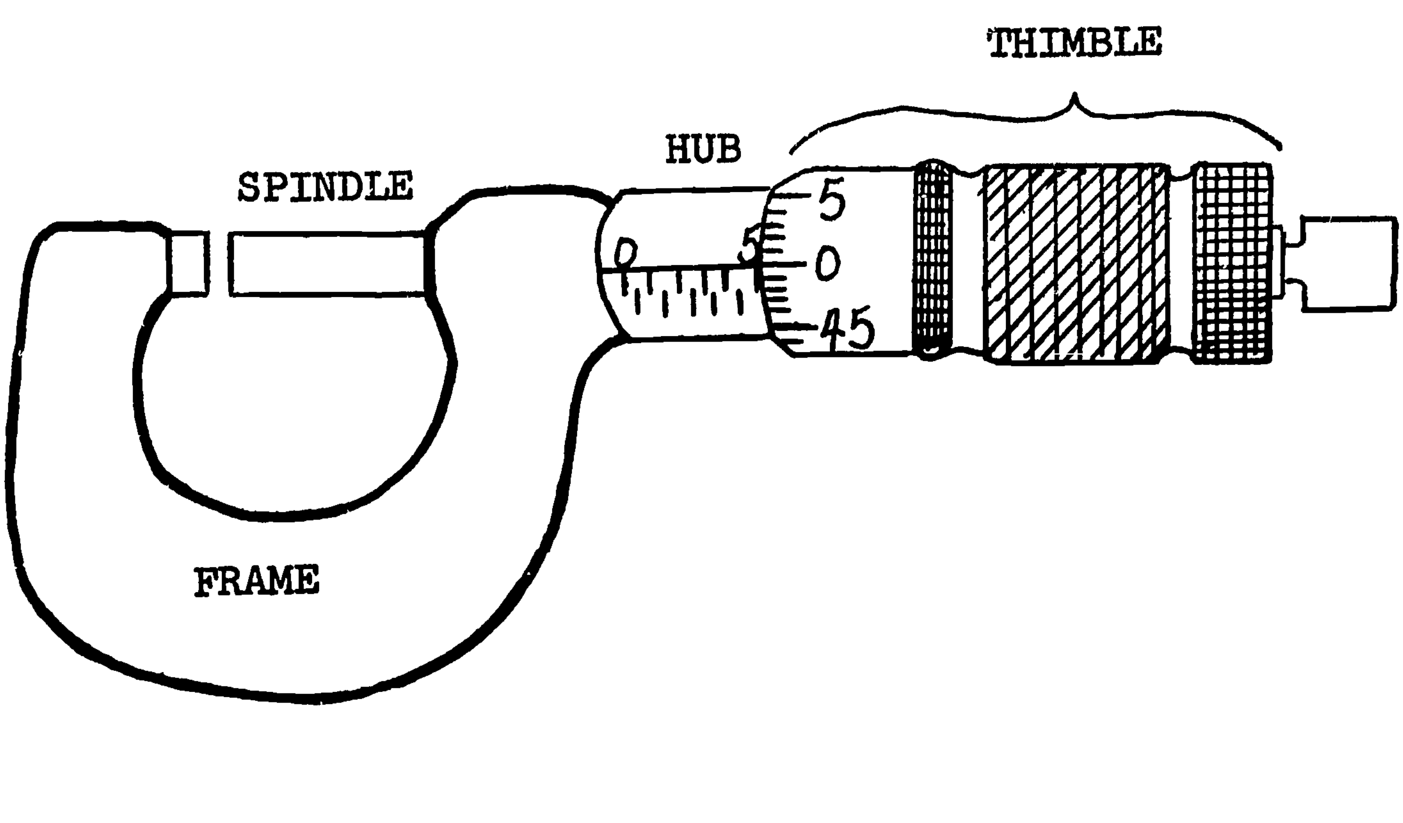
MICROMETER

A micrometer is an instrument for measuring linear distance. The distances which are measured with a micrometer are very small, the thickness of a sheet of paper for instance. The micrometers which we will be using are calibrated in millimeters. The millimeter is a unit of measure in the metric system. A line segment which has a measure of one inch will have a length of about 25½ millimeters. Your ruler will show this.

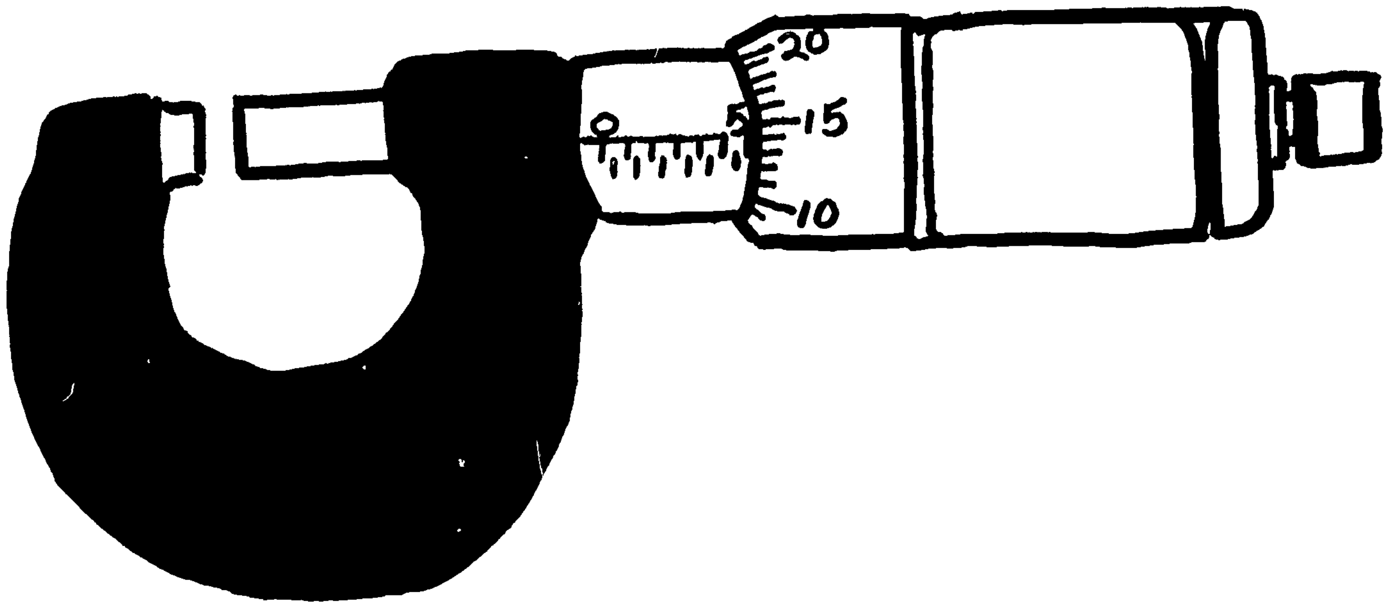


With this micrometer, measurements to the nearest one-hundredth (1/100) of a millimeter can be made. Do you see that this means measurements in the neighborhood of 1/100 of 1/25 of an inch or 1/2500 of an inch can be made using a micrometer.

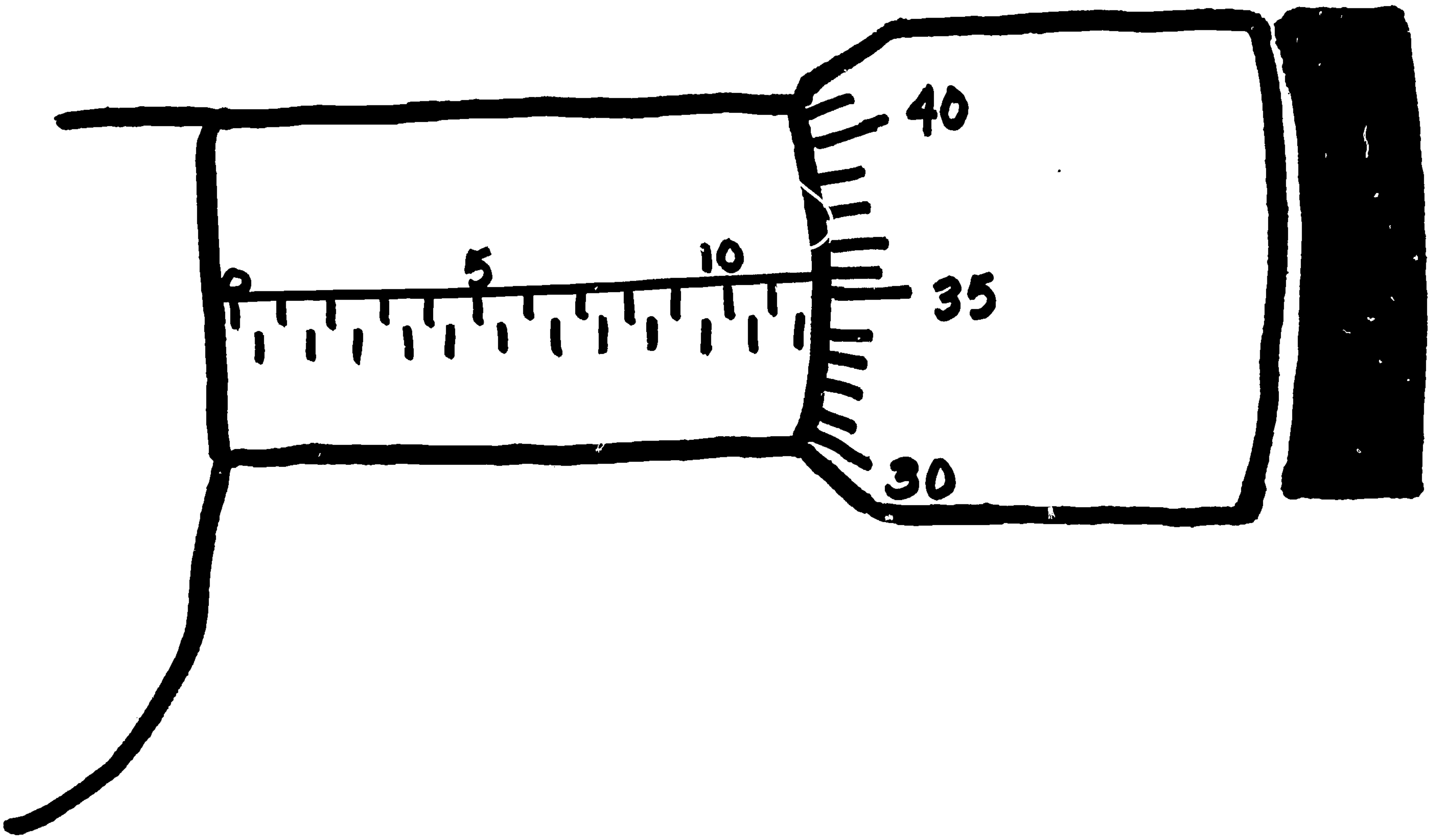
The following illustration gives the names of the parts of the micrometer.



The previous picture shows a reading of 5 millimeters. Zero on the thimble is matched with 5 on the hub. This means that the measure is 5.00 mm. (mm. is the abbreviation for millimeter). Each of the upper divisions on the hub is 1 mm. The numerals on the thimble represent hundredths of a millimeter. The following illustration shows a micrometer reading of 6.14 mm. (six and fourteen hundredths millimeters).



The reading below is 11.86 mm. This is arrived at by reading 11.50 mm. from the hub and 0.36 mm. from the thimble, or 11.50 mm. + 0.36 mm.



Activities

1. Measure the thickness of a piece of notebook paper. ______________
2. Measure the thickness of one page of this booklet. ______________
3. Which of the above two pages is the thicker? How much thicker? ____________
4. Measure the thickness of the cover of this linear measure booklet. _________

One inch equals about $25\frac{1}{2}$ millimeters. For each $25\frac{1}{2}$ millimeters of linear measure, there is 1 inch of linear measure. Since 2 x $25\frac{1}{2}$ is 51, the length of a line segment 51 mm. must be about 2 inches long. Do you see that a line segment of 12.25 mm. is about $\frac{1}{2}$ inch in length?

Solution: _________ X 25.50 = 12.25

Activities

In problems 1 - 5 fill in the blanks with the correct <u>numeral</u>.

1. _________ X $25\frac{1}{2}$ = $76\frac{1}{2}$
2. _________ X 25.50 = 2.55
3. _________ X $25\frac{1}{2}$ = 102
4. _________ X 25.50 = 2550
5. _________ X 25.50 = 6.375

6. A line segment has a length of 30 mm. Is this segment more of less than 1 inch in length? ______________
7. A line segment has a length of 255 mm. Is the length of this line segment nearer a foot in length or a yard? ______________

In problems 8 - 13 give the number of inches or fractional part of an inch in each of the line segments whose measures are given in mm.

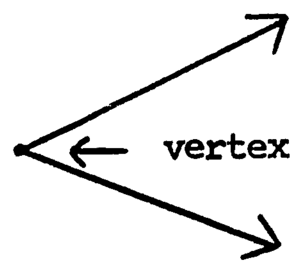
8. $76\frac{1}{2}$ mm. = _________ in.
9. 2.55 mm. = _________ in.
10. 102 mm. = _________ in.
11. 2550 mm. = _________ in.
12. 6.375 mm. = _________ in.
13. 89.25 mm. = _________ in.

Metric Geometry

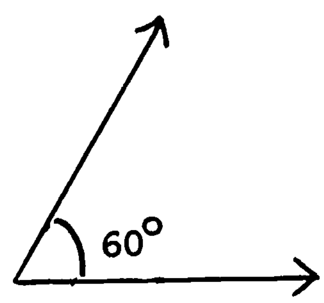
Concepts of Linear Measure

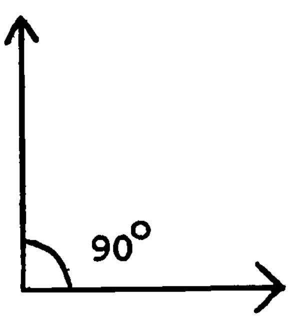
ILLUSTRATION OF TERMS

angle, the figure formed by two rays drawn from the same point; the point common to both is called the vertex.



angular measure, an angle is measured by a unit called a degree; the number of degrees in an angle is its angular measure.





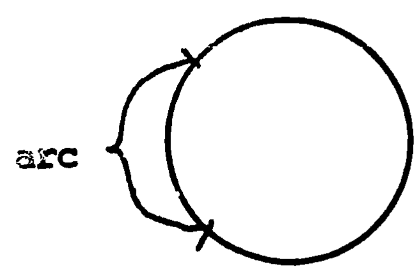
approximate, a number which is nearly but not exactly correct.

1.96 is approximately 2

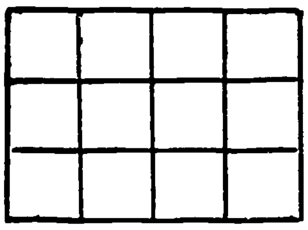
$8\frac{1}{2}$" is approximately $\frac{2}{3}$ of a foot—$8\frac{1}{8}$ is about 8

$$\frac{8}{12} = \frac{4 \times 2}{4 \times 3} = \frac{2}{3}$$

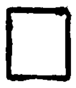
arc, a part of any curve, especially a circle.



__area__, the number of square units of a given size (usually square inches, square feet, square meters, etc.) which would fit a flat region; the amount of surface cut off by some boundary.



1 square unit



area = 12 square units

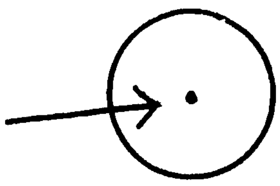
__average__, to find an average add up the terms and then divide by the number of terms.

Terms {1, 7, 10, 4, 8}   1 + 7 + 10 + 4 + 8 = 30

The number of terms is 5

$5\overline{)30}$ = 6 average

__center__, the point within a circle at the same distance from every point on the circle.

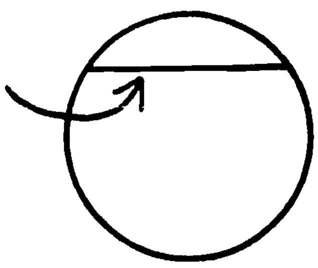


__centi__, a part of a word which means $\frac{1}{100}$.

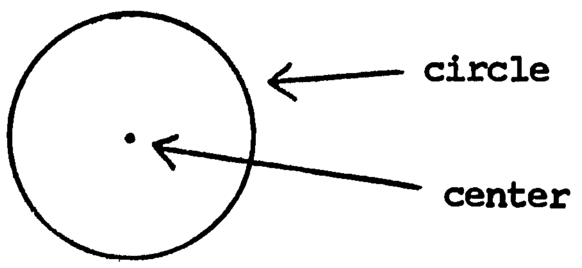
cent $\frac{1}{100}$ of one dollar

centimeter $\frac{1}{100}$ of a meter

__chord__, a line segment whose endpoints are points of the circle.



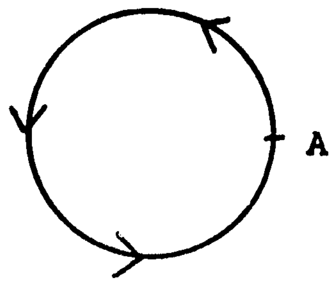
circle, a set of points in a plane which are all a given distance from a designated point called the center.



Notice that the points of the circle are all on the same flat surface. This is what is meant by the phrase "in a plane".

circular, round; shaped like a circle.

circumference of a circle, the perimeter of or the distance around the circle.



If you start at point A and travel on the circle, you will eventually return to A. The distance you have moved is equal to the circumference of the circle.

common fraction, a fraction in the usual sense; a fraction having a numerator and denominator separated by a line.

$\frac{4}{5}$, $\frac{3}{8}$, $\frac{6}{5}$, $\frac{\text{numerator}}{\text{denominator}}$ (not zero)

By fraction in the usual sense we mean as opposed to decimal fraction.

compass, an instrument used to draw circles or parts of circles (arcs).

computing, to determine, using mathematical methods (arithmetic, algebra, calculus, etc.), an answer to some question.

Compute the average of 2, 4, 9

$2 + 4 + 9 = 15 \qquad 3\overline{)15} = 5$

The average is 5

__conversion__, a change from one system of units to another such as meters to feet, inches to centimeters, etc.

15 inches = ? centimeters

1 inch = 2.54 centimeters

x 15   x 15

15 inches = 37.6 centimeters

__corresponding__, to be in a similar position with; to be in the same situation as.

A, B, C, D, E

2, 4, 6, 8, 10

B corresponds with 4

D corresponds with 8

__cubit__, an ancient unit of length which is based on the distance from the point of the elbow to the tip of the middle finger of the outstretched hand.

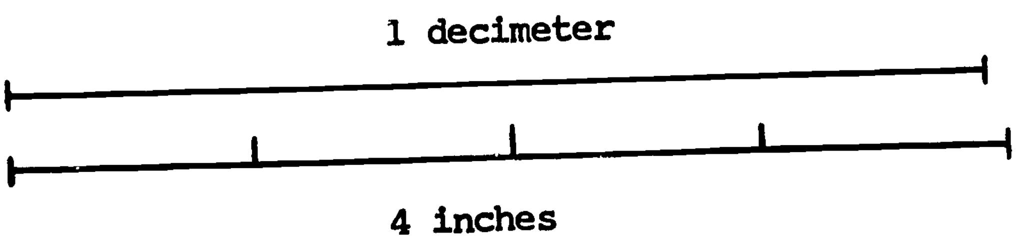
__curve__, a line which always bends but has no angles.

__deca__, a word element (part of a word) which means ten.

__decameter__, ten meters

__deci__, a word element which means one-tenth.

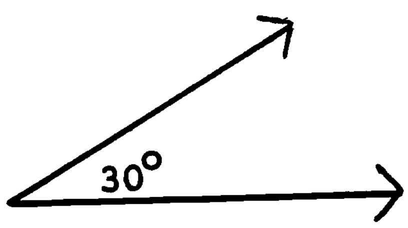
__decimeter__, one-tenth of a meter.



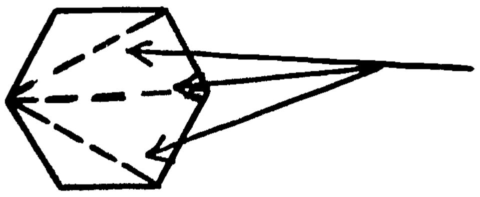
A decimeter is about as long as 4 inches (actually 3.937 inches).

__degree__, the unit by which angles are measured.

an angle which
measures 30 degrees

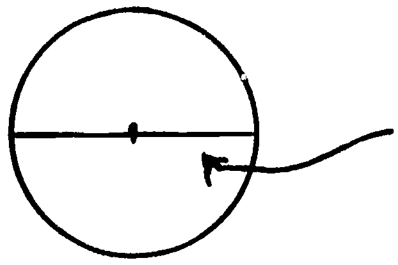


<u>diagonal</u>, in a polygon (a many-sided plane figure) a segment from the vertex of one angle to the vertex of an nonadjacent angle.



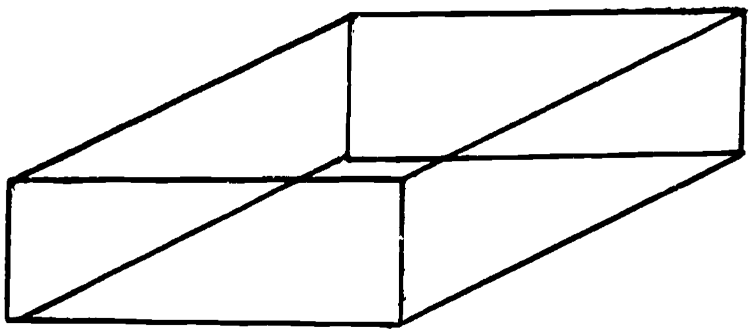
Notice that from the vertex of an angle of a polygon there may be more than one diagonal.

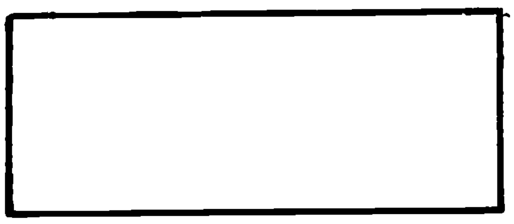
<u>diameter</u>, a line segment from one point on the circle through the center to another point on the circle.



<u>digit</u>, any of the Arabic figures—0, 1, 2, 3, 4, 5, 6, 7, 8, 9; Egyptian linear measure for the width of the middle finger.

<u>dimensions</u>, the measurements in various directions which characterize a particular form.





The dimensions of the rectangular solid are 4 cm x 1.5 cm x 3 cm.

The dimensions of the rectangular plane are 2 cm x 5 cm.

<u>distance between two points</u>, the length of the line segment between the two points.

<u>distributive principal</u>, when a number multiplies a sum of two numbers.

$$4\ (5 + 6) = (4 \times 5) + (4 \times 6)$$

endpoints, the last point to the left and the last point to the right of a line segment.

equilateral, sides of equal length.

an equilateral triangle

equivalent, different names for the same number.

.8 is equivalent to $\frac{4}{5}$.

fathom, a unit of length equal to 6 feet.

foot, a unit of length equal to 12 inches.

fraction, one or more parts of a unit; a small portion of fragment; the ratio of any two whole numbers.

$\frac{1}{2}$ proper fraction

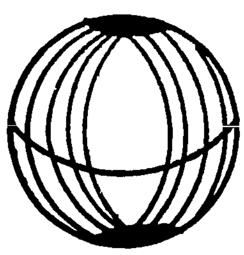
$\frac{5}{3}$ improper fraction

common fraction

.6 decimal fraction

16% number of parts in 100—16% = $\frac{16}{100}$

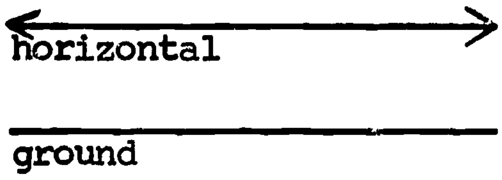
great circle, the circle on the surface of a sphere that would be described by a plane passing through the center of the sphere; a circle of maximum circumference drawn on the surface of a sphere. To demonstrate, the sphere which is the earth has many lines (longitudes), circling it going through the North and South Poles. These are great circles. The earth has but one great circle going around it horizontally, which is its equator. Also, if an orange were cut in half, the knife represents a plane through the center. The circle made by the cut of the knife is a great circle for the spherical orange.



hecto, a word element (part of a word) which means 100.

hectometer, 100 meters.

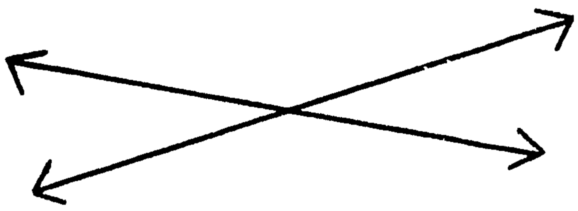
horizontal, in the direction of the line where the earth meets the sky; a line which moves neither uphill nor downhill but stays at the same height.



Notice the word horizon in horizontal. Horizontal is sometimes defined as moving toward the horizon.

inch, a unit of length equal to 2.54 centimeters or $\frac{1}{12}$ of a foot.

intersection, points in common.



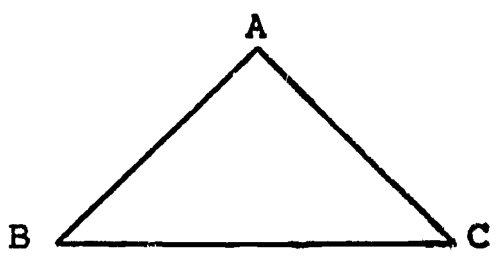
The intersection of two lines is the point at which they cross (if they cross).

$A = \{a, b, c, d, e\}$

$B = \{a, c, d, f, g\}$

The intersection of two sets are the elements common to both sets. The intersection of the two sets above are $\{a, c, d\}$.

isoceles triangle, a triangle which has two sides the same length.



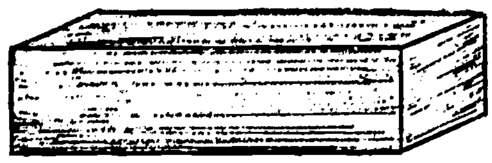
$\overline{AB}$ is the same length as $\overline{AC}$.

kilo, a part of a word meaning thousand.

kilometer, 1000 meters

lateral, side

length, the longest dimension of any figure; the magnitude of an object as measured from end to end.



The length of this rectangular solid is 4 cm.

line, the path a point takes as it moves through space which, since a point has no thickness or height, also has no thickness or height. (A line has only length.)

linear, involving measurement along lines.

line segment, part of a line; although lines extend indefinitely to the left and right, line segments have a definite length.

mathematics, the science which deals with the measures, properties, and relations of sets of objects.

maximum, the highest number, largest amount.

measure, process used to determine a measurement.

measurement, the amount determined by measuring.

meh, a cubit; the length of the forearm.

meridian mile, an early Egyptian linear measure given as 4000 cubits.

meter, a unit of length about the same as a yard (actually 39.37 inches).

<u>metric system</u>, a system of measure based on multiples of ten.

10 centimeters = 1 decimeter
10 decimeters = 1 meter
10 meters = 1 decameter

<u>micrometer</u>, an instrument used to measure very small distances.

<u>mile</u>, a linear measure equal in length to 5,280 feet.

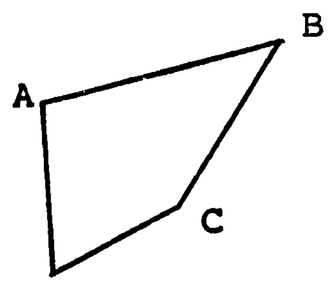
<u>milli</u>, a word element (part of a word) which means $\frac{1}{1000}$.

<u>millimeter</u>, $\frac{1}{1000}$ of a meter; 1000 millimeters are the same length as 1 meter.

<u>number</u>, a number is an idea. We communicate our ideas by using symbols (called numerals).

<u>numeral</u>, a word or symbol expressing a number idea.
Roman numerals I, II, III, IV, V, VI, . . .
Arabic numerals 0, 1, 2, 3, 4, 5, 6, . . .

<u>opposite sides</u>, in a quadrilateral the sides which are not adjacent are opposite.

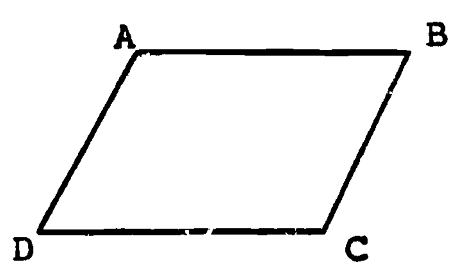


$\overline{AD}$ is opposite $\overline{BC}$
$\overline{AB}$ is opposite $\overline{DC}$

<u>pace</u>, a Roman linear unit, approximately 5 feet, based on a double step.

<u>palm</u>, an Egyptian linear unit based on the width of the hand.

<u>parallelogram</u>, a four-sided plane figure with exactly two pairs of parallel sides.

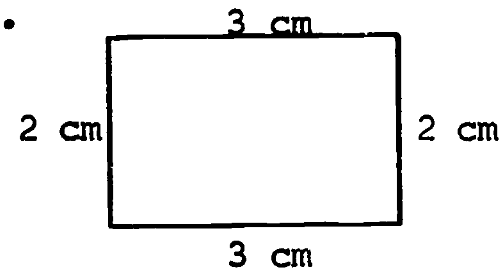


$\overline{AB}$ is parallel to $\overline{CD}$
$\overline{AD}$ is parallel to $\overline{BC}$

<u>parallel lines</u>, lines in the same plane which never meet.

<u>parasang</u>, a Roman linear unit approximately 4 miles.

<u>perimeter</u>, the length of the boundary of plane geometric figures, circumference (perimeter of a circle).



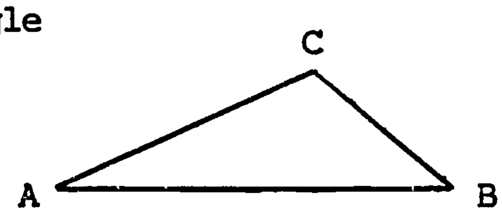
Perimeter: 2 cm + 3 cm + 2 cm + 3 cm = 5 cm + 5cm = 10 cm

<u>π (pi)</u>, the ratio of the circumference to the diameter of a circle: 3.141592 . . .
Notice this remarkable fact: The ratio between the circumference of a circle and its diameter is always the same, regardless of the circle in question.

<u>plane</u>, a surface extending indefinitely in two of the three directions. A plane has indefinite length and indefinite width but no height.

<u>plane geometric figures</u>, certain combinations of line segments. A geometric figure is a set of line segments and not the enclosed region.

Example: triangle

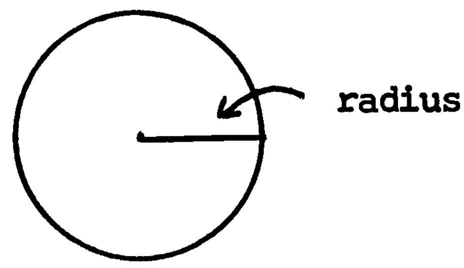


Triangle ABC is the set of line segments AB, AC, and BC in a combination so that all 3 of the points A, B, and C are not points of the same straight line.
Rectangles, squares, hexagons, parallelograms, and trapezoids are some more plane geometric figures.

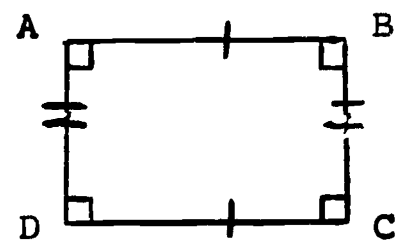
<u>precision</u>, accuracy in measuring. 5.3 is more precise than 5 since 5.3 indicates the measure is correct to the nearest tenth while 5 is correct to the nearest unit.

pyramid, a solid having any plane geometric figure as a base and triangular sides which meet at a point not in the plane of the base.

radius, a line segment whose endpoints are the center of the circle and a point of the circle.



rectangle, a four-sided plane geometric figure with four right angles.



AB = CD

AD = BC

$m\angle A = m\angle B = m\angle C = m\angle D = 90$

regrouping, making a new arrangement.

5' 7"

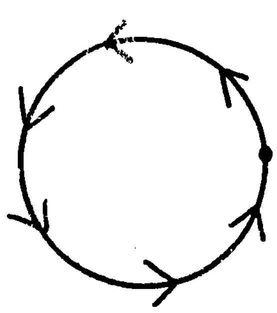
6' 8"

11'15" This may be regrouped as 12' 3" by noticing 15" = 1'3"

\+ 11'

12'3"

revolution, to start at a point on a circle, move in one direction around the circle, and return to the starting point.



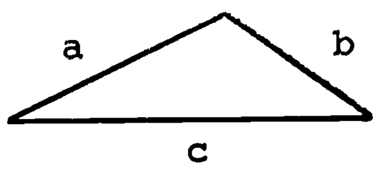
1 revolution

2 revolutions would occur if one went around the circle twice.

rod, a linear measure equal to $16 \frac{1}{2}$ feet.

scale, a proportion used on maps so that large distances may be represented by relatively short ones.

scalene, a triangle in which all sides are of different lengths.



a scalene triangle

$a \neq b \neq c$

solution, the answer.

span, the distance from the thumb to the tip of the little finger when the hand is outstretched.

stadia, a Roman and Greek unit of length estimated at 600 feet.

standard, to set up as a basis of comparison on approved model. The Bureau of Standards in Washington keeps the models which are the standards of measure used in the United States today.

terminating decimal fraction, a decimal fraction which can be represented as a ratio of two integers.

4.125 is a terminating decimal fraction

4.125125125 . . . is a non-terminating decimal fraction

triangle, a plane geometric figure having three sides and three angles.

unit, a known quantity that is used to measure an unknown quantity.

Some linear units are—inch, centimeter, foot, and yard.

Some area units are—square inch, square centimeter, square yard.

Some volume units are—cubic centimeter, cubic inch, pint, liter, and quart.

volume, the amount of space enclosed by a geometric solid. Volume is measured in cubic units.

yard, a measure of length equal to 36 inches.