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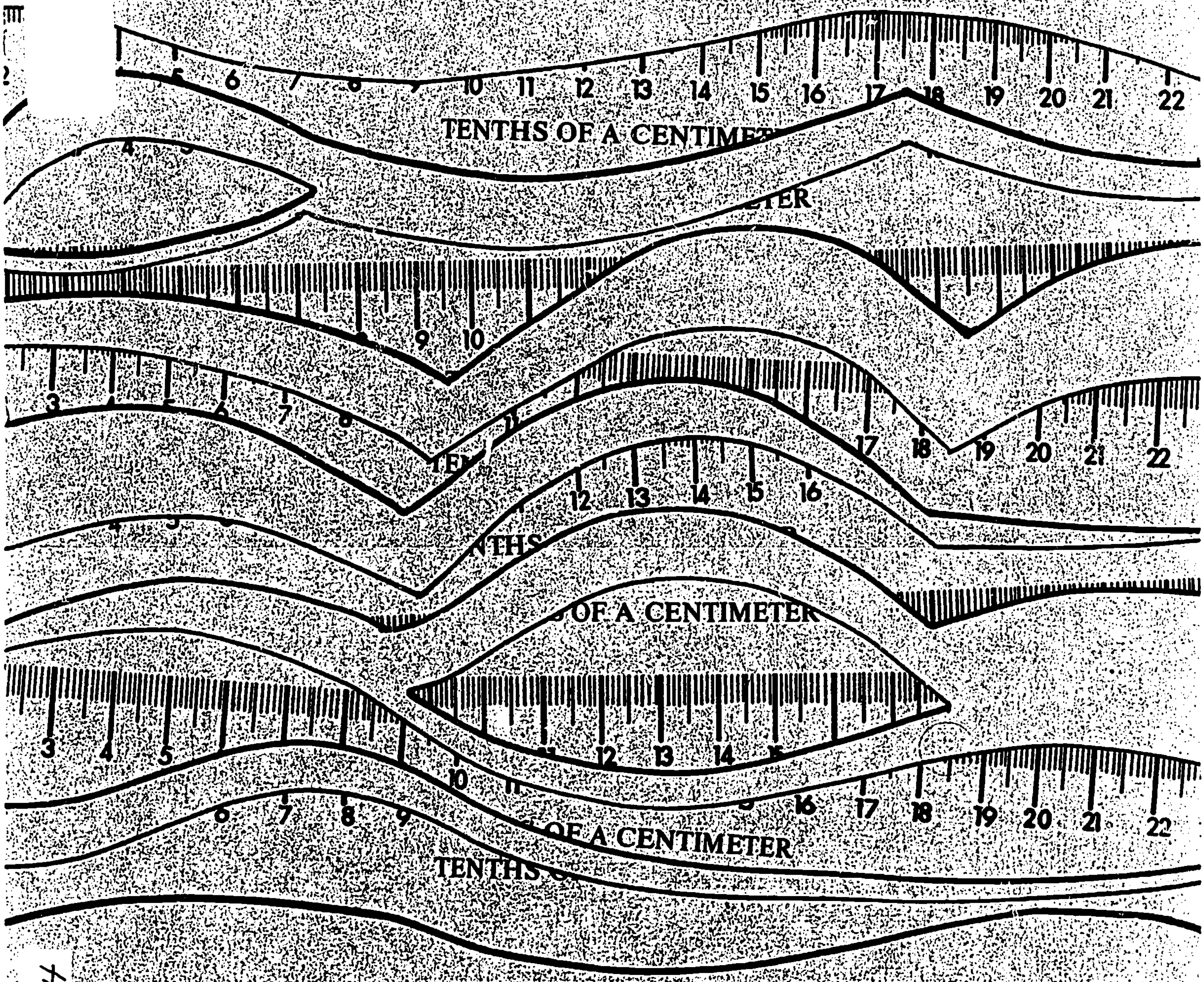
ABSTRACT

This material is an instructional unit on measuring and estimating. A variety of activities are used with manipulative devices, worksheets, and discussion questions included. Major topics are estimating lengths, accuracy of measurement, metric system, scale drawings, and conversion between different units. A teacher's guide is also available. Related documents are SE 015 335 - SE 015 347. This work was prepared under an ESEA Title III contract. (LS)

EXPLORING LINEAR MEASURE



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EXPLORING LINEAR MEASURE

OAKLAND COUNTY MATHEMATICS PROJECT

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PREFACE

Without accurate measurement, our present industrial society would not be possible. Most everyday activities involve some kind of measurement.

This book concentrates on measuring and estimating distances. Each lesson concentrates on one or two main ideas. A variety of activities will be used to develop methods for estimating and for using a ruler properly.

Read the booklet carefully, work the exercises, and participate in the class activities and discussions. This material will help you learn, but only if you use it correctly.

When you complete this booklet, you should be able to...

1. ... give an equivalent length in feet and inches for a measurement given in caveman units.

2. ... give a reasonable estimate for the length of a distance to be measured. (Whether or not an estimate is reasonable depends upon the purpose of the measurement. In this booklet, the closeness of your estimates will be checked by computing the difference between the estimate and the measured length.)

3. ... rank a given list of metric and English units of length from smallest to largest.

4. ... define the most commonly used metric prefixes.

5. ... state the numerical relationship between the basic units of length within the metric and English systems.

6. ... answer questions such as ....

   a. If $\frac{5}{8} = \frac{x}{16}$, then x = _____.

   b. If $\frac{3}{8} + \frac{5}{16} = \frac{y}{16}$, then y = ______.

7. ... determine which of a list of measurements is more precise.

8. ... measure accurately to the nearest $\frac{1}{16}$ in., .1 in., and .1 cm. using any arbitrary point on the ruler scale as the starting point.

9. ... find the missing value given information such as ...

   100 cm. = 1 m.
   367 cm. = ? m.

10. ... select a metric and an English unit suitable for measuring a given distance.

As you study the material, use the EXERCISES, CLASS ACTIVITIES, DISCUSSION QUESTIONS, and ✓POINTS to evaluate your progress in achieving the objectives for the booklet.

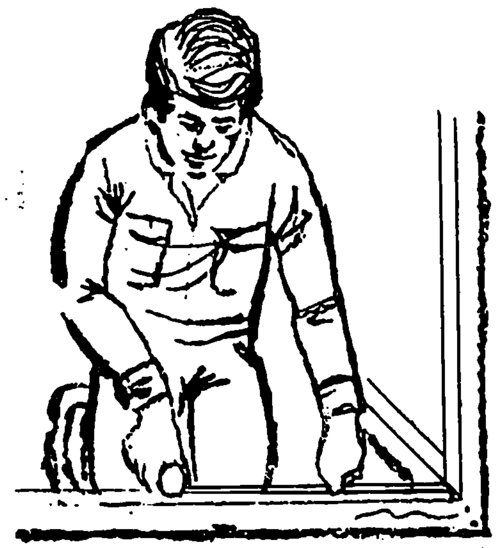
If you get "stuck", try again. If you are still confused after careful study, ask for help.

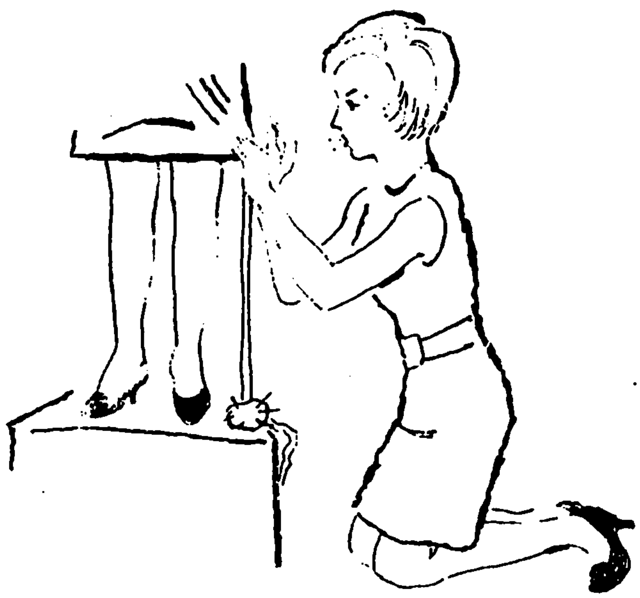
TABLE OF CONTENTS

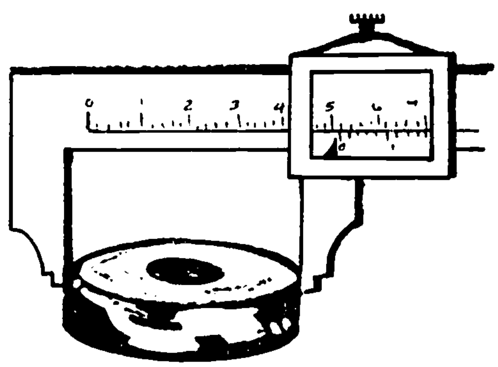
WHY MEASURE LENGTH?

Hardly an hour goes by that you do not think about or perform some measurement. Measuring instruments are commonplace items. (Yardsticks, tape measures, speedometers, thermometers, clocks...)

This unit will concentrate upon the measuring of length. Illustrated below are some situations involving length.







MEASUREMENT IS APPROXIMATE.

WE CAN NOT HOPE TO ELIMINATE ALL ERRORS ---

OUR GOAL IS TO REDUCE THE SIZE AND

NUMBER OF THESE ERRORS.

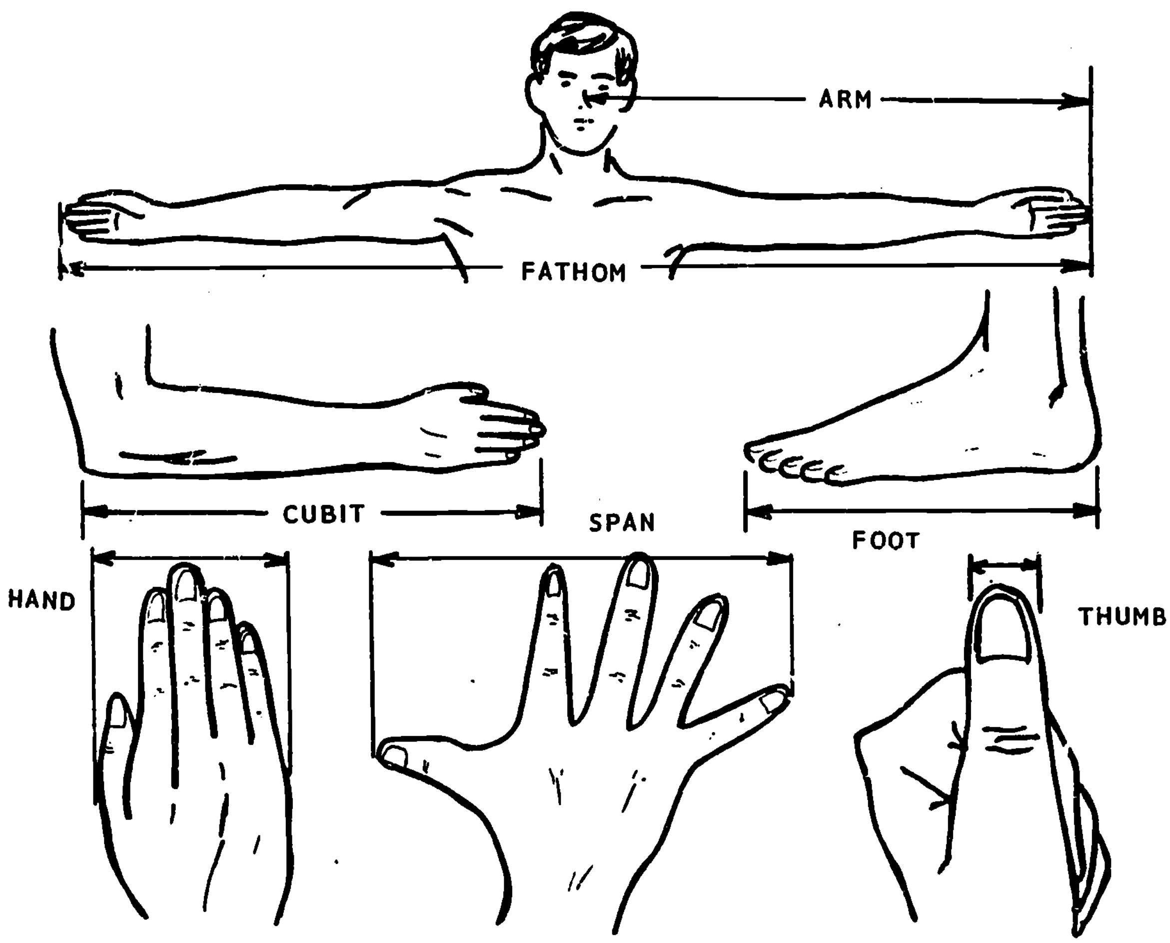
THE WALKING YARDSTICK

OUR WORLD OF MEASUREMENT . . .

Man has always measured objects around him. The illustrations on page 1 indicate some uses of measurement. You are familiar with most of these.

SINCE TIME BEGAN . . .

Some situations require accurate measurements. The caveman did not need accuracy. Any cave would do if it would hold him and his family. Distances were judged by sight or time and sizes were measured by paces or by matching the objects to be measured with stones, trees, and other objects familiar to him.

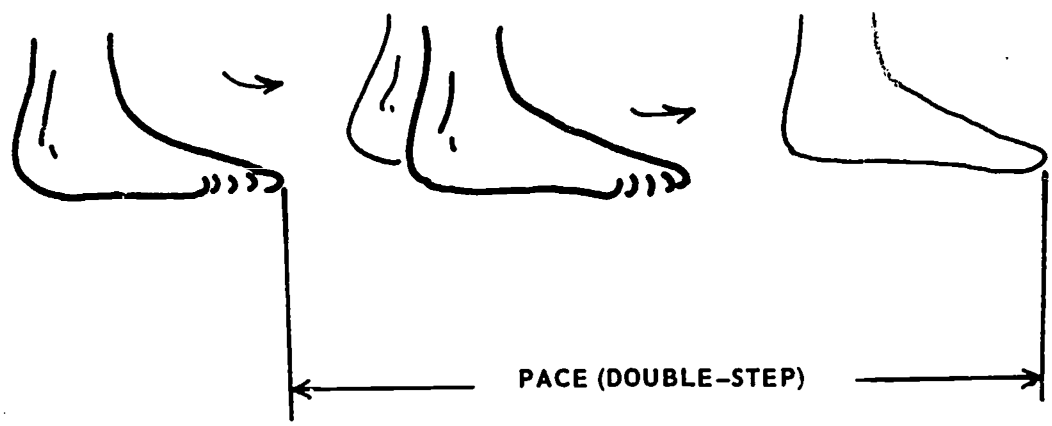


THE BODY BECOMES A YARDSTICK...

Many of the units of length used by the caveman were based on parts of the body. The human body actually served as a walking yardstick! Except as a guide in estimation, these early units are no longer widely used. However, some of our present-day units are related to them.

The following list describes some units of length related to parts of the body. (See sketches on the previous page and at the bottom of this page.)

a. Width of THUMB
b. Distance from first joint to end of FOREFINGER
c. HAND - width of hand
d. SPAN - distance from end of the thumb to end of little finger when the hand is fully stretched out
e. CUBIT - length of forearm (from tip of elbow to tip of the middle finger of the outstretched arm)
f. Length of FOOT
g. Distance from nose to thumb of outstretched arm (ARM)
h. Distance across outstretched arms (FATHOM)
i. PACE - length of one double-step



MEASURING LENGTH

Given a distance to be measured...

(1) Select some length to use as a unit of length.

(2) "Mark off" the distance being measured in unit lengths.

(3) Count the number of unit lengths it takes to "fill up" the distance being measured.

EXAMPLE 1:

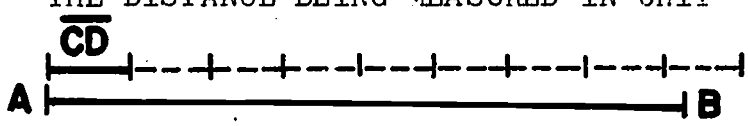
Measure the length of $\overline{AB}$ (read "segment AB" to the nearest whole unit.

SOLUTION :

(1) SELECT SOME LENGTH TO USE AS A UNIT OF LENGTH.

Suppose $\overline{CD}$ is selected as the unit of length.

(2) "MARK OFF" THE DISTANCE BEING MEASURED IN UNIT LENGTHS.



(3) COUNT THE NUMBER OF UNIT LENGTHS IT TAKES TO "FILL UP" THE DISTANCE BEING MEASURED.

It takes more than 8 and less than 9 units to "fill up" the length of $\overline{AB}$. This is written...

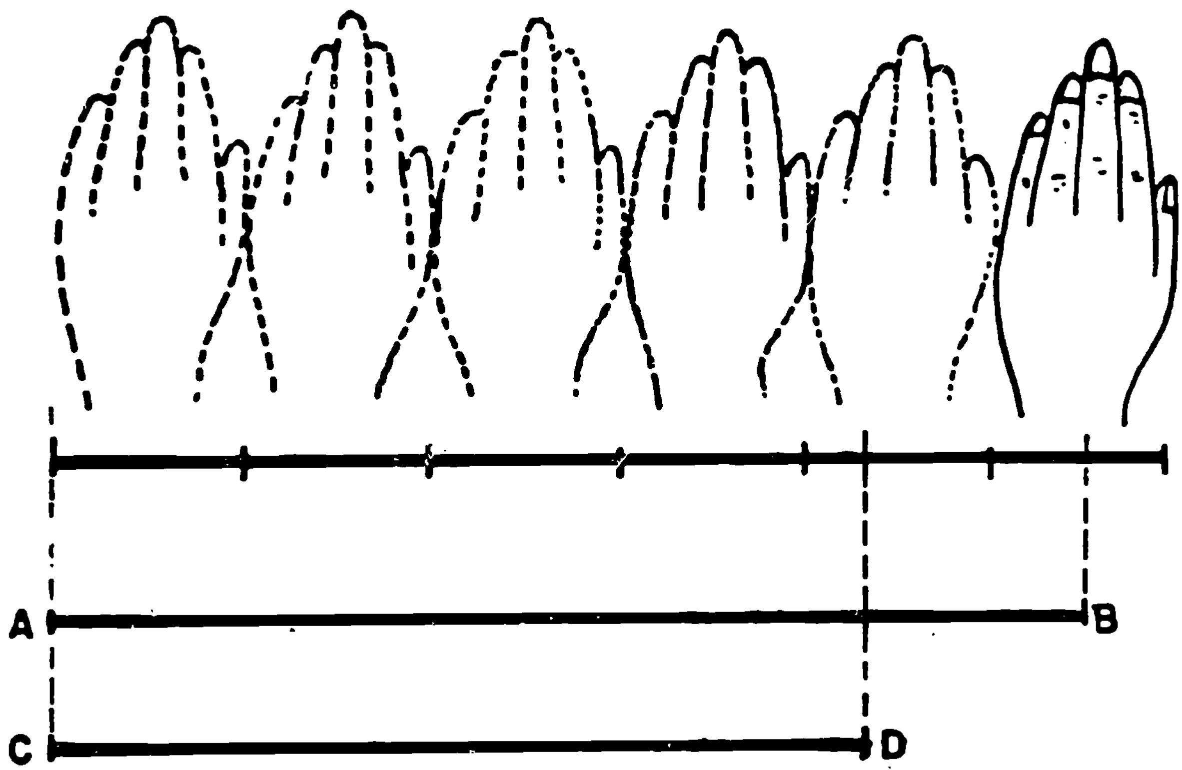
$$8 \text{ units} < m(\overline{AB}) < 9 \text{ units}.$$

[$m(\overline{AB})$ is read "the measure of segment AB".]

The length of $\overline{AB}$ is closer to 8 units than 9 units. When measured to the nearest whole unit,...

$m(\overline{AB})$ is 8 units long.

EXAMPLE 2: Measure $\overline{AB}$ and $\overline{CD}$ to the nearest hand.



SOLUTIONS :

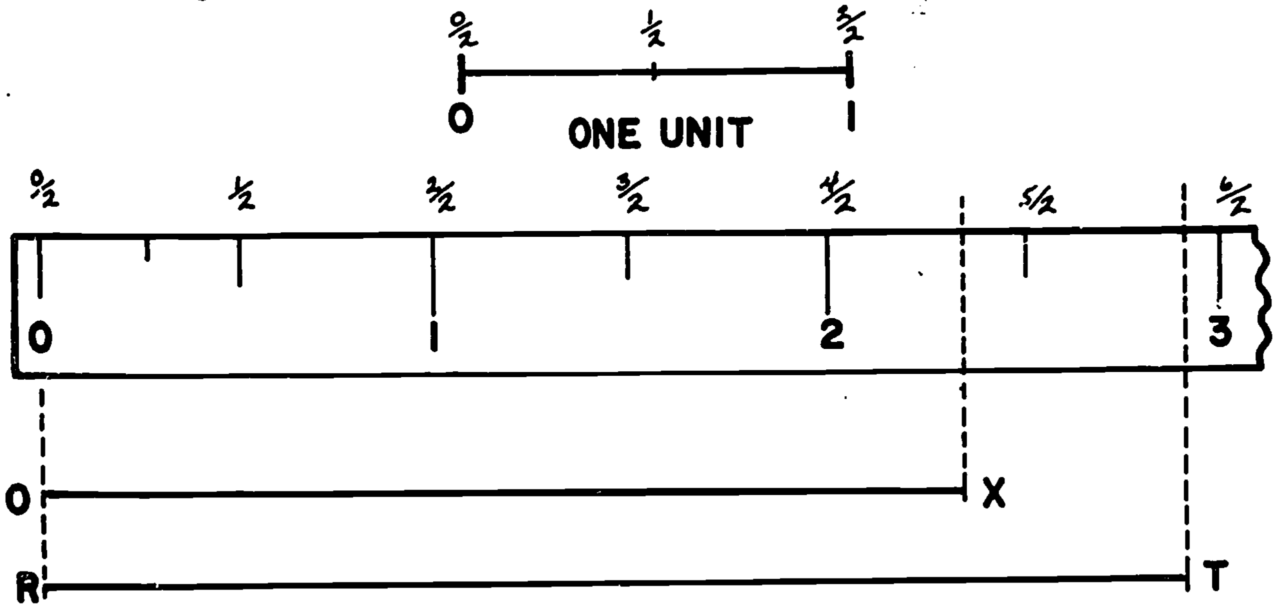
5 hands < $m(\overline{AB}) <$ 6 hands.

To the nearest hand, $m(\overline{AB}) =$ 6 hands.

4 hands < $m(\overline{CD}) <$ 5 hands.

To the nearest hand, < $m(\overline{CD}) =$ 4 hands.

EXAMPLE 3: Measure OX and RT to the nearest $\frac{1}{2}$ unit.



SOLUTIONS :

For $m(\overline{CX})$

$\frac{4}{2}$ units < $m(\overline{OX})$ < $\frac{5}{2}$ units.

$m(\overline{OX})$ is closer to $\frac{5}{2}$ units.

To the nearest $\frac{1}{2}$ unit,...

$m(\overline{OX}) = \frac{5}{2}$ or $2\frac{1}{2}$ units.

For $m(\overline{RT})$

$\frac{5}{2}$ units < $m(\overline{RT})$ < $\frac{6}{2}$ units.

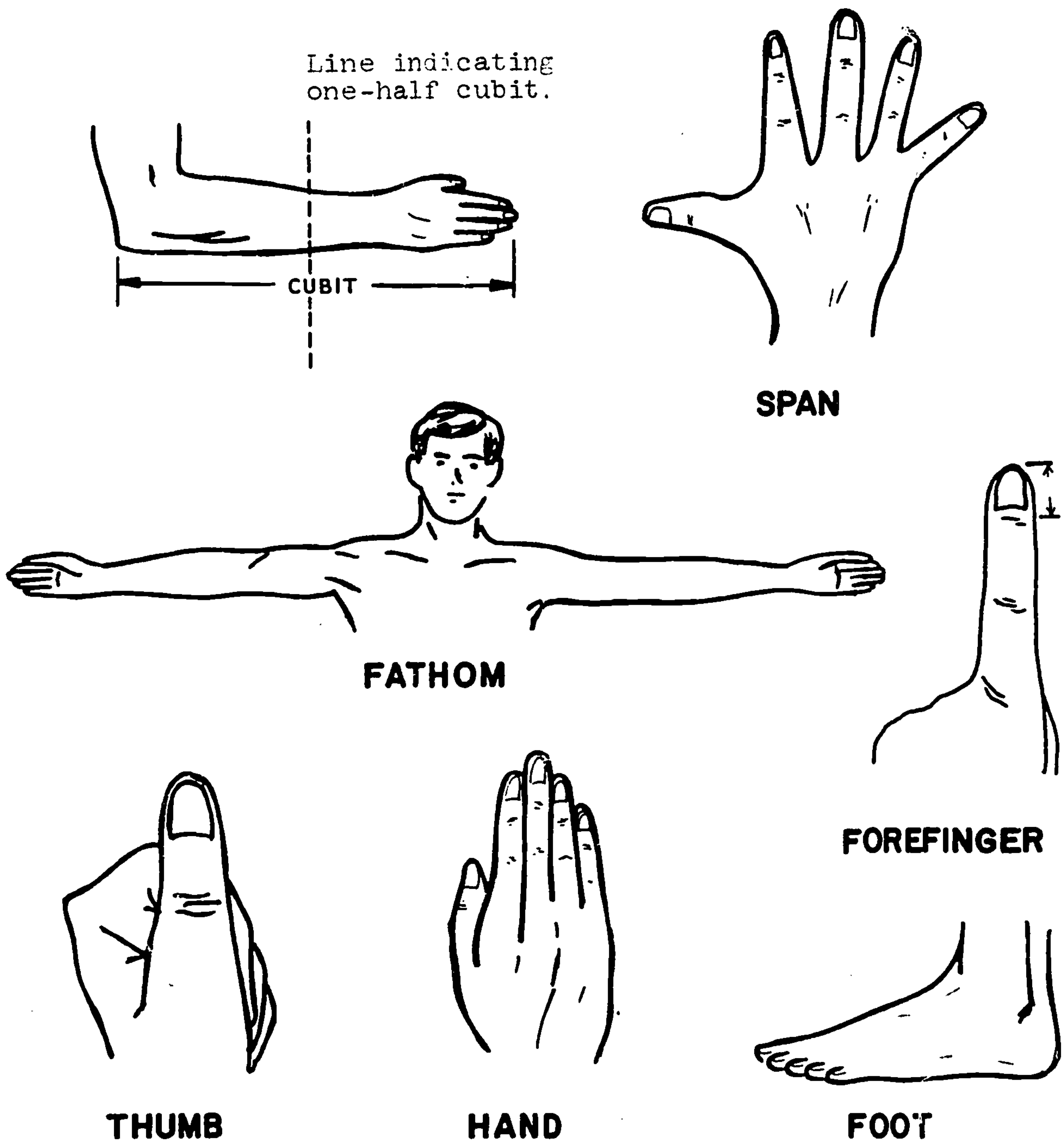
$m(\overline{RT})$ is closer to $\frac{6}{2}$ units.

To the nearest $\frac{1}{2}$ unit,...

$m(\overline{RT}) = \frac{6}{2}$ or 3 units.

CLASS ACTIVITY: PART 1

1. For each caveman unit of length pictured on page 8, draw a vertical line which you think divides the unit in half. The line for the cubit has been drawn as an example.



2. <u>Check your estimates</u>. You will be given an acetate overlay for this purpose. How close were you?

CLASS ACTIVITY : Part II

1. (a) Select six distances in the classroom or vicinity, to be measured. (example: width of locker, length of room, height of desk,...)

   (b) Choose a unit of length from the list on page 4 and measure each distance to the nearest unit and ½ unit. (This will require some estimating.)

   (c) Record your results in TABLE 1-1.

TABLE 1-1.

DISTANCE MEASURED	UNIT OF LENGTH USED	LENGTH TO NEAREST...	
		UNIT	½ UNIT

2. (a) Select one of the six distances from 1 (a).

   (b) Measure this distance to the nearest ½ unit, using two units of length other than the one you used to get the measurement recorded in TABLE 1-1.

   (c) Record your results on the last two lines of TABLE 1-1.

DISCUSSION QUESTIONS

1. Compare your results in TABLE 1-1 with those of your classmates. Are they the same? Why or why not?

1

Cont'd

2. Two persons measured the width of a desk to the nearest whole unit. One measured the width to be 6 hands, while the second person measured the same distance as 7 hands. Does this mean that one of the persons is incorrect? Why or why not?

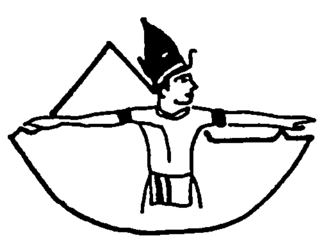
3. If you need 30 cubits of rope and you send a friend to get it, will you probably get the length you wanted? Why or why not?

4. Suppose you measured the length of your classroom. Which unit of length, fathom or cubit, will give you the larger number for the length?

5. If one unit of length is longer than a second unit and you measure the same distance using both units, which unit gives the larger number? (See CLASS ACTIVITY; Part II, and question 4 on this page).

6. Describe the measurement involved when a football official "marks off" a 15 yard penalty.

WHERE DID IT COME FROM?



FATHOM: Dating at least as far as early Egyptian times, the fathom was the measure of a man's outstretched arms: 5, $5\frac{1}{2}$, and now 6 feet in length.

LET'S COMPARE

Many daily uses of measurement require only an estimate. Using parts of the body as units of measure (span, cubit,...) will never replace the foot, inch, meter, and centimeter. However, if caught without a ruler or if only an accurate estimate is required, the caveman units used in Lesson 1 should be precise enough to handle many household and shop situations.

<u>One</u> approach to obtaining an accurate estimate to the width of your text is described below.

EXAMPLE: Estimate the width of your text.

SOLUTION :

1. Select a unit of length. Suppose we use the thumb (which is about 1 inch wide).

2. Use this unit (thumb width) to "step off" the desired length.

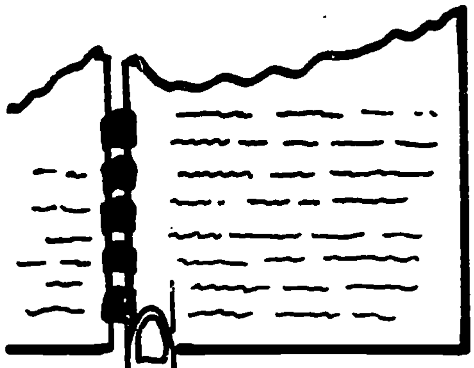


Figure A

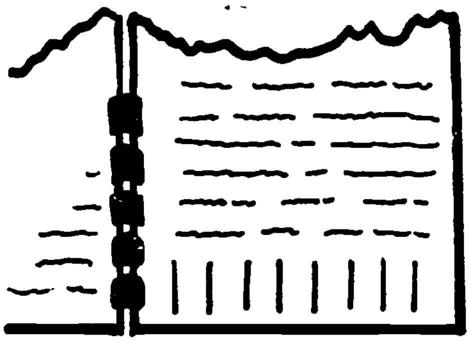


Figure B

3. In this example, the text is about 9 <u>thumbs</u> wide. Since a thumb is about 1 inch wide, your estimate would be 9 inches.

DISCUSSION QUESTIONS

1. In the example on page 11, what other caveman units could have been used instead of the thumb to obtain an accurate estimate for the width of the text?

2. Would the cubit have been a suitable unit of length to use in the example on page 11? Why or why not?

DEVELOP YOUR OWN METHODS . . .

Being able to estimate accurately is an important skill with many useful applications. You should develop your own methods of estimating distances. There is no one right way to estimate.

Lessons 2 and 3 use caveman units as guides for estimating distances. Other estimation guides could be used but caveman units are among the most convenient ones to use.

RULE OF THUMB . . .

This expression means a reliable rule for rough calculations (or estimations). It refers to the fact that people once used the first joint of the thumb as a one-inch measure.

CLASS ACTIVITY I

With the aid of a partner, obtain these measurements for yourself to the nearest $\frac{1}{2}$ inch. Record your results in TABLE 2-1.

TABLE 2-1

DESCRIPTION OF UNIT	LENGTH TO NEAREST $\frac{1}{2}$ INCH
a) Width of THUMB	
b) Distance from first joint to end of FOREFINGER	
c) HAND	
d) SPAN	
e) CUBIT	
f) Length of FOOT	
g) Distance from nose to thumb of outstretched arms (ARM)	
h) Distance across outstretched arms (FATHOM)	
i) PACE	

COMPARING SIZES . . .

Compare your measurements in TABLE 2-1 with those of your classmates. Are they the same? Why or why not?

Complete TABLE 2-2. Use the longest and shortest lengths in your class for the units listed.

TABLE 2-2

UNIT	LONGEST LENGTH	SHORTEST LENGTH	DIFFERENCE
Width of thumb			
Hand			
Span			
Cubit			
Pace			

EXERCISES

1. Using your own measurements, (see TABLE 2-1) complete the following relationships between the "caveman units" and our present units of length. (≈ is read "approximately the same as.")

   a. 1 thumb ≈ ______in.
   b. 1 span ≈ ______in.
   c. 1 hand ≈ ______in.
   d. 1 cubit ≈______in. ≈______ft.
   e. 1 pace ≈______in. ≈______ft.
   f. 1 fathom ≈______ft.
   g. 1 arm ≈__________ft.

2. Given the following lengths, convert them to feet and inches.

   a. 7 forefingers ≈______in.
   b. $2\frac{1}{2}$ spans ≈ ______in.
   c. 4 hands ≈ ______in.
   d. 2 cubits ≈ _____ ft.
   e. 10 paces ≈______ft.
   f. $2\frac{1}{2}$ hands ≈______in.
   g. $3\frac{1}{2}$ thumbs ≈____in.
   h. $\frac{1}{2}$ cubit ≈ ______in.

CHECK YOUR RESULTS FOR EXERCISES 1 AND 2
BEFORE GOING TO THE DISCUSSION QUESTIONS

DISCUSSION QUESTIONS

1. Which of the units in TABLE 2-1 could <u>you</u> use as an approximation for an inch? a foot? a yard?

2. Will the answers to question 1 be the same for all students in the class? Why or why not?

3. Which of the units in TABLE 2-1 would be convenient for <u>you</u> to use as a guide for estimating distance? Why?

4. Will the answer to question 3 be the same for all students in the class? Why or why not?

EDUCATED GUESSING

CLASS ACTIVITY 1

Follow the instructions below. Record all results in TABLE 3-1.

1. Select six distances to be measured. List the distances under DISTANCE MEASURED.

2. Measure each distance to the nearest $\frac{1}{2}$ unit with some caveman unit and record your results under MEASURED LENGTH (caveman units).

3. Convert the measurements in# 2 to their equivalents in feet and inches. Record these results under ESTIMATE (feet and inches).

4. Check your estimates by using a ruler, tape measure, or yardstick to measure each of these six distances to the nearest $\frac{1}{2}$ inch. Record these measurements under MEASURED LENGTH (nearest $\frac{1}{2}$ inch).

5. See how close your estimate is to the measured distance by finding the difference between the measured and estimated distances. Record the differences under DIFFERENCE.

TABLE 3-1

DISTANCE MEASURED	MEASURED LENGTH (caveman units)	ESTIMATE (feet and inches)	MEASURED LENGTH (nearest $\frac{1}{2}$ inch)	DIFFERENCE

DISCUSSION QUESTIONS

1. What disadvantages would occur if parts of the body were used as units of length and as measuring instruments instead of our present units and rulers? What advantages?

2. The following statement was made on page 12. "Other estimation guides could be used but caveman units are among the most convenient ones to use." Do you agree with this statement? Why or why not?

3. What are some other lengths which could be used as guides for estimating distances?

4. To be useful, what properties must a "good" estimation guide have?

CLASS ACTIVITY II

1. Estimate by sight (without "marking off") distances with the following properties. Indicate the endpoints of each estimate by placing two pieces of tape that distance apart on a flat surface (desk, floor, ...).

2. Check each of your guesses <u>by measuring with the given caveman unit</u>.

   a. 3 cubits < Length A < 4 cubits
      to the nearest whole cubit,
      m(Length A) = 3 cubits.

   b. 6 paces < Length B < 7 paces
      to the nearest whole pace,
      m(Length B) = 7 paces.

c. 2 spans < Length C < 3 spans.
To the nearest whole span,
m(Length C) = 3 spans.

d. 6 thumbs < Length D < 7 thumbs.
To the nearest whole thumb,
m(Length D) = 6 thumbs.

DO YOU AGREE ?

One writer has stated that "with a little practice you should be able to measure from a half-inch to 8 inches with just your hand--and come to within a sixteenth of an inch every time."

Mechanix Illustrated, September 1963, p.96.

MORE EDUCATED GUESSING ...

Your answers to the following questions should be educated guesses. Do not do any computation. For each multiple-choice question, you are to select the answer that you believe to be the best estimate.

1. What is the length in inches of the diameter of a quarter?

   a) $\frac{3}{4}$ in. b) 1 in. c) $1\frac{1}{4}$ in. d) $\frac{1}{2}$ in. e) $1\frac{1}{2}$ in.

2. The length of a dollar bill is about:

   a) 6 in. b) 7 in. c) 8 in. d) 9 in. e) 10 in.

3. The length of a full-sized automobile is about:

   a) 12 ft. b) 18 ft. c) 25 ft. d) 10 ft. e) 30 ft.

4. The length of this text book is about:

   a) $6\frac{1}{2}$ in. b) $8\frac{1}{2}$ in. c) 11 in. d) 15 in. e) 1 ft.

After completing your educated guessing, try to find answers to the above questions. Careful measurement will enable you to determine the best estimate for each situation.

Now try these.

1. About how many pennies in an ounce?
2. Approximately how many pennies in a pound of pennies?

   a) 60 b) 120 c) 180 d) 240 e) 300

3. About how many pennies (stacked on top of each other) to make a stack one inch high? one foot high?
4. About how many pennies would have to be stacked one on top of the other to reach from the floor to the ceiling of a room eight feet high?

   a) 600 b) 800 c) 1100 d) 1600 e) 2200

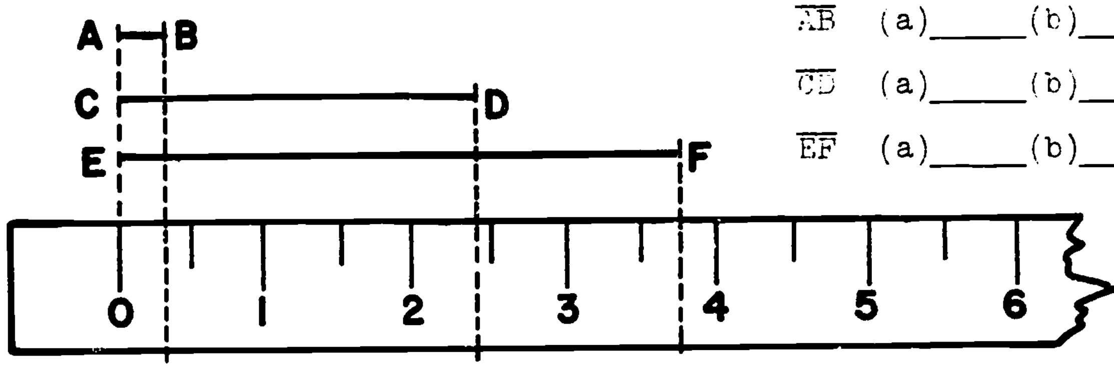
KEEP IN PRACTICE . . .

The ability to make reasonable estimates is not a skill which can be developed in a couple of lessons. Keep in practice by estimating whenever possible. If you can make reasonable estimates, you will be able to check the reasonableness of any measuring you do.

✓ POINT

Use the following questions and problems to check your understanding of Lessons 1-3. If you have difficulty with any question, it may indicate a topic you should review.

1. Use the ruler shown to measure each segment to the nearest a) unit, and b) $\frac{1}{2}$ unit.



$\overline{AB}$ (a)_____ (b)_____

$\overline{CD}$ (a)_____ (b)_____

$\overline{EF}$ (a)_____ (b)_____

2. For each measurement in caveman units, give an equivalent length in feet and inches.

a. 2 spans ______ c. $1\frac{1}{2}$ hands ______ e. 2 cubits ______

b. 3 paces ______ d. 5 thumbs ______ f. 3 arms ______

3. Arrange the following units in order of length from smallest to largest. (Indicate the smallest by 1, next smaller by 2,...)

______ hand ______ span

______ fathom ______ pace

______ forefinger ______ arm

______ foot ______ cubit

4. You should be able to....

   a. demonstrate how caveman units can be used to estimate distances.

   b. list some advantages and disadvantages of using caveman units to measure length.

ESTIMATES ARE NOT ENOUGH

BECOMING MORE PRECISE...

Estimation is useful for many everyday household and industrial situations. However, industry also needs measurements that are extremely accurate and precise. Industrial uses often demand measurements to the nearest thousandth and even millionth of an inch.

All measurements are approximations. The science of measurement is the art of obtaining better approximations. A more precise measure of a length is one in which a better approximation of the length is obtained.

EXAMPLE

$\overline{OX}$ has been measured using two different units of measure. Which unit gives the more precise measure (the better approximation of the length of $\overline{OX}$)?

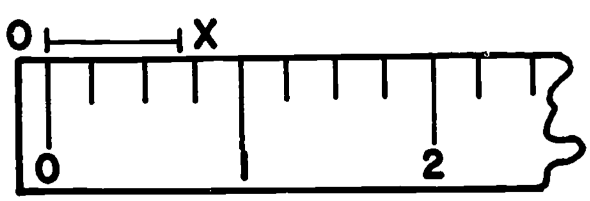


Figure 1

When measured to the nearest $\frac{1}{4}$ inch,...

$\frac{2}{4}$ inches $< m(\overline{OX}) <$ $\frac{3}{4}$ inches.

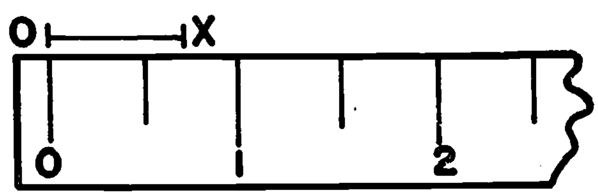


Figure 2

When measured to the nearest $\frac{1}{2}$ inch,...

$\frac{1}{2}$ inch $< m(\overline{OX}) <$ $\frac{2}{2}$ inches.

SOLUTION

In Figure 1:

$m(\overline{OX})$ lies somewhere in the interval between $\frac{2}{4}$ inches and $\frac{3}{4}$ inches. The measure is located in an interval equal in length to $\frac{1}{4}$ inch, smaller the unit of measure.

In Figure 2:

$m(\overline{OX})$ lies somewhere in the interval between $\frac{1}{2}$ inch and $\frac{2}{2}$ inches. The measure is located in an interval equal in length to $\frac{1}{2}$ inch, the unit of measure.

Which of the two measurements is more precise? The more precise measurement will give the better approximation of the length of the segment.

Since the interval is shorter in Figure 1, the measure obtained for $\overline{OX}$ in Figure 1 is a better approximation of its actual length.

Therefore, measuring to the nearest $\frac{1}{4}$ inch gives a more precise measure than measuring to the nearest $\frac{1}{2}$ inch because it locates $m(\overline{OX})$ in a shorter interval.

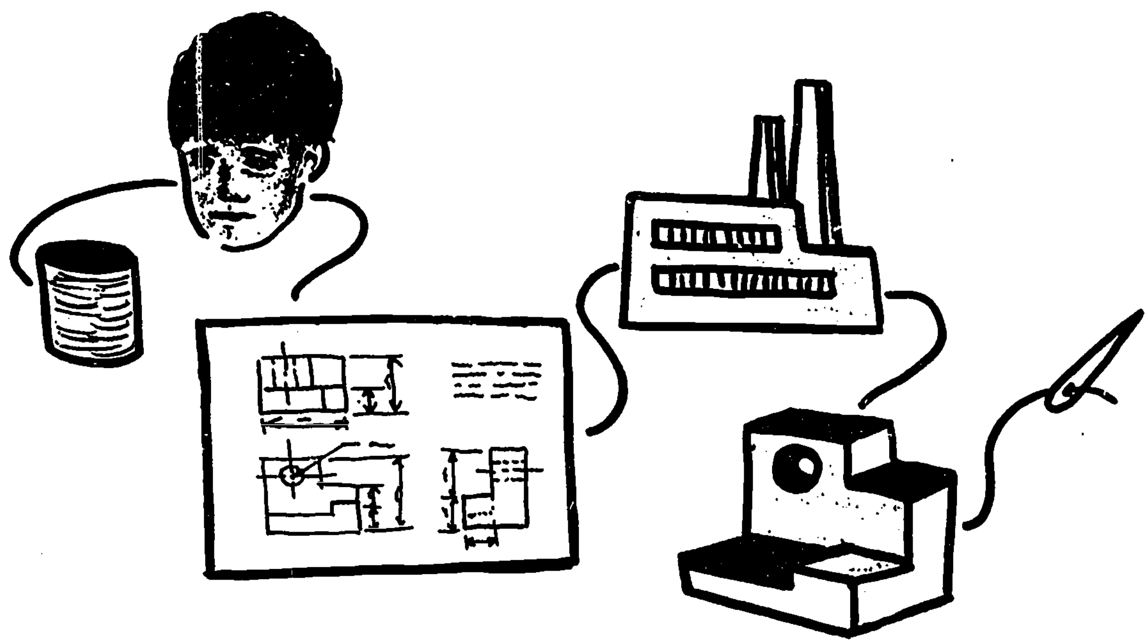
PRECISION	— depends on the unit of measure. The smaller the unit of measure, the more precise the measurement. Thus, a measurement made to the nearest $\frac{1}{16}$ inch is more precise than one made to the nearest $\frac{1}{10}$ inch.

DISCUSSION QUESTIONS

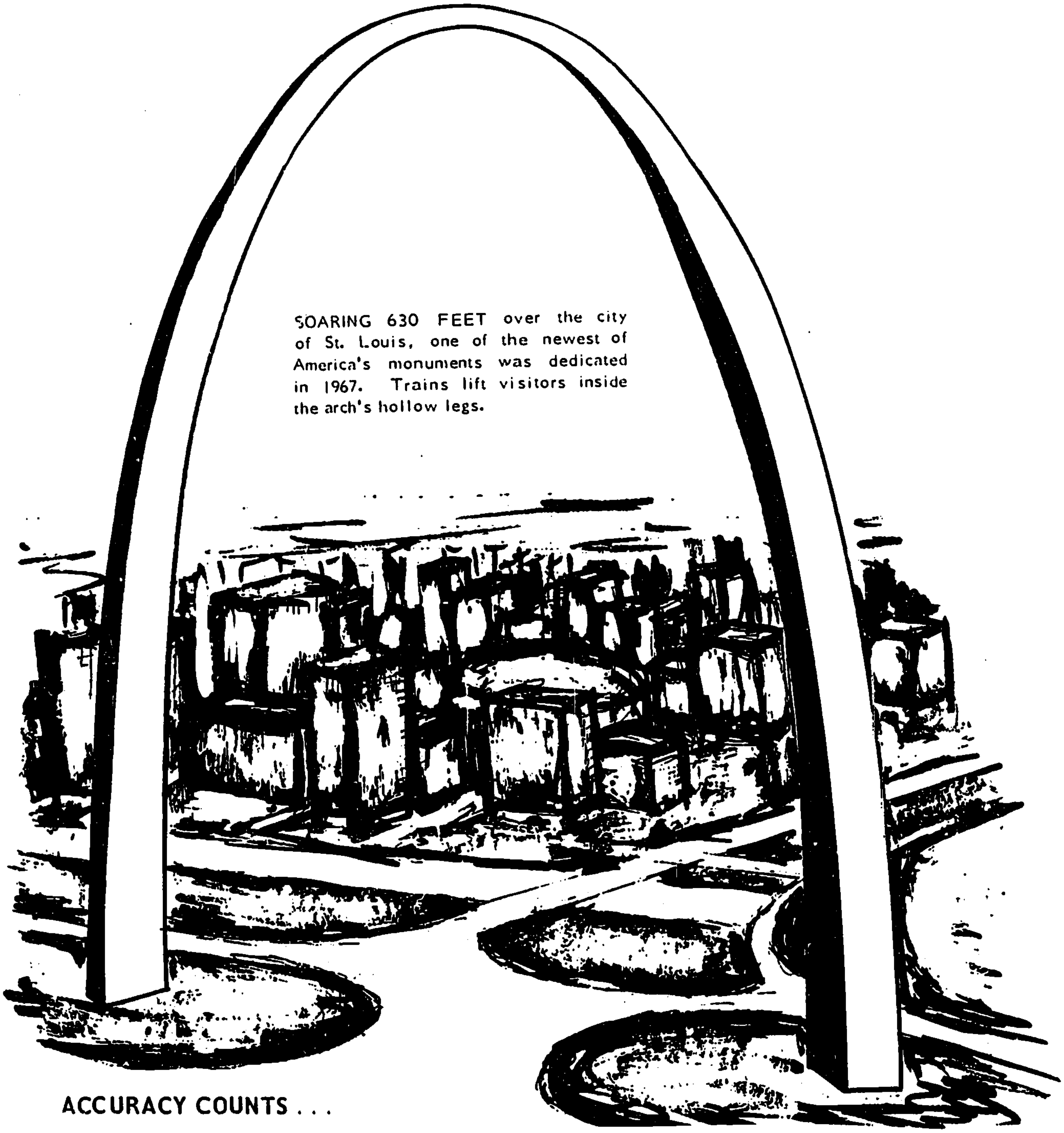
1. What is $m(\overline{OX})$ when measured to the nearest $\frac{1}{4}$ inch? to the nearest $\frac{1}{2}$ inch?
2. Explain how using a smaller unit of measure gives a better approximation for the length of a segment.

PRECISE MEASUREMENTS ARE NEEDED

Mass production demands that everything fit together just right. The assembly line emerged as man learned to measure more accurately and precisely. The blueprint is the only thread between the designer and the men who make the product. The assembly line cannot operate unless the blueprint dimensions can be accurately reproduced. Precise measuring instruments and methods of measuring make this possible.



THE BLUEPRINT IS THE ONLY THREAD BETWEEN THE DESIGNER AND THE MEN WHO MAKE THE PRODUCT.



SOARING 630 FEET over the city of St. Louis, one of the newest of America's monuments was dedicated in 1967. Trains lift visitors inside the arch's hollow legs.

ACCURACY COUNTS . . .

When constructing the 630-foot Gateway Arch in St. Louis, an error of $\frac{1}{64}$ inch in pouring the foundations would have meant that the legs of the arch could not meet. Fortunately, this error was avoided!

✓ POINT

Circle the more precise measurement in each pair.

To the nearest...
a. .1 m. .01 m.
b. $\frac{1}{10}$ in. $\frac{1}{8}$ in.
c. ft. in.

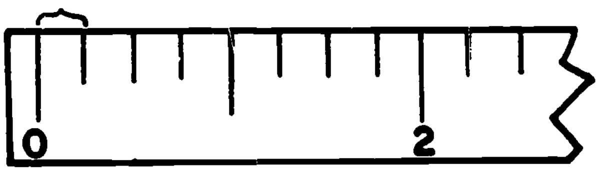
d. $3\frac{3}{4}$ in. to the nearest $\frac{1}{4}$ in.
$6\frac{7}{8}$ in. to the nearest $\frac{1}{8}$ in.

e. 3.02 cm. to the nearest .01 cm.
1.4 cm. to the nearest .1 cm.

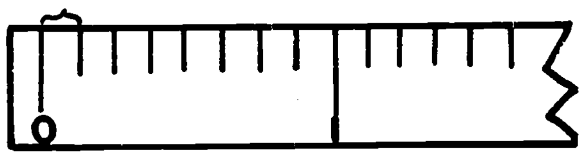
EXERCISES

The following exercises begin a review and summary of some basic skills that enable a person to master the reading of a ruler to varying degrees of precision.

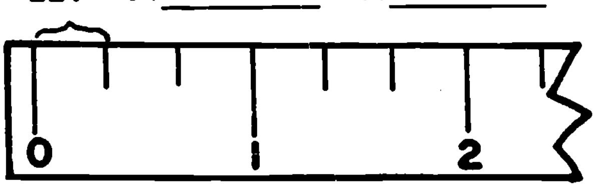
1. Answer the following questions for each of the rulers pictured.
   a. How many sub-divisions per unit?
   b. The size of the smallest sub-division on the ruler is what fractional part of a unit?



I. a.________ b.________

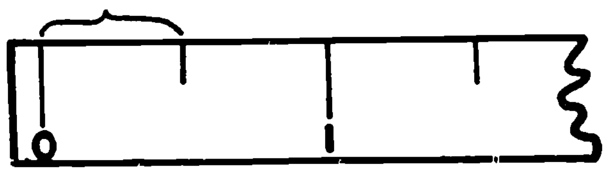


II. a.________ b.________



III. a.________ b.________

A brace ($\overbrace{\quad}$) is used to indicate <u>one</u> sub-division on each ruler.



IV. a.________ b.________

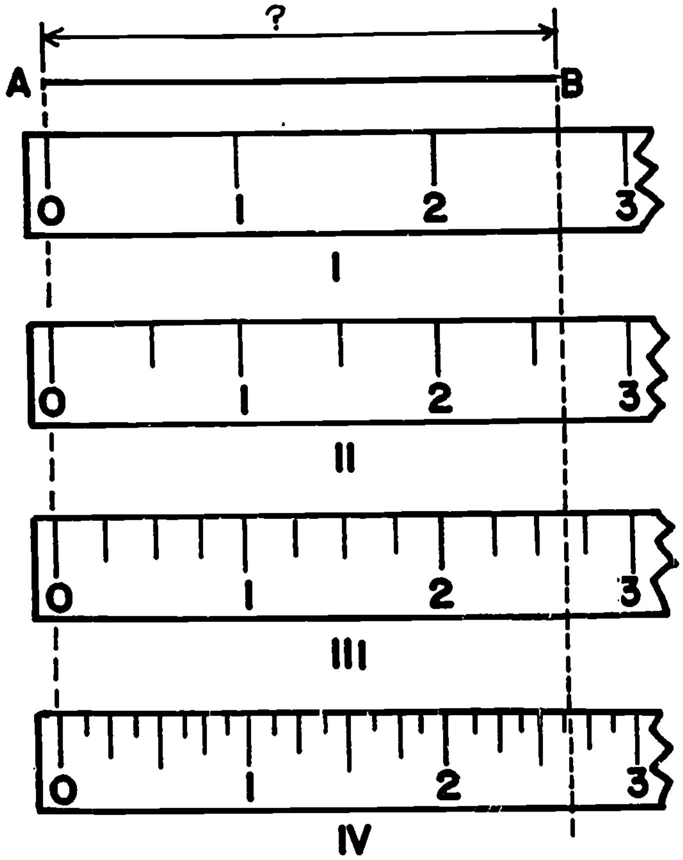
. Each of the measurements below is to a different degree of precision.

a. Which measurement(s) is (are) correct? ________

b. Which measurement is "best"? __________

c. Which measurement(s) is (are) "exact"? ___________

d. Which measurement is the most precise? _________



$m(\overline{AB})$ is read "the measure of segment AB."

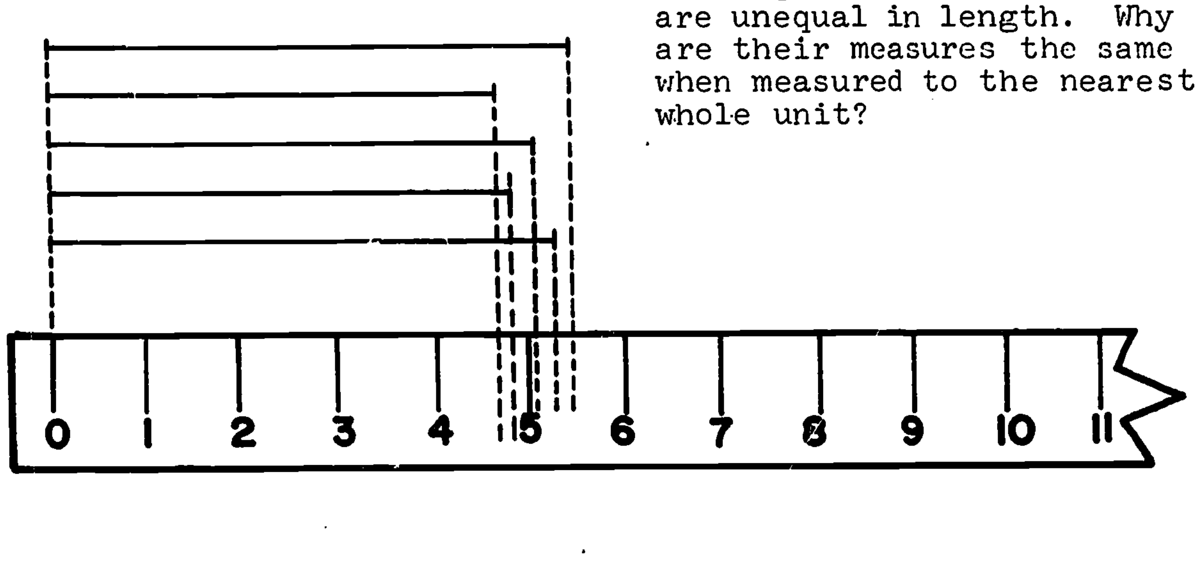
$m(\overline{AB}) = 3$ units to the nearest unit.

$m(\overline{AB}) = \frac{5}{2}$ or $2\frac{1}{2}$ units to the nearest $\frac{1}{2}$ unit.

$m(\overline{AB}) = 1\frac{1}{4}$ or $2\frac{3}{4}$ units to the nearest $\frac{1}{4}$ unit.

$m(\overline{AB}) = \frac{21}{8}$ or $2\frac{5}{8}$ units to the nearest $\frac{1}{8}$ unit.

3. The segments to the left are unequal in length. Why are their measures the same when measured to the nearest whole unit?



4. For each pair circle the phrase that indicates the more precise measurement.

To the nearest...		
	a. $\frac{1}{2}$ inch	$\frac{1}{4}$ inch
	b. .1 cm.	.01 cm.
	c. $\frac{1}{16}$ cubit	$\frac{1}{8}$ cubit
	d. $\frac{1}{8}$ inch	$\frac{1}{2}$ inch
	c. $\frac{1}{2}$ inch	$\frac{1}{2}$ foot

EVERY MAN FOR HIMSELF . . .

One disadvantage to using parts of the body as units of length is that the size of each unit differs from person to person. This did not create serious problems for the caveman. Each family was independent. They did not rely on others to provide food, clothing, shelter and other daily needs. As a result, each locality used units that fit their own needs without much consideration for the world around them. Therefore, units of measure varied from town to town and sometimes from family to family.

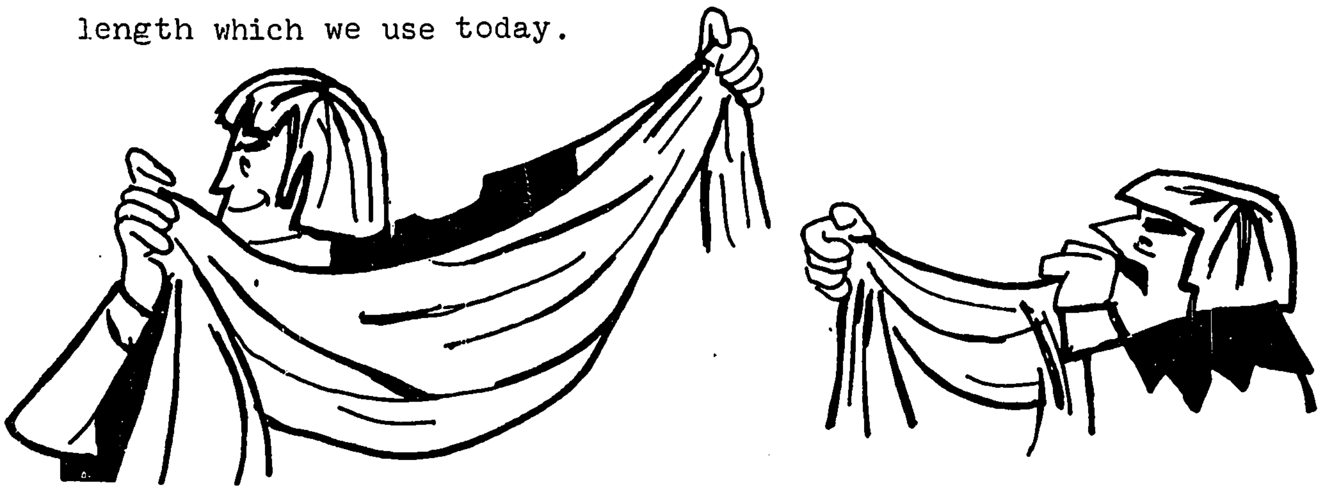
> STANDARD UNIT —— a unit of measure agreed upon and used by a large number of people.

✓ POINT

1. Name some standard units of length that are currently used.

NO MAN IS AN ISLAND . . .

The units which we use for measuring have interesting histories. Mankind's need for standard units of length has evolved over centuries in a way quite similar to the development outlined in this booklet: The early inch was the width of a man's thumb, or that of three barley corns; the foot was the length of a man's foot; and the yard was the distance from the nose to the fingertips of an outstretched arm. Since these units of length varied from one person to another, it became necessary to establish the common standard units of length which we use today.



As man developed an industrial society, the need for units that were the same regardless of locality became more apparent. Universally accepted standard units became mandatory with the introduction of assembly-line techniques in the early 1800's.

Some units became widely used and were standardized by law or agreement and used by entire countries or regions.

The first known standard units of measure were established about 8000 years ago. Our present standards originated much later.

1790	metric system developed in France
1866	use of metric system legalized in U.S.
1959	present United States inch standardized

EXERCISES

1. Several standard units of length are not commonly known as they either (a) are used only for special types of distances or (b) have been replaced by more recently adopted standard units.

   Use a dictionary or encyclopedia to find a definition of the following standard units.

   a. league
   b. bolt of cloth
   c. light-year
   d. cable
   e. pica
   f. furlong
   g. ell
   h. nautical mile
   i. chain
   j. link
   k. rod

2. Who determines the official standard units of length used in the United States? What is the official U.S. standard of length? (Use a dictionary or encyclopedia.)

HOW LONG IS AN INCH?

In the 14th century, King Edward II of England proclaimed that the English inch should be the length of "three barley-corns, dry, round, and laid end-to-end." He thought that he had finally standardized the inch.

However, there has been disagreement about the inch ever since. Until 1959, the British, United States, and Canadian inches were defined as follows:

British inch - 2.53999560 cm.
Canadian inch - 2.54000000 cm.
U.S.A. inch - 2.54000508 cm.

Although very small, this difference resulted in some World War II supplies requiring precise measurement (guns, planes,...) being custom-made. As a result, some supplies were delayed for months.

In 1959, the United States, England, Australia, Canada, New Zealand, and South Africa agreed to adopt the Canadian inch as their official standard.

COMMONLY USED UNITS

SYSTEMS IN USE . . .

Two major systems of measurement are currently in use throughout the world-the English system and the metric system. The metric system is more widely used. With the exception of the United States and Canada, all major countries in the world are presently using the metric system or are in the process of changing to the metric system for use by the general public.

While the centimeter and other units of the metric system are not in common use in this country, they are likely to be in the not-too-distant future.

Some units of length are not used often and their relationships with other units are not worth memorizing (they can be looked up when needed). Following are relationships between some of the basic units of length within the English and metric systems of measurement. Those marked with an asterisk (*) should be memorized, if you have not done so already. These are the ones most commonly used by the general public.

STANDARD UNITS OF LENGTHS

ENGLISH SYSTEM	METRIC SYSTEM
* 12 inches = 1 foot	* 10 millimeters = 1 centimeter
* 3 feet = 1 yard	10 centimeters = 1 decimeter
16.5 feet = 1 rod	* 100 centimeters = 1 meter
* 5280 feet = 1 mile	* 1000 meters = 1 kilometer

METRIC OR ENGLISH???

The article on page 30 indicates some of the pros and cons of switching to the metric system in the United States.

Conversion to the Metric System Eyed

By Science Service

WASHINGTON—Conversion to the metric system seems inevitable for the United States, particularly with 90 per cent of the world's people already using it. The question is when and how.

As to when, Sen. Robert P. Griffin, R Mich., who helped draft recently passed federal legislation calling for a three-year study on the ramifications of metric conversion, says that "by 1980 most of the country will be on the metric system."

The question of how to switch is the basic purpose of the three-year study. The secretary of commerce, who will coordinate the study, has been directed to make specific recommendations on overcoming the "practical difficulties" involved.

Many expect the biggest practical difficulty to be the cost of changing over, which most estimates put between $10 billion and $20 billion.

HIGHLY UNLIKELY

General Electric Co. estimates that it would cost them $200 million to convert if they redesigned all their equipment, which is highly unlikely.

However, others say that the relevant question is not "what will it cost to convert" but rather "what will it cost not to."

One economist states that the Stanford Research Institute estimate of $11 billion to change U.S. industry over to the metric system could be paid for in 16 years by the savings made in teaching only the metric system in grade schools.

He says that 25 per cent of the time spent teaching arithmetic could be saved by the elimination of most common fractions and complicated units of measure, and that this would amount to a $705 million a year savings for all pupils across the country.

Heading up the Commerce Department group that will make the three-year study is A.G. McNish, assistant to the director, National Bureau of Standards.

While not wanting to prejudice the results of the study, McNish does not agree that the cost of conversion will run necessarily into the billions.

He says the study will pin down the economic benefits of adopting metric and weigh them against the costs.

McNish says that, from the data obtained, estimates will be made on how fast conversion should go for several industries, so as to keep costs lowest and get the biggest benefits, primarily increased foreign trade.

Dr. John F. Kincaid, assistant secretary of commerce for science and technology, points out that the metric conversion issue has a critical bearing on the amount of the country's foreign trade and its balance of payments.

He believes, along with a number of economists, that until the U.S. switches, it will be denied much of the world market that is developing as the emerging nations industrialize, a market that Dr. Kincaid says will reach "almost astronomical proportions."

In addition, the study will explore the costs and problems of teaching the metric system in the country's schools, and of changing consumer transactions to metric, such as buying milk by the liter, meat by the kilogram or carpeting by the meter.

When the study is completed, the fireworks will begin. It will be up to Congress to decide specifically how to convert. This will involve the potentially explosive question of the extent to which metric adoption will be mandatory, rather than voluntary.

STAGED BASIS

For example, the British have begun mandatory conversion to metric in a staged basis so that by 1975 every segment of the country will be on metric.

McNish says that he doubts very much that this is the way it will go for the U.S.

He thinks industry would not tolerate a mandatory approach, although he believes federal tax incentives to ease the cost burden where it exists may be provided.

He says it is probable that only consumer transactions would be covered by mandatory federal legislation. And as for teaching metric in the schools, McNish sees this as a state and local matter.

This article appeared in the Pontiac Press, Pontiac, Michigan, November 6, 1968.

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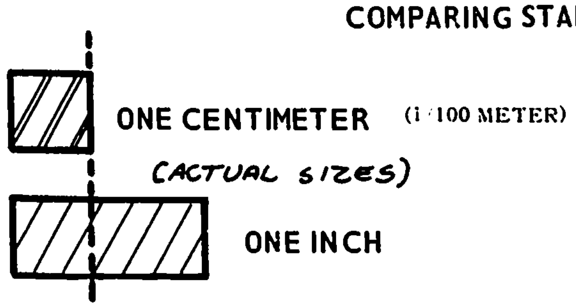
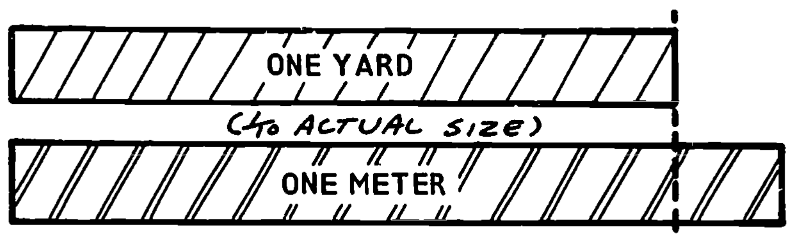
COMPARING STANDARD UNITS



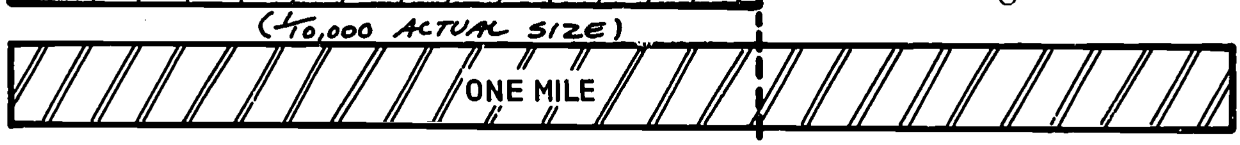
One centimeter is about .4 (or $\frac{2}{5}$) inches long.



1 yard = 36 inches

1 meter = 39.37 inches.

One Kilometer is about .625 (or $\frac{5}{8}$) miles long.



The above scale drawings indicate the relative lengths of some comparable English and metric units of length. Notice that the drawings are drawn to different scales.

✓ **POINT**

1. Circle the longer unit in each pair.

   a. Mile Kilometer

   b. Yard Meter

   c. Inch Centimeter

   d. Mile Meter

PREFIXES AND THE DECIMAL SYSTEM . . .

The metric system is convenient to use because all units of length are related to the basic unit, the meter, in the same way that the place values (thousandths, hundredths, tenths, tens, hundreds,...) of the decimal system of numeration are related to the units ... (or ones) place.

For example, a centimeter is $\frac{1}{100}$ of a meter and a kilometer is 1000 meters. The relationship between the metric units is determined by using the metric prefixes.

METRIC PREFIXES

milli- $\frac{1}{1000}$	(.001)	deca- 10
centi- $\frac{1}{100}$	(.01)	hecto- 100
deci - $\frac{1}{10}$	(.1)	kilo- 1000

The prefixes underlined are those most commonly used.

These same prefixes are used with the basic metric units of mass (gram) and capacity (liter).

In contrast, the relationships between English units of length are not as consistent.

✓POINT

1. Give the meaning of the following metric prefixes.

   a. milli _______
   b. kilo _______
   c. centi _______

EXERCISES

1. Circle the longer unit in each pair.

   a. meter yard
   b. centimeter inch
   c. centimeter meter
   d. kilometer mile
   e. centimeter millimeter
   f. foot yard
   g. meter foot
   h. inch millimeter

2. Complete:

   a. 1 mile = _____ feet
   b. 1 meter = _____ millimeters
   c. 1 meter = _____ centimeters
   d. 1 centimeter = _____ millimeters

3. Suppose that the metric system, with the prefixes, milli, deci, centi, and kilo, was used to measure time.

   a. If your class period was a deciday long, would you like it better? Why or why not? _______________

   ____

   ____

   b. About how many centidays would it take to make an hour? __________
   c. A kiloday would be about how many years? __________

4. What is a more common name for a centidollar? a decidollar?

   __________ __________

5. Arrange the following units in order of length from smallest to largest. (Indicate the smallest by 1, next smaller by 2,...)

   _____ inch
   _____ kilometer
   _____ yard
   _____ millimeter
   _____ foot
   _____ meter
   _____ mile
   _____ centimeter

6.

a. Name the segment which you believe is closest to an inch in length. ________

b. Name the segment which you believe is closest to a centimeter in length. __________

7. Circle the unit which best completes the statement.

a. The longest unit is...

a centimeter a meter an inch

b. The length of a room would be measured in...

centimeters kilometers meters

c. The distance from Detroit to Chicago would be measured in...

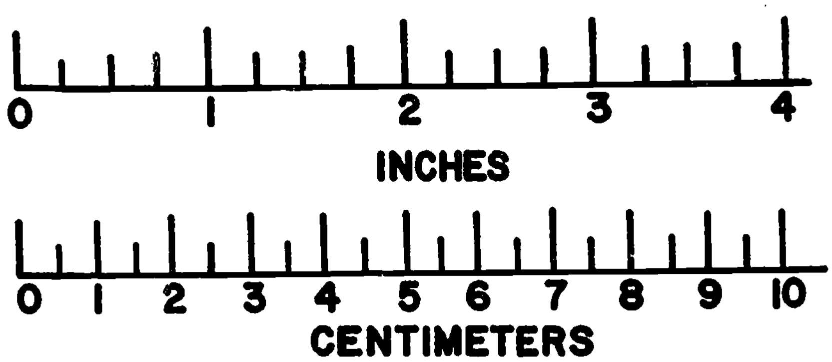
kilometers millimeters meters

d. Your height would be measured in...

millimeters meters centimeters

e. 100 centimeters equals...

1 kilometer 1 meter 1 yard



8. Comparing the inch and centimeter scales above, complete the following.

a. 5 cm. ≈ _____ in. c. 20 cm. ≈ _____ in.

b. 3 in. ≈ _____ cm.

(≈ is read "approximately the same as".)

MORE OF THE SAME

The previous lesson (pp.29-34) introduced the more commonly used English and metric units of length and the metric prefixes. The exercises in this lesson continue the development of these topics. Work the exercises carefully, referring to the information given. Ask for assistance if there are problems which give you difficulty.

EXERCISES

Refer to the information below for questions 1 and 2.

UNITS OF LENGTH

English System	Metric System
12 inches = 1 foot	10 millimeters = 1 centimeter
3 feet = 1 yard	100 centimeters = 1 meter
5280 feet = 1 mile	1000 meters = 1 kilometer

1. Write the ratios of the following English units.

___ a. 1 foot to 1 inch $\left(\frac{1\text{ foot}}{1\text{ inch}} = \frac{12\text{ inches}}{1\text{ inch}} = \frac{?}{?}\right)$

___ b. 1 yard to 1 foot

___ c. 1 inch to 1 yard

___ d. 1 mile to 1 foot

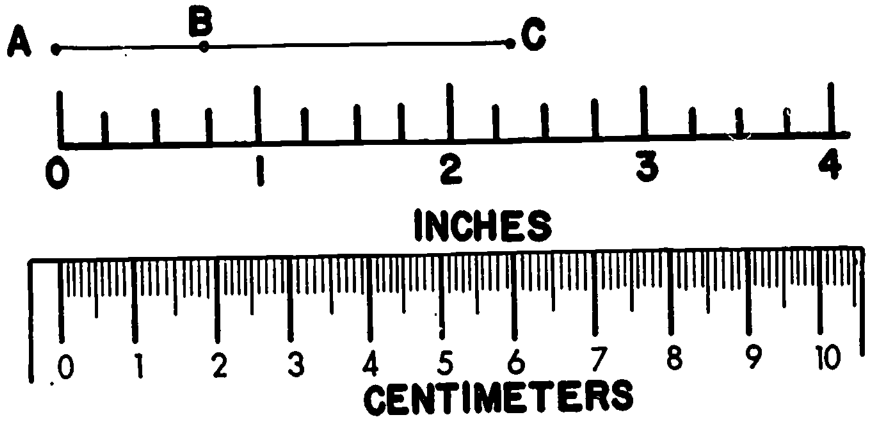
2. Write the ratios of the following metric units.

___ a. 1 centimeter to 1 millimeter $\left(\frac{1\text{ cm.}}{1\text{ mm.}} = \frac{10\text{ mm.}}{1\text{ mm.}} = \frac{?}{?}\right)$

___ b. 1 centimeter to 1 meter

___ c. 1 meter to 1 millimeter

___ d. 1 kilometer to 1 meter.



Refer to the above illustration for exercises 3-7.

3. Each inch on the top ruler is divided into four equal parts. Each part is what fractional part of an inch? ____

4. Each centimeter on the bottom ruler is divided into ten equal parts. What is the name of each of these parts? ______

5. Give the measures of the following segments to the nearest centimeter (cm.).
   a. $m(\overline{AB})$ = ____ cm.   c. $m(\overline{BC}) = m(\overline{AC}) - m(\overline{AB})$ = ____ cm.
   b. $m(\overline{AC})$ = ____ cm.

6. A 35 mm. camera uses film that is 35 millimeters (3.5 cm.) wide. What is the width of this film to the nearest $\frac{1}{4}$ inch? ____________

7. To obtain a wide-screen effect, commercial theaters use motion-picture film that has a width of 70 mm.
   a. How many centimeters wide is this film? _____
   b. What is the width of this film to the nearest $\frac{1}{4}$ inch? ________

8. Electricity for lights and other electrical applicances is measured by an electric meter. The unit of measure is the watt-hour or kilo-watt hour (kwh), which is 1000 watt-hours. (kilo = 1000)

An appliance rated 40 watts will use 40 watts of electricity per hour.

For example, a 1000-watt heater will use 1 kilowatt hour of electricity in 1 hour (1000 watts x 1 hr. = 1000 watt-hours = 1 kwh). In 10 hours, a 100-watt bulb will also use 1 kwh of electricity (100 watts x 10 hrs. = 1000 watt-hours = 1 kwh).

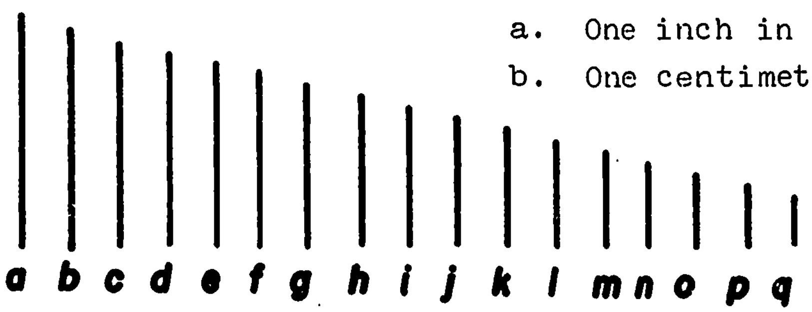
a. How many hours will it take for two 100-watt bulbs to use 1 kwh of electricity? ________

b. An electric fan is marked "40 watts." How many hours will it take to use 2 kwh of electricity? _______

9. Circle the best estimate in each exercise.

a.	Height of a man	1 meter	2 meters	100 centimeters
b.	Length of a School Bus	25 yards	18 feet	18 yards
c.	Length of a dollar bill	6 inches	10 inches	12 inches

10. Indicate the letter of the segment which you believe is nearest to...



a. One inch in length. ___________

b. One centimeter in length. ________

*11. Metric prefixes are used in conjunction with several units of measures and objects. For example the prefix <u>mega</u> means 1,000,000 and a megaton is 1,000,000 tons. What is the meaning of the following words?

a. decade

b. decathlon

c. micrometer

d. centigrade

e. mill

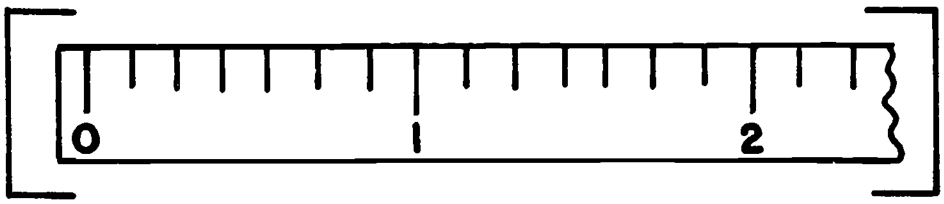
✓POINT

Use the following questions to check your understanding of Lessons 4-6. If you have difficulty with any questions, it may indicate a topic you should review.

1. For each pair circle the phrase that indicates the more precise measurement.

To the nearest...	a.	.1 in.	.1 cm.
	b.	yard	meter
	c.	$\frac{1}{8}$ in.	$\frac{1}{16}$ in.

2. The ruler below is graduated in ________________ (what fractional part?) of a unit.



3. Define the following metric prefixes.

   a. centi c. kilo

   b. milli

4. Complete:

   a. _____ centimeters = 1 meter

   b. 1 centimeter = ____ millimeters

   c. 1 yard = _____ feet

   d. 1 in. $\approx$ _____ cm.

5. Arrange each set of units in order from largest to smallest.

   a. centimeter inch millimeter

   b. yard foot meter

   c. inch meter mile kilometer

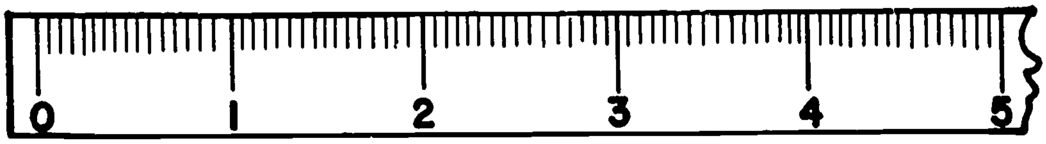
ORIGIN OF THE MILE. . .

The mille or mile, as used by the Romans, was defined as 1,000 paces (double steps). The Latin words for 1,000 paces were millia passuum, later translated into English as mile.

About the year 1500, the mile was changed to 5,280 feet. This was done so that a mile could be divided into exactly 8 furlongs, the most common units of length for land measure at that time.
(1 furlong = 40 rods = 660 feet)

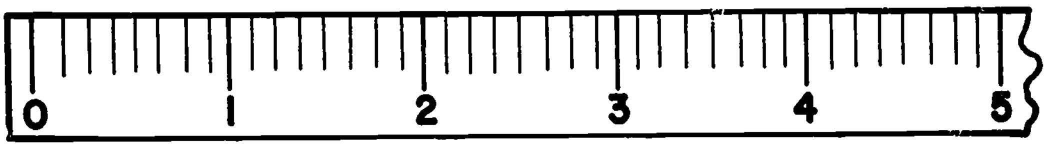
$$\begin{array}{r|l} & \ \ 8 \\ 660 & \ \ 5280 \\ & -5280 \\ \hline & \ \ \ \ \ \ 0 \end{array}$$

A.



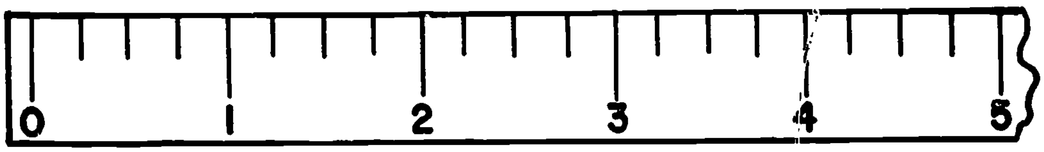
SIXTEENTHS OF AN INCH

B.



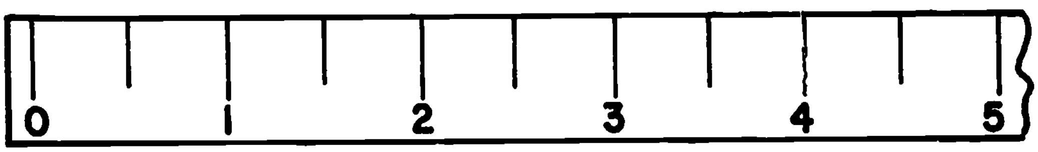
EIGHTHS OF AN INCH

C.



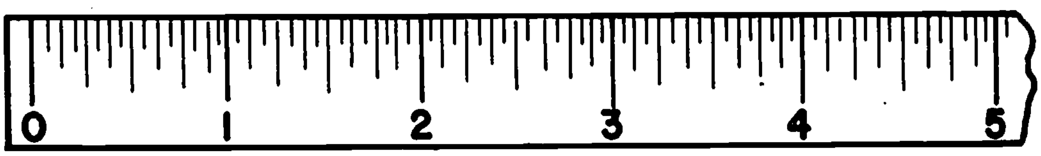
FOURTHS OF AN INCH

D.



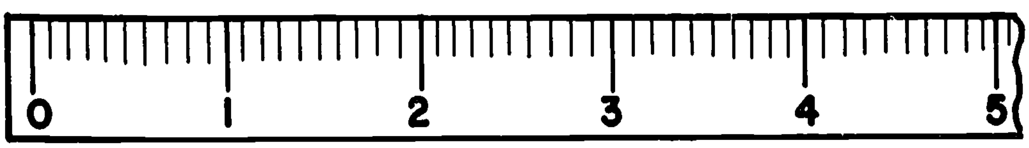
HALF-INCHES

E.



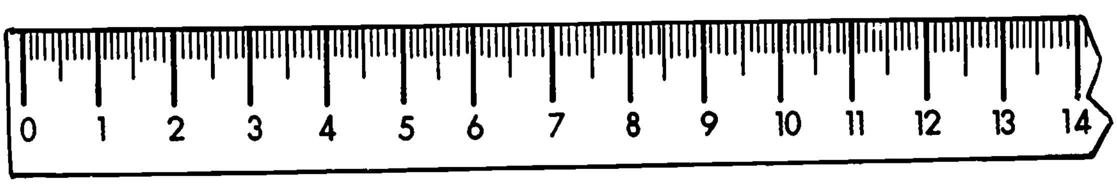
SIXTEENTHS OF AN INCH

F.



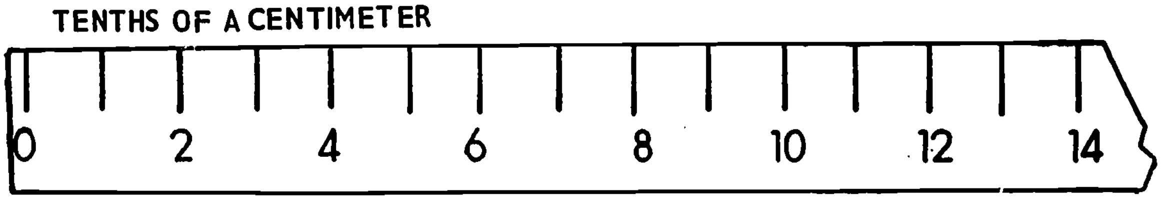
TENTHS OF AN INCH

G.



TENTHS OF A CENTIMETER

H.



CENTIMETERS

WHAT IS THE SCALE?

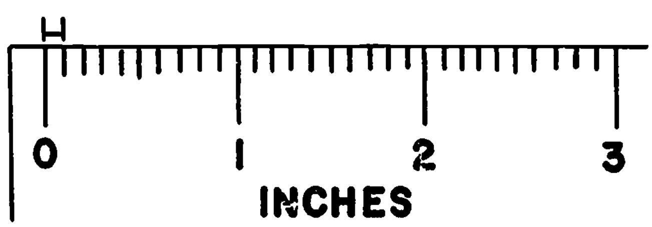
You will be given a packet of rulers like those pictured on page 40. These rulers will be used in the remainder of this booklet.

The markings of ruler E are the most commonly used for every-day purposes. You must understand what the marks of different length mean before you can use a ruler accurately.

THE SCALE IS . . .

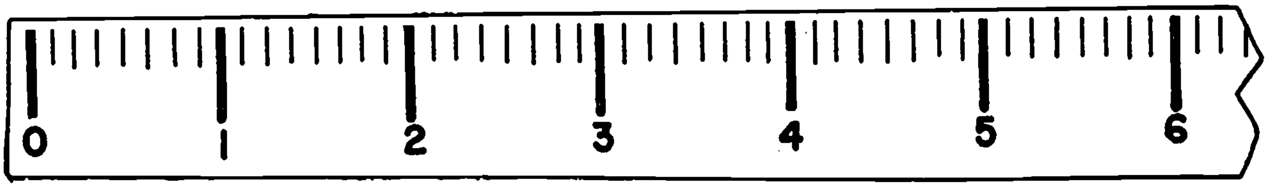
Before a ruler can be used to measure distances, its scale must be determined. The scale depends on the length of the ruler's smallest subdivision.

For example, each inch of the ruler pictured below is divided into ten equal parts.

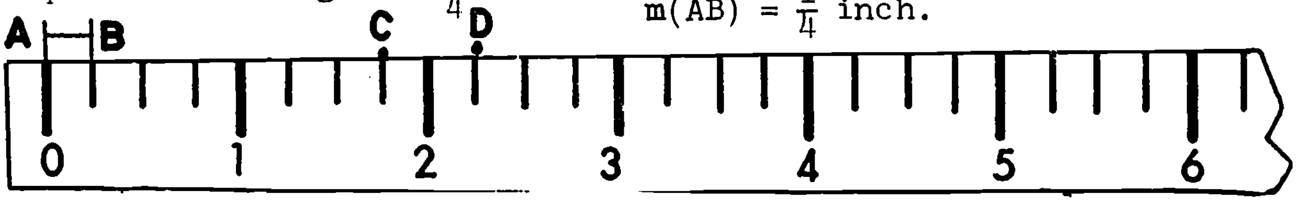


Therefore, each of the small subdivisions on the above ruler (one subdivision is indicated above the ruler) represents a length of $\frac{1}{10}$ inch. We say that the ruler has a scale graduated in tenths of an inch.

The ruler below is graduated in eighths of an inch. (How can you tell?) It could be used to measure lengths to the nearest eighth of an inch.



Each of the smaller subdivisions on the ruler below represents a length of $\frac{1}{4}$ inch. $m(\overline{AB}) = \frac{1}{4}$ inch.



Point C on the scale represents 7 one-fourth inches.

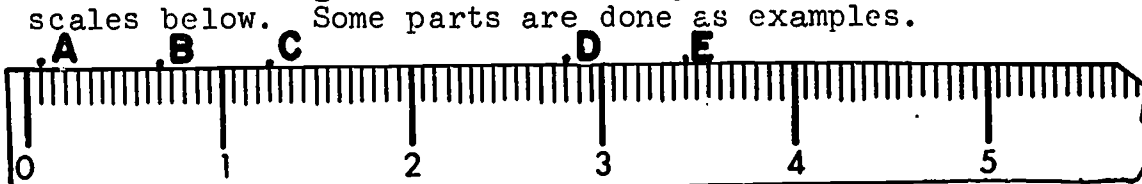
7 one-fourth inches = $7 \times \frac{1}{4}$ inches = $\frac{7}{4}$ in. = $1\frac{3}{4}$ in.

Point D represents how many inches?

✓ **POINT**

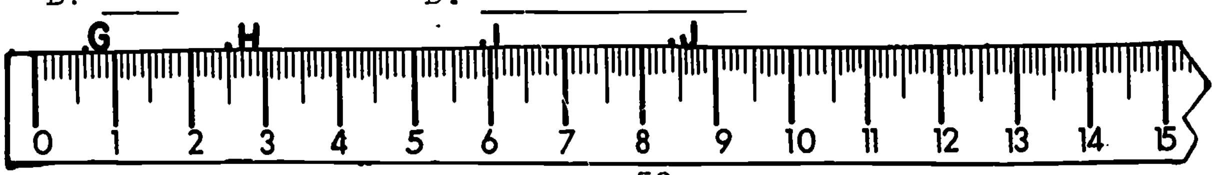
1. Give the meaning for each labeled point on the ruler scales below. Some parts are done as examples.

a.



A: $\frac{1}{16}$ in. C:_____ E:_______

B: ____ D: $\frac{45}{16}$ or $2\frac{13}{16}$ in.

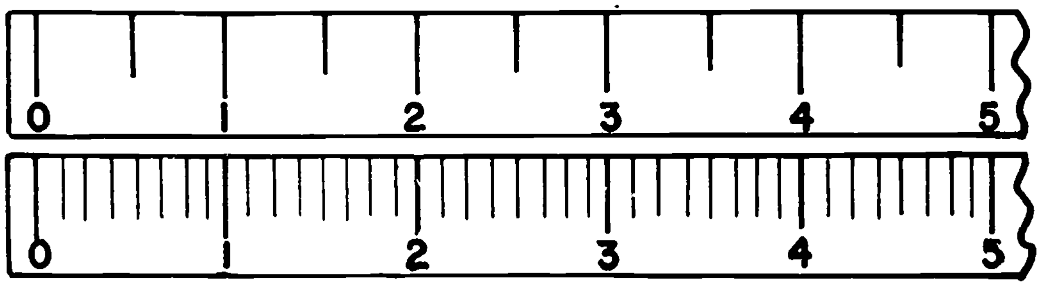


G:______ I: 5.9 cm. ($\frac{59}{10}$ cm.)

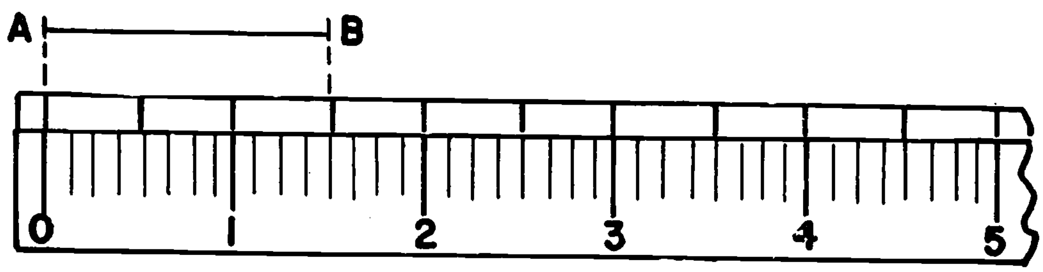
H:______ J:______

EQUIVALENT RULER LENGTHS

Ruler scales can also be used to indicate fractions that are equivalent (have the same value). For example, suppose two rulers graduated in half inches and eighths of an inch are used.



Place the two ruler scales next to each other.



Depending on the ruler used.

$m(\overline{AB}) = 3$ one-half inches

$= 3 \times \frac{1}{2}$ in.

$m(\overline{AB}) = \frac{3}{2}$ in. $= 1\frac{1}{2}$ in.

or

$m(\overline{AB}) = 12$ one-eighth inches

$= 12 \times \frac{1}{8}$ in.

$m(\overline{AB}) = \frac{12}{8}$ in. $= 1\frac{4}{8}$ in.

These results indicate that $\frac{3}{2} = \frac{12}{8}$ (How?)

The truth of this result could be checked by the <u>cross-product method</u> which was developed in ACTIVITIES WITH RATIO AND PROPORTION.

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

✓ POINT

Give the missing numbers so that the fractions for each part are equivalent. (Your rulers may be used.)

1. $\frac{\square}{16} = \frac{7}{8}$

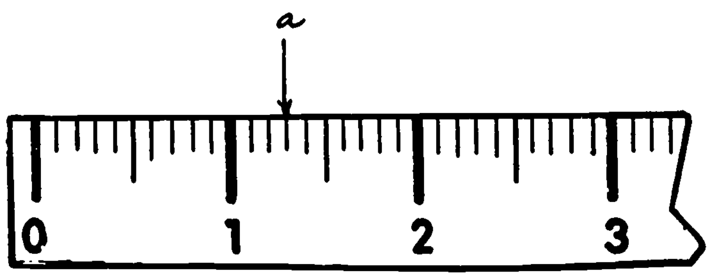
2. $\frac{\square}{4} = \frac{4}{16}$

3. $\frac{3}{\square} = \frac{12}{8}$

4. $\frac{10}{8} = \frac{\square}{4}$

EXERCISES

1. The ruler below is graduated in tenths of an inch.



Indicate by a letter and arrow each of the following locations on the above ruler scale. Part a is done as an example.

a. $1\frac{3}{10}$ in. c. 3.2 in. e. 1.9 in.

b. 2.5 in. ($2\frac{5}{10}$ in.) d. $\frac{7}{10}$ in. f. .2 in.

You may refer to the ruler in #1 for questions 2 and 3.

2. a. How many tenths in one inch? _____
   b. How many tenths in 2 inches? _____
   c. How many tenths in a half-inch? _____
   d. Is .4 inch more or less than a half-inch? _____
   e. Is 2.8 inches more or less than $2\frac{1}{2}$ inches? _____

3. For each ruler location, circle the whole inch measure to which it is closest. If it is equally close to both, circle both.

	RULER LOCATION	**WHOLE INCHES**	
a.	1.4 in.	1 in.	2 in.
b.	.7 in.	0 in.	1 in.
c.	.3 in.	0 in.	1 in.
d.	1.5 in.	1 in.	2 in.
e.	2.3 in.	1 in.	3 in.

4. Give the numbers which when substituted for the letters will make the fractions for each part equivalent. Write your answers in the blanks provided.

a $\frac{5}{8} = \frac{x}{16}$, x = ________ b. $\frac{c}{4} = \frac{6}{8}$, c = ______

If $\frac{5}{8} = \frac{x}{16}$. then x = ______ If $\frac{c}{4} = \frac{6}{8}$, then c = _____

c. If $\frac{a}{16} = \frac{3}{4}$, then a = ______ d. If $\frac{b}{16} = \frac{3}{8}$. then b = _____

e. If $2\frac{x}{8} = 2\frac{1}{2} = 2\frac{y}{10}$, then x = ________ and y = ________

f. If $\frac{28}{16} = \frac{r}{4} = 1\frac{s}{4}$, then r = ________ and s = __________

5. Give the numbers which when substituted for the letters will make each of the following statements true. Write your answers in the blanks provided.

a. If $\frac{3}{4} + \frac{1}{16} = \frac{x}{16} + \frac{1}{16} = \frac{y}{16}$, then x = ________ and y = ________.

b. If $\frac{1}{2} + \frac{3}{8} = \frac{c}{8} + \frac{3}{8} = \frac{d}{8}$, then c = ________ and d = ________.

c. If $\frac{3}{16} + \frac{5}{8} = \frac{3}{16} + \frac{r}{16} = \frac{s}{16}$, then r = ________ and s = ________.

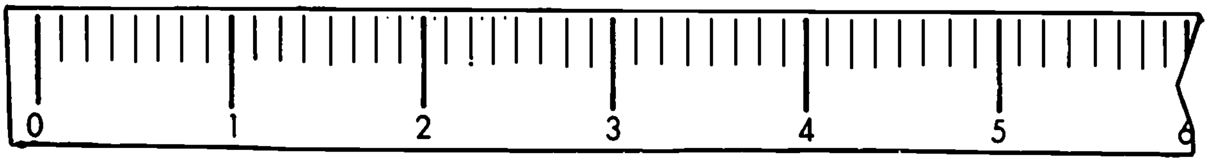
d. If $\frac{3}{4} + \frac{5}{8} = \frac{a}{8} + \frac{5}{8} = \frac{b}{8} = 1\frac{c}{8}$, then a = _____, b = _____, and c = _____.

e. If $\frac{7}{8} - \frac{1}{2} = \frac{7}{8} - \frac{m}{8} = \frac{n}{8}$, then m = _______ and n = _______.

f. If $\frac{1}{4} + \frac{3}{8} = \frac{t}{8}$, then t = ________.

g. If $\frac{5}{16} + \frac{3}{8} = \frac{a}{b}$, then a = ______ and b = _______.

h. If $\frac{9}{10} - \frac{1}{2} = \frac{j}{k}$, then j = ______ and k = ______.



6. Indicate by a letter and arrow each of the following locations on the above ruler scale.

a. $\frac{5}{8}$ in.

b. $1\frac{7}{8}$ in.

c. $1\frac{1}{2}$ in. ($1\frac{4}{8}$ in.)

d. $2\frac{3}{4}$ in.

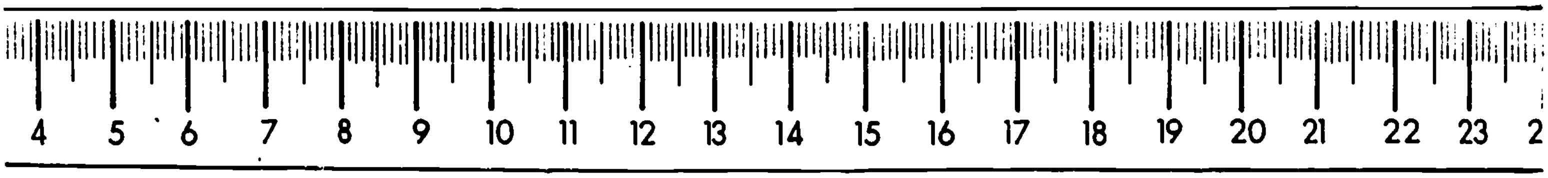
e. $3\frac{3}{8}$ in.

f. $4\frac{1}{4}$ in.

7. For each ruler location, circle the whole inch measure to which it is closest. If it is equally close to both, circle both.

RULER LOCATION	WHOLE INCHES	
a. $1\frac{5}{8}$ in.	1 in.	2 in.
b. $\frac{3}{8}$ in.	0 in.	1 in.
c. $4\frac{3}{4}$ in.	4 in.	5 in.
d. $2\frac{1}{2}$ in.	2 in.	3 in.
e. $3\frac{7}{8}$ in.	4 in.	3 in.

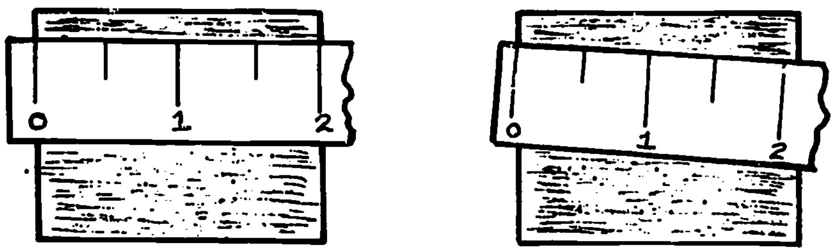
RULES TO LIVE BY



GUIDE LINES FOR RULER USE

1. Use rulers that have square, clean-cut edges. A ruler that is warped, rounded, or worn will give inaccurate results despite careful use.

2. When measuring the length or width of a rectangular object, measure parallel and close to the edge being measured.

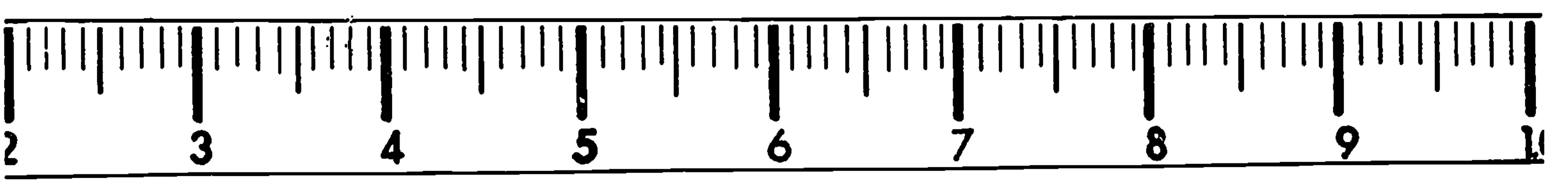


CORRECT INCORRECT

3. Use a unit of length suitable for the distance being measured and the purpose for which it is being used. (This idea will be further developed in Lesson 12.)

4. Know the scale used on the ruler before reading the measurement.

5. For best results, place the ruler in such a position so that the scale is as close as possible to the object being measured.



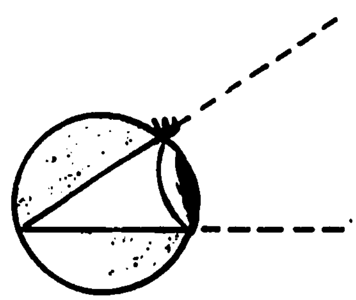
COMPETENCE ASSUMED.....

When lengths are measured, the ability to use the measuring instrument properly is usually assumed. However, carelessness and lack of knowledge may cause any measuring instrument to be used improperly. Many mistakes can be easily corrected by following some basic guidelines in the proper use of a ruler. (See page 47.)

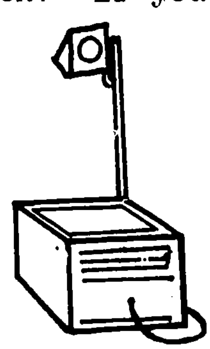
REDUCING ERRORS....

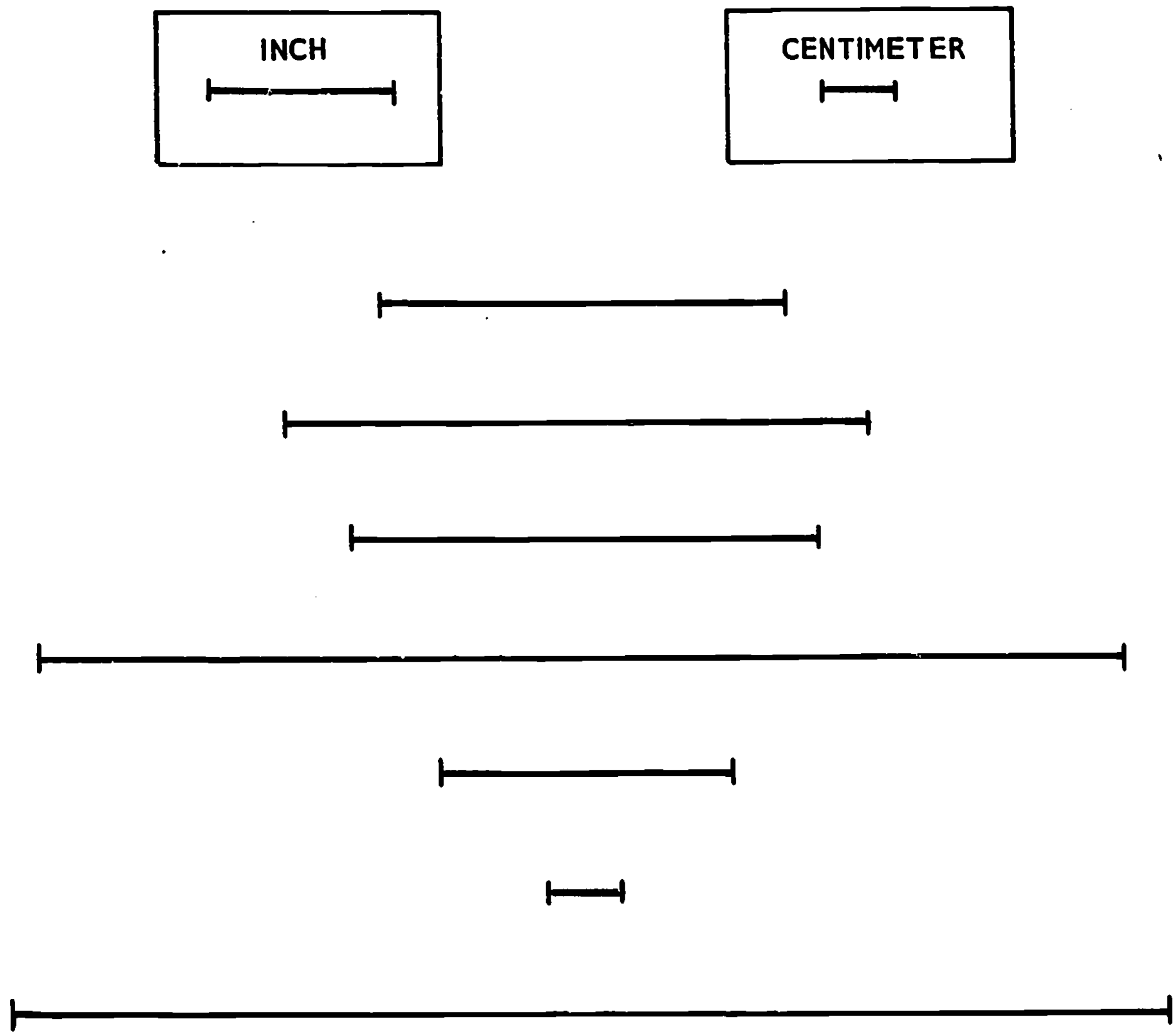
Even with careful use, small "errors" occur. Some things which cause errors are: The user is tired, the ruler slipped, the ends of the distance being measured are not lined up carefully with the ruler scale, or the ruler is warped or rounded. Reading a ruler involves sighting, estimating, and judgment. All three tend to give an approximate value to the measurement, resulting in small "errors". We cannot hope to eliminate all errors but with practice, the size of these errors can be reduced.

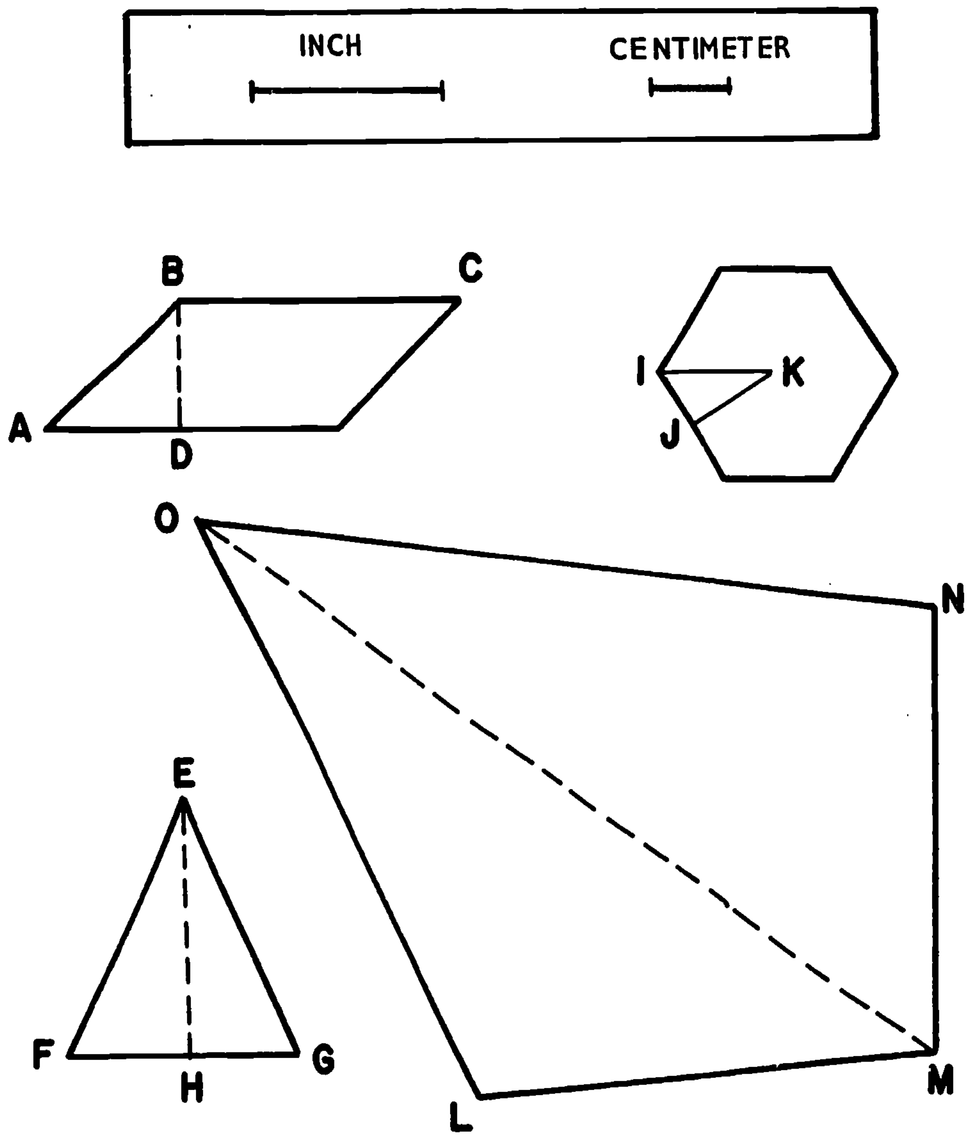
WATCH CAREFULLY...



The remainder of this lesson will be developed with the aid of the overhead projector. Listen carefully and participate in the discussion. If you have questions during the discussion, ask them.




INCH
CENTIMETER


INCH
CENTIMETER
B
C
A
D
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J
O
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F
H
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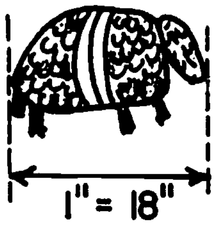
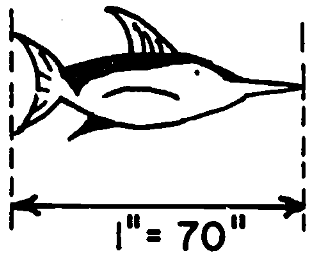
L
M

SCALE DRAWINGS

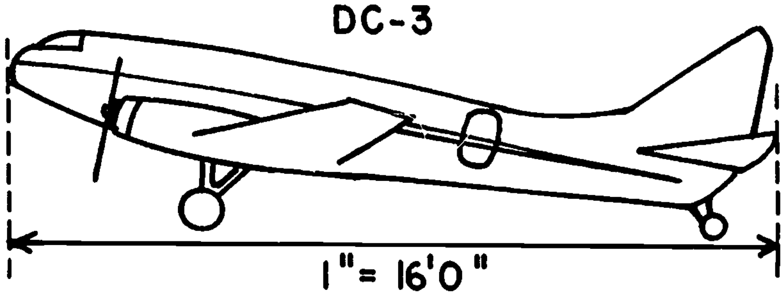
ARMADILLO

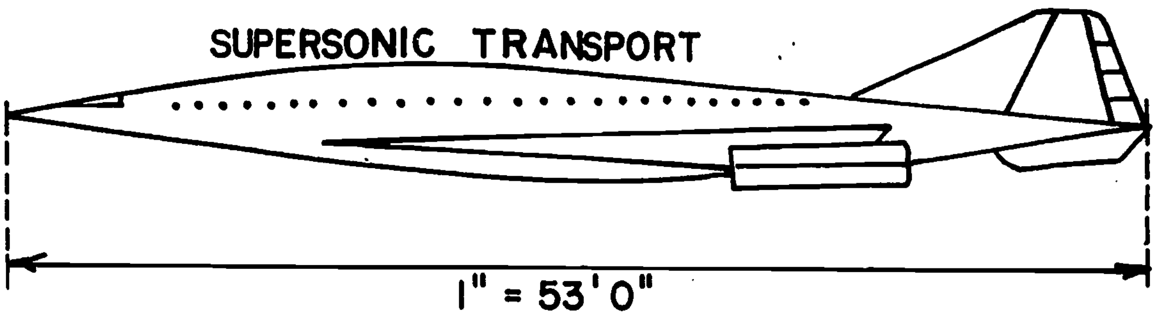


SWORDFISH

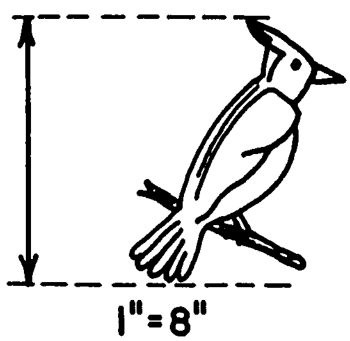


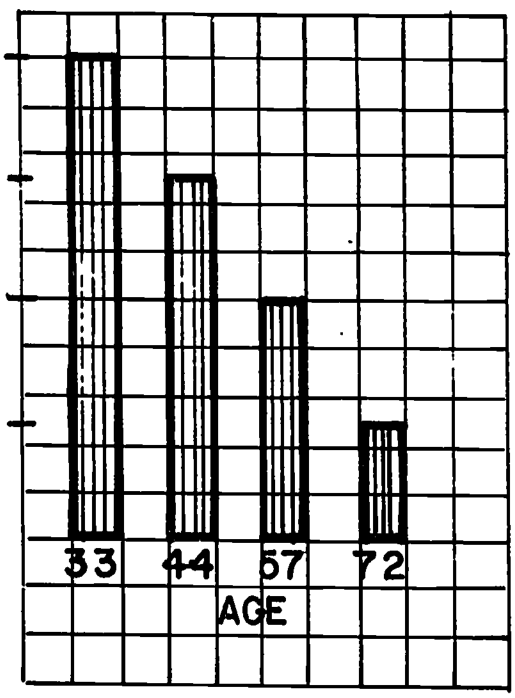
DC-3





BLUE JAY



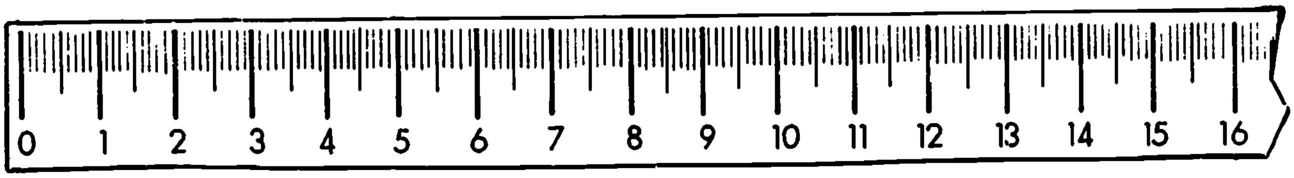


LIFE EXPECTANCY

From Life Insurance Fact Book - 1968
Institute of Life Insurance.
Years are to the nearest whole year.

EXERCISES

1. The ruler below is graduated in tenths of a centimeter.



Indicate by a letter and arrow each of the following locations on the above ruler.

a. 6.4 cm. c. 2.2 cm.

b. 10.0 cm. d. 7.3 cm.

2. For each part, draw a segment which fits the given description. Draw each segment in the space below its description. A starting point for each segment is given.

a. $\overline{RS}$: $3\frac{1}{2}$ in. $<$ m($\overline{RS}$) $<$ 4 in.

To the nearest $\frac{1}{2}$ in., m($\overline{RS}$) = $3\frac{1}{2}$ in.

R.

b. $\overline{OR}$: 3.2 cm. $<$ m($\overline{OR}$)$<$3.3 cm.

To the nearest .1 cm., m($\overline{OR}$)= 3.3 cm.

O.

c. $\overline{WX}$: $2\frac{1}{4}$ in. $<$ m($\overline{WX}$) $<$ $2\frac{2}{4}$ in.

To the nearest $\frac{1}{4}$ in., m($\overline{WX}$) = $2\frac{1}{4}$ in.

W.

d. $\overline{GH}$: To the nearest $\frac{1}{16}$ in., m($\overline{GH}$) = $2\frac{11}{16}$ in.

G.

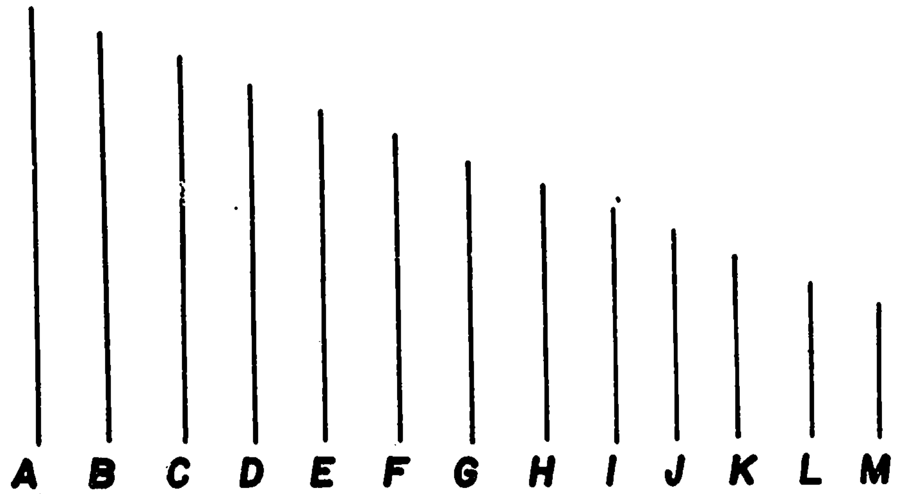
e. $\overline{IJ}$: To the nearest cm., m($\overline{IJ}$) = 8 cm.

.I

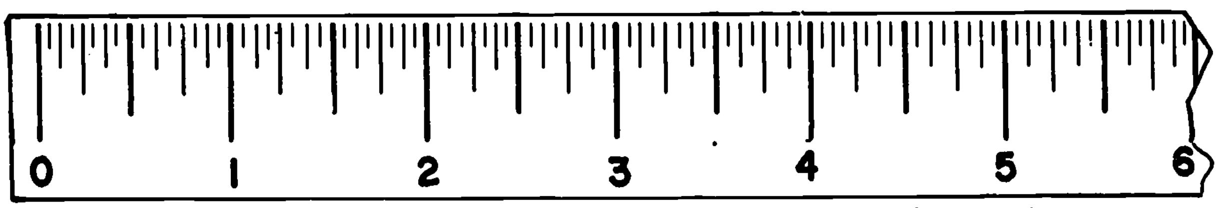
3. Estimate which segment below is nearest to...

   a. two inches in length. __________

   b. two centimeters in length. _______



4. The ruler below is graduated in sixteenths of an inch.



Indicate by a letter and arrow each of the following locations on the above ruler scale.

a. $1\frac{3}{16}$ in.

b. $2\frac{1}{4}$ in. ($2\frac{4}{16}$ in.)

c. $\frac{1}{2}$ in.

d. $1\frac{5}{8}$ in.

e. $2\frac{13}{16}$ in.

f. $\frac{7}{8}$ in.

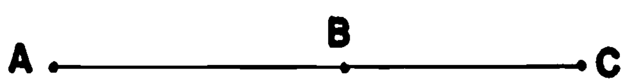
5. For each ruler location, circle the whole inch measure to which it is closest. If it is equally close to both, circle both.

RULER LOCATION	WHOLE INCHES	
a. $2\frac{3}{8}$ in.	2 in.	3 in.
b. $\frac{9}{16}$ in.	1 in.	0 in.
c. $1\frac{7}{16}$ in.	1 in.	2 in.
d. $1\frac{15}{16}$ in.	3 in.	1 in.
e. $\frac{3}{8}$ in.	0 in.	1 in.

For questions 6 and 7 do the measuring and drawing required and complete the blanks so that each statement is true. Some parts are done as examples.

6. a. Draw $\overline{AB}$ $1\frac{1}{2}$ in. long. Draw $\overline{BC}$ $1\frac{1}{4}$ long.

$m(\overline{AC})$ = **$2\frac{3}{4}$** in. $1\frac{1}{2} + 1\frac{1}{4}$ = ______ .



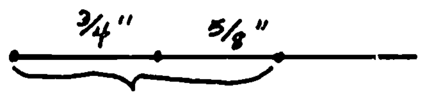
b. Draw $\overline{RS}$ $\frac{7}{8}$ in. long. Draw $\overline{ST}$ $\frac{3}{16}$ in. long.

$m(\overline{RT})$ = _____ in. $\frac{7}{8} + \frac{3}{16}$ = ______ .

c. Draw $\overline{WX}$ 2.8 cm. long. Draw $\overline{XY}$ 3.5 cm. long.

$m(\overline{WY})$ = ______ cm. 2.8 + 3.5 = ______.

7. Use the given line segment to compute the following sums. The precision of measurement is given in parentheses.

a. 

(to nearest $\frac{1}{8}$ in.)

$\frac{3}{4} + \frac{5}{8} =$ ____

b. (to nearest $\frac{1}{16}$ in.)

$\frac{7}{16} + \frac{7}{8} =$ ____

c. (to nearest $\frac{1}{16}$ in.)

$\frac{3}{16} + 1\frac{3}{4} =$ ____

d. (to nearest .1 cm.)

$5.8 + 3.9 =$ ____

e. (to nearest .1 in.)

$2.7 + 1.6 =$ ____

f. (to nearest $\frac{1}{8}$ in.)

$1\frac{5}{8} + 2\frac{7}{8} =$ ____

8. For each segment named in TABLE 8-1, (1) estimate its length, and (2) measure its length to the nearest $\frac{1}{8}$ in., $\frac{1}{16}$ in., and .1 cm.

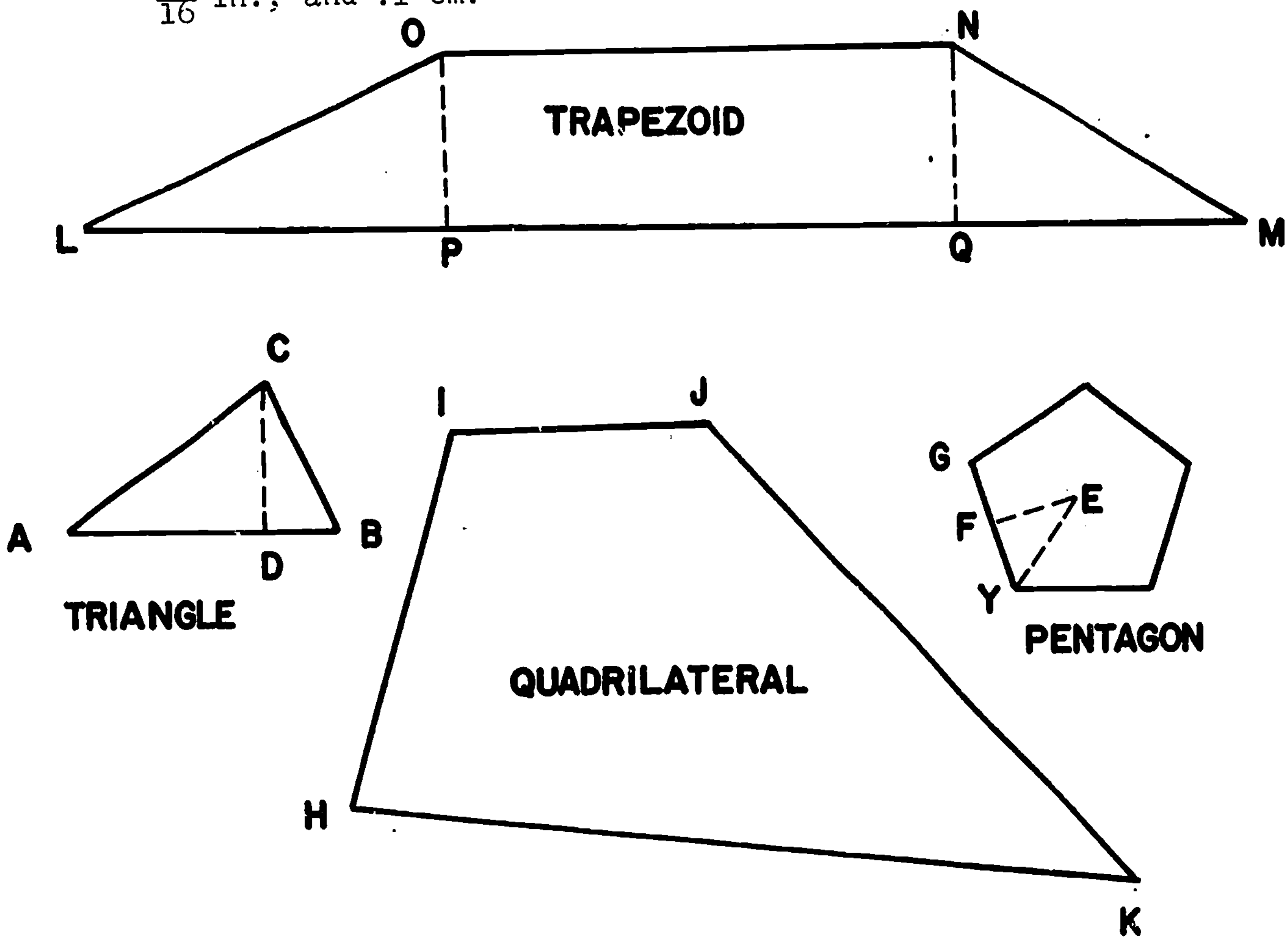


TABLE 8-1

SEGMENT	ESTIMATE	LENGTH TO THE NEAREST...		
		$\frac{1}{8}$ in.	$\frac{1}{16}$ in.	.1 cm.
$\overline{CD}$				
$\overline{OP}$				
$\overline{NQ}$				
$\overline{HK}$				
$\overline{FE}$				
$\overline{EY}$				

9. To the nearest .1 inch, the length of $\overline{HI}$ is 5.4 cm. Estimate in tenths of a centimeter the lengths of the following segments.

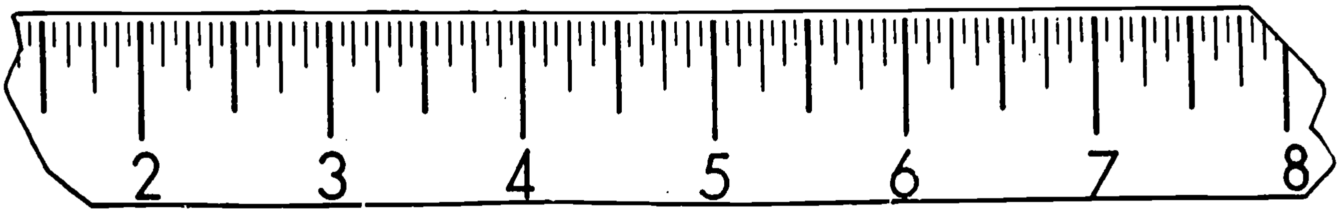
   a. $\overline{IJ}$ ______   c. $\overline{LM}$ _____

   b. $\overline{AC}$ ______

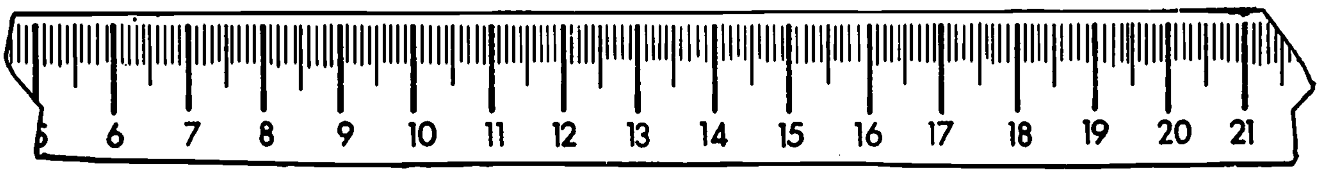
10. Find the perimeter (distance around) to the nearest .1 cm. for the quadrilateral pictured on page 56. ______

WHEN RULES ARE BROKEN

In the next set of EXERCISES you will use two broken rulers like those pictured below.



RULER A



RULER B

EXERCISES

1. Measure each of the following segments to the nearest...

   a. $\frac{1}{8}$ inch using ruler A, and

   b. $\frac{1}{10}$ centimeter using ruler B.

   Record your results in the TABLE 9-1. (in rows labeled <u>Broken</u> <u>ruler</u>)

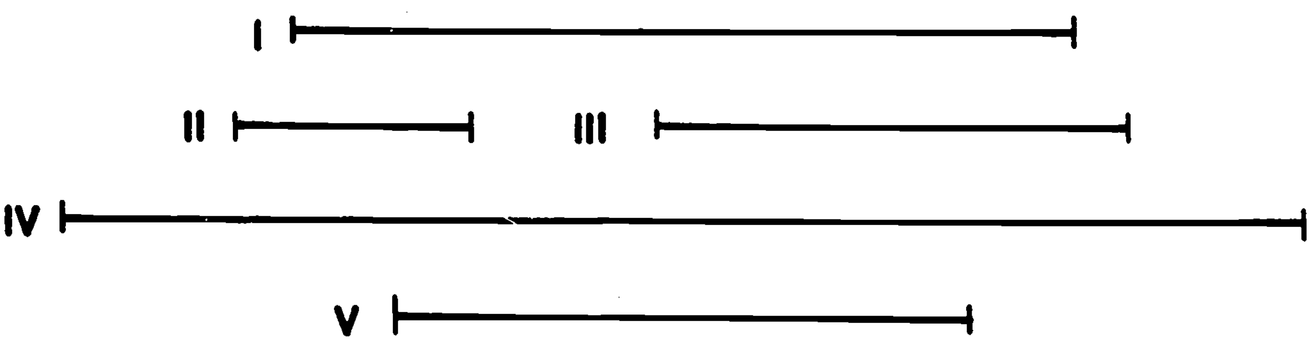


TABLE 9-1

SEGMENT	LENGTH TO THE NEAREST...		
	$\frac{1}{8}$ inch	$\frac{1}{10}$ cm.	
I			Broken ruler
			Unbroken ruler
II			Broken ruler
			Unbroken ruler
III			Broken ruler
			Unbroken ruler
IV			Broken ruler
			Unbroken ruler
V			Broken ruler
			Unbroken ruler

2. Measure each of the same segments to the same precisions using rulers that are not broken. Record your results in TABLE 9-1. (in rows labeled Unbroken ruler)

DISCUSSION QUESTIONS

1. For problem 1, did everyone in the class use the same point on the ruler as their "zero point"?

2. Could you use any point on the ruler scale as the "zero point"? Would some points be more convenient to use than others?

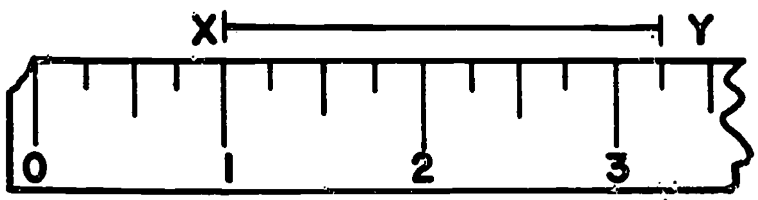
3. Why were the measures using either the broken ruler or the unbroken ruler the same?

START WHERE YOU WANT TO. . .

The previous EXERCISES demonstrated that it is not necessary to use the point labeled zero as the"zero point" when reading a ruler. In fact, there are times when it may be preferable to begin your reading with some point other than the "zero point" labeled on the ruler.

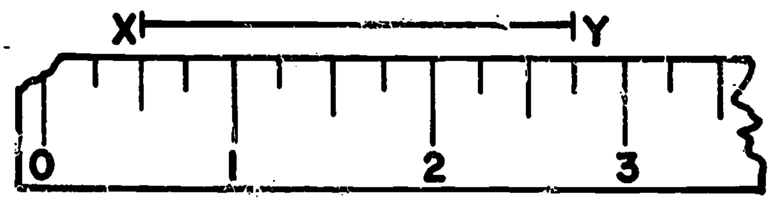
For example, the ruler pictured below has an end which is "broken off" making the zero point hard to locate. Therefore, it would be preferable to use another point as the starting point. Shown below is $\overline{XY}$ being measured using three different points as the "zero point."

A.



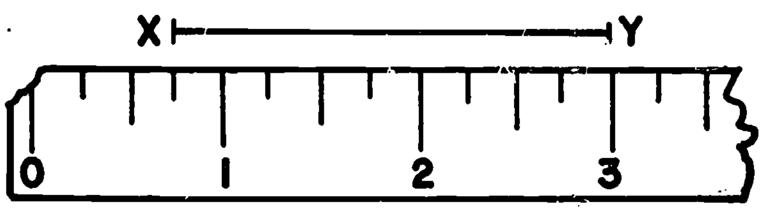
$m(\overline{XY}) = 3\frac{1}{4} - 1 = 2\frac{1}{4}$ inches

B.



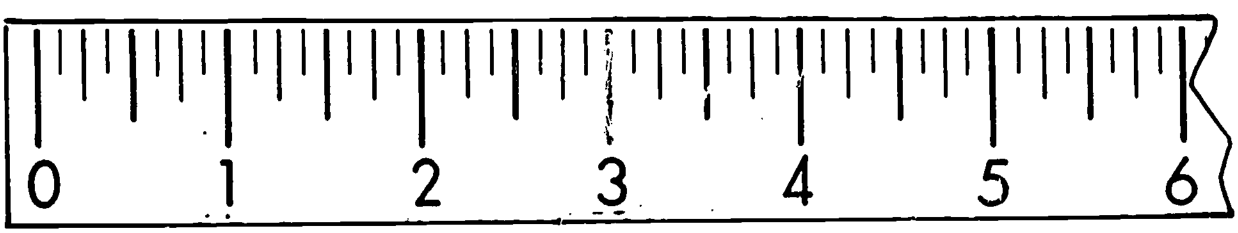
$m(\overline{XY}) = 2\frac{3}{4} - \frac{2}{4} = 2\frac{1}{4}$ inches

C.



$m(\overline{XY}) = 3 - \frac{3}{4} = 2\frac{1}{4}$ inches

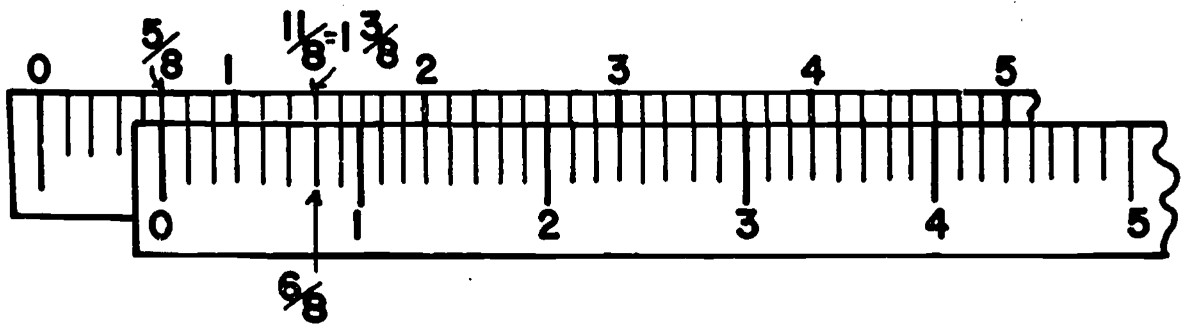
In all cases, $m(\overline{XY}) = 2\frac{1}{4}$ inches when measured to the nearest $\frac{1}{4}$ inch. Because ruler edges tend to wear and become rounded with use, some rulers inset the zero point of the scale so that the zero point can be determined despite the rounding. (See sketch below.) The rulers you are using in this unit are marked in this manner.



ADDITION AND SUBTRACTION WITH RULERS

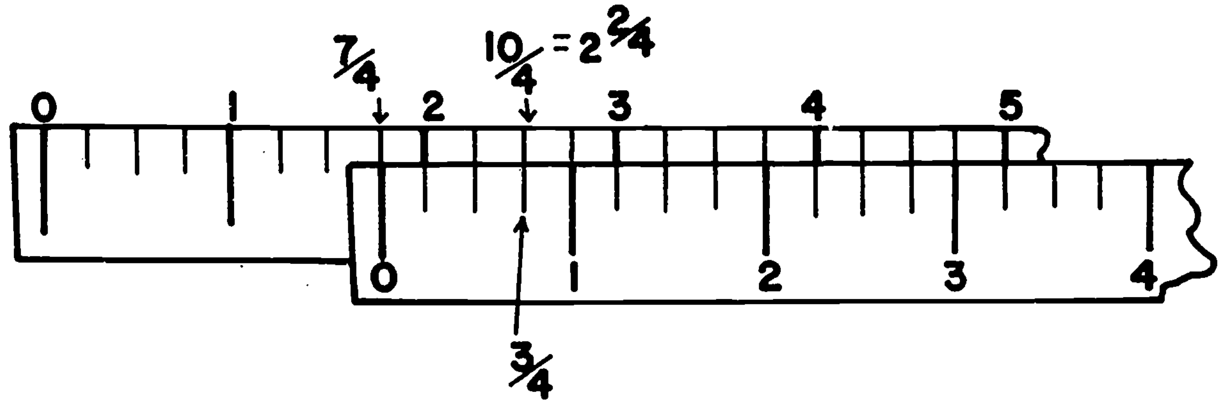
Lessons 7 and 8 included some exercises in which rulers and segment lengths were used to illustrate the addition and equivalence of certain fractions.

For example, the rulers below are illustrating the sum $\frac{5}{8} + \frac{6}{8} = \frac{11}{8} = 1\frac{3}{8}$.



The same picture can be used to illustrate two related subtraction facts:

$$1\frac{3}{8} - \frac{5}{8} = \frac{6}{8} \quad \text{and} \quad 1\frac{3}{8} - \frac{6}{8} = \frac{5}{8}.$$

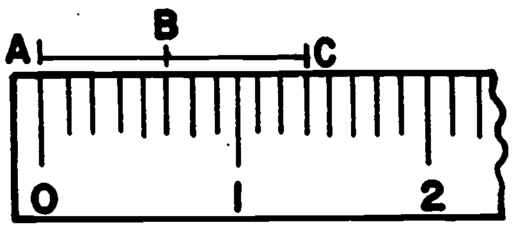


The two rulers above are illustrating the sum $\frac{7}{4} + \frac{3}{4} = \frac{10}{4} = 2\frac{2}{4}$ (This could be written $1\frac{3}{4} + \frac{3}{4} = 2\frac{2}{4}$).

What two subtraction facts are related to this sum?

Segment lengths could also be used to illustrate the addition and subtraction of fractions.

For example, consider the sum $\frac{5}{8} + \frac{6}{8}$.



$m(\overline{AC}) = m(\overline{AB}) + m(\overline{BC})$

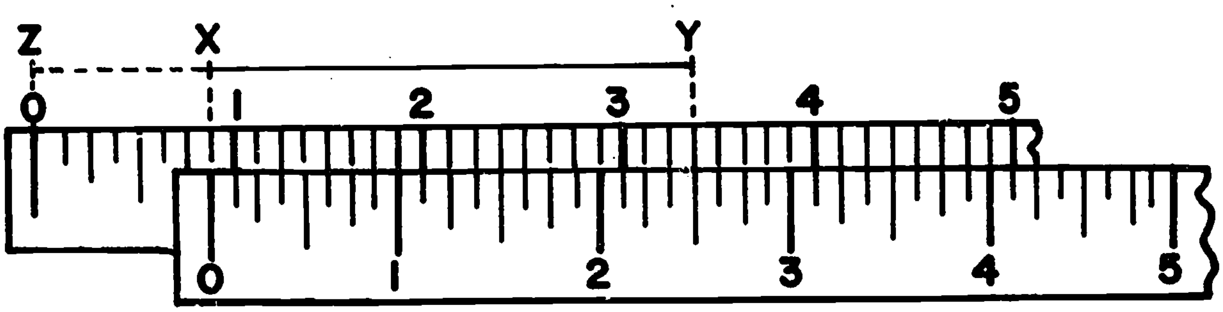
$m(\overline{AC}) = \frac{5}{8}$ in. $+ \frac{6}{8}$ in.

$m(\overline{AC}) = \frac{11}{8}$ in. $= 1\frac{3}{8}$ in.

$$\frac{5}{8} + \frac{6}{8} = \frac{11}{8} = 1\frac{3}{8}$$

Since $m(\overline{AC}) - m(\overline{AB}) = m(\overline{BC})$ and $m(\overline{AC}) - m(\overline{BC}) = m(\overline{AB})$, the picture also illustrates $1\frac{3}{8} - \frac{5}{8} = \frac{6}{8}$ and $1\frac{3}{8} - \frac{6}{8} = \frac{5}{8}$.

What is $m(\overline{XY})$ in the figure below?



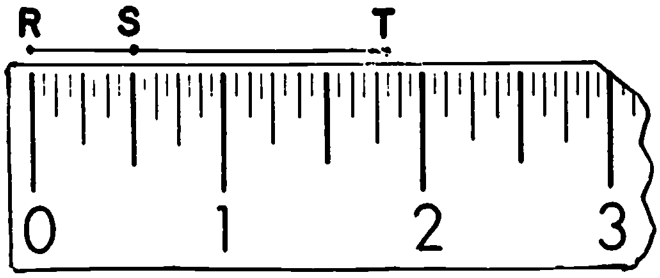
$m(\overline{XY}) = m(\overline{ZY}) - m(\overline{ZX})$

$m(\overline{XY}) = 3\frac{3}{8}$ in. $- \frac{7}{8}$ in.

$m(\overline{XY}) = \frac{27}{8}$ in. $- \frac{7}{8}$ in.

But the bottom ruler shows that $m(\overline{XY}) = 2\frac{4}{8}$ or $\frac{20}{8}$ in.

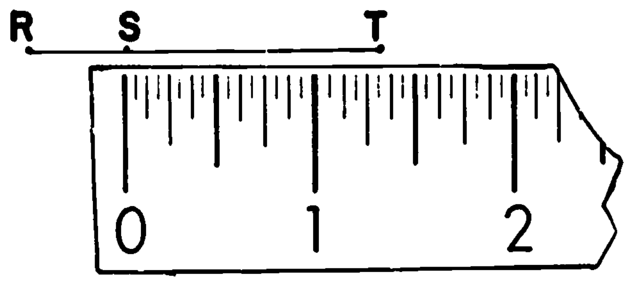
Therefore, $3\frac{3}{8} - \frac{7}{8} = \frac{27}{8} - \frac{7}{8} = \frac{20}{8} = 2\frac{4}{8}$.



$m(\overline{RT}) = 1\frac{13}{16}$ inches.

$m(\overline{RS}) = \frac{1}{2}$ inch.

$m(\overline{ST}) = \underline{\ ?\ }$ in.



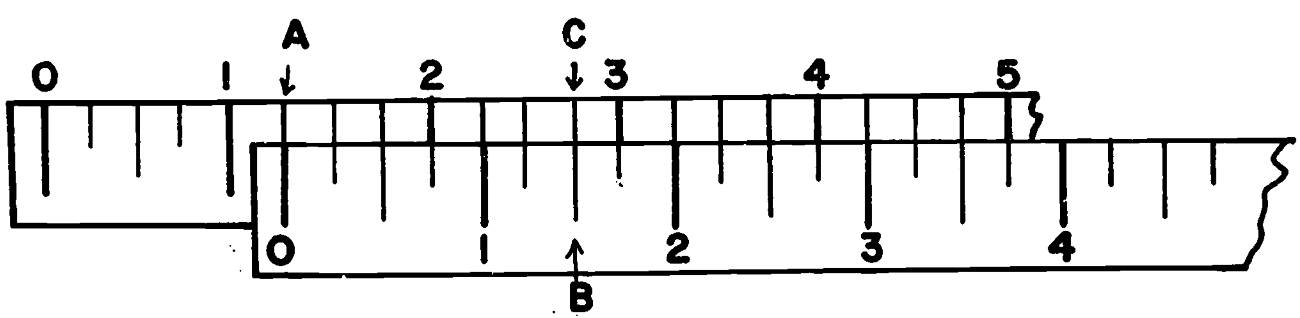
$m(\overline{ST}) = m(\overline{RT}) - m(\overline{RS})$

$m(\overline{ST}) = 1\frac{13}{16}$ in. $- \frac{1}{2}$ in.

$m(\overline{ST}) = 1\frac{5}{16}$ in.

Therefore. $1\frac{13}{16} - \frac{1}{2} = 1\frac{13}{16} - \frac{8}{16} = 1\frac{5}{16}$

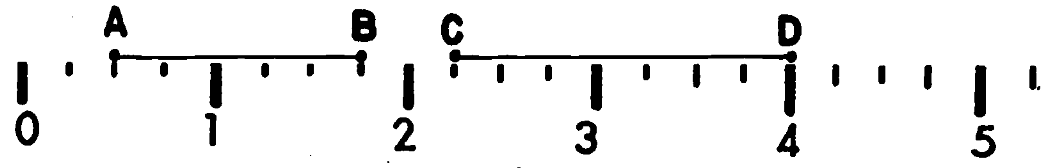
✓ **POINT**



1. Give the sum illustrated by the two rulers above.

   (A + B = C) ____________

2. Give the two subtraction facts related to the above sum.



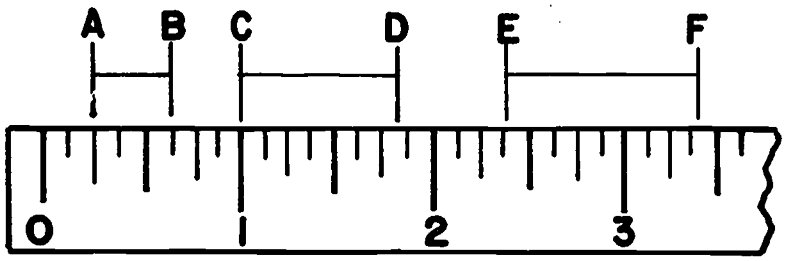
3. Give the measures of the following segments to the nearest $\frac{1}{4}$ inch.

a. $m(\overline{AB})$ = ____ - ____ = ____ in.

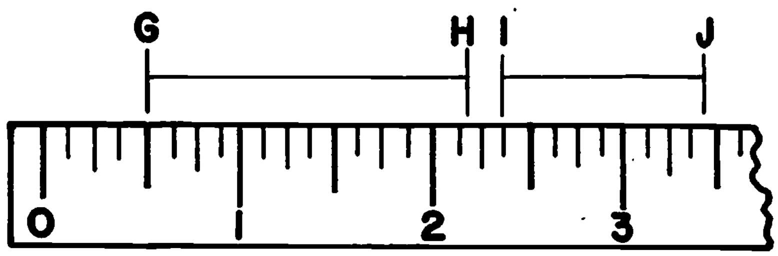
b. $m(\overline{CD})$ = _____ in.

EXERCISES

1. Find the length of each segment below to the nearest $\frac{1}{8}$ inch.

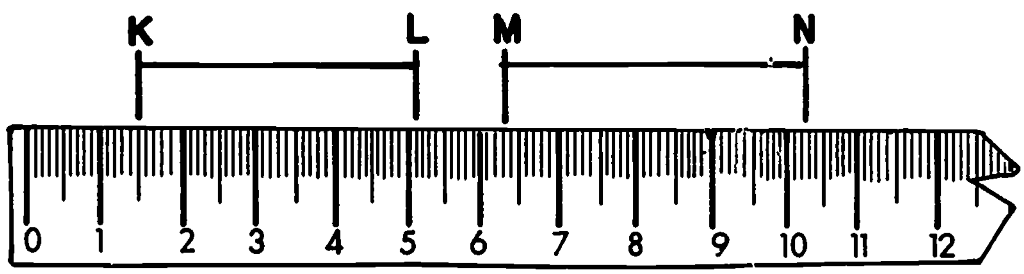


$m(\overline{AB})$ = __________ $m(\overline{CD})$ = __________ $m(\overline{EF})$ = ________



$m(\overline{GH})$ = ________ $m(\overline{IJ})$ = __________

2. Find the length of the segments below to the nearest .1 centimeter.

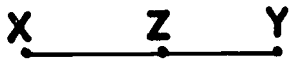


$m(\overline{KL})$ = __________ $m(\overline{MN})$ = ____________

3. In question 3, do the measuring and drawing required and complete the blanks so that each statement is true. One part is done as an example.

a. Draw $\overline{XY}$ $1\frac{5}{16}$ in. long. Draw $\overline{XZ}$ $\frac{3}{4}$ in. long.

$m(\overline{ZY})$ = 9/16 in $\qquad 1\frac{5}{16} - \frac{3}{4} =$ ______



b. Draw $\overline{PR}$ $2\frac{3}{4}$ in. long. Draw $\overline{PS}$ $1\frac{3}{8}$ in. long.

$m(\overline{SR})$ = ______ in. $\qquad 2\frac{3}{4} - 1\frac{1}{8} =$ ______

c. Draw $\overline{OD}$ 6.8 cm. long. Draw $\overline{OR}$ 3.5 cm. long.

$m(\overline{RD})$ = ______ cm. $\qquad 6.8 - 3\ 5 =$ ______

d. Draw $\overline{AS}$ $3\frac{7}{8}$ in. long. Draw $\overline{AT}$ $1\frac{3}{16}$ in. long.

$m(\overline{TS})$ = ______ in. $\qquad 3\frac{7}{8} - 1\frac{3}{16} =$ ______

4. Compute the following differences.

a. $\frac{13}{16} - \frac{3}{8} =$ ______

b. $2\frac{1}{2} - 1\frac{3}{8} =$ ______

c. $6.2 - 4.5 =$ ______

d. $\frac{7}{8} - \frac{3}{4} =$ ______

5. In the space below, draw a rectangle whose longest side is $3\frac{5}{16}$ inches long and whose shortest side is $1\frac{7}{8}$ inches long.

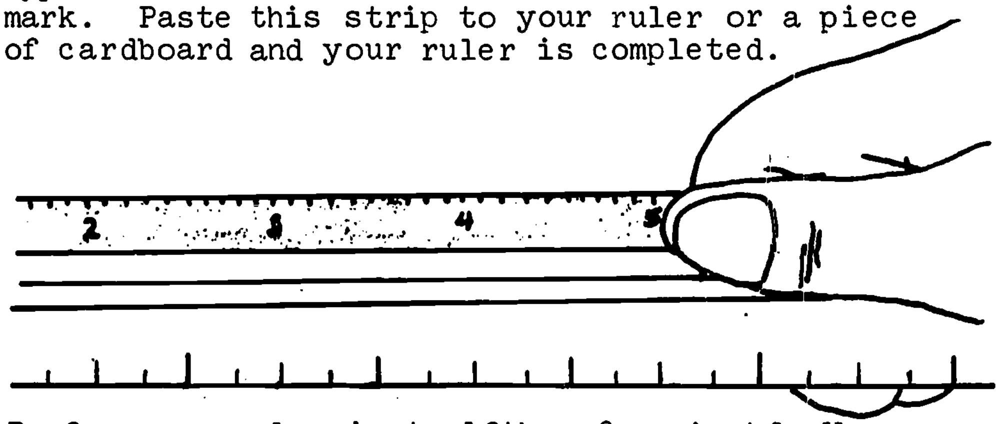
6. What is the perimeter (distance around) for the rectangle you drew in exercise 5? _____

MARKING OFF TENTHS OF AN INCH . . .

You can calibrate a ruler in tenths of an inch with a pica typewriter. Just type a series of single quotation marks on a strip of paper. The distance between each quotation mark is .1 inch.

```
''''''''''''''''''''''''''''''''''''''''''''''
0         1         2         3         4
```

Type the whole numbers in order under each tenth mark. Paste this strip to your ruler or a piece of cardboard and your ruler is completed.



Prefer your ruler in twelfths of an inch? Use an elite typewriter.

✓ **POINT**

Use the following statements and problems to check your understanding of Lessons 7-9. If you have difficulty with any questions, it may indicate a topic you should review.

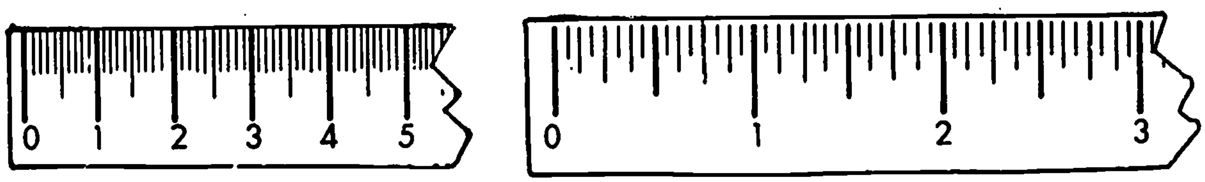
1. Supply the missing numbers so that the fractions in each part are equivalent.

   a. If $\frac{3}{4} = \frac{x}{16} = \frac{6}{y}$, then x = ___ and y = ___.

   b. If $\frac{3}{8} = \frac{d}{16}$, then d = ________

   c. If $\frac{1}{2} = \frac{2}{r} = \frac{s}{8}$, then r = ______ and s = ______.

   d. If $\frac{1}{2} = \frac{a}{10}$, then a = ____.



2. Indicate by a letter and arrow each of the following locations on the rulers above.

   a. 1.8 cm. c. $2\frac{5}{8}$ in. e. $2\frac{1}{2}$ cm.

   b. $1\frac{3}{16}$ in. d. $\frac{3}{4}$ in. f. $\frac{11}{16}$ in.

3. a. $3\frac{11}{16} - 1\frac{1}{4}$ = ______ c. $\frac{7}{8} + \frac{1}{2}$ = ______

   b. 9.3-2.9 = ______ d. $2\frac{3}{8} + 1\frac{5}{16}$ = ______

4. You should be able to measure to the nearest...

   a. $\frac{1}{2}$ in. b. $\frac{1}{4}$ in. c. $\frac{1}{8}$ in.

   d. $\frac{1}{16}$ in. e. .1 in. f. .1 cm.

...using any point of the ruler scale as the starting point.

HOW UNITS ARE RELATED

The length of an average classroom is...

a. 10 yards
b. 30 feet
c. 360 inches.

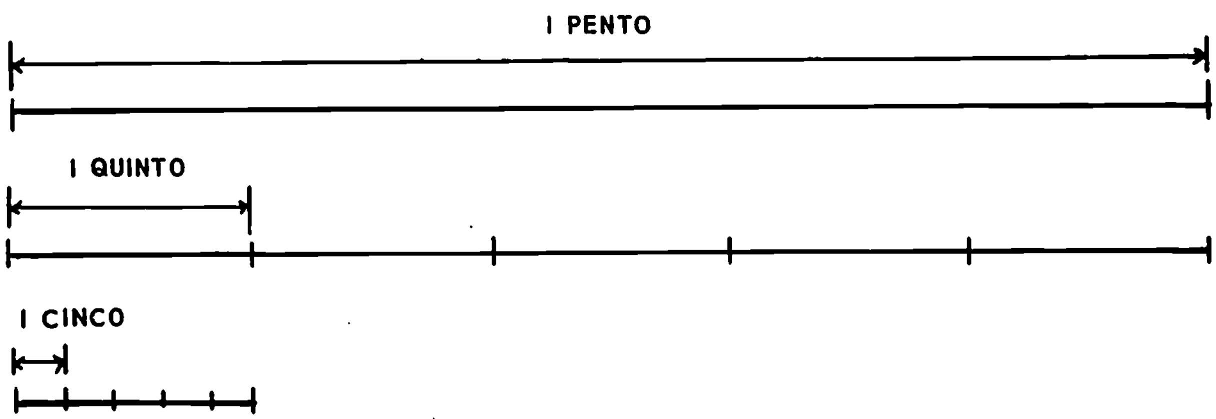
If measured to the nearest inch, the above choices are equivalent lengths. Therefore, they could be used interchangeably to complete the statement correctly.

However, in some situations one of these units may be more convenient or suitable to use than the other two. For example, the length of a room is more commonly expressed in feet or some combination of feet and inches than in inches or yards. It is sometimes necessary to convert a length given in one unit to an equal length in some other unit.

Suppose we used the following units for measuring length. At present, we will not be concerned with the lengths of these units, only the relationship between them. (shown by the following drawing)

1 pento = 5 quintos

1 quinto = 5 cincos



EXERCISES

1. Complete: a. 10 quintos = _____ pentos

   b. 15 cincos = _____ quintos

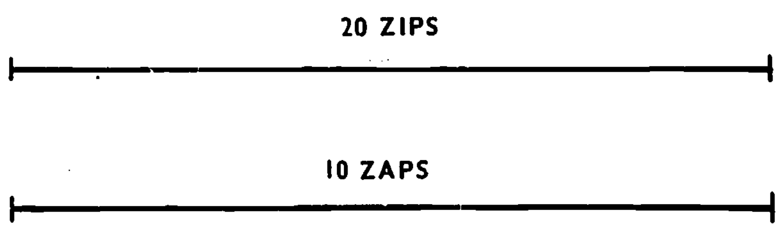
   c. 6 quintos = _____ cincos

   d. 1 pento = _____ cincos

2. Which of the three units is the longest? the shortest?

3. If the measure in pentos is doubled, what happens to the measure in quintos?

4. The two segments shown below have the same length and are measured using another system of measure. (zips and zaps)



   a. Which unit is longer?

   b. 10 zips = _____ zaps

   c. 40 zips = _____ zaps

   d. 1 zip = _____ zaps

DISCUSSION QUESTIONS

1. Does using a different unit of measure change the length of a segment? The number used to express the length? Why or why not?

2. Which of three units (pento, quinto, cinco) will give the most precise measurement?

FROM ONE UNIT TO ANOTHER...

As soon as you know how two units compare in size, you can convert measures from one unit to another. The previous EXERCISES included some practice in conversion of units. Use the unit relationships in the box to complete TABLE 10-1

1 pento = 5 quintos	1 ft. = 12 in.
1 quinto = 5 cincos	1 yd. = 3 ft.

10 millimeters = 1 centimeter
100 centimeters = 1 meter
1000 meters = 1 kilometer

Complete TABLE 10-1 so the measures in each row represent equivalent lengths. The first two examples are done for you.

TABLE 10-1

	EQUIVALENT LENGTHS		Which unit is longer?
a.	24 inches	$\boxed{2}$ feet	foot
b.	20 quintos	$\boxed{4}$ pentos	pento
c.	$\boxed{}$ quintos	3 pentos	
d.	20 quintos	$\boxed{}$ cincos	
e.	4 feet	$\boxed{}$ inches	
f.	$\boxed{}$ yards	36 feet	
g.	20 mm.	$\boxed{}$ cm.	
h.	3 meters	$\boxed{}$ cm.	
i.	7 cm.	$\boxed{}$ mm.	
j.	$\boxed{}$ km.	4000 m.	

STOP

CHECK YOUR RESULTS BEFORE GOING TO THE NEXT PAGE.

DO I MULTIPLY OR DIVIDE???

To complete TABLE 10-1, you probably multiplied or divided by some number to get each result. The problem is to decide which operation to use.

FIND A PATTERN . . .

Answer the following questions using the results of TABLE 10-1. (page 70)

1. a. List all examples in which you converted the measure from a smaller to a larger unit. (a is one such example)

   b. When converting from a smaller to a larger unit, which operation (multiplication or division) did you use?

2. a. List all examples in which you converted the measure from a larger to a smaller unit. (c is one such example)

   b. When converting from a larger to a smaller unit, which operation (multiplication or division) did you use?

3. Complete the following statements.

   a. When converting from a smaller unit to a larger unit, ____________ by the number of smaller units in each larger unit.

   b. When converting from a larger unit to a smaller unit, ____________ by the number of smaller units in each larger unit.

ANOTHER METHOD

Most situations requiring conversion of units can be handled using the guidelines from the previous lesson. However, other methods could be used. Some people have difficulty in determining whether they should divide or multiply.

Another method for conversion of units can be developed using proportions. For example, suppose you needed to convert 54 inches to an equivalent length in feet.

EXAMPLE: 54 in. = ? ft.

SOLUTION:

1. The ratio of feet to inches is $\frac{1}{12}$ as 1 foot = 12 inches.
2. Let x represent the unknown number of feet.
3. The ratio of unknown number of feet to the given number of inches is $\frac{x}{54}$.
4. A proportion you could use to solve this problem is... $\frac{1 \text{ foot}}{12 \text{ inches}} = \frac{x \text{ feet}}{54 \text{ inches}}$

   or

   $$\frac{1}{12} = \frac{x}{54}$$
5. Solve the proportion using the cross-product method.

   $$\frac{1}{12} = \frac{x}{54}$$

   $$12x = 54$$

   $$x = \frac{54}{12} = 4\frac{6}{12} = 4\frac{1}{2}$$

ANSWER: $\boxed{54 \text{ in.} = 4\frac{1}{2} \text{ ft.}}$

The proportion for the example above could also be set up as $\frac{12}{1} = \frac{54}{x}$, using the ratio of inches to feet instead of feet to inches.

NOTE: 12 x is an abbreviation for "12 times x".

It does not matter which ratio you use as long as you are consistent, using the same ratio on both sides of the proportion.

Before working the exercises, become more familiar with this method of solution by studying the following examples.

Example 1. 3 feet = 1 yard

80 feet = ? yds.

$$\frac{\text{feet}}{\text{yards}} = \frac{3}{1} = \frac{80}{x}$$

$$3x = 80$$

$$x = \frac{80}{3} = 26\,\frac{2}{3}$$

$$\boxed{80 \text{ feet} = 26\,\frac{2}{3} \text{ yards}}$$

Example 2. 1 kilometer = .625 miles

60 miles = ? km.

$$\frac{\text{km.}}{\text{mi.}} = \frac{1}{.625} = \frac{x}{60}$$

$$.625x = 60$$

$$x = 60 \div .625$$

$$x = 96$$

$$\begin{array}{r} 96. \\ .625\overline{)60.000} \\ -5625 \\ \hline 3750 \\ -3750 \\ \hline \end{array}$$

$$\boxed{60 \text{ miles} = 96 \text{ km.}}$$

Example 3. 1 cm. = 10 mm.

86 mm. = ? cm.

$$\frac{\text{cm.}}{\text{mm.}} = \frac{1}{10} = \frac{x}{86}$$

$$10x = 86$$

$$x = 86 \div 10$$

$$x = 8.6$$

$$\boxed{86 \text{ mm.} = 8.6 \text{ cm.}}$$

Example 4. 1 meter = 100 cm.

6.8 meters = ? cm.

$$\frac{m.}{cm.} = \frac{1}{100} = \frac{6.8}{x}$$

$$x = (6.8)\cdot(100)$$

$$x = 680$$

$$\boxed{6.8 \text{ m.} = 680 \text{ cm.}}$$

EXERCISES

1. Complete the following. Use the ratio-proportion method of conversion. Show your work.

   a. 3.4 km. = ______ meters
   b. 65 mm. = ______ meters
   c. 185 cm. = ______ meters
   d. 3.74 m. = ____cm.
   e. 3735 mm. = ____m.
   f. 40 km. = ____miles

2. One centimeter is equivalent in length to about four tenths (.4) of an inch. Assuming 1 cm. = .4 inch, 6 inches = ? cm.

3. One yard is equivalent in length to about nine-tenths (.9) of a meter. Assuming 1 yd. = .9 meter, 4.5 meters = ? yards.

DISCUSSION QUESTION

1. Consider the following statement.

   " I don't see the need for all these different units of of length. All they do is confuse me. Why not have only one or two units of length to measure all distances?"

   Do you agree with this statement? Why or why not?

WHICH IS LONGER?

Make each statement true by inserting > or < . Remember that > means is greater than and < means is less than. You may use your rulers and tables of measures.

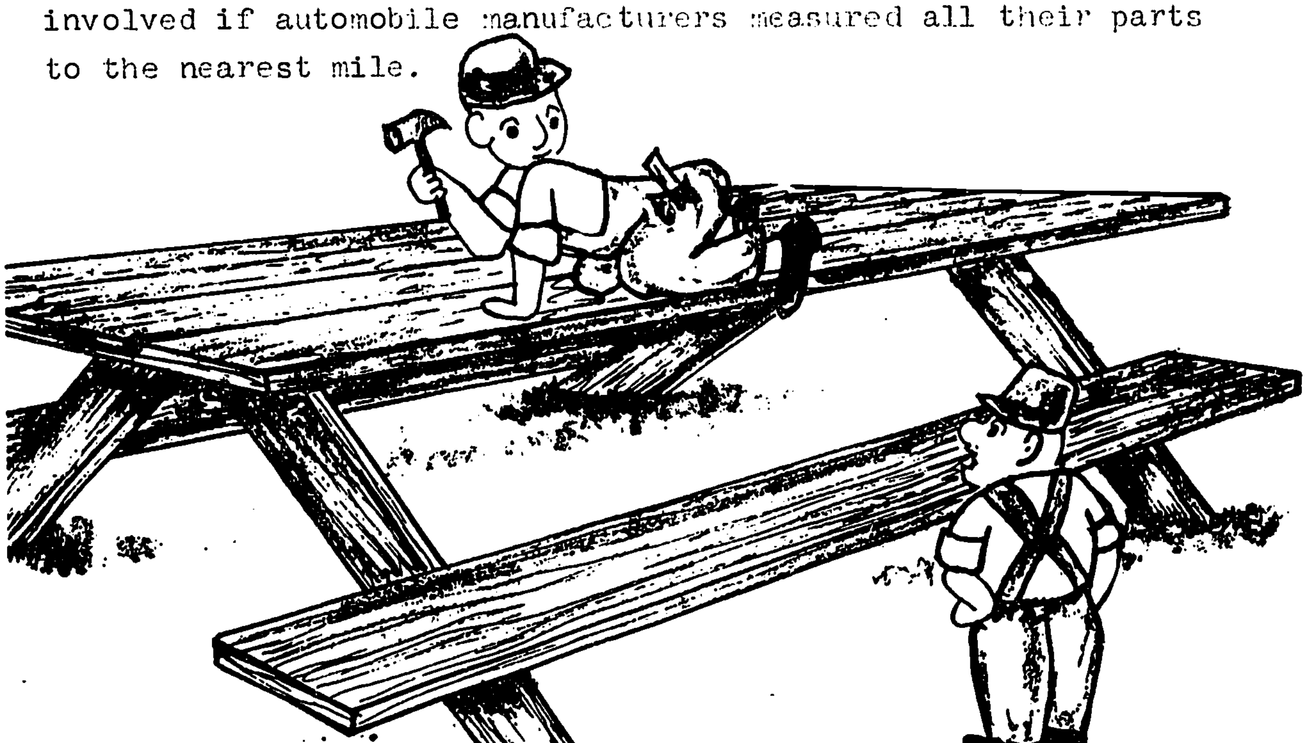
1. 1 m. ____ 120 cm.
2. 20 mm. ____ 1 cm.
3. 15 mm. ____ 1 in.
4. 2 cm. ____ 1 in.
5. 3 cm. ____ 1 in.
6. 1 m. _____ 1 yard
7. 1 mile ____ 1 km.
8. 1 cm. _____ 1 in.
9. 5 ft. _____ 62 in.
10. 1.3 cm. ____ 15 mm.
11. Based on your results (questions 4 and 5), what can you conclude concerning the number of centimeters it takes to make a length equal to 1 inch?

WHAT UNIT SHOULD I CHOOSE???

Before any measurement is made, a person must decide which unit of measure to use. You used several different units of length in Lessons 1-11. The length of the distance to be measured is one factor which will determine the most suitable unit to use.

For example, suppose you measured the distance between Chicago and Detroit. A mileage chart gives this distance as 265 miles. Theoretically, this distance could have been measured using any other English unit of length such as inches, feet, or yards. (265 mi. = 466,400 yds. = 1,399,200 ft. = 16,790,400 in.) However, the mile was selected as the most suitable (or "best") unit to use in this case, partially due to the long distance involved. (A mileage chart in Europe would express a distance as long as the above in kilometers.)

In like manner, a shorter distance or length is usually measured with a unit of shorter length. Imagine the problems involved if automobile manufacturers measured all their parts to the nearest mile.



"Incidentally, those dimensions were in feet not yards!"

EXERCISES

1. Circle what you would consider the best English unit and the best metric unit for measuring the following. Be able to defend your answer.

a. Length of a river	inch	foot	yard	mile	
	centimeter	meter	kilometer		
b. Height of a man	inch	foot	yard	mile	
	centimeter	meter	kilometer		
c. Length of a nail	foot	mile	inch	yard	
	centimeter	kilometer	meter		
d. Width of a house	inch	yard	mile	foot	
	kilometer	meter	centimeter		
e. Distance of a track race	mile	foot	yard	inch	
	kilometer	meter	centimeter		

2. List suitable units for the following measurements. (In some instances, more than one unit may be suitable.)

   a. The altitude of an airplane. ____________

   b. The depth of an ocean. ____________

   c. The length of an arm. ____________

   d. The width of a picture frame. ____________

   e. The distance from the Earth to the moon. ____________

   f. The width of a room. ____________

3. Circle the measurements from each set that are good estimates for each distance. More than one answer from each set may be appropriate.

   a. Height of a classroom. (10 ft., 20 ft., $3\frac{1}{3}$ yd., 10 meters)

   b. Height of an adult man. (6 ft., 2 meters, 4 yds., 72 in.)

4. Make each statement reasonable by filling the blank with a suitable unit of length. (inch, centimeter, foot, meter,...) or its plural.

   a. The rails of a railroad track are about 4 ______ part.

   b. The height of a telephone pole is about 30 __________.

   c. The width of a newspaper column is about 2 __________.

   d. The width of a one-dollar bill is about 6.6 __________.

   e. The length of a stick of chewing gum is about 8 _____.

   f. The height of a dining room table is about $\frac{3}{4}$ of a _____.

5. For each list, arrange the distances in order from shortest to longest. (Indicate the shortest by 1, next shorter by 2,...)

   a. 50 meters _____
      150 feet _____
      Length of an airliner _____

   b. 1.1 in. _____
      $1\frac{1}{2}$ in. _____
      $1\frac{3}{4}$ in. _____
      $1\frac{7}{16}$ in. _____

   c. 1 meter _____
      1 yard _____
      $3\frac{1}{2}$ ft. _____
      48 in. _____

   d. 1 cm. _____
      1 in. _____
      2 cm. _____
      2 in. _____

   e. 4 inches _____
      $\frac{1}{2}$ meter _____
      Length of a one-dollar bill _____

   f. $\frac{1}{2}$ mile _____
      1000 yd. _____
      $\frac{1}{2}$ km. _____

6. What metric unit of length would you use to measure each of the following?

   a. One lap around a school track. ______

   b. The distance from earth to the nearest star. ______

   c. The width of a quarter. ______

S T O P

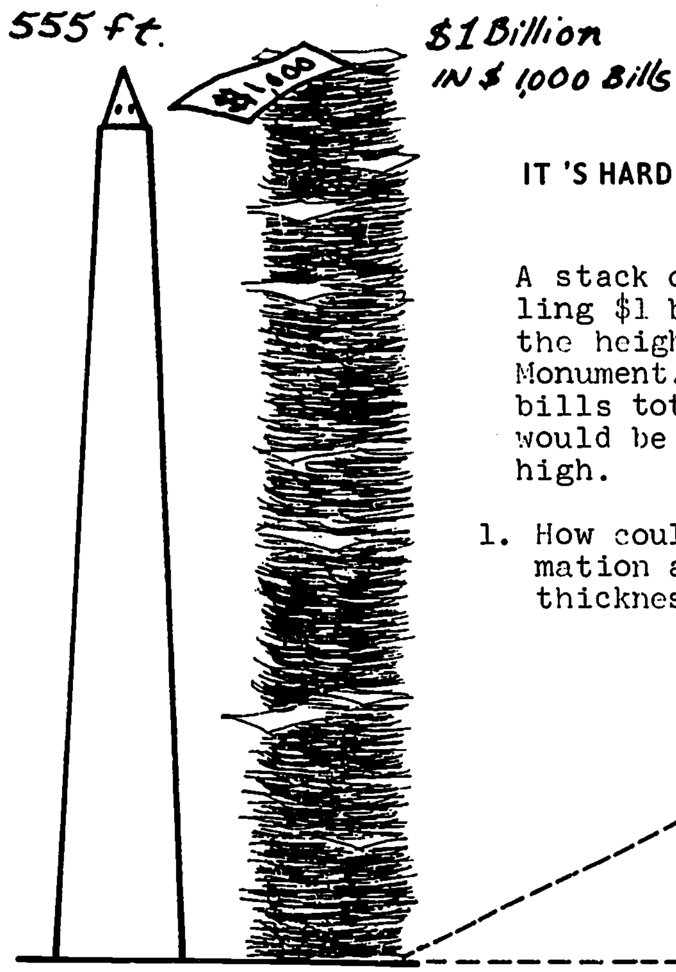
CHECK YOUR RESULTS FOR THE EXERCISES
BEFORE GOING TO THE DISCUSSION QUESTIONS.

DISCUSSION QUESTIONS

1. Compare your choices in Exercises 1 and 2 with those of your classmates. Did your choice of unit always agree with the choices of your classmates? Why or why not?

2. How would the purpose a person has in knowing a measurement affect his choice of a unit to use in finding the measure?

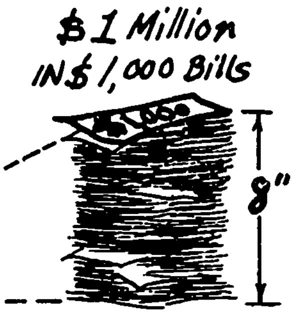
3. Give as many factors as you can which will influence your choice of a suitable unit for a distance to be measured.



IT 'S HARD TO BELIEVE . . .

A stack of $1,000 bills totalling $1 billion would surpass the height of the Washington Monument. A stack of $1,000 bills totalling $1 million would be only eight inches high.

1. How could you use the information above to find the thickness of one $1,000 bill?



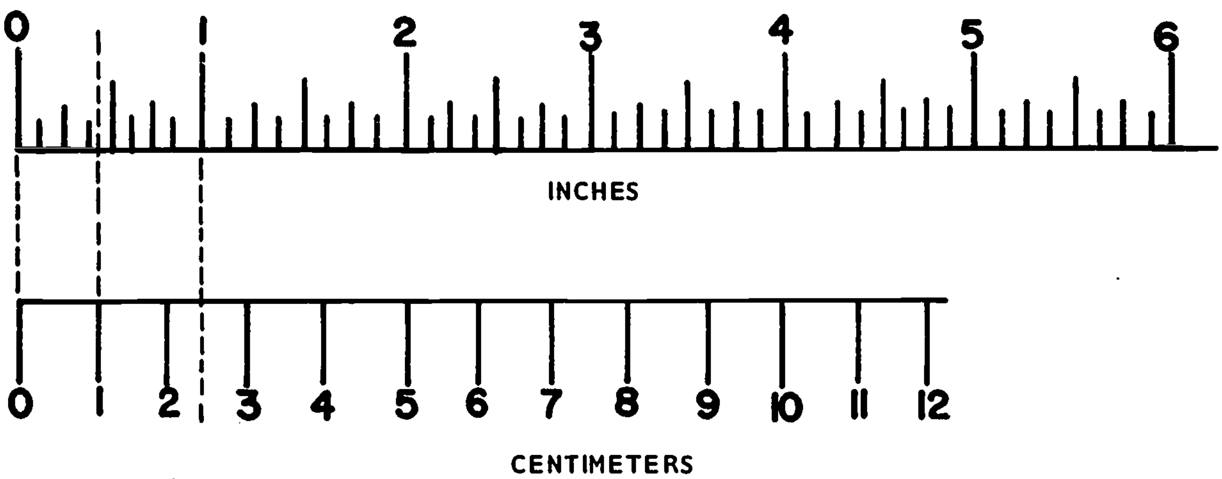
2. Describe a procedure for determining the thickness of one sheet of paper or a 3"x 5" card. The two paragraphs above give some clues to a procedure which could be used.

3. Using the above information as a guide, what would be the approximate height of a stack of $1 million in $500 bills? in $100 bills? in $20 bills?

SMORGASBORD TIME

The exercises of this section review and extend some of the basic ideas of measurement and estimation discussed in this booklet. Rulers and other linear measuring instruments will be used throughout the remainder of this course. In many situations, you can use your ability to estimate accurately to check the reasonableness of your work.

If you have difficulty with some of these exercises, it may indicate a topic which you should review.



EXERCISES I

1. One inch is equal in length to a little more than 2.54 centimeters. (See above sketch.) One meter is 39.37 inches. Multiply 39.37 by 2.54 and interpret your result.

2. Races in Olympic and international competition are measured in metric units. The Olympic Games include a 100-meter dash rather than a 100-yard dash. Would you expect the record time for 100 meters to be more or less than the record for 100 yards? Why?

3. If a runner can run the 100-yard dash in 10 seconds, about how long would you expect him to run the 100-meter dash? (1 m. ≈ 1.1 yd.)

4. Express 387 yards in inches; 387 meters in centimeters. Which answer is easier to compute?

5. Insert > or < in the blanks to make each of the following statements true.

   > means "is greater than"

   < means "is less than"

   a. The Saturn V rocket is 362 feet long.
   Ten school busses bumper to bumper _____ the length of the Saturn V rocket.

   b. The scale on a map is 1 inch = 75 miles
   The distance represented by $2\frac{1}{2}$ in. ____ 200 miles.

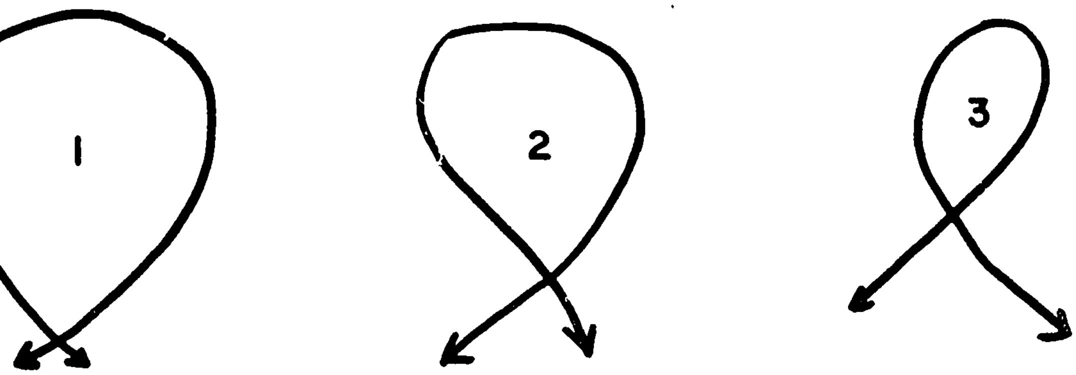
   c. A railroad box-car is about 45 feet long.
   100 box-cars _____ a mile.

   d. Using special equipment, French explorers recently went down into the ocean to a depth of 100 meters.
   This was _______ a mile.

EXERCISES II

1. Gone to waist...

   For this problem you will be given a piece of string. Lay the string on a flat surface and pull the two ends in the direction of the arrows until the distance around the loop equals the distance around your waist. (See page 62.)



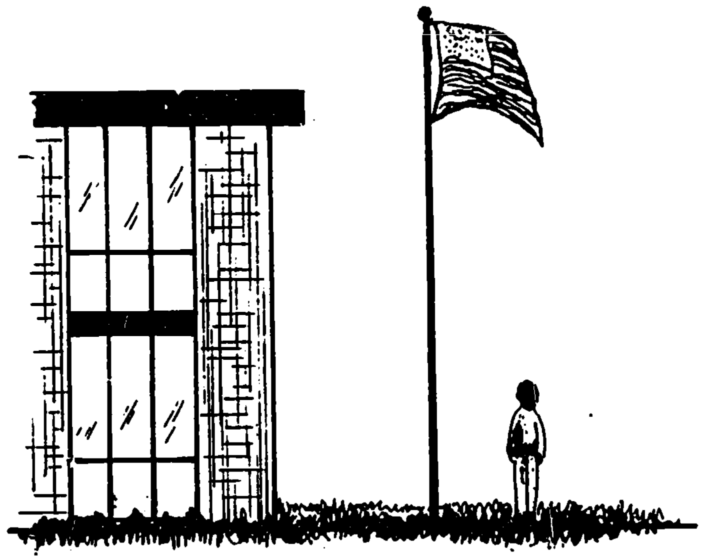
Check your estimate by wrapping the loop around your waist. How close was your estimate to your actual waist measurement in inches? in centimeters?

2. A fish story...

Stu caught a 22 inch pike while ice fishing. Demonstrate the length of the fish by holding your hands 22 inches apart. Try this once with your eyes closed. Have a classmate check each estimate by measuring the distance between your hands.

Questions 3 and 4 are related to the following story and cartoon. (See page 63.)

Estimates can be made in a variety of ways. The following story illustrates one method used to obtain an estimate.



Terry wished to estimate the height of the school flagpole. (Why? I don't know. Let's assume he had a good reason.) How could he get an estimate? One method would be to reason as follows.

> "Each floor of the school is about 10 ft. high, making the school building about 20 ft. high. The flagpole is about a half-floor taller than the school building. Therefore, the flagpole is about 25 ft. high."

3. What are some of the factors which will determine the distance that is used as a guide in estimating?

4. Find some other method for estimating the height of the flagpole.

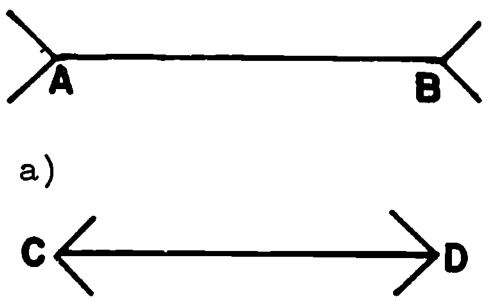
5. Estimate each of the following lengths by placing two pieces of tape that distance apart on a flat surface. (desk, floor,...) Check your estimates by measurement, and record your results.

a. 10 feet   c. [illegible] inches

b. 5 meters   d. 30 centimeters

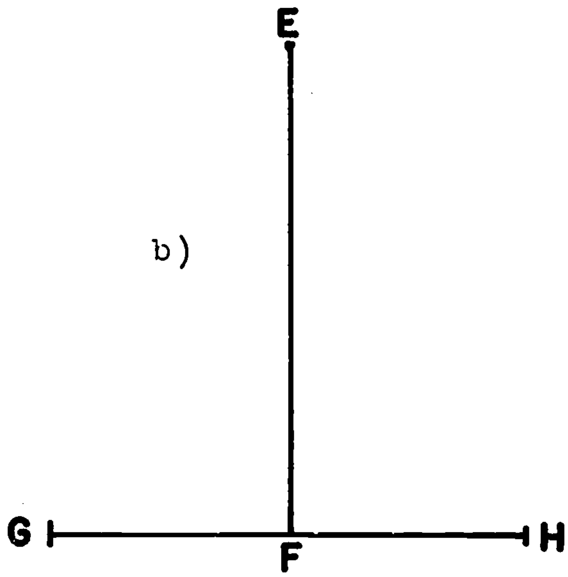
6. Estimate which of each pair of segments is longer. Check your estimates by measurement.

a)



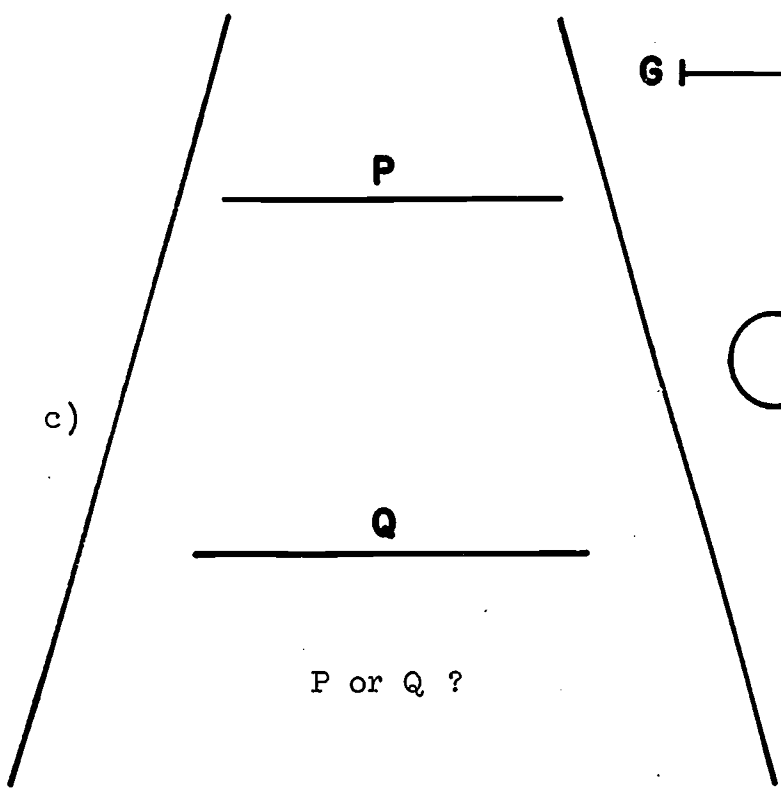
$\overline{AB}$ or $\overline{CD}$?

b)



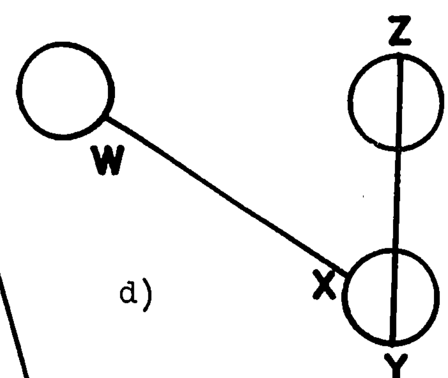
$\overline{EF}$ or $\overline{GH}$?

c)



P or Q ?

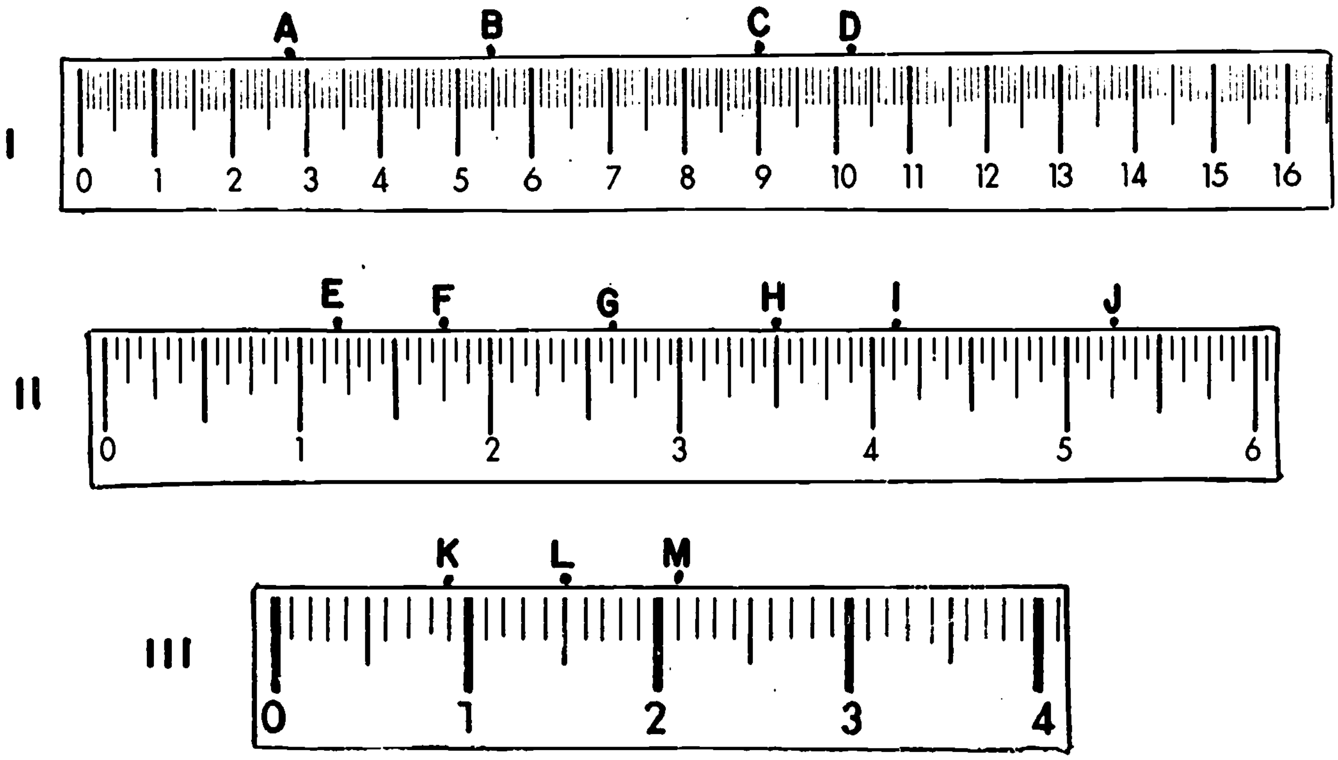
d)



$\overline{WX}$ or $\overline{YZ}$?

EXERCISES III

1. Give the distance from 0 for each point indicated. Ruler I is graduated in centimeters. Rulers II and III are graduated in inches.



2. Using the rulers pictured above, give the distance between the following pairs of points.

   a. B and C   c. G and H

   b. F and H   d. L and M

3. For each ruler location, give the whole number measure to which it is closest. Part a is done for you.

   a. $1\frac{5}{16}$ in.   __1__ in.

   b. 8.7 cm.   _____ cm.

   c. $4\frac{5}{8}$ in.   _____ in.

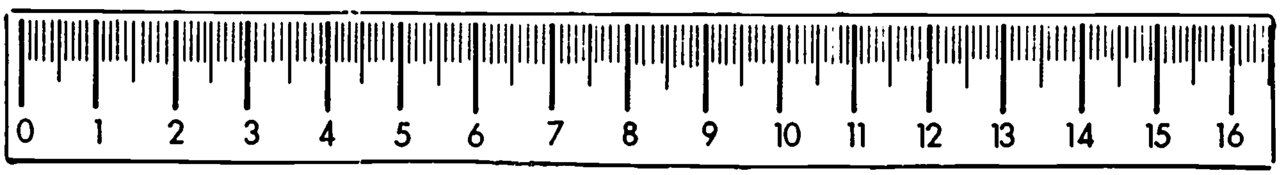
   d. $2\frac{1}{4}$ in.   _____ in.

4. Indicate by a letter and arrow each of the following locations on the rulers below. Ruler I is graduated in centimeters. Ruler II is graduated in inches.

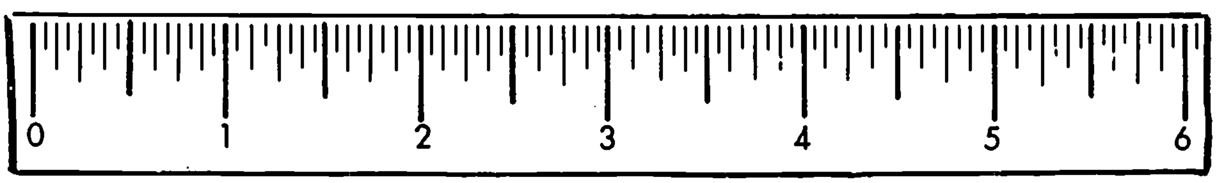
A. 6.8 cm. C. $3\frac{7}{8}$ in. E. $6\frac{9}{16}$ in.

B. 4.5 cm. D. $4\frac{3}{4}$ in. F. $\frac{5}{8}$ in.

I



II



5. Draw segments of the following lengths.

A. 8.7 in. C. 10.4 cm. E. $\frac{1}{2}$ in.

B. $6\frac{1}{8}$ in. D. $4\frac{5}{16}$ in. F. $4\frac{1}{4}$ in.

✓ POINT

Use the following questions and problems to check your understanding of Lessons 10-12. If you have difficulty with any questions, it may indicate a topic you should review.

1. Complete the following.

a. 2.8 m. = ____ cm.	e. 85 cm. = ____ mm.
b. 87 mm. = ____ cm.	f. 27 in. = ____ ft.
c. $1\frac{3}{4}$ ft. = ____ in.	g. 85 cm. = ____ m.
d. 6 yd. = ____ ft.	h. 2.1 km = ____ m.

2. Suppose that 2 sticks = 5 logs, where sticks and logs are units of length.
   a. Which unit is longer?
   b. 15 logs = __?__ sticks.

3. For each list, arrange the distances in order from shortest to longest. (Indicate the shortest by 1, next shorter by 2,...)

   a. 2 meters ______
   2 yards ______
   2 kilometers ______

   b. 3 meters ______
   8 feet ______
   height of an adult man ______

   c $3\frac{11}{16}$ inches ______
   $3\frac{3}{4}$ inches ______
   $3\frac{5}{8}$ inches ______

   d. 1 kilometer ______
   1 mile ______
   1 centimeter ______
   1 inch ______

4. Given a distance to be measured you should be able to choose a English and a metric unit that would be a suitable unit for measuring the distance. (See Lesson 12.)

AND IN CONCLUSION . . .

This booklet concentrated on the measurement of length. The standard units for measuring the lengths of common objects are well known. A person's height is measured in feet and/or inches. Lengths of smaller objects are given in inches or centimeters (or fractions of these units). Longer distances are measured in miles or kilometers.

However, this is not the final word on length. Just as the caveman invented units of length for his use (hand, span, cubit,...), new units of length are being invented today. In this booklet, measurements were made to the nearest $\frac{1}{16}$ in. and .1 cm. However, measurements are being made by scientists to the nearest billionth of an inch! To make measurements this precise, new measuring instruments and units have been invented.

Since there is no such thing as man-made perfection (despite the claims of many advertisements), there will never be any truly exact measurements. However, measurements and instruments will continue to be invented and refined. Lengths which are unmeasurable today will become measurable in the future.

Many of these measures and instruments are used only by persons in special fields of science and industry. It is not necessary that anyone know about all of them. It is important, however, that you be aware of their existence and what implications they hold for the future.

Future booklets and lessons concerning linear measurement will expose you to some of these units (their definition and use) and indicate instruments and methods that are used to obtain these precise measurements.