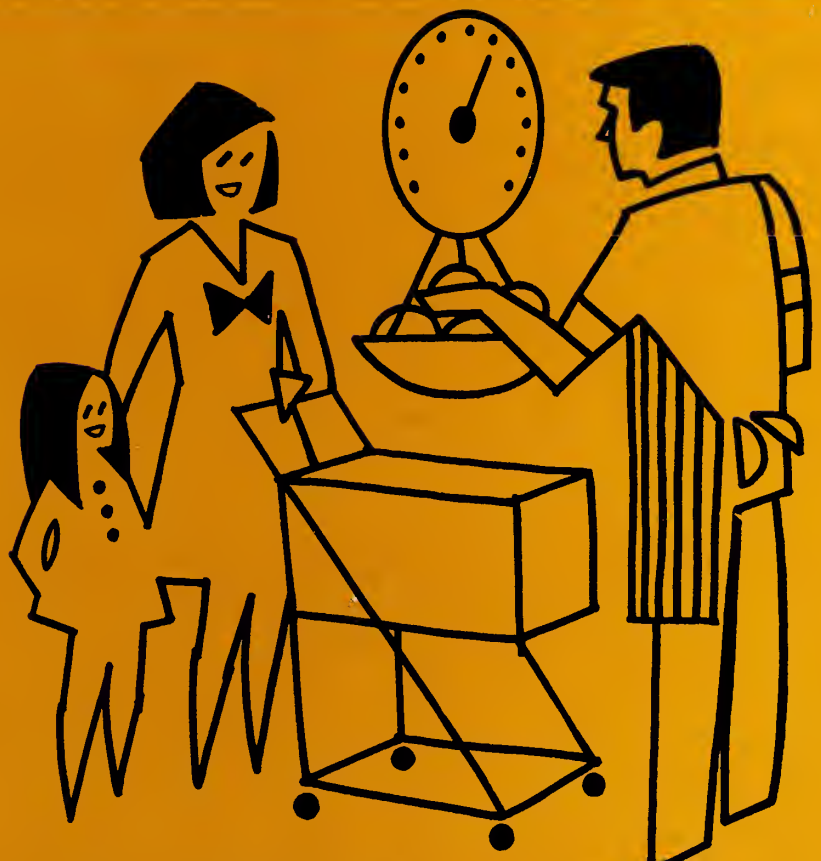
WHAT ABOUT METRIC?



ARTMENT OF COMMERCE / National Bureau of Standards

GOOD NEWS

There is much discussion today concerning change from the traditional **customary** system of measurement (the foot and pound) to the **metric** system of measurement (the meter and kilogram). American industry is already making use of the metric system, and such use is rapidly increasing. Industry is doing so because of its finding that increased metric usage is in its best interests, and in the best interests of our country.

As you can see from the map on pages 6 and 7, every industrial nation on earth except the United States has officially adopted or committed itself to the use of the metric system. It is apparent that metric measurements and the metric language will be increasingly important to each of us, whether or not the Congress enacts additional metric legislation. Consequently, it is to our advantage to learn the metric language, and how to use it.

Although the metric system is different from the customary measurement system, it is **not** basically strange to us. Our country, at its founding, pioneered among the nations of the world with adoption of a decimal system for its money—a system in which currency denominations are related by tens. All of the other nations of the world have since found it to their advantage to follow our lead, with Great Britain being the last nation to place its system on a decimal basis.

Now, we are finding it advantageous to follow the rest of the world by adopting a decimal system—the metric system—as our predominant but not exclusive system of measurement.

As we change to the metric system several units of measure that we currently use will not be changed. Time will continue to be measured in hours, minutes, and seconds; the electricity we consume will continue to be measured in watts; and when we purchase a light bulb we may still refer to the number of lumens of light it will emit, as marked on the bulb or its wrapper.

No change in Money or Time

ONE THOUSAND		$1000.00
ONE HUNDRED		100.00
TEN		10.00
DOLLAR		1.00
DIME		0.10
CENT		0.01
MIL		0.001

---

60 SECONDS =
1 MINUTE

More GOOD NEWS

You use weights and measures every day of your life. Without them, work, shopping, trade, recreation, and education would be in a state of hopeless confusion.

You learned the language of measurement so early that you have probably forgotten the day you first understood the meaning of "inch, foot, yard, and mile;" of "ounce, pound, and ton;" of "cup, pint, quart, and gallon;" of "second, minute, and hour;" and that "100°F" is uncomfortably hot, while "30°F" is uncomfortably cold. These are familiar units of the "customary" system of measurement that we traditionally have shared with other nations.

The worldwide trend today is toward a comparatively new system called the "modernized metric" system of measurement. The names of the units sound strange to the American ear at first, but fortunately there are only a few words that have to be learned for everyday use. These are: the *millimeter, centimeter, meter,* and *kilometer* for describing length and distance; the *milliliter* and *liter* for capacity or volume; the *gram, kilogram,* and *tonne* for weight; the *kilometer-per-hour* for highway speed; and the *degree Celsius* (formerly called Centigrade) for temperature.

You are already making more frequent use of the metric system than you probably realize. In international athletic competition, such as swimming and field track events, length measurements are referred to by sports reporters in *meters* rather than in yards or feet. Our astronauts, from the surface of the moon, excitedly told a worldwide audience how far their rocket had landed from a lunar hill—in *meters*. If your automobile is imported or even if it is of domestic production with a metric-designed motor, the end wrenches or socket wrenches that you need if you want to work on your car are metric rather than customary. You already know about 35-*millimeter* film and cigarettes that are 100 *millimeters* long, or even 1 *millimeter* longer than that. You read and hear that air pollution is measured in micrograms per cubic *meter*. You see weights expressed in *grams* on more and more packaged items at the grocery store. And the trend is toward even greater use.

In science, the metric system has been in extensive use for many years, although not to the exclusion of the customary system. But today, as the problems in science become more complex, educators throughout the world are seeking to simplify computation and teaching by using the metric system in terms of everyday measurements.

meter

liter

gram

degree

Celsius

Why is the metric system being *Increasingly Used?*

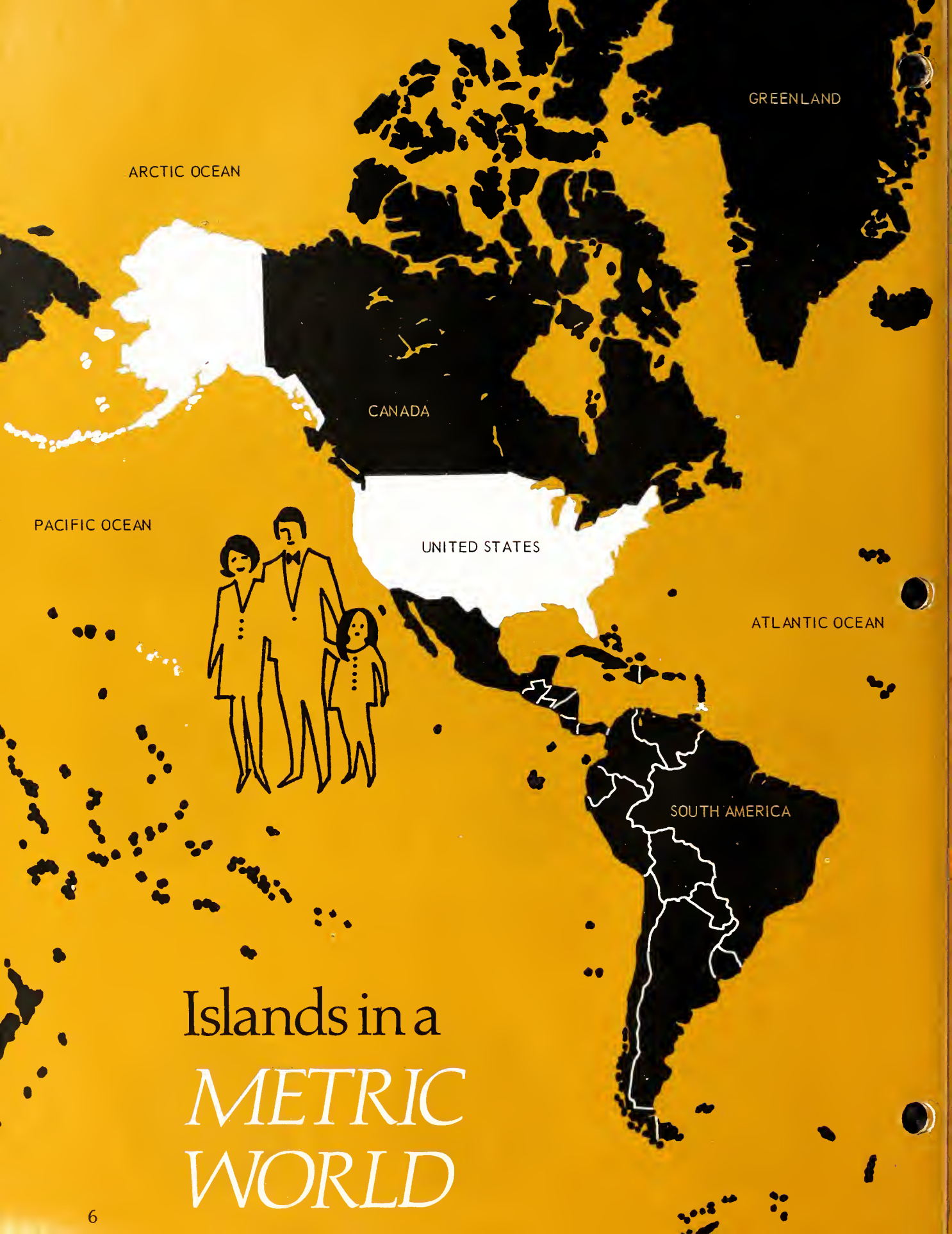
The metric system is increasing in use throughout the world for two principal reasons: It is a *simple* system, and it is a *decimal* system.

It is simple because each physical quantity, such as length or weight, has its own unit of measurement *(meter* and *kilogram),* and no unit is used to express more than one quantity. By contrast, the customary system has several units of length (inch, foot, yard, mile) or weight (ounce, pound, ton, etc.); "pound" can mean either force (as in pounds required to break a rope) or weight (as in a pound of sugar); and "ounce" can mean either volume (as the number of ounces in a quart) or weight (as the number of ounces in a pound). The metric system is easier than the customary system to learn to use in solving problems that involve computation. This is because metric units bear a decimal relationship to one another, as opposed to the non-decimal mixed numbers and fractions that characterize relationships between our customary units.

The U.S. monetary system has been based on decimals (factors of ten) since the founding of our country; that is, the dime equals one-tenth of a dollar and the cent equals one-hundredth of a dollar. By contrast, our customary measurement system involves units that are not decimally related to each other and thus requires the use of common fractions. Consider the measurement of length. In the metric system a centimeter is one-hundredth of a meter; a millimeter is one-thousandth of a meter; and a kilometer is one thousand meters. In the customary system, an inch is one thirty-sixth of a yard; a foot is one-third of a yard, and a mile is 1,760 yards. Centimeters are divided into millimeters, each of which is 1/10 centimeter. But inches are divided into halves, quarters, eighths, and so forth. Therefore, computations using the decimal steps of the metric system are much simpler than those using the non-decimal mixed numbers and fractions common in our customary system.

Confusion...

...to order



Islands in a *METRIC WORLD*


ASIA
EUROPE
AFRICA
INDIAN OCEAN
AUSTRALIA
METRIC OR COMMITTED TO METRIC
UNCOMMITTED
ANTARCTIC OCEAN

What will the metric system mean in the *Marketplace?*

When metric measures become commonplace, one of the first things you will notice as you shop will be the new words for weight, volume and length on packaged goods.

Currently, in packaged foods the number of different types of measurement you encounter in one day's shopping is bewildering. Some weights are expressed in avoirdupois ounces and pounds; fluid measures are expressed in gallons, liquid quarts, pints, and fluid ounces; and dry measures are expressed in bushels, pecks, dry quarts, and pints. A dry quart is 16 percent larger in volume than a liquid quart. By contrast, the metric system has one unit for liquid volume: the liter, or some decimal fraction or multiple thereof (e.g., the milliliter, sometimes called cubic centimeter). Only our long familiarity with the customary system has made it useable.

One important fringe benefit of the metric system that could be realized is the elimination of the need for unit pricing of food products. Our current practice for dry products, for example, is to package and label them in pounds and ounces—often with no simple pattern of package sizes. This hodgepodge is what makes unit pricing necessary in comparative shopping. The change to metric might well be concurrent with the adoption of packaging standards under which such products could be packaged in a simple metric series of weights, such as 125, 250, 500, and 1,000 grams (approximately ¼, ½, 1 and 2 pounds respectively). The price per 1000 grams for the first 3 package sizes would then be obtained simply by multiplying the package prices by 8, 4, and 2 respectively, thus obviating the need for unit pricing.

Metric in everyday use

Most of us have developed a sense or feel for the customary measurement units that we use every day. We know, for example, our weight in pounds and our height in feet and inches; that a substantial individual serving of steak may weigh a pound; that our living room rug is 9 by 12 feet; that a half pint of milk is usually sufficient with a meal; and that it is uncomfortably hot on days when the temperature is 90°F.

The illustrations on the following pages are designed to give you a similar feeling for metric units, as they are used in familiar ways to measure weight, length, volume and temperature.

1 WEIGHT

Weight is a measure related to heaviness.

2 LENGTH

Length is a measure of extent or distance.

3 VOLUME

Volume is a measure of space occupied.

4 TEMPERATURE

Temperature is a measure of hotness or coldness.

1 WEIGHT

1 kilogram = 1000 grams
1 hectogram = 100 grams
1 dekagram = 10 grams
1 gram = 1 gram
1 decigram = 0.1 gram
1 centigram = 0.01 gram
1 milligram = 0.001 gram

2 LENGTH

1 kilometer = 1000 meters
1 hectometer = 100 meters
1 dekameter = 10 meters
1 meter = 1 meter
1 decimeter = 0.1 meter
1 centimeter = 0.01 meter
1 millimeter = 0.001 meter

METRICounter... a handy guide for estimating the most common household measurements

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards

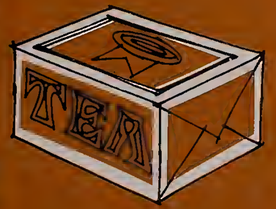
1 WEIGHT

1 kilogram = 2.2 pounds

500 grams
= 1.1 pounds

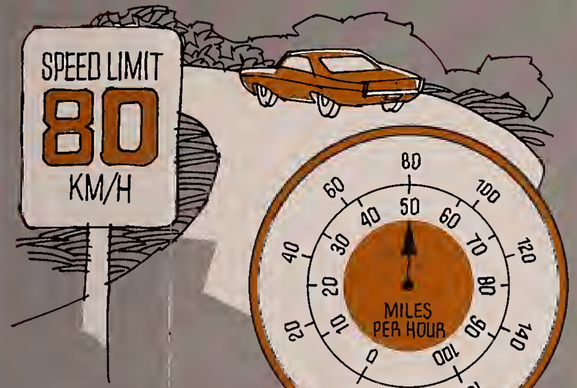
250 grams = 9.0 ounces

30 grams
= 1.1 ounces



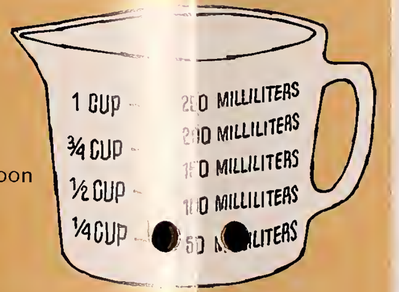
100 grams = 3.6 ounces

2 LENGTH



30 centimeters=1 foot

3 VOLUME



5 milliliters = 1 teaspoon

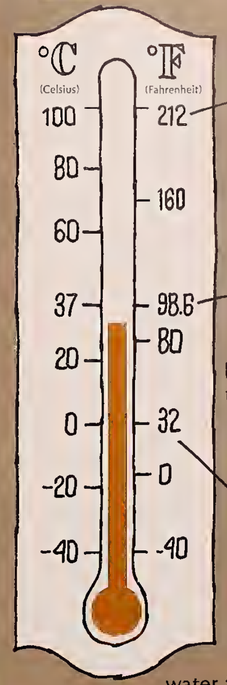
15 milliliters = 1 tablespoon

4 liters = 1.06 gallons

1 liter = 1.06 quarts

0 milliliters
= 1.06 pints

4 TEMPERATURE



water boils

body
temperature

water freezes

3 VOLUME

1 hectoliter = 100 liters
1 dekaliter = 10 liters
1 liter = 1 liter
1 deciliter = 0.1 liter
1 centiliter = 0.01 liter
1 milliliter = 0.001 liter

4 TEMPERATURE

Prefixes are not commonly used with temperature measure ments as they are with those for weight, length and vol - ume. Temperatures in degrees Celsius, as in the familiar Fahrenheit system, can only be learned through experi- ence. The following may help to orient you with regard to temperatures you normally encounter.

0 °C	Freezing Point of Water (32 °F)
10 °C	A warm winter day (50 °F)
20 °C	A mild spring day (68 °F)
30 °C	Quite warm—almost hot (86 °F)
37 °C	Normal body temperature (98.6 °F)
40 °C	Heat wave conditions (104 °F)
100 °C	Boiling point of water (212 °F)

What will the metric system mean for *Workers?*

For workers who are not involved in the manufacture or assembly of mechanical articles—sales people and office personnel for example—the changeover to metric would have little or no job impact. The knowledge of metric units that they should gain quickly as consumers will enable them to carry out their duties as efficiently as in the past. Many mechanics, machinists, and assembly plant workers, however, will have to use metric tools, such as wrenches, dies, and taps that are different in size from those now used. For a while, because of the need to maintain tools in metric and customary unit sizes, they will have a larger number of such tools from which to select the ones needed. In the long run, however, use of metric units and tools should reduce the number of tools required as the number of sizes of fasteners and other components used in the manufacture of products is reduced.

Sources of Additional Information

Familiarity with metric language and metric use is certain to become increasingly important to the consumer. Time spent now in learning the metric units will make it easier to use them in the years ahead. To assist you further, a chart entitled "All You Will Need to Know About Metric (For Your Everyday Life)" is available free of charge from the Metric Information Office, National Bureau of Standards, Washington, D.C. 20234.

For your convenience, the National Bureau of Standards has produced a pocket-sized card that will be useful in converting from customary to metric, and from metric to customary measurement units. The card may be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for 20 cents a copy. (Order as 0303-0168.)

Other sources of information on the metric system include the following publications, also available from the Superintendent of Documents:

The Modernized Metric System, NBS Special Publication 304A (Revised October 1972): order as C13.10:304A. 25 cents a copy.

The International System of Units (SI), NBS Special Publication 330, 1972 Edition; order as C13.10:330/2. 30 cents a copy.

A Metric America—A decision whose time has come (NBS Special Publication 345) order as C13.10:345.$2.25 a copy.

A comparison of the metric system and the customary system of measurement

The simplest way to compare the **metric** with the **customary** system of measurement is to place the two systems side by side. In parallel columns we will identify the metric and customary units of measurement; compare them visually; show how the two systems differ in the solution of everyday problems involving addition and multiplication; and give a few examples of how the metric system may affect your everyday life.

PREFIXES

You have probably noticed that the names of metric units sometimes include *prefixes* (milli, centi, kilo, etc.) as in milliliter, centimeter, and kilogram. These prefixes indicate multiples or submultiples of the units.

The most commonly-used prefixes, and the multiplication factors they indicate, are given below:

Prefix	*Multiplication factor*
kilo	1,000 (one thousand)
centi	0.01 (one hundredth)
milli	0.001 (one thousandth)

Thus, the term *kilometer* means 1,000 meters; a *centimeter* is 1/100 of a meter; and a *millimeter* is 1/1000 of a meter.

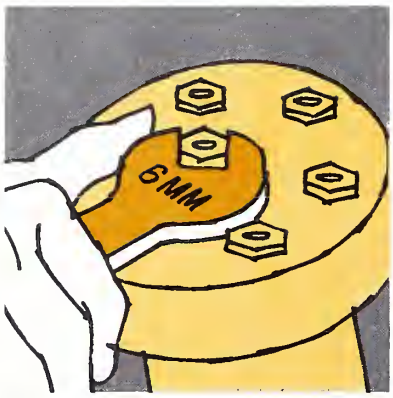
Everyday units of measurement

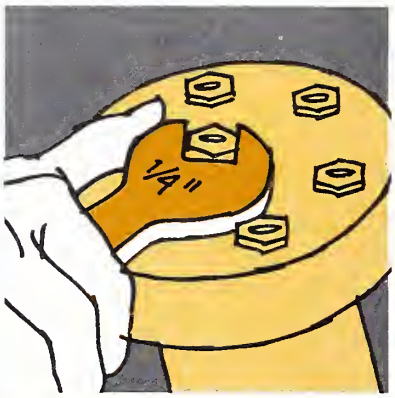
The units of metric and customary measure given on this page are not equivalents, except in the case of *time*, for which the metric and customary units are identical.

Unit of Measure	The Metric System	The Customary System
Length:	millimeter centimeter meter kilometer	inch foot yard mile
Weight:	gram kilogram tonne	ounce pound ton
Volume:	milliliter liter	ounce cup pint quart gallon
Time:	second minute hour day	second minute hour day
Temperature:	degree Celsius	degree Fahrenheit
Speed:	kilometer per hour	mile per hour
Pressure:	pascal kilopascal	inch of mercury pound per square inch

A visual comparison of metric and customary units of measurement

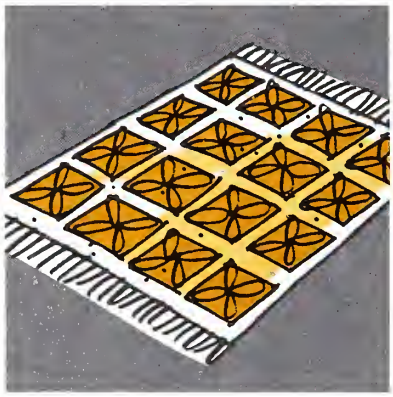
In the examples below, a visual comparison is made of the major units of the customary and metric systems, by using everyday quantities and sizes for purposes of illustration.

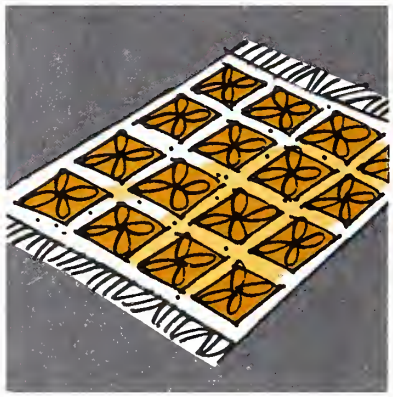




Small linear dimensions

For expressing small linear dimensions, such as wrench sizes, millimeters will replace inches. For example, a 6-mm wrench will be a more commonly-used size than a ¼-inch wrench



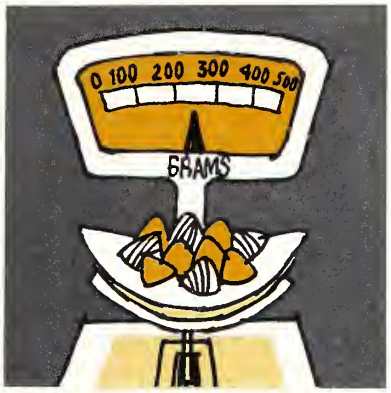


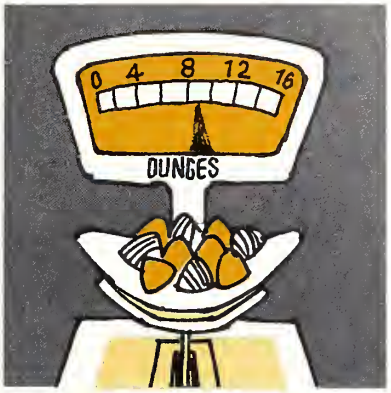
Larger linear dimensions

In expressing larger sizes, the meter will replace both the foot and the yard. In the example shown, a 3 × 4 meter carpet will generally be sold rather than a 9 × 12 foot (or 3 × 4 yard) carpet.

Great Distances

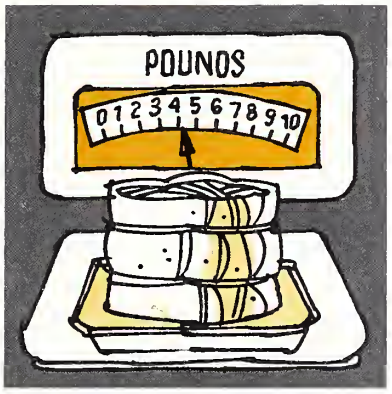
The kilometer will replace the mile in expressing great distances, such as distances between cities. The example shows the replacement for a sign 25 miles from Centerville: it would read 40 kilometers.





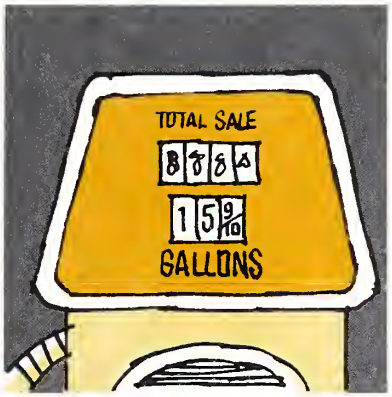
Small Weights

When we purchase small quantities of things, such as candy, we will use grams instead of ounces. For example, 250 grams will replace 9 ounces.



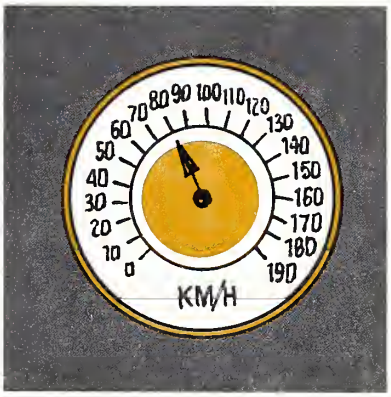
Larger Weights.

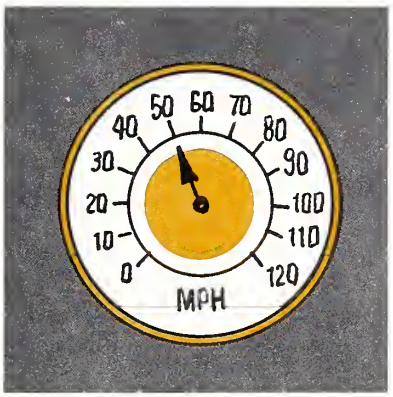
The purchase of large items, such as meat, will be figured in kilograms rather than pounds. In the example shown, a 2 kilogram roast will replace a 4.5 pound roast.



Volume.

When you order a tankful of gas, you may note that it will take 60 liters rather than 16 gallons.





Speed.

Our automobile speedometers will change from miles per hour to kilometers per hour as the speed limit signs on our highways are likewise changed. On the speedometers shown, an 80 kilometers per hour speed replaces 50 miles per hour.

Some measurement unit *Comparisons*

LENGTH

Metric			Customary		
1000 millimeters	=	1 meter	12 inches	=	1 foot
100 centimeters	=	1 meter	3 feet	=	1 yard
1000 meters	=	1 kilometer	36 inches	=	1 yard
			5280 feet	=	1 mile

WEIGHT

Metric			Customary		
1000 grams	=	1 kilogram	438 grains	=	1 ounce
1000 kilograms	=	1 tonne	16 ounces	=	1 pound
			2000 pounds	=	1 short ton

VOLUME

Metric			Customary		
1000 milliliters	=	1 liter	2 cups	=	1 pint
			2 pints	=	1 quart
			4 quarts	=	1 gallon
			8 pints	=	1 gallon

Calculations
using metric and customary units

The statement and solution of three everyday problems are given in both customary and metric units, providing a side by side comparison of the systems.

a.

Problem: What is the area of the floor of a room with the following dimensions?

	Customary Units	Metric Units
Length	15 ft 7 in	475 centimeters
Width	12 ft 6 in	380 centimeters

SOLUTION. The area is determined by multiplying the length of the room by its width. Note that for room dimensions given in mixed customary units it is necessary to first reduce them to a common unit expression which, in this case, may be either feet or inches.

CUSTOMARY—
Room Dimensions in Inches

Multiply feet by 12 to convert to inches

Length $(15 \times 12) + 7 = 187$ in
Width $(12 \times 12) + 6 = 150$ in

187×150
$= 28{,}050$ square inches

Total square inches divided by number of square inches in a square foot (144) equals number of square feet

$28{,}050 \div 144 = 195$ square feet (approx.)

Total square feet divided by number of square feet in a square yard (9) equals number of square yards

$195 \div 9 = 22$ square yards (approx.)

METRIC—
Room Dimensions in Centimeters

Length 475 cm
Width 380 cm

475×380
$= 180{,}500$ square cm

Total square centimeters divided by number of square centimeters in a square meter (10,000) equals number of square meters; i.e. move decimal point 4 places to left

$180{,}500 \div 10{,}000 =$ 18 square meters (approx.)

Alternate Solution
Room Dimensions in Feet

Length

$15\frac{7}{12}$ feet

Width

$12\frac{1}{2}$ feet

$15\frac{7}{12} \times 12\frac{1}{2}$ square feet

$\frac{187}{12} \times \frac{25}{2} =$

$\frac{4675}{24}$ square feet

$= 194\frac{19}{24}$ square feet

= 22 square yards (approx.)

b.

What is the approximate total weight of the contents of a basket that contains the following items:

Weight

	Customary Units	Metric Units
Meat	4 lb 9 oz	2.07 kilograms
Potatoes	3 lb 4 oz	1.47 kilograms
Tomatoes	2 lb 15 oz	1.33 kilograms
Cereal	1 lb 7 oz	650 grams

Solution of Problem

	Customary Weight in Ounces Weight in pounds multiplied by 16 gives weight in ounces	Metric Weight in Grams
Meat	$(4 \times 16) + 9 = 73$	2070
Potatoes	$(3 \times 16) + 4 = 52$	1470
Tomatoes	$(2 \times 16) + 15 = 47$	1330
Cereal	$(1 \times 16) + 7 = 23$	650
	195	5520

195 divided by 16 = 12 lb (approx.) or 5.5 kilograms (approx.)

Alternate Solutions

	lb	oz	*kg*
Meat	4	9	2.07
Potatoes	3	4	1.47
Tomatoes	2	15	1.33
Cereal	1	7	0.65
	10	35	5.52
Or	12	3	
Or	12 lb (approx.)	or	5.5 kg (approx.)

c.

Volume

What is the volume of the following two comparable but not equal mixtures:

	Customary Units	Metric Units
Milk	1 gal 2 qt 1 pt	6.5 liters
Water	3 qt 1 pt	3.5 liters
Flavoring	½ pt	250 milliliters

Solution of Problem

Customary Volume in Pints Multiply gallons by 8, and quarts by 2 to convert to pints	Metric Volume in Milliliters multiply liters by 1000 to convert to milliliters
Milk	6500
$(1 \times 8) + (2 \times 2) + 1 = 13$	3500
Water	250
$(3 \times 2) + 1 = 7$	10250
Flavoring ½	
$20\frac{1}{2}$	

$20\frac{1}{2} \div 2 = 10$ qt (approx.) or 10.25 liters

$10 \div 4 = 2\frac{1}{2}$ gal (approx.) or 10 liters (approx.)

Alternate Solutions

	gal	*qt*	*pt*	*liters*
Milk	1	2	1	6.5
Water		3	1	3.5
Flavoring			½	0.25
Totals	1	5	2½	10.25
	2	2	½	
	or 2½ gal (approx.)			or 10 liters (approx.)

A Word from the Director

From the grocery scales to the gasoline pump, accuracy of measurement in the marketplace is important for the consumer's economic well-being. Without widespread confidence by consumers in the integrity of the measurement system, business and trade would be severely handicapped.

The National Bureau of Standards was created by Congress in 1901 to meet the needs of a growing Nation for a unified measurement system. The primary responsibility of NBS is to serve, for this nation, as the authoritative source of accurate, compatible, and useful physical measurements. Working with state and Federal agencies, universities, industry, and many special groups, NBS helps assure the integrity of measurements used throughout the United States.

In keeping with its vital role in measurement science, the National Bureau of Standards is under special obligation to provide consumers with useful information on the metric system, at a time when its use is increasing. We hope that this booklet has served to help you understand how change to the metric system will affect you and how to use it in your daily life.

Richard W. Roberts

RICHARD W. ROBERTS

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Washington, D.C. 20234

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