

Measurement Resources

Measuring in Science

Collecting and comparing data in the science classroom often involves using tools and units of measure. In fact, measuring is a key science process skill at every level of science education, beginning with the use of nonstandard units in early childhood. Through the hands-on activities in Delta Science Modules, students gain proficiency in measuring and using numbers. Depending on the focus of the module, students may measure and calculate linear dimensions, surface area, mass, weight, volume, fluid capacity, time, and temperature. They may also calculate rates based on two measures, such as rate of speed (units of distance per unit of time). Skill in understanding and applying basic measurement concepts is an essential tool of science.

SI Units

Today all systems of weights and measures, metric and nonmetric, are linked through a network of international agreements supporting the International System of Units. The International System is called **SI**, using the first two initials of its French name, *Système International d'Unités*. Scientists around the world use SI measurements so that scientific information can be shared. Basic SI units include the meter for length, the gram for mass, and the liter for volume. Multiples and fractions of the basic units are created by multiplying or dividing by 10. (For example, 10 millimeters equal 1 centimeter; 100 centimeters equal 1 meter; 1,000 meters equal 1 kilometer.) SI is used worldwide not only in science study but in all areas of life, and the United States is gradually shifting to full use of SI. Currently, though, two systems of measurement are used in the United States: the U.S. Customary system (also called the English system) and SI. Students in your classroom may find themselves using Customary measurements at home and working with SI measurements in the science classroom.

Conversion Skills

Hands-on investigations sometimes require students to convert measurements *within* the same system. Students also benefit from understanding how to convert *between* the SI and Customary systems. Duplicate, distribute, and discuss the measurement **copymasters** on the following pages. Have students place them in their science notebooks.

- **Measurement Units and Equivalents** Names, abbreviations, and equivalents of basic units in the SI and U.S. Customary systems.
- **Converting Units** Instructions for applying understanding of prefixes and using conversion factors to convert units within the SI system.
- **Conversion Chart** Multiplication factors for converting between systems. Show students how to use the table; for example, 12 inches \times 2.54 = 30 cm; 8 liters \times 1.09 = 8.7 quarts.

Display the Measurement poster included in the kit in the classroom or laboratory. These references will help students better understand the relationships among types of measurements, units of measure, and measurement systems.

Measurement Copymasters are on the following pages.>

Measurement Units and Equivalents

SI (International System)

Length and Distance

10 millimeters (mm) = 1 centimeter (cm)

100 cm = 1 meter (m)

1,000 m = 1 kilometer (km)

Mass

1,000 milligrams (mg) = 1 gram (g)

1,000 g = 1 kilogram (kg)

Volume

1,000 cubic millimeters (mm³) =
1 cubic centimeter (cm³)

1,000,000 cm³ = 1 cubic meter (m³)

Liquid Capacity

1,000 milliliters (mL) = 1 liter (L)

Area

100 square millimeters (mm²) =
1 square centimeter (cm²)

10,000 cm² = 1 square meter (m²)

1,000,000 m² = 1 square kilometer (km²)

Temperature

degrees Celsius (°C)

Freezing point of water = 0°C

Average room temperature = 20°C

Average human body temperature = 37°C

Boiling point of water = 100°C

Time

60 seconds (s) = 1 minute (min)

60 min = 1 hour (h)

24 h = 1 day (d)

365 d = 1 year (yr)

U.S. Customary System

Length and Distance

12 inches (in) = 1 foot (ft)

36 in = 1 yard (yd)

3 ft = 1 yd

5,280 ft = 1 mile (mi)

1,760 yd = 1 mi

Weight

16 ounces (oz) = 1 pound (lb)

2,000 lb = 1 ton (t)

Volume

1,728 cubic inches (in³) =
1 cubic foot (ft³)

27 ft³ = 1 cubic yard (yd³)

Liquid Capacity

8 fluid ounces (fl oz) = 1 cup (c)

2 c = 1 pint (pt)

2 pt = 1 quart (qt)

4 qt = 1 gallon (gal)

Area

144 square inches (in²) =
1 square foot (ft²)

9 ft² = 1 square yard (yd²)

4,840 yd² = 1 acre

3,097,600 yd² = 1 square mile (mi²)

Temperature

degrees Fahrenheit (°F)

Freezing point of water = 32°F

Average room temperature = 68°F

Average human body temperature = 98.6°F

Boiling point of water = 212°F

Time

60 seconds (s) = 1 minute (min)

60 min = 1 hour (h)

24 h = 1 day (d)

365 d = 1 year (yr)

Converting Units

Converting Measurements Within the SI System

Measurement is the process of describing observations precisely with the use of numbers. Sometimes you need to convert measurements from one unit to another. Converting measurements involves mathematical calculations using conversion factors. A **conversion factor** is a ratio that expresses the relationship between two units. A conversion factor always equals 1. For example:

$$1 \text{ m} = 100 \text{ cm} \qquad \text{Conversion factor: } \frac{1 \text{ m}}{100 \text{ cm}} = 1$$

Units in the SI system are based on multiples of 10. The unit prefixes are clues to the conversion factors.

Common SI Prefixes

Prefix	Meaning	Example	Conversion Factor
kilo-	1,000	1 kilometer (km) = 1,000 meters (m) 1 kilogram (kg) = 1,000 grams (g)	$\frac{1 \text{ km}}{1,000 \text{ m}}$ or $\frac{1 \text{ m}}{0.001 \text{ km}}$ $\frac{1 \text{ kg}}{1,000 \text{ g}}$ or $\frac{1 \text{ g}}{0.001 \text{ kg}}$
centi-	0.01 (one hundredth)	1 centimeter (cm) = 0.01 meter (m)	$\frac{1 \text{ cm}}{0.01 \text{ m}}$ or $\frac{1 \text{ m}}{100 \text{ cm}}$
milli-	0.001 (one thousandth)	1 millimeter (mm) = 0.001 meter (m) 1 milliliter (mL) = 0.001 liter (L)	$\frac{1 \text{ mm}}{0.001 \text{ m}}$ or $\frac{1,000 \text{ mm}}{1 \text{ km}}$ $\frac{1 \text{ mL}}{0.001 \text{ L}}$ or $\frac{1,000 \text{ mL}}{1 \text{ L}}$

Sample Conversions

- To convert 3,300 mL to liters, write the conversion factor for milliliters and liters. The unit that you are converting *from* is the denominator: $\frac{1 \text{ L}}{1,000 \text{ mL}}$. Multiply the measurement you are converting by the conversion factor. The same units cancel and leave the units you want. Simplify the fraction to get your measurement.

$$3,300 \cancel{\text{ mL}} \times \frac{1 \text{ L}}{1,000 \cancel{\text{ mL}}} = \frac{3,300 \text{ L}}{1,000} = 3.3 \text{ L}$$

- To convert 78 meters to centimeters, write the conversion factor, making meters (the unit you are converting *from*) the denominator: $\frac{100 \text{ cm}}{1 \text{ m}}$. Multiply the measurement you are converting by the conversion factor. Cancel similar units and simplify to complete the calculation.

$$78 \cancel{\text{ m}} \times \frac{100 \text{ cm}}{1 \cancel{\text{ m}}} = \frac{7,800 \text{ cm}}{1} = 7,800 \text{ cm}$$

Conversion Chart

SI/U.S. Customary, U.S. Customary/SI

	When you know	multiply by	to find
Length and distance	inches	2.54	centimeters
	centimeters	0.39	inches
	feet	0.30	meters
	meters	3.28	feet
	yards	0.91	meters
	meters	1.09	yards
	miles	1.61	kilometers
	kilometers	0.62	miles
Mass and weight (on Earth)	ounces	28.35	grams
	grams	0.04	ounces
	pounds	0.45	kilograms
	kilograms	2.20	pounds
	tons (short)	0.91	tonnes (metric tons)
	tonnes (metric tons)	1.10	tons (short)
	pound-force	4.45	newtons
	newtons	0.22	pound-force
Volume	cubic inches	16.39	cubic centimeters
	cubic centimeters	0.06	cubic inches
Liquid capacity	fluid ounces	29.57	milliliters
	milliliters	0.03	fluid ounces
	quarts	0.95	liters
	liters	1.06	quarts
	gallons	3.79	liters
	liters	0.26	gallons
Area	square inches	6.45	square centimeters
	square centimeters	0.16	square inches
	square yards	0.84	square meters
	square meters	1.20	square yards
	square miles	2.59	square kilometers
	square kilometers	0.39	square miles
	acres	0.40	hectares
	hectares	2.47	acres
	Temperature	°Fahrenheit	$\frac{5}{9} (^{\circ}\text{F} - 32)$
°Celsius		$\frac{9}{5} (^{\circ}\text{C}) + 32$	°Fahrenheit