

SCIENTIFIC MEASUREMENT AND CONVERSION

● SI Units and Conversions Between Them

SI, or *Système Internationale*, is the system for measuring that is used by scientists throughout the world. The six basic SI units that your textbook uses are listed in **Table 1**.

Table 1 SI Units

Basic unit	Abbreviation	Quantity measured
second	s	time
meter	m	length and distance
kilogram	kg	mass
kelvin	K	absolute temperature
mole	mol	quantity of matter
ampere	A	electric current

Other units can be derived as combinations of SI units. Some derived units that are used in the textbook are given in **Table 2**.

Table 2 Units Derived from SI

Derived unit	Definition	Quantity measured
newton (N)	$\text{kg} \cdot \text{m/s}^2$	force
joule (J)	$\text{N} \cdot \text{m} = \text{kg} \cdot \text{m}^2/\text{s}^2$	energy
watt (W)	$\text{J/s} = \text{kg} \cdot \text{m}^2/\text{s}^3$	power
hertz (Hz)	1/s	frequency

SI Conversion

One advantage of SI is that units are scaled by factors of 10. For instance, if you are measuring small amounts of mass in grams, you can express this quantity in the much larger units of kilograms because 1000 g make up a kilogram. In these simple conversions, the prefixes shown in **Table 3** are added to a given unit. For example, a frequency of 5 million Hz can be expressed more simply as 5 MHz. The letter M stands for the prefix “mega,” which comes from the Greek word for “mighty.”

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Symbol	Prefix	Is equal to
n	nano-	10^{-9} (a billionth)
μ	micro-	10^{-6} (a millionth)
m	milli-	10^{-3} (a thousandth)
c	centi-	10^{-2} (a hundredth)
k	kilo-	103 (a thousand)
M	mega-	106 (a million)
G	giga-	109 (a billion)

Math Skills

Convert 745 mm to meters.

Solution

1. Determine the possible conversion factors. The two units in this problem are millimeters and meters. You can see in Table 3 that the prefix “milli-” means 10^{-3} (a thousandth). This means that $1 \text{ mm} = 10^{-3} \text{ m}$. So,

$$\frac{1 \text{ mm}}{10^{-3} \text{ m}} = 1 \quad \text{and} \quad \frac{10^{-3} \text{ m}}{1 \text{ mm}} = 1$$

2. Decide which conversion factor will give you the correct unit for the answer. The answer needs to be in meters. To get meters, use the conversion factor that multiplies by meters and divides by millimeters (to cancel millimeters in the number from the problem).

$$\frac{10^{-3} \text{ m}}{1 \text{ mm}} = 1$$

3. Write down the number from the problem, and multiply it by the conversion factor.

$$745 \text{ mm} \times \frac{10^{-3} \text{ m}}{1 \text{ mm}} = 0.745 \text{ m}$$

Practice

1. Convert 100 m, the length of a well-known track event, to kilometers.

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● SI Units and Conversions Between Them *continued*

2. Convert 5.98×10^{24} kg, the mass of Earth, to milligrams, mg.

3. If you reported how quickly energy was used, measuring energy in joules, J, and time in seconds, s, which unit would you use?

4. ~~Convert a force of 4.448 N to units of $\text{g} \cdot \text{cm}/\text{s}^2$.~~

5. ~~Convert the gravitation constant $6.67 \times 10^{-11} \text{ N} \cdot \text{m}^2/\text{kg}^2$ to units of $\text{N} \cdot \text{km}^2/\text{g}^2$.~~

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• Converting Between U.S. Conventional and SI Measurements

In the United States, most people express distances in inches, feet, yards, or miles. Those units, along with the units we use for speed, volume, and other quantities, are known as the *U.S. Conventional System*.

Most scientists use a different system called the *Système Internationale* (SI). This system has units such as the meter, the kilogram, the second, and the kelvin. Each base unit measures a different quantity. For example, the meter measures length, and the kilogram measures mass.

The units of the two systems are different, but the quantities they represent do not change. The units have a fixed relationship to each other. You can use this relationship to convert a value from one system to the other. Table 1 lists some common U.S. System units and their SI equivalents.

Table 1 Conversions between U.S. and SI units

U.S. System	SI	U.S. System	SI
1 mi	1.6093 km	1 in.	2.54 cm
1 ft	0.3048 m	1 gal	3.7853 L
1 pt	0.4732 L	1 lb	4.448 N
1 mi/h	1.6093 km/h	1 qt	0.9463 L

Math Skills

How many kilometers are in a 5.44 mi bicycle race?

Solution

1. Locate the conversion factor for the units in question.

$$1 \text{ mi} = 1.6093 \text{ km}$$

2. Use the units you found in step 1 to make a fraction, with the units you are converting *into* on top. Now the units will cancel after you multiply. Because the top and bottom of the fraction are equal, the fraction is equal to one.

$$\frac{1.6093 \text{ km}}{1 \text{ mi}} = 1$$

3. Write the measurement you wish to convert, and multiply it by the fraction you found in step 2. Because the fraction is equal to one, it will not change the value of your original measurement.

$$5.44 \text{ mi} \times 1 = 5.44 \text{ mi} \times \frac{1.6093 \text{ km}}{1 \text{ mi}}$$

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● **Converting Between U.S. Conventional and SI Measurements** *continued*

4. Multiply through and cancel out any repeated units.

$$\frac{5.44 \cancel{\text{mi}} \times 1.6093 \text{ km}}{1 \cancel{\text{mi}}} = 8.754 \text{ 592 km}$$

5. Round to the correct number of significant figures. The original measurement has three significant figures, so the answer is rounded to 8.75 km.

Math Skills

Your friend from Europe is sending you a 20.5 N package. How much will it weigh in pounds?

Solution

1. Locate the conversion factor for the units in question.

$$1 \text{ lb} = 4.448 \text{ N}$$

2. Make a fraction with the units from step 1, putting the units you are converting to on top. Multiply this fraction by the quantity you wish to convert.

$$20.5 \text{ N} \times \frac{1 \text{ lb}}{4.448 \text{ N}}$$

3. Multiply through and cancel out any repeated units.

$$\frac{20.5 \text{ N} \times 1 \text{ lb}}{4.448 \text{ N}} = 4.608 \text{ 812 95 lb}$$

4. Round to the correct number of significant figures. The original measurement has three significant figures, so round the answer to 4.61 lb.

Practice

1. In Canada, you pass a speed limit sign that says 75 km/h. How fast can you drive in mi/h?
2. How many liters of milk are in 3.5 gal?
3. How many meters long is a 100 yd football field? (Note that 1 yd = 3 ft.)

Unit Conversions Worksheet

- 1) How many inches are there in 45.6 cm? (There are 2.54 cm in 1 inch)

- 2) How many centimeters are there in 1.23×10^{-6} kilometers?

- 3) How many hours are there in 34.5 years?

- 4) How many inches are there in 355 millimeters?

- 5) How many milliliters are in a cubic meter? (There are 1,000 L in 1 m^3)

- 6) How many miles are there in 3.44×10^8 inches? There are 0.61 miles in 1 km).

Metric Conversion Worksheet
Problem set #3

UNIT CONVERSION WORKSHEET

1. How many centimeters are in 32 inches?

2. The dimensions of your living room are 13ft. by 16 ft. How many **square yards** of carpet do you need to buy?

3. How many grams are in 17 lbs.?

4. 85 °F equals how many °C?

5. The density of lead is 11.4 g/cm^3 . How much will 42cm^3 of lead weigh?

6. The speed of light is $3.00 \times 10^8 \text{ m/sec}$. Convert that to ft./sec.

Unit Conversions Worksheet - Solutions

- 1) How many inches are there in 45.6 cm? (There are 2.54 cm in 1 inch)
18.0 inches

- 2) How many centimeters are there in 1.23×10^{-6} kilometers?
0.123 cm

- 3) How many hours are there in 34.5 years?
 3.02×10^5 hours

- 4) How many inches are there in 355 millimeters?
14.0 inches

- 5) How many milliliters are in a cubic meter? (There are 1,000 L in 1 m^3)
 1.00×10^6 mL

- 6) How many miles are there in 3.44×10^8 inches? There are 0.61 miles in 1 km).
 5.33×10^3 miles