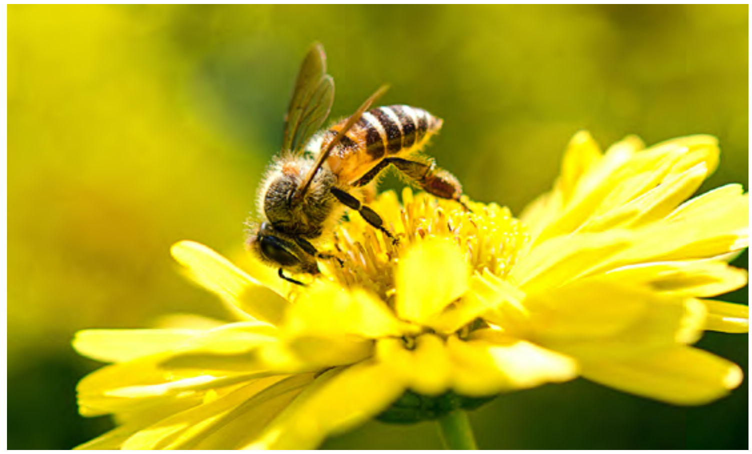
Chapter 1

About Science



1.5 Working With Numbers

Science starts with observations. When possible, it is helpful to quantify observations by taking measurements. By quantifying observations, we are able to make objective comparisons, share accurate information with others, or look for trends that might reveal some inner workings of nature.

Scientific Notation

Scientific notation is a different way of writing numbers. You know that one million is 1,000,000 and that one billion is 1,000,000,000. Pretty quickly, it becomes cumbersome to write out all those digits. This is where scientific notation comes in. Scientific notation is especially useful for very big numbers and very small numbers, but it can be used for just regular numbers as well.

In *scientific notation*, you use digits, with a decimal point after the first digit, multiplied by a power of 10. For example, remember that 10^3 is 10 x 10 x 10, and so one thousand in scientific notation is:

$1,000 = 1 \times 10^3$

One million is: $1,000,000 = 1 \times 10^6$

Three million is: $3,000,000 = 3 \times 10^6$

And the number 4,800,000 is: $4,800,000 = 4.8 \times 10^6$

You can also write small numbers in scientific notation by using a negative exponent:

$0.001 = 1 \times 10^{-3}$

$0.00001 = 1 \times 10^{-5}$

$0.00000000007 = 7 \times 10^{-11}$

The Metric System

Scientists measure physical quantities. Some examples of physical quantities common to science, including biology, are length, time, weight, volume, energy, temperature, and so on.

It would be meaningless, for example, to say that your dog weighs 40, because without a specific unit, no one would know what that meant: 40 ounces, 40 pounds, 40 kilograms? A dog that weighed 40 kg would be more than 35 times heavier than one that weighed 40 oz. Units such as ounces, pounds, and kilograms, or feet, yards, and kilometers allow us to make meaningful comparisons when we measure physical quantities, and they must be included to complete the description. Again for emphasis: Any quantity must be accompanied by a unit.

There are two major unit systems used in the world today. One is the United States Customary System (USCS, formerly called the British System of Units), used in the United States, primarily for nonscientific purposes. The other is the Système International (SI), which is used in most other nations. This system is also known as the International System of Units or as the *metric system*. The orderliness of this system makes it useful for scientific work, and it is used by scientists all over the world, including those in the United States. (And the International System is beginning to be used for nonscientific work in the United States, as Figure 1.8 shows.

FIGURE 1.8

The metric system is finally making some headway in the United States, where various commercial goods, such as Evan's favorite soda, are now sold in metric quantities.

This book uses the SI units given in Table 1.1. On occasion, USCS units are also used to help you make comparisons. One major advantage of the metric system is that it uses a decimal system, which means all units are related to the next smaller or larger units by a factor of 10. Some of the more commonly used prefixes, along with their decimal equivalents, are shown in Table 1.2. From this table, you can see that 1 kilometer is equal to 1000 meters, where the prefix *kilo-* indicates 1000. Likewise, 1 millimeter is equal to 0.001 meter, where the prefix *milli-* indicates 1/1000. You need not memorize this table, but you will find it a useful reference when you come across these prefixes in your course of study.

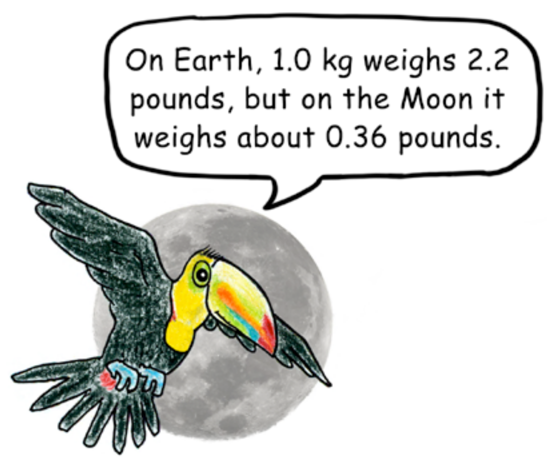


Table 1.1 Metric Units for Physical Quantities and Their USCS Equivalents

PHYSICAL QUANTITY	METRIC UNIT	ABBREVIATION	USCS EQUIVALENT
length	kilometer	km	1 km = 0.621 miles (mi)
	meter	m	1 m = 3.285 feet (ft)
	centimeter	cm	1 cm = 0.3937 inches (in.)
			1 in. = 2.54 cm
	millimeter	mm	none commonly used
time	second	s	second also used in USCS
mass	kilogram	kg	1 kg = 2.205 pounds (lb)
	gram	g	1 g = 0.03528 ounces (oz)
			1 oz = 28.345 g
	milligram	mg	none commonly used
volume	liter	L	1 L = 1.057 quarts (qt)
	milliliter	mL	1 mL = 0.0339 fl oz
	cubic centimeter	cm^3	1 cm^3 = 0.0339 fl oz
energy	kilojoule	kJ	1 kJ = 0.239 kilocalories (kcal)
	joule	J	1 J = 0.239 calories (cal)
			1 cal = 4.184 J
temperature	degree Celsius	°C	(°C × 1.8) + 32 = degrees Fahrenheit, °F
	kelvin	K	°C + 273 = K

Table 1.2 Metric Prefixes

PREFIX	SYMBOL	DECIMAL EQUIVALENT	EXPONENTIAL FORM	EXAMPLE
tera-	T	1,000,000,000,000.	10^{12}	1 **tera**meter (Tm) = 1 trillion meters
giga-	G	1,000,000,000.	10^{9}	1 **giga**meter (Gm) = 1 billion meters
mega-	M	1,000,000.	10^{6}	1 **mega**meter (Mm) = 1 million meters
kilo-	k	1000.	10^{3}	1 **kilo**meter (km) = 1 thousand meters
hecto-	h	100.	10^{2}	1 **hecto**meter (hm) = 1 hundred meters
deka-	da	10.	10^{1}	1 **deka**meter (dam) = ten meters
no prefix	–	1.	10^{0}	1 meter (m) = 1 meter
deci-	d	0.1	10^{-1}	1 **deci**meter (dm) = 1 tenth of a meter
centi-	c	0.01	10^{-2}	1 **centi**meter (cm) = 1 hundredth of a meter
milli-	m	0.001	10^{-3}	1 **milli**meter (mm) = 1 thousandth of a meter
micro-	μ	0.000 001	10^{-6}	1 **micro**meter (μm) = 1 millionth of a meter
nano-	n	0.000 000 001	10^{-9}	1 **nano**meter (nm) = 1 billionth of a meter
pico-	p	0.000 000 000 001	10^{-12}	1 **pico**meter (pm) = 1 trillionth of a meter

READING CHECK

1. What is the number 56,780,000 in scientific notation?

2. A cell is 30 micrometers in diameter. How many meters is this?

CHECK YOUR ANSWER

1. In scientific notation, 56,780,000 = 5.678×10^{7}
2. This cell is 30 micrometers = 30×10^{-6} meters = 30×0.000001 meters = 0.00003 meters

Read about scientific notation and practice with numbers:

https://www.mathsisfun.com/numbers/scientific-notation.html

Learn about the metric system and compare it to the USCS system:

https://www.mathsisfun.com/measure/metric-system.html

https://www.interexchange.org/articles/career-training-usa/2012/05/24/imperial-vs-metric-system/