

Background

All measurements in science have units. Just as $3b$ times $4c$ equals $12bc$, units are manipulated along with the numbers. For example: 6 meters divided by 3 seconds equals 2 m/s , not just "2". The proper unit is required for all answers to scientific inquiries. Your calculator will not keep track of units for you, so this is a manual process. **WARNING:** don't plug numbers into your calculator and then jam the "proper" units at the end. Units help you keep track of progress, and are the best check to see if you are attacking a problem properly.

Here in America, we use the English Customary system for weights and measures – feet, inches, and pounds. In science, we use SI units (sometimes called MKS – meters, kilograms, seconds). Base units are the seven fundamental dimensions from which all other quantities are derived. For example, meters are the unit for the dimension of length. Derived units are combinations of base units. Force is measured in Newtons, which is a derived unit ($\text{kg}\cdot\text{m/s}^2$). All numbers used in science class should be expressed in SI units.

Fundamental (or Base) Dimension	SI Unit	Symbol
Length	Meter	m
Mass	Kilogram	kg
Time	Second	s
Electric current	Ampere	A
Thermodynamic Temperature	Kelvin	K
Amount of substance	Mole	mol
Luminous intensity	candela	cd

We use prefixes as a shorthand method to indicate large or small quantities of units. Below is a table of a wide range of prefixes used in expressing scientific quantities. Some are used more often than others, depending on the branch of science you are studying.

Power	Prefix	Symbol	Power	Prefix	Symbol
10^{24}	yetta	Y	10^{-1}	deci	d
10^{21}	zeta	Z	10^{-2}	centi	c
10^{18}	exa	E	10^{-3}	milli	m
10^{15}	peta	P	10^{-6}	micro	μ
10^{12}	tera	T	10^{-9}	nano	n
10^9	giga	G	10^{-12}	pico	p
10^6	mega	M	10^{-15}	femto	f
10^3	kilo	k	10^{-18}	atto	a
10^2	hecto	h	10^{-21}	zepto	z
10^1	deka	da	10^{-24}	yocto	y

The Factor Label Method (Dimensional Analysis)

An equation is an expression of equality. Not only must the numbers on both sides be equal, but the units on each side must agree also.

Some expressions are definitions, where the numbers and units do not appear to match. For example, we all know that 1 hour equals 60 minutes. Writing this relationship in strict equation form, we have: $1 \text{ h} \equiv 60 \text{ min}$. That unusual three-line equal sign means “is defined as”. By dividing one side of the equation by the other, this equation will yield two conversion factors:

$$1 \text{ h} / 60 \text{ min} \equiv 1 \text{ and } 60 \text{ min} / 1 \text{ hr} \equiv 1$$

Any definition will yield two factor conversion methods (1 inch \equiv 2.54 cm, 1 mi \equiv 1.602 km, etc). You can even apply this method to prefixes: 1 km \equiv 1000 m, 1 m \equiv 100 cm, and so on.

Definition	1 st Conversion factor = 1	2 nd Conversion factor = 1
1 h \equiv 60 min	1/60 h/min	60 min/h
1 in \equiv 2.54 cm	1/2.54 in/cm	2.54 cm/in
1 mi \equiv 1.602 km	1/1.602 mi/km	1.602/1 km/mi
1 km \equiv 1000 m	1/1000 km/m	1000 m/km
1 m \equiv 100 cm	1/100 m/cm	100 cm/m

Why is this so important? As you know, any number which is multiplied by one is still equal to itself. So if you take 1.5 h, multiply it by 60 min/h, you get 90 minutes. $1.5 \text{ hr} = 90 \text{ min}$, the only time you can have units on opposite sides of the equation not in agreement is when they are “mixed units”, such as hours and minutes. In solving science problems, you will establish common units (SI units) so that there is always agreement on both sides of the equation.

We attach units to all scientific measurements, and use the factor label method whenever we need to convert units from one system to another, or from one prefix to another.

The acceleration due to gravity is given as approximately 9.8 m/s^2 , while the initial speed of a projectile might be given as 25 km/h. How can you use both numbers in the same equation? The factor-label method is one way to convert units.

$$25 \frac{\text{km}}{\text{h}} \times \frac{1000\text{m}}{1\text{km}} \times \frac{1\text{min}}{60\text{s}} \times \frac{1\text{h}}{60\text{min}} = 6.9 \frac{\text{m}}{\text{s}}$$

Helpful hint: don't be afraid to use a strictly vertical structure for your conversion factors, rather than a convenient horizontal a/b. The cancellations are more obvious, and you'll make fewer mistakes.

Now, you can use 9.8 m/s^2 and 6.9 m/s in the appropriate kinematic equation of motion (for example: $v_f = v_i - gt$) and your answer will be in the proper form.