UNIT CONVERSION

- How many minutes in a year?
- How can I convert the speed of 120 km/h to MPH?

Most measurements require a *number* and a *unit* to specify.

SI units

The vast majority of the world use a common set of units to simplify international trade and science. The system is called the *International System of Units* or *SI units*. Here are a few of the basic SI units:

Quantity	**SI unit**	**Abbreviation**
Distance, Length	Meter	m
Mass	Kilogram	kg
Time	Second	s
Area	Meter squared	m^2
Volume	Cubic meter	m^3
Speed, Velocity	Meter per second	$\mathrm{m/s}$
Acceleration	Meter per second squared	$\mathrm{m/s^2}$
Force	Newton	N

Conversion of units is the conversion between different units of measurement for the same quantity, typically through multiplicative conversion factors.

In order to do a conversion, we first need to know the conversion factor, or "how many of these equals how many of those".

Time	Weight (on Earth)
1 day = 24 hours (hr)	1 pound (lb) = 16 ounces (oz)
1 hour = 60 minutes (min)	1 pound (lb) = 4.448 N
1 minute = 60 seconds (sec)	1 ton = 2000 pounds
Length	**Volume**
1 inch (in.) = 2.54 centimeters (cm)	8 fluid ounces (fl oz) = 1 cup (c)
1 meter (m) = 3.28 feet (ft) = 39.4 inches	1 pint (pt) = 2 cups
1 foot = 12 in. = 0.305 m	1 quart (qt) = 2 pt = 0.95 liter (L)
1 yard (yd) = 3 feet = 0.914 m	4 quarts = 1 gallon (gal) = 3.786 L
1 mile (mi) = 5280 ft = 1760 yd = 1.61 km	
Temperature	1 fl oz = 30 mL = 30 cm^3 (cc)
Fahrenheit (°F) = 1.8 Celsius (°C) + 32	1 m^3 = 1000 L
Kelvin (K) = (°F) or (°C) + 273.15	1 ft^3 = 7.48 gal

A *conversion factor* is used to change the units of a measured quantity without changing its value.

By using the identity property of multiplication, we can convert units without affecting the value of the measured quantity.

If we multiply a fraction in which the numerator and the denominator of the fraction are equivalent, then the fraction is equal to 1 and doesn't change the original value.

Since 1 meter = 3.28 feet,

$$\frac{3.28\, feet}{1\, meter} = \frac{1\, meter}{3.28\, feet} = 1.$$

So, we can express 500 feet in meters as

$$500\, ft = \frac{500\, ft}{1} \times 1 = \frac{500\, \cancel{ft}}{1} \times \frac{1\, m}{3.28\, \cancel{ft}} = 152\, m.$$

Now, let's find answers of the first two questions!

Ex 1) How many minutes in a year?

Recall that: 1 year = 365 days
1 day = 24 hours
1 hour = 60 minutes

Conversion factors: $\frac{365\ days}{1\ year} = \frac{24\ hours}{1\ day} = \frac{60\ minutes}{1\ hour} = 1.$

$$1\ year = \frac{1\ \cancel{year}}{1} \times \frac{365\ \cancel{days}}{1\ \cancel{year}} \times \frac{24\ \cancel{hours}}{1\ \cancel{day}} \times \frac{60\ minutes}{1\ \cancel{hour}} = 525{,}600\ minutes$$

Ex 2) How can you convert the speed of 120 km/h to MPH?

Recall that: 1 mile = 1.609 km

$$\frac{120km}{h} = \frac{120\cancel{km}}{1\ hour} \times \frac{1\ mile}{1.609\ \cancel{km}} = \frac{120\ miles}{1.609\ hours} = 74.58\ miles/hour\ = 74.58\ MPH$$

Metric System

The Metric System helps us to deal with very large and very small numbers. It is decimal-based system of measurement which allows for *prefixes* to be used with the basic SI units. Each prefix describes a larger or smaller quantity of the basic SI unit, allowing us to easily scale up or scale down a quantity to a more appropriate magnitude.

Here is a list of the most used prefixes:

Getting Smaller				Getting Larger			
Prefix	Abbreviation	Scientific Notation	Common English	Prefix	Abbreviation	Scientific Notation	Common English
deci	d	10^{-1}	Tenth	deca	D	10^{1}	ten
centi	c	10^{-2}	Hundredth	hecto	H	10^{2}	hundred
milli	m	10^{-3}	Thousandth	kilo	K	10^{3}	thousand
micro	μ	10^{-6}	Millionth	mega	M	10^{6}	million
nano	n	10^{-9}	Billionth	giga	G	10^{9}	billion
pico	p	10^{-12}	Trillionth	terra	T	10^{12}	trillion

Note that the *milli* prefix is 10^{-3}, which is $\frac{1}{1000}$ or 1000 times **smaller**, while a kilo is 10^{3}, which is 1000 times **larger!**

With these prefixes we can regularly convert a quantity to a bigger or smaller magnitude, which makes it easier to understand just how much of a quantity there actually is. Usually, this means reducing the number of digits in a quantity so we can focus on only the *significant figures*, or simply expressing the quantity as a natural number (or whole number).

For example, <u>Concise</u> <u>Scientific Notation</u> <u>Decimal</u>

$$35\ \mathbf{m}\mathrm{m}\ (\boldsymbol{milli}meters) = 35 \times \mathbf{10^{-3}}\ meters = 0.035\ \mathrm{m}$$

Here the 35 millimeters is easier to understand than 0.035 m (which includes a decimal)

$$67\ \mathbf{k}\mathrm{N}\ (\boldsymbol{kilo}Newtons) = 67 \times \mathbf{10^{3}}\ \mathrm{Newton} = 67000\ \mathrm{N}$$

Here the 67 kiloNewtons is easier to understand than 67000 N (which includes several more digits)

Then, how can we express 250 $\boldsymbol{\mu}$g (micrograms) in g(grams)?

$$250\ \boldsymbol{\mu}\mathrm{g}\ (\boldsymbol{micro}grams) = \boxed{}\ \mathrm{g}$$

Converting between Mass and Volume

❖ *Will It Float?*

The density of an object determines whether it floats or sinks in water. Pure water has a density of $1g/cm^3$. Objects that are less dense than water (d < $1g/cm^3$) float, while objects denser than water (d > $1g/cm^3$) sink.

➢ Examples:

1. A toy submarine has a volume of 14.3 mL and a mass of 15.2 grams. Will the toy float or sink?
2. An unknown liquid has a volume of 15.0 mL and a mass of 11.3 g. What is the density of this liquid? Based on this information, what mass would you expect for a 2.50 L sample of this liquid?
3. A cylindrical steel tank with a diameter of 20.0 cm, a length of 150.0 cm, and an overall mass of 150.0 kg is accidentally dropped into a lake. What is the cylinder's density in g/cm^3? Will it sink or float?

Converting between Temperature Scales

❖ *Measuring Temperature*

Important equations:

❖ $°F = \frac{9}{5} \cdot °C + 32$ ❖ $°C = \frac{5}{9} \cdot (°F - 32)$ ❖ $K = °C + 273.15$

➢ Examples:

1. The average temperature of the human body is 98.6 $°F$. What is this temperature in $°C$ and K?
2. Convert 400 K to degrees Celsius and degrees Fahrenheit.
3. Room temperature is typically around 72 $°F$. Convert this temperature to degrees Celsius and to Kelvins.

Dealing with difficult conversions

We can get overwhelmed when questions provide you with units that are more obscure and have difficult conversion factors. Also, some questions may include multiple units of measurements, further making conversions more difficult to handle. If you are struggling to convert your units from one to another, try using a few of these strategies:

- *Figure out what type of unit(s) of measurement you are dealing with.*

This helps you to focus on only the *conversion factors* that are related to that unit of measurement.

EX: Are you dealing with **mass**? How about **volume?** Try using the mass or volume related conversions. Let us remember that each type of measurement has its own set of conversions. Therefore, focus on the conversions that are relevant to that specific unit of measurement.

- *Figure out what unit(s) you are trying to end up with.*

This helps you to plan a path ahead leading to the desired units.

EX: Were you given a quantity in yards and wanted to convert it to inches? Try looking for the relevant conversion factors and see if you can make a connection between the units from start to finish.

- *Focus on ONE unit at a time, if necessary.*

This helps you to stay organized and make all the proper conversions to solve a question and avoid any conversions that are unnecessary.

EX: Were you given a combination of units, such as MPH (miles per hour)? Try focusing on each unit individually until can convert them to what you need.

Exercises:

1. Express 6.3km (kilometer) to m (meter).
2. Express 150 ng (nanogram) in µg (microgram).
3. Express 13 µm (micrometer) in nm (nanometer).
4. Express 250 mg (milligram) in g (gram).
5. How many centimeters are there in one foot?
6. A human is 68 inches tall. Express this height in cm (centimeter).
7. Express 37 GPM (gallons per minute) to liters per second.
8. Express 500 CFM (cubic feet per minute) to gallons per day.
9. A dose of medication was prescribed to be 35mL. What is that volume in cL?
10. Bromine has a density of 3.12 g/mL. What is the density in kg/nL?
11. A layer of graphene covers an area of 1.50 mm^2. What is the area in m^2?
12. A car has a gas mileage of 32 MPG (miles per gallon). Express this mileage in liters per kilometer.
13. An eight-ounce cup of Starbuck's cappuccino has 75 mg of caffeine. How many grams of caffeine are in 3 gallons of cappuccino?
14. A sprinkler system pumps 27 liters per second of water. Convert this volume flow rate to gallons per minute (GPM).
15. You have a 100-watt light bulb on your front porch that is turned on 10 hours every night. If the cost of electricity is 12 cents per KWHR (kilowatt hour), how much does that bulb add to your monthly electric bill? (Note 1 Watt = 1 Joule/sec)

Answer Key

1. 6300 m

2. $150\ \cancel{ng}\ x\ \frac{1\ \cancel{g}}{10^9\ \cancel{ng}}\ x\ \frac{10^6\ \mu g}{1\ \cancel{g}} = \frac{150\ \mu g}{10^3} =\ 0.15\mu g$

3. $13\ \cancel{\mu m}\ x\ \frac{1\cancel{m}}{10^6\ \cancel{\mu m}}\ x\ \frac{10^9\ nm}{1\ \cancel{m}} = 13000\ nm$

4. 0.25 g

5. 30.5 cm

6. 173 cm

7. $37GPM\ =\ 37\frac{\cancel{gal}}{\cancel{min}}\ x\ \frac{3.786\ L}{1\ \cancel{gal}}\ x\ \frac{1\ \cancel{min}}{60\ sec} = 2.33\ L/sec$

8. 5.39 x 10^6 gal/day

9. 3.5 cL

10. $3.12\frac{g}{mL}\ x\ \frac{1\ kg}{1000\ g}\ x\ \frac{10^3\ mL}{1\ L}\ x\ \frac{1\ L}{10^9\ nL} =\ 3.12\ \text{x}\ 10^{-9}\ kg/nL$

11. 1.50 x $10^{-6}\ m^2$

12. 0.073 L/km

13. 3.6 g

14. 427 GPM

15. $100\ \cancel{Watt}\ x\ \frac{1\ \cancel{KW}}{1000\ \cancel{W}}\ x\ \frac{10\ \cancel{hrs}\ (active)}{1\ \cancel{day}\ (or\ per\ day)}\ x\ \frac{365\ \cancel{days}\ (normally)}{12\ months}\ x\ \frac{\$0.12}{1\ \cancel{KWHR}} =$ \$ 3.65 / month