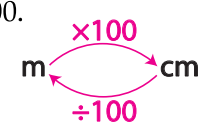
## 11 Units

The table below shows a list of common unit prefixes.

| n | $\mu$ | m | c | d | - | k | M | G |
|---|---|---|---|---|---|---|---|---|
| nano | micro | milli | centi | deci | - | kilo | mega | giga |
| $\times 10^{-9}$ | $\times 10^{-6}$ | $\times 10^{-3}$ | $\times 10^{-2}$ | $\times 10^{-1}$ | - | $\times 10^{+3}$ | $\times 10^{+6}$ | $\times 10^{+9}$ |

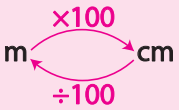
For example, $1$ cm $= 1 \times 10^{-2}$ m. This is equivalent to $1$ cm $= 1 \times \frac{1}{100}$ m.

When converting from one set of units to another, write down a fact for each quantity you need to convert, turn that into a scale factor, and then apply this factor. For example, the fact $1$ cm $= 1 \times \frac{1}{100}$ m tells us that to convert a quantity in centimetres to a quantity in metres, divide by $100$. To go the other way, from a quantity in metres to a quantity in centimetres, multiply by $100$. The scale factor is $100$.




Example 1 – Convert $3$ cm into metres.

Fact: $1\,\text{m} = 100\,\text{cm}$ Scale factor:




Answer: $3\,\text{cm} = 3 \div 100\,\text{m} = 0.03\,\text{m} = 3.0 \times 10^{-2}\,\text{m}$

Sometimes you may need more than one scale factor. This often happens with time problems.

Example 2 – Change $2.5$ hours into seconds.

Fact: $1$ hour $= 60$ minutes $1$ minute $= 60$ s

Scale factors:


Answer: $2.5$ hours $= 2.5 \times 60 \times 60$ s $= 9000$ s

You may have a fact in which neither quantity is exactly $1$ unit. In this case, scale down the fact to make one quantity exactly $1$ unit in size, and then proceed as in the previous examples.

Example 3 – A cat weighs $8.0$ lb (pounds). What is its weight in kilograms? $14.00$ lb (one stone) is $6.3503$ kg.

Fact: $14.0\text{ lb} = 6.3503\text{ kg}$

Divide by $14.00$ to find how to convert $1.000$ lb into kilograms.

Read off the scale factor.

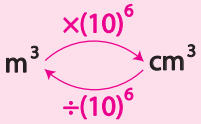

Answer: $8.0\text{ lb} = (8.0 \times 0.4536)\text{ kg} = 3.7\text{ kg}$ to 2 s.f.

When dealing with units which involve powers other than one, or when handling compound units, convert each power of each unit in turn.

Example 4 – Convert $3\text{ m}^3$ to $\text{cm}^3$.

Fact: $1\text{ m} = 100\text{ cm}$

$$\therefore 1\text{ m}^3 = (100\text{ cm})^3 = (100)^3\text{ cm}^3$$
$$\Rightarrow 1\text{ m}^3 = 100 \times 100 \times 100\text{ cm}^3$$
$$\Rightarrow 1\text{ m}^3 = 10^6\text{ cm}^3$$

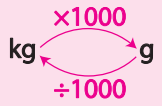


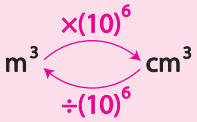

Answer: $3\text{ m}^3 = 3 \times 10^6\text{ cm}^3$

Example 5 – Convert a density of $3\text{ kg/m}^3$ to $\text{g/cm}^3$.

Fact: $1\text{ kg} = 1000\text{ g}$ $\quad$ $1\text{ m} = 100\text{ cm}$

Scale factors:




Answer: $3\text{ kg/m}^3 = 3\,\frac{kg}{m^3} = 3 \times \frac{1000}{10^6}\,\frac{g}{cm^3} = 3 \times \frac{10^3}{10^6}\,\frac{g}{cm^3}$

$$\therefore 3\text{ kg/m}^3 = 3 \times 10^{-3}\text{ g/cm}^3$$

Note: You may see units with a denominator part written in an alternative form with a negative index. For example, the units of speed, m/s, may also be written $\text{m s}^{-1}$, and the units of density, $\text{kg/m}^3$, may also be written $\text{kg m}^{-3}$.

11.1 Write:
(a) 2 300 g in kilograms
(b) 0.002 g in milligrams
(c) 0.6 kg in grams
(d) 150 mg in grams

11.2 Write:
(a) 15 cm in metres
(b) 3.48 km in metres
(c) 67.2 km in centimetres
(d) 0.1 cm in kilometres

11.3 Write:
(a) 0.15 kg in grams
(b) 2.5 hours in seconds
(c) 365 days in seconds

11.4 Write:
(a) 3.31 mm in metres
(b) 15.2 $\mu$m in metres
(c) 60 km in millimetres
(d) 0.12 cm in nanometres

11.5 Perform the following unit conversions:
(a) 30 km/s to m/s (b) 16 N/m$^2$ to kN/m$^2$ (c) 15 000 Hz to MHz

11.6 Perform the following calculations, giving your answer in the units stated and to the given accuracy:
(a) $3.875 \times 0.985$ V, to 3 s.f., in units of V.
(b) 51.85 cm $\times$ 98.75 cm, to 3 s.f., in units of cm$^2$.
(c) 106.75 m$^3$ $\div$ 43.1, to 2 s.f., in units of m$^3$.

11.7 Concentrations are often written as values in moles per litre. An example is 4 moles/litre. 1 litre $=$ 1 dm$^3$, and 1 dm $=$ 10 cm. Convert 4 moles/litre into units of
(a) moles/m$^3$.
(b) moles/cm$^3$.

11.8 Perform the following unit conversions. In this question you will need to know that 1 mile $=$ 1 609.34 metres, "mph" stands for miles per hour, "kph" for kilometres per hour, and "m/s" for metres per second. Give your answers to 2 significant figures.
(a) 15 kph to m/s
(b) 33 m/s to kph
(c) 16 mph to m/s
(d) 64 kph to mph

11.9 A student claims that $15$ cm is exactly the same as $6$ inches. A conversion calculator states that $50$ cm $= 1.64042$ feet. What is the percentage error in the student's claim? Give your answer to $2$ significant figures.

11.10 Perform the following calculations, giving your answer in the units stated and to the given accuracy:

(a) $0.02511$ cm $\times$ $78.34$ cm, to $3$ s.f., in units of m$^2$.

(b) $91.25 \times 0.00006751$ V, to 2 s.f., in units of mV.

(c) Find, to 2 significant figures, the distance in metres covered by a car which travels for $45$ minutes at $15$ km per hour.

11.11 Put ticks in the table to show whether these expressions represent lengths, areas, volumes, or none of these. You are told that $r$ and $l$ have units of metres.

| Expression | Length | Area | Volume | None of these |
|---|---|---|---|---|
| $\frac{4}{3}\pi r^3$ | | | | |
| $\pi rl$ | | | | |
| $\pi(r+l)$ | | | | |
| $\pi r^2$ | | | | |
| $r+l$ | | | | |

11.12 Put ticks in the table to show whether these expressions represent lengths, areas, volumes, or none of these. You are told that $\pi, p, q$ and $s$ are unitless constants, and $k, l$ and $m$ have units of metres.

| Expression | Length | Area | Volume | None of these |
|---|---|---|---|---|
| $\pi m^2$ | | | | |
| $plmk$ | | | | |
| $\frac{qm^2}{k}$ | | | | |
| $\frac{s\pi l}{mk}$ | | | | |
| $\frac{pqs}{2}$ | | | | |