16 More on mathematical skills

16.1 Data handling

This chapter covers the mathematical skills you will require for your whole AS Physics A course.

Table 1 *SI base units*

physical quantity	unit
mass	kilogram (kg)
length	metre (m)
time	second (s)
electric current	ampere (A)
temperature	kelvin (K)

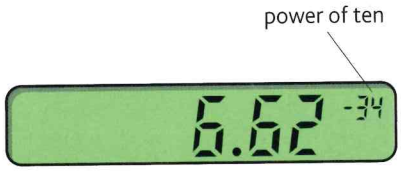
Scientific units

Scientists use a single system of units to avoid unnecessary effort and time converting between different units of the same quantity. This system, the **Système International** (or **SI system**) is based on a defined unit for certain physical quantities including those listed in Table 1. Units of all other quantities are derived from the SI base units.

The following examples show how the units of all other physical quantities are derived from the base units.

- The unit of area is the square metre (m^2).
- The unit of volume is the cubic metre (m^3).
- The unit of density is the kilogram per cubic metre ($kg\,m^{-3}$).
- The unit of speed is the metre per second ($m\,s^{-1}$).

More about using a calculator



number displayed = 6.62×10^{-34}

Figure 1 *Displaying powers of ten*

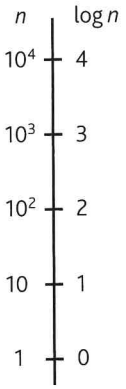


Figure 2 *A logarithmic scale*

1 '**Exp**' (or 'EE' on some calculators) is the calculator button you press to key in a **power of ten**. To key in a number in standard form (e.g. 3.0×10^8), the steps are as follows:
   - Step 1 Key in the number between 1 and 10 (e.g. 3.0).
   - Step 2 Press the calculator button marked 'Exp' (or 'EE' on some calculators).
   - Step 3 Key in the power of ten (e.g. 8).

   If the display reads '3.0 08' this should be read as 3.0×10^8 (not 3.0^8 which means 3.0 multiplied by itself 8 times). If the power of ten is a negative number (e.g. 10^{-8} not 10^8), press the calculator button marked '+/–' after step 3 (or before, if you are using a graphic calculator) to change the sign of the power of ten.

2 '**Inv**' is the button you press if you want the calculator to give the value of the inverse of a function. For example, if you want to find out the angle, which has a sine of 0.5, you key in 0.5 on the display then press ' inv' then 'sin' to obtain the answer of 30°. Some calculators have a 'second function' or 'shift' button that you press instead of the 'inv' button.

3 '**log**' (or 'lg') is the button you press to find out what a number is as a power of ten. For example, press 'log' then key in 100 and the display will show 2, because $100 = 10^2$. Logarithmic scales have equal intervals for each power of ten.

4 **To raise any number to any power**, use the ^ button or y^x button (or x^y on some calculators). For example, if you want to work out

the value of 2^8, key in 2 onto the display then y^x (or ^), then 8, and press =. The display should then show 256 as the decimal value of 2^8.

The y^x button can be used to find roots. For example, given the equation $T^4 = 5200$, you can find T by keying in 5200 onto the display, then pressing the y^x button, followed by (1 ÷ 4) which will give the answer 8.49.

Significant figures

A calculator display shows a large number of digits. When you use a calculator, you should always round up or round down the final answer of a calculation to the same number of significant figures as the data given. Sometimes, a numerical answer to one part of a question has to be used in a subsequent calculation, in which case, the numerical answer to the first part should be carried forward without rounding it up or down. For example, if you need to calculate the value of $d \sin 65°$, where $d = 1.64$, the calculator will show $9.063077870 \times 10^{-1}$ for the sine of 65°. Multiplying this answer by 1.64 then gives 1.486344771, which should then be rounded off to 1.49 so it has the same number of significant figures as 1.64 (i.e. to 3 significant figures).

Worked example:

Calculate the cube root of 2.9×10^6.

Solution

Step 1 Key in 2.9×10^6 as explained earlier

Step 2 Press the y^x button

Step 3 Key in (1÷3)

Step 4 Press =

The display should show '1.426 02' so the answer is 142.6

Summary questions

Write your answers to each of the following questions in standard form, where appropriate, and to the same number of significant figures as the data.

1 Copy and complete the following conversions.

a i 500 mm = ____m,

ii 3.2 m = ____cm,

iii 9560 cm = ____m,

b i 0.45 kg = ____g,

ii 1997 g = ____kg,

iii 54 000 kg = ____g,

c i $20\ cm^2$ = ____m^2,

ii $55\ mm^2$ = ____m^2,

iii $0.050\ cm^2$ = ____m^2

2 a Write the following values in standard form.

i 150 million km in metres, ii 365 days in seconds, iii 630 nm in metres, iv 25.7 µg in kilograms, v 150 m in millimetres, vi 1.245 µm in metres,

b Write the following values with a prefix instead of in standard form.

i 3.5×10^4 m = ____km,

ii 6.5×10^{-7} m = ____nm,

iii 3.4×10^6 g = ____kg,

iv 8.7×10^8 W = ____MW = ____GW

3 a Use the equation 'average speed = distance/time' to calculate the average speed in $m\ s^{-1}$ of:

i a vehicle that travels a distance of 9000 m in 450 s,

ii a vehicle that travels a distance of 144 km in 2 h,

iii a particle that travels a distance of 0.30 nm in a time of 2.0×10^{-18} s,

iv the Earth on its orbit of radius 1.5×10^{11} m, given the time taken per orbit is 365.25 days.

b Use the equation

$$\text{Resistance} = \frac{\text{potential difference}}{\text{current}}$$

to calculate the resistance of a component for the following values of current I and pd V.

i $V = 15$ V, $I = 2.5$ mA,

ii $V = 80$ mV, $I = 16$ mA,

iii $V = 5.2$ kV, $I = 3.0$ mA,

iv $V = 250$ V, $I = 0.51$ µA,

v $V = 160$ mV, $I = 53$ mA.

4 a Calculate each of the following: i 6.7^3 ii $(5.3 \times 10^4)^2$ iii $(2.1 \times 10^{-6})^4$ iv $(0.035)^2$ v $(4.2 \times 10^8)^{1/2}$ vi $(3.8 \times 10^{-5})^{1/4}$

b Calculate each of the following:

i $\dfrac{2.4^2}{3.5 \times 10^3}$

ii $\dfrac{3.6 \times 10^{-3}}{6.2 \times 10^2}$

iii $\dfrac{8.1 \times 10^4 + 6.5 \times 10^3}{5.3 \times 10^4}$

iv $7.2 \times 10^{-3} + \dfrac{6.2 \times 10^4}{2.6 \times 10^6}$