VISUAL PHYSICS ONLINE

SIGNIFICANT FIGURES

A measurement is the result some process of observation or experiment. The aim of any measurement is to estimate the "true" value of some physical quantity. However, we can never know the "true" value and so there is always some **uncertainty** associated with the measurement (except for some simple counting processes).

A rough method of indicating the degree of uncertainty is through quoting the correct number of **significant figures**. The usual convention is to quote no more than **one** uncertain figure. So, when you write down a number

The last figure in that number should be the one that is in doubt.

Rules for assigning significance to a digit

- Digits other than zero are always significant.
- Final zeros after a decimal point are always significant.
- Zeros between two other significant digits are always significant.
- Zeros at the end of a number maybe ambiguous in counting the number of significant figures.

Example 1

In a lab activity, four students calculated the mass of a brass block. The measurements they recorded were

M_1 = 2000.2041578 g

M_2 = 2002 g

M_3 = 2000 g

M_4 = 2000.2 g

Measurement 1 is given to 11 significant figures, the recording of such a measurement is ridiculous. The mass could not be calculated to this number of significant figures.

Measurement 2 has 4 significant figures.

Measurement 4 has 5 significant figures.

But, what about measurement 3 – it is ambiguous. The best way to clearly indicate the correct number of significant figures is to write the number in **scientific notation** with one digit to the left of the decimal place, so for measurement 3, we could write

$M_3 = 2 \times 10^3$ g (**1** significant figure)

$M_3 = 2.0 \times 10^3$ g (**2** significant figures)

$M_3 = 2.00 \times 10^3$ g (**3** significant figures)

$M_3 = 2.000 \times 10^3$ g (**4** significant figures)

A measurement such as 2000 g has an ambiguous number of significant figures, but without any other information, you can assume that it has 4 significant figures in doing a calculation.

Example 2

Remember, **the last digit is usually the one in doubt**.

For example, you probably know your height to a few centimetres and you could write it as

$h = 1.73$ m **3** is uncertain.

For a tall friend of yours, you can only guess their height and so you would record

$h = 1.9$ m **9** is the doubtful number.

Example 3

(a) 0.00341 (3 significant figures since $0.00341 = 3.41\times10^{-3}$).

(b) 2.0040×10^{4} (5 significant figures).

(c) 2.004 (4 significant figures).

Example 4

Counting numbers 101, 102, 103, … have an unlimited number of significant figures(sf).

Example 5 addition or subtraction

$160.45 + 6.73223 \quad \Rightarrow \quad 160.45 + 6.73 = 167.21$

Example 6 multiplication or division

In multiplication and division, the result should have no more significant figures than the number having the fewest number of sf. For example, 0.00172×120.46. 0.000172 has only 3 significant digits, and 120.46 has 5. So according to the rule the product answer could only be expressed with 3 significant digits.

$0.00172 \times 120.46 =$ **0.207**

Example 7 square root

The root or power of a number should have as many significant figures as the number itself. $\sqrt{3.142} = 1.773$

Recording a measurement of a physical quantity

The best way to record a measurement is to use one of the following formats:

(1) name of physical quantity, symbol (often used with subscript) = value ($\pm$ uncertainty) unit

(2) name of physical quantity, symbol (often used with subscript) = value unit

For the final recording of your measurement, the

last digit in any number is the one which in doubt

Small and large values should always be written in scientific notation.

Example 8

The measurement of Ian's waist can be recorded as

L = 0.87 m the digit is 7 is in doubt

$L = 8.7\times10^2$ mm the digit is 7 is in doubt (870 mm is misleading)

L = 0.875 m the digit is 5 is in doubt

$L = 8.75\times10^2$ mm the digit is 5 is in doubt

$L = (0.87 \pm 0.01)$ m uncertainty is $\pm$ 0.01 m (10 mm)

$L = (8.7 \pm 0.1) \times10^2$ mm uncertainty is $\pm$ 0.01 m (10 mm)

$L = (0.875 \pm 0.005)$ m uncertainty is $\pm$ 0.005 m (5 mm)

$L = (8.75 \pm 0.05)\times10^2$ mm

uncertainty is $\pm$ 0.005 m (5 mm)

L = 0.8764 mm

incorrect – cannot measure waist to < 1 mm

Example 9

Ian's height, h_1 = 1.70 m

Jan's height, $h_2 = (1.70 \pm 0.02)$ m

Ian's mass, m_1 = 65.2 kg

Jan's mass, $m_2 = (7.13 \pm 0.05) \times 10^3$ g

speed of light, $c = 3.000\times10^8$ m.s^{-1}

charge on electron, $e = 1.602\times10^{-19}$ C

VISUAL PHYSICS ONLINE

If you have any feedback, comments, suggestions or corrections please email:

Ian Cooper School of Physics University of Sydney

ian.cooper@sydney.edu.au