

Advanced Higher Physics

Uncertainties

Problems:

Solutions

# Uncertainty Tutorial 1.0 – Solutions

1 Total mass = 112 + 252 + 151 = 515 kg

Thus the uncertainty in the sum is given by: = 2.4 kg

Thus total mass = (515 ± 2) kg

~~Thus total mass = (515 ± 3) kg~~

Notice that simply adding the uncertainties in the masses is over pessimistic, giving 4 kg. The square root of the sum of the squares is better statistically in that uncertainties of this nature will sometimes cancel each other).

**Note**: the uncertainty is given as ± 2, not ± 2.4. Giving an excessive number of figures must be avoided. In general the uncertainty is given to one figure. Remember to give the value to the same number of decimal places as the uncertainty, see question 3 below where the 2.75 becomes 2.8

**~~Note~~**~~: the uncertainty is given as ± 3, not ± 2.4. Giving an excessive number of figures must be avoided. In general the uncertainty is given to one figure unless the leading digit is one, see question 4 below. Final uncertainty values are normally rounded up regardless of the following figures.~~

~~Remember to give the value to the same number of decimal places as the uncertainty, see question 3 below where the 2.75 becomes 2.8.~~

2 (a) & (b) uncertainty in the sum and difference =

= 0.3 mm (one sig. fig.)

Thus % uncertainty in sum = x 100 = 0.1 %

Thus % uncertainty in difference = x 100 = 13 %

(c) Usually the difference in two readings is needed when using the travelling microscope. Great care has to be taken when measuring very small distances, even with an “accurate” instrument large uncertainties can be incurred.

3 (a) Volume = L x B x H = 0.050 x 0.100 x 0.040 = 2.00 x 10-4 m3

density = = = 2.8 x 103 kg m-3

(b) % uncertainty in mass = x 100 = 0.4 %

% uncertainty in length = 2 %, % uncertainty in breadth = 1 %,

% uncertainty in height = 3 %

Thus % uncertainty in volume = = 3.7 % or 4%

The dominant uncertainty is in the volume. Thus the % uncertainty in density will be 4 %.

density = 2.8 x 103 ± 4 % kg m-3

= (2.8 ± 0.1) x 103 kg m-3

4 % uncertainty in radius, r = x 100 = 8 %

The volume depends on the cube of r:

the % uncertainty in the volume = 3 x 8 % = 24 %

volume =  (1.2 x 10-2)3 m3 = 7.24 x 10-6 m3

volume = (7.2 ± 1.7) x 10-6 m3

5 % uncertainty in mass = x 100 = 0.25 %

mean diameter = 0.248 m

random uncertainty in mean = = 0.0015

= 0.002 m

% uncertainty in mean diameter = x 100 = 0.8 %

The % uncertainty will be the same for the radius.

Thus moment of inertia of the disc = M R2 = 0.5 x 4.04 x (0.124)2

= 0.0311 kg m2

The dominant uncertainty here is in the radius, which is squared:

total % uncertainty = 2 x 0.8 % = 1.6 %

Thus moment of inertia = 0.0311 ± 1.6 %

= (0.0311 ± 0.0005) kg m2

6 refractive index, n = = = = 1.53

The easiest way to work out the uncertainty in a sine value is to work out the maximum and minimum values. Find the difference between these values and halve it.

Thus for 1 : sin 47° = 0.7314 sin 45° = 0.7071

Range = 0.0243 uncertainty = = 0.0122

Thus % uncertainty in sin 1 = x 100 = 1.7 % .

For 2 : sin 29° = 0.4848 sin 27° = 0.4540

Range = 0.0308 uncertainty = = 0.0154

Thus % uncertainty in sin 2 = x 100 = 3.3 %.

To find the overall uncertainty in refractive index these two uncertainties have to be combined.

% uncertainty in refractive index, n = =

= 3.7 % or 4 %

Final value : n = 1.53 ± 4 %

= 1.53 ± 0.06