Page 294 Test yourself

1 Remember to convert all measurements to standard units in this question.

a) Volume = 0.02 m × 0.02 m × 0.02 m = 8×10^{-6} m^3

b) Percentage uncertainty will be the sum of the percentage uncertainties in each measurement.

% uncertainty in measurement of one dimension = $\frac{2 \times 10^{-4}}{0.02} \times 100\% = 1\%$

∴ % uncertainty in volume = (1% + 1% + 1%) = 3%

c) density $= \frac{\text{mass}}{\text{volume}}$

$= \frac{0.0582}{8 \times 10^{-6}}$

= 7 280 kg m^{-3} (to 3 sf)

d) % uncertainty in density = % uncertainty in mass + % uncertainty in volume

uncertainty in mass = $\left(\frac{2 \times 10^{-4}}{0.0582}\right) \times 100\% = 0.3\%$

so % uncertainty in density = 3.3%

absolute uncertainty = $\frac{(3.3 \times 7\,280)}{100}$ = 240 kg m^{-3}

The density is therefore written as 7 280 kg m^{-3} ± 240 kg m^{-3}

2 Spring constant = $\frac{10\text{ N}}{0.032\text{ m}}$ = 313 N m^{-1}

% uncertainty in force = $\left(\frac{0.1\text{N}}{10\text{N}}\right) \times 100\% = 1\ \%$

% uncertainty in extension = $\left(\frac{0.001\text{ m}}{0.032\text{ m}}\right) \times 100\% = 3.1\%$

total percentage uncertainty = 1% + 3.1% = 4.1%

So the spring constant is 313 N m^{-1} ± 4.1%

3 speed = $\frac{distance}{time}$

speed = $\frac{100.00\text{ m}}{9.63\text{ s}}$ = 10.38 m s^{-1}

% uncertainty in distance = $\left(\frac{0.01\text{ m}}{100.00\text{ m}}\right) \times 100\% = 0.01\ \%$

% uncertainty in time = $\left(\frac{0.01\text{ s}}{9.63\text{ s}}\right) \times 100\% = 0.1\ \%$

So % uncertainty in speed = 0.11 %

absolute uncertainty = $\frac{(0.11 \times 10.38)}{100}$ = 0.01 m s^{-1}

so average speed = 10.38 m s^{-1} ± 0.01 m s^{-1}

Page 295 Activity

Dropping a bouncy ball

1 Ball may not be dropped from measured height. Mitigate by ensuring ruler is fixed and vertical (plumb line), positioning head to ensure no parallax errors or even using another ruler/card at right angles to rule position base of ball.

Measuring maximum bounce height is very subjective. Could do trials from each height to get rough idea of where ball will get to to ensure observer is in a suitable position. If have a suitable camera, could film experiment and examine relevant frames to determine position.

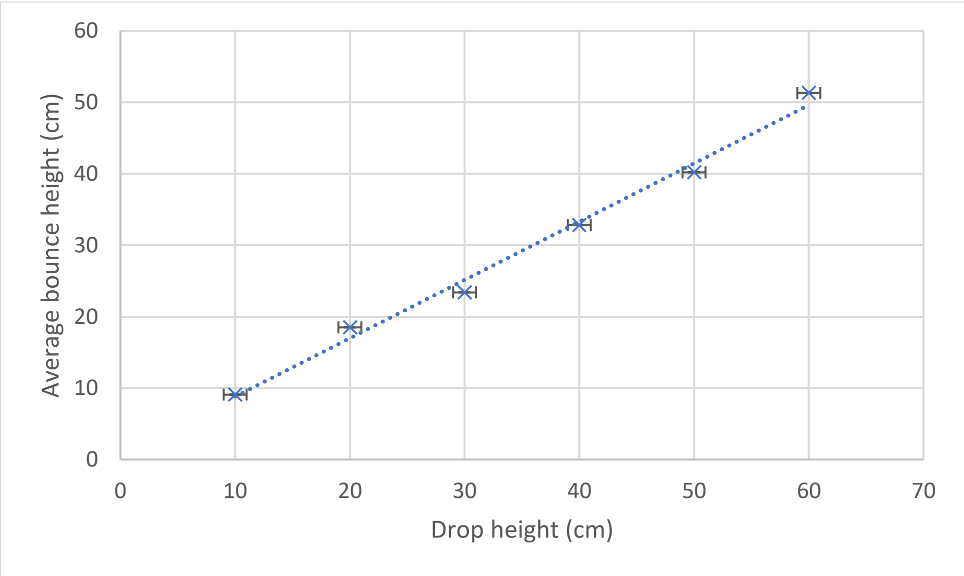
2 If a method is used that ensures good alignment, the uncertainty in drop height could be as little as ± 0.1cm

3

Drop height (cm)	10.0	20.0	30.0	40.0	50.0	60.0
Bounce 1 (cm)	9.0	18.0	23.2	32.0	40.0	50.5
Bounce 2 (cm)	9.5	17.5	23.0	33.5	40.5	52.0
Bounce 3 (cm)	8.8	20.0	24.0	32.8	40.0	51.5
Average bounce height (cm)	**9.1**	**18.5**	**23.4**	**32.8**	**40.2**	**51.3**
Uncertainty in bounce height (cm)	0.35	1.25	0.5	0.75	0.25	0.75

4 (no answer required)

5



6 Using the value of the gradient calculated by Excel, the efficiency is 82 %.
By drawing lines of steepest and shallowest fit, the uncertainty can be estimated at 3%.

Pages 296–297 Test yourself

4 a) The reading 0.81 is much larger that the other four readings, and may be discarded. If she had noticed during her measurements, the student should have retaken the reading. A possible source of the error might be due to the student writing down the value incorrectly (i.e. writing 0.81 mm instead of 0.18 mm).

Mean value = 0.19 mm

b) Uncertainty = ½ x range of measurement values

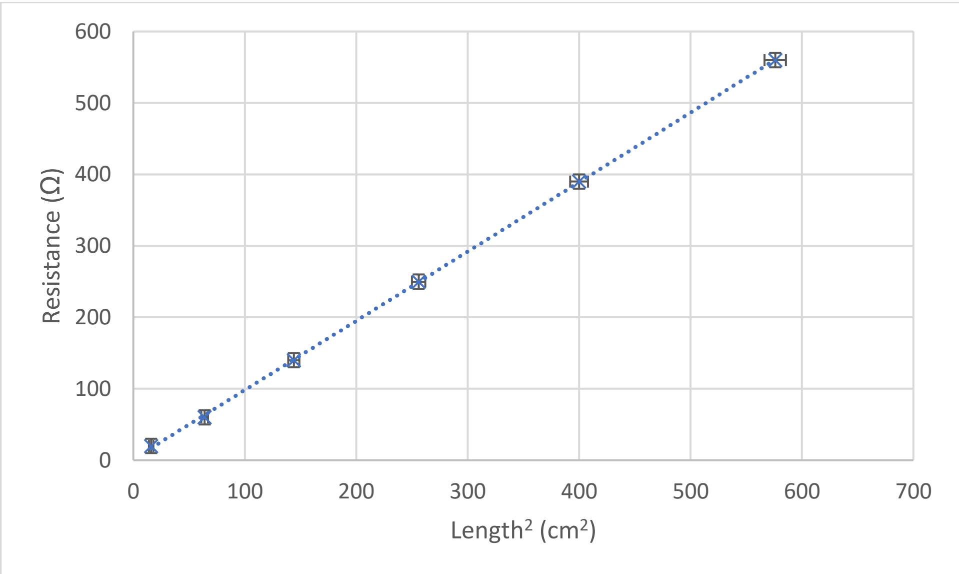
= 0.02 mm

5 a) Rewriting the equation in the form y = mx + c we get $R = \frac{\rho}{V} l^2$. So if a plot of R against l^2 is a straight-line graph with no y intercept, then the relationship is correct.

b) i) To calculate the uncertainty in l^2 we need to double the percentage uncertainty in l and then calculate the absolute uncertainty. This is because we are multiplying the length by itself.

The data to be plotted is given in the table.

l^2 / cm^2	R / Ω
16 ± 2	20 ± 10
64 ± 3	60 ± 10
144 ± 5	140 ± 10
256 ± 6	250 ± 10
400 ± 8	390 ± 10
576 ± 9.6	560 ± 10



ii) Gradient = 0.973 Ω cm^{-2}

iii) This will depend on the lines drawn. Gradients of these lines will be between 0.910 Ω cm^{-2} and 1.02 Ω cm^{-2}. The uncertainty of the gradient will therefore be around $\pm$ 0.055 Ω cm^{-2}.

c) gradient = $\frac{\rho}{V}$

So resistivity = gradient × V = 0.979 Ω cm^{-2} × 26.8 cm^3 = 26.2 Ω cm

6 For each paperclip chain the length and the period need to be measured.

Link together a number (e.g. 20) of paperclips.

Use a ruler to measure the length of the chain and record the data.

Suspend the chain from a fixed point such as clamp stand. Displace the chain to one side and note the position to which it is displaced.

Release the chain and record the time taken for 10 oscillations. The period is calculated by dividing this time by 10.

The timing could be repeated three times.

Repeat the measurements for at least 5 further lengths of chain.

Chain must be released from same position each time, and in the same way. It should swing in the same plane. A marker should be used to indicate this position.

Using 10 oscillations reduces the effect of human error / reaction time on the measurement of period. Place a marker behind the equilibrium position and using that position to time the oscilliations will further reduce error.

A graph of periodic time against √length is plotted. A straight line graph through the origin would indicate that the relationship is correct.