1 The table shows some physical quantities.

Which row correctly identifies the quantities as scalars or vectors?

	acceleration	charge	kinetic energy	wavelength
A	scalar	vector	vector	scalar
B	vector	vector	scalar	scalar
C	scalar	scalar	scalar	vector
D	vector	scalar	scalar	scalar

2 Two quantities are measured.

$$L = 6.8 \pm 0.1\,\text{cm}$$

$$T = 2.42 \pm 0.08\,\text{s}$$

L and T are related to X by the equation shown.

$$X = \frac{4\pi^2 L}{T^2}$$

What is the calculated value and uncertainty of X?

A $45.8 \pm 0.2\,\text{cm s}^{-2}$

B $45.8 \pm 0.3\,\text{cm s}^{-2}$

C $46 \pm 2\,\text{cm s}^{-2}$

D $46 \pm 4\,\text{cm s}^{-2}$

3 What are the SI base units of the watt?

A J s^{-1} **B** $\text{kg m}^2\text{s}^{-3}$ **C** $\text{kg m}^2\text{s}^{-1}$ **D** N m s^{-1}

15 A man of weight 600 N stands with both feet flat on the ground.

What is a reasonable estimate of the pressure exerted on the ground by the weight of the man?

A $1 \times 10^0\,\text{Pa}$ **B** $1 \times 10^2\,\text{Pa}$ **C** $1 \times 10^4\,\text{Pa}$ **D** $1 \times 10^6\,\text{Pa}$

22 What are the SI base units of stress?

A kg m s^{-2} **B** $\text{kg m}^{-1}\text{s}^{-2}$ **C** $\text{kg m}^{-2}\text{s}^{-2}$ **D** $\text{kg m}^{-3}\text{s}^{-2}$

2 In this experiment, you will investigate the rolling of a plastic bottle.

(a) **(i)** You are provided with a plastic bottle with a cap, as shown in Fig. 2.1.

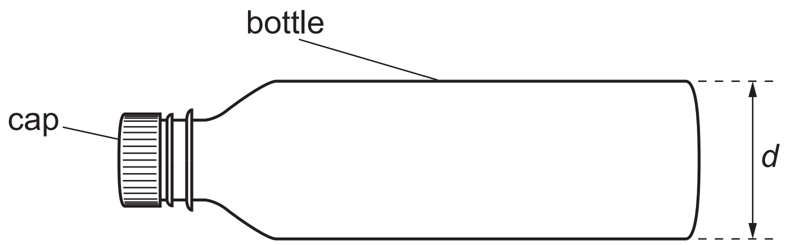

Fig. 2.1

The diameter of the base of the bottle is *d*.

Measure and record *d*.

d = ... [1]

(ii) Estimate the percentage uncertainty in your value of *d*. Show your working.

percentage uncertainty = ... % [1]

(b) • Set up the apparatus as shown in Fig. 2.2.

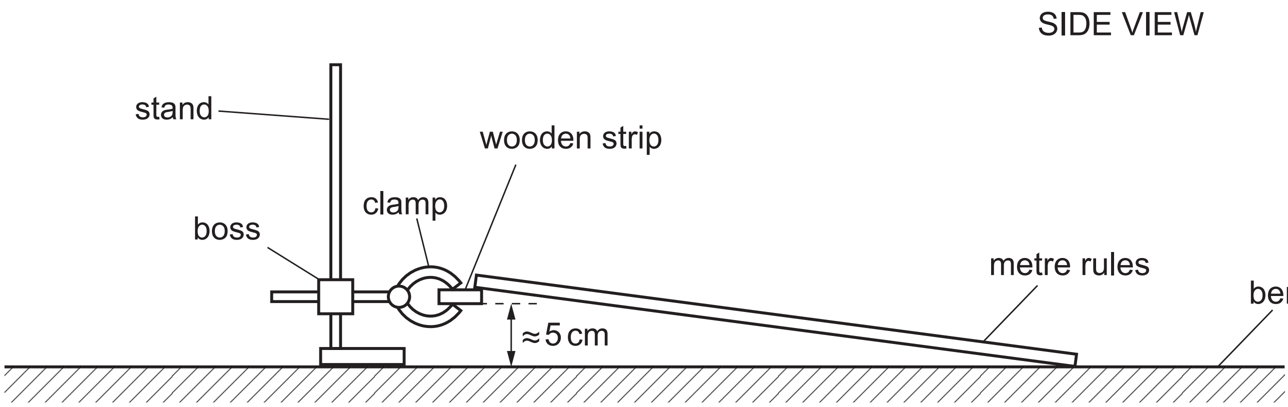

Fig. 2.2

- Adjust the two metre rules so that the rules are approximately parallel to each other, as shown in Fig. 2.3.

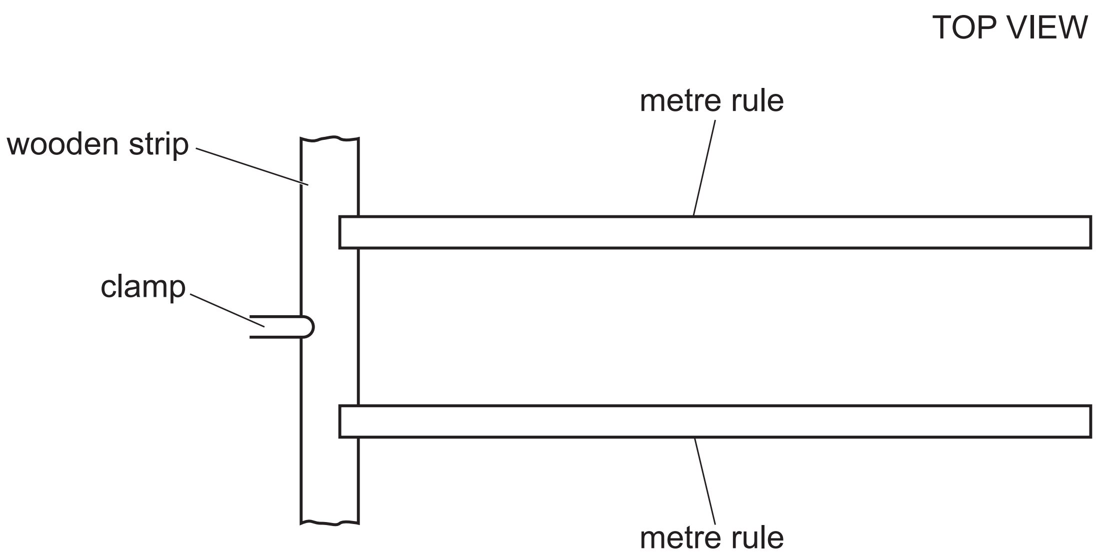

Fig. 2.3

- Pour all the water from the beaker into the bottle.

- Place the bottle on the two rules as shown in Fig. 2.4.

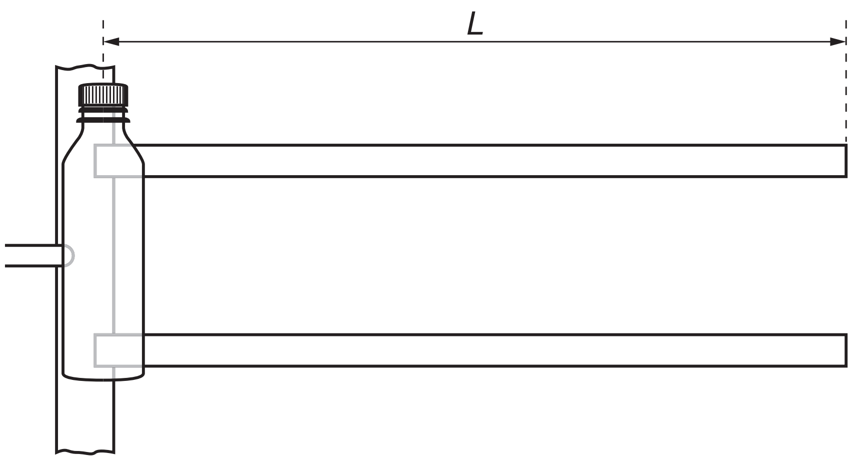

Fig. 2.4 (not to scale)

- Release the bottle. Adjust the rules so that the bottle rolls to the end of the rules.

- The distance that the bottle rolls on the rules is L, as shown in Fig. 2.4.

  Measure and record L.

L = ... [1]

(c) (i) • Stand the bottle upright on the bench.

• The height of the water in the bottle is h, as shown in Fig. 2.5.

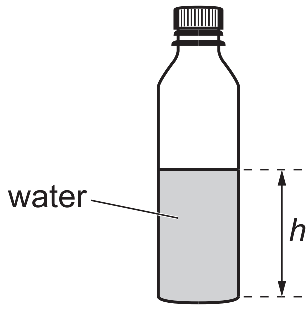

Fig. 2.5

Measure and record h.

h = ...

• The time for the bottle to roll distance L on the rules is t.

Take measurements to determine t.

t = ...
[3]

(ii) A value for the acceleration a of the bottle is given by

$$a = \frac{2L}{t^2}.$$

Calculate a.

a = ... [1]

(iii) Justify the number of significant figures that you have given for your value of a.

....

....

.... [1]

(d) • Pour approximately half the water from the bottle into the beaker.

• Repeat **(c)(i)** and **(c)(ii)**.

h = ...

t = ...

a = ...
[2]

(e) It is suggested that the relationship between a and h is

$$a = \frac{kd\sqrt{\pi h}}{2}$$

where k is a constant.

Using your data, calculate **two** values of k.

first value of k = ...

second value of k = ...
[1]

(f) It is suggested that the percentage uncertainty in the values of k is 15%.

Using this uncertainty, explain whether your results support the relationship in **(e)**.

....

....

....

.... [1]

(g) **(i)** Describe **four** sources of uncertainty or limitations of the procedure for this experiment.

For any uncertainties in measurement that you describe, you should state the quantity being measured and a reason for the uncertainty.

1 ....

....

2 ....

....

3 ....

....

4 ....

....
[4]

(ii) Describe **four** improvements that could be made to this experiment. You may suggest the use of other apparatus or different procedures.

1 ....

....

2 ....

....

3 ....

....

4 ....

....
[4]

[Total: 20]

1 In this experiment, you will investigate the phase difference between the oscillations of two mass–spring systems.

(a) • Assemble the apparatus as shown in Fig. 1.1.

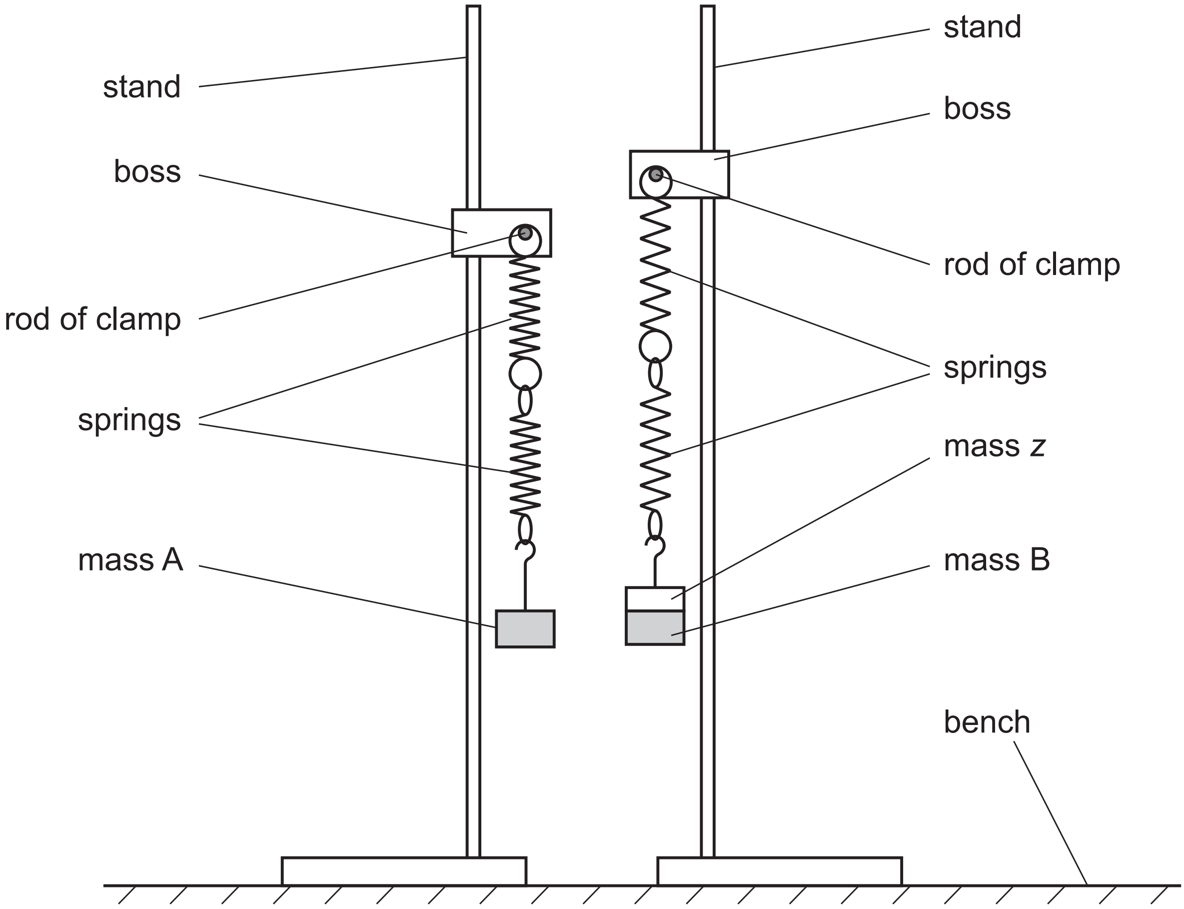

Fig. 1.1

- Mass A and mass B are each 200 g.
- Add a mass z of 40 g to mass B.

  Record the value of z.

z = ... g

- M is given by $M = 200\,\text{g} + z$.

  Calculate M.

M = ... g

- Pull both A and B down a short distance and release them together. Observe the oscillations. A and B initially oscillate in phase (both moving up and down together), then their oscillations go out of phase and then become in phase again.

- The time from A and B oscillating in phase to the next time they oscillate in phase is *P*.

  Measure and record *P*.

P = ...

[2]

(b) Change z and determine P. Repeat until you have six sets of values of z and P.

Record your results in a table. Include values of M, $\frac{1}{\sqrt{M}}$ and $\frac{1}{P}$ in your table.

[10]

(c) **(i)** Plot a graph of $\frac{1}{P}$ on the y-axis against $\frac{1}{\sqrt{M}}$ on the x-axis. [3]

(ii) Draw the straight line of best fit. [1]

(iii) Determine the gradient and y-intercept of this line.

gradient = ...

y-intercept = ...

[2]

(d) It is suggested that the quantities P and M are related by the equation

$$\frac{1}{P} = \frac{a}{\sqrt{M}} + b$$

where a and b are constants.

Use your answers in **(c)(iii)** to determine the values of a and b.
Give appropriate units.

a = ...

b = ...
[2]

[Total: 20]

You may not need to use all of the materials provided.