1. A simple pendulum may be used to determine a value for the acceleration of free fall g.

Measurements are made of the length L of the pendulum and the period T of oscillation.

The values obtained, with their uncertainties, are as shown.

$$T = (1.92 \pm 0.02)\text{ s}$$

$$L = (91 \pm 1)\text{ cm}$$

(a) Calculate the percentage uncertainty in the measurement of

(i) the period T,

$= \dfrac{\Delta T}{T} \times 100\%$

$= \dfrac{0.02}{1.92} \times 100\%$

= 1.04 % -----A(1)

uncertainty = ………1.04……. % [1]

(ii) the length L.

$= \dfrac{\Delta L}{L} \times 100\%$

$= \dfrac{1}{91} \times 100\%$

= 1.10 % -------A(1)

uncertainty = ……1.10……. % [1]

(b) The relationship between T, L and g is given by

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

Using your answers in (a), calculate the percentage uncertainty in the value of g.

$\dfrac{\Delta g}{g} \times 100\% = \dfrac{\Delta L}{L} \times 100\% + 2\dfrac{\Delta T}{T} \times 100\%$

$= 1.10\% + 2(1.04\%)$ …..C(1)

= 3.2 % ----A(1)

uncertainty = …3.2% [2]

(c) The values of L and T are used to calculate a value of g as 9.745 m s^{-2}.

By reference to the measurements of L and T, suggest why it would not be correct

to quote the value of g as 9.745 m s^{-2}.

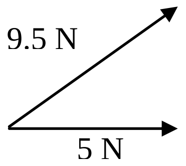
..values have more s.f than data ------- (B2)

Or actual uncertainty is $\pm 0.3 ms^{-2}$ ---------(B2) [2]

(b) An object is acted upon by two forces at right angles to each other. One of the forces has a magnitude of 5.0 N and the resultant force produced on the object is 9.5 N.

Determine

(i) the magnitude of the other force,



$F = \sqrt{(9.5)^2 - 5^2}$ ----C(1)

= 8.1 N-----A(1)

force = 8.1N [2]

(ii) the angle between the resultant force and the 5.0 N force.

$\cos\theta = \frac{5}{9.5}$ ------C(1)

θ = 58 ° ------A(1)

angle = 58° [2]

2 (a) Complete Fig. 2.1 to show whether each of the quantities listed is a vector or a scalar.

	vector/scalar
distance moved	scalar.......... B1
speed	scalar.......... B1
acceleration	vector.......... B1

Fig 2.1 [3]

(b) A ball falls vertically in air from rest. The variation with time t of the distance d moved by the ball is shown in Fig. 2.2

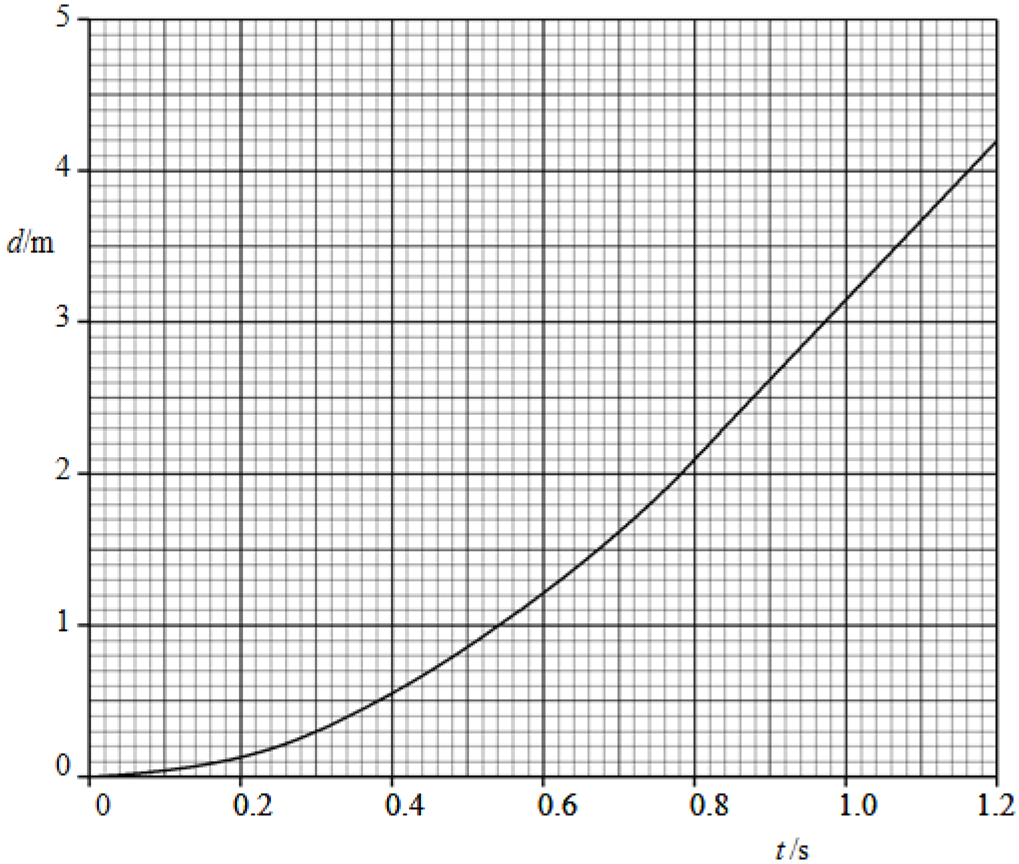


Fig. 2.2

(i) By reference to Fig. 2.2, explain how it can be deduced that

1. the ball is initially at rest,
gradient (of graph) is the speed/velocity (can be scored here or in 2) B1
initial gradient is zero .... B1 [2]

2. air resistance is not negligible.
.... gradient (of line/graph) becomes constant .... B1 [1]

(ii) Use **Fig. 2.2** to determine the speed of the ball at a time of 0.40 s after it has been released.

speed = (2.8 ± 0.1) ms^{-1} .... A2 [2]
(if answer > ±0.1 but ≤ ±0.2, then award 1 mark)

(iii) On Fig. 2.2, sketch a graph to show the variation with time *t* of the distance *d* moved by the ball for negligible air resistance. You are not expected to carry out any further calculations. [3]

curved line never below given line and starts from zero B1
continuous curve with increasing gradient B1
line never vertical or straight .... B1 [3]

3 (a) State the relation between force and momentum.

. force = rate of change of momentum .... (allow symbols if defined) .... B1 [1]

(b) A rigid bar of mass 450g is held horizontally by two supports A and B, as shown in Fig. 3.1.

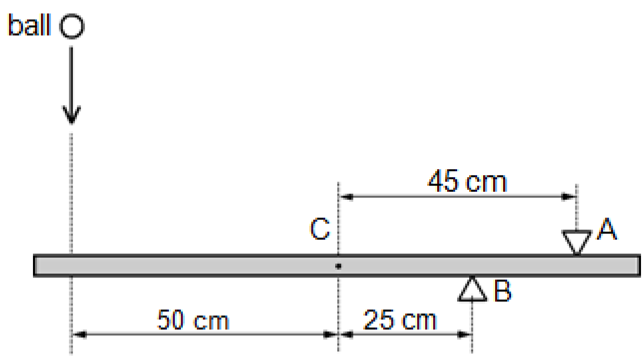


Fig. 3.1

The support A is 45 cm from the centre of gravity C of the bar and support B is 25 cm from C.

A ball of mass 140 g falls vertically onto the bar such that it hits the bar at a

distance of 50 cm from C, as shown in Fig. 3.1.
The variation with time t of the velocity v of the ball before, during and after hitting the bar is shown in Fig. 3.2

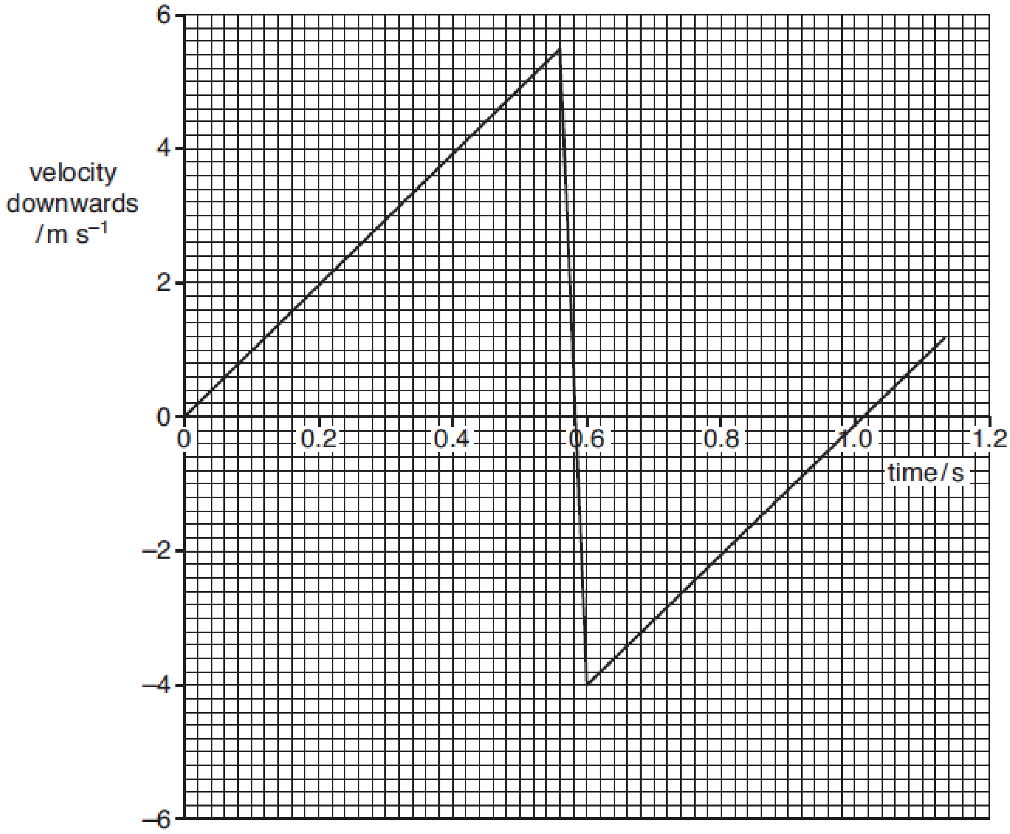


Fig. 3.2

For the time that the ball is in contact with the bar, use Fig. 3.2

(i) to determine the change in momentum of the ball,

$\Delta\rho = 140 \times 10^{-3} \times (5.5 + 4.0)$ C1
$= 1.33$ kg m s^{-1} .... A1 [2]

(ii) to show that the force exerted by the ball on the bar is 33 N.

force = 1.33 / 0.04 .... M1
= 33.3 N .... A0 [1]

(c) For the time that the ball is in contact with the bar, use data from Fig. 3.1 and **(b)(ii)** to calculate the force exerted on the bar by

(i) the support A,

taking moments about B C1
$(33 \times 75) + (0.45 \times g \times 25) = F_A \times 20$ C1
$F_A = 129$ N A1 [3]

(ii) the support B.

$F_B = 33 + 129 + 0.45g$ C1
$= 166$ N A1 [2]

5 (a) must show working M1
$v = 30.6$ m s^{-1}. A0

(b)(i) $W = 750 \times 10 \times 10^3$ C1
$= 7.5 \times 10^6$ J A1

(ii) output power $P = 750 \times 30.6$ C1
$= 2.30 \times 10^3$ W A1

(III) Input power $= \dfrac{100}{30} \times 2.30 \times 10^3$ C1
$= 7.67 \times 10^3$ W

6 (a) Elastic deformation: no permanent extension after force is removed
Plastic deformation: permanent extension after force is removed. B1

Elastic deformation: energy is recovered
Plastic deformation: energy lost as heat B1

(b) each graph correct
.... B1
(Total : B3)

7 (a)(i) $f = 1/(5 \times 10^{-3})$ C1
=200 Hz A1

(ii) $I \propto A^2$, or other working.. C1
Amplitude = ½ A A1

(b) Graph sketched has : correct amplitude B1
Same frequency as T_1 .... B1
Phase difference correct B1

8(a)(i) monochromatic light: light of single value of wavelength B1

(ii) Coherent: constant phase difference …………………………….. B1

(b) $\lambda = \frac{xa}{D} = \frac{2.0x10^{-3}\,x0.60x10^{-3}}{2.0}$ ……………………………………. C1

= 6.0×10^{-7} m…………………………………………………….. A1

9 (a) at least 3 parallel lines, equal separation apart, perpendicular to plate B1

(b) electric field e = $\frac{300}{25x10^{-3}}$ = 12,000 NC^{-1} ……………………………. C1

Force = $1.60 \times 10^{-19} \times 12000$ ………………………………………….. C1

= 1.92×10^{-15} N …………………………………………….. A1

(c) (i) $1.92 \times 10^{-15} = 9.11 \times 10^{-31}$ a ……………………………………. C1

a = 2.11×10^{15} ms^{-2} …………………………………………………… A1

(ii) $v^2 = 0 + 2 \times 2.11 \times 10^{15} \times 25 \times 10^{-3}$ ……………………………. C1

v = 1.03×10^7 ms^{-1} …………………………………………… A1