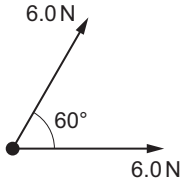
4 The diagram shows two forces of 6.0 N acting on an object. The angle between the lines of action of the two forces is 60°.

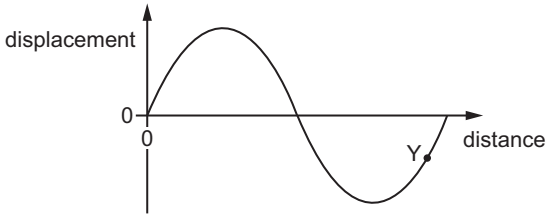


What is the magnitude of the resultant force?

A 6.0 N **B** 7.9 N **C** 10 N **D** 12 N

25 A source emits a progressive sound wave in the horizontal direction. The wave travels away from the source in a direction towards the right.

The graph shows the variation of the displacement of the particles from their equilibrium positions with distance from the source at a particular instant in time. Displacements to the right of the equilibrium positions are shown as positive.



Position Y represents the displacement of a particle in the sound wave at a particular distance from the source at this instant.

Which statement about the motion of this particle is correct?

A The particle is moving away from the source.

B The particle is moving towards the source.

C The particle is moving upwards.

D The particle is moving downwards.

5 A projectile is fired at an angle of 45° upwards from horizontal ground. Air resistance is negligible.

Which row describes the horizontal motion and the vertical motion of the projectile after it is fired until immediately before it reaches the ground again?

	horizontal motion	vertical motion
A	constant velocity	constant acceleration
B	constant velocity	varying acceleration
C	varying velocity	constant acceleration
D	varying velocity	varying acceleration

6 An aircraft on a runway accelerates uniformly from rest to its take-off speed of 58 m s^{-1}.

The acceleration of the aircraft is 4.2 m s^{-2}, and the aircraft uses 74% of the length of the runway to reach its take-off speed.

What is the length of the runway?

A 300 m **B** 540 m **C** 590 m **D** 800 m

1 **(a)** In terms of velocity and acceleration, describe uniform circular motion of an object.

.....

.....

..... [2]

(b) Fig. 1.1 shows the view from above of a polystyrene ball undergoing horizontal circular motion of radius *R*.

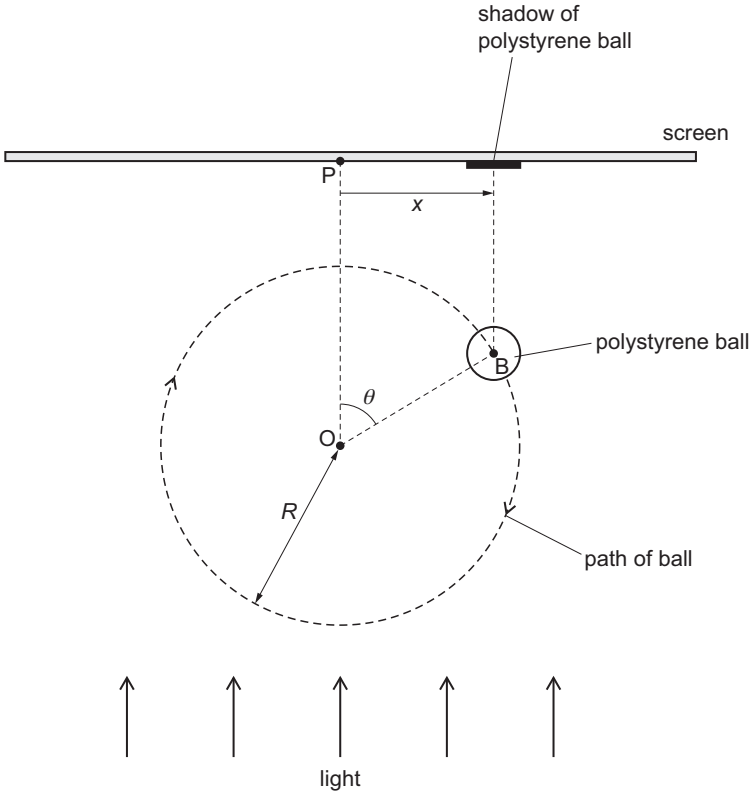


Fig. 1.1

The ball is illuminated by parallel light so that a shadow of the ball forms on a screen placed on the opposite side of the ball from the light source.

The line joining points O and P is perpendicular to the screen.

The angular speed of the circular motion is ω.

(i) State an expression, in terms of *R* and ω, for the speed *v* of the ball.

v = ... [1]

(ii) Determine an expression, in terms of *v* and ω, for the centripetal acceleration of the ball.

centripetal acceleration = ... [2]

(c) The ball in **(b)** is in the position shown in Fig. 1.1, such that line OB is at an angle θ to the line OP.

(i) Determine an expression, in terms of *R* and θ, for the displacement *x* of the shadow from P.

x = ... [1]

(ii) The value of θ is zero at time $t = 0$.

State an expression for θ in terms of ω and *t*.

θ = ... [1]

(iii) Use your answers in **(c)(i)** and **(c)(ii)** to show that *x* is given by

$$x = R\sin\omega t.$$

[1]

(iv) Explain, with reference to the equation in **(c)(iii)**, why the motion of the shadow of the ball on the screen may be modelled as simple harmonic.

.....

[1]

(d) The circular motion of the ball in Fig. 1.1 has a diameter of 0.46 m and an angular speed of 1.9 rad s^{-1}.

For the simple harmonic motion of the shadow of the ball in Fig. 1.1, calculate:

(i) the amplitude

amplitude = ... m [1]

(ii) the period

period = ... s [2]

(iii) the maximum acceleration.

maximum acceleration = ... m s^{-2} [2]

(e) On Fig. 1.1, draw, and label with the letter A, the position of the shadow on the screen when the shadow has its maximum positive acceleration. [1]

[Total: 15]

19 The momentum of a car of mass m increases from p_1 to p_2.

What is the increase in the kinetic energy of the car?

A $\frac{(p_2^2 - p_1^2)}{2m}$ **B** $\frac{(p_2 - p_1)^2}{2m}$ **C** $\frac{p_2 - p_1}{2m}$ **D** $\frac{p_1 - p_2}{2m}$

7 A solid object of mass 1.0 kg falls vertically downwards in a vacuum.

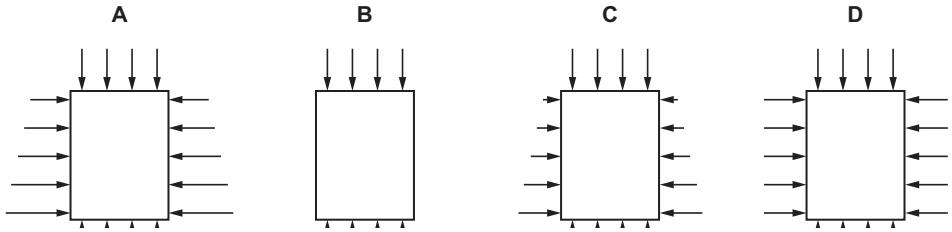
When the speed of the object is 60 m s^{-1}, an additional constant force of 50 N suddenly starts to act vertically upwards on the object.

What is the speed of the object 2.0 s after the additional force starts to act?

A 20 m s^{-1} **B** 40 m s^{-1} **C** 80 m s^{-1} **D** 100 m s^{-1}

16 A block is submerged vertically in a liquid. The four diagrams show the block viewed from the side.

Which diagram shows, to scale, the forces exerted on equal areas of the block by the liquid?



32 A wire is made from a metal of constant resistivity. There is a constant current in the wire.

Which statement about the potential difference across the wire is correct?

A It is directly proportional to the length of the wire.

B It is inversely proportional to the length of the wire.

C It is directly proportional to the diameter of the wire.

D It is inversely proportional to the diameter of the wire.

1 What represents a vector quantity?

A 1 N upwards

B 2 kg decrease

C 3 K cooler

D 4 s later

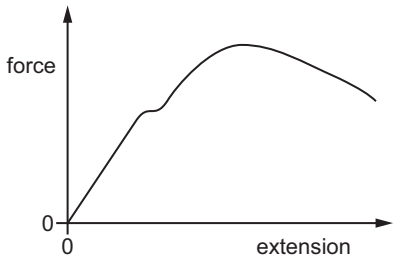
15 A measuring cylinder contains 80 cm^3 of a liquid.

The pressure due to the liquid at the 60 cm^3 mark is 1200 Pa.

What is the pressure due to the liquid at the base of the measuring cylinder?

A 1200 Pa **B** 1600 Pa **C** 3600 Pa **D** 4800 Pa

21 The force–extension graph for a metal wire is shown.



Which quantity is represented by the area under the graph?

A power transferred to the wire

B temperature increase in the wire

C time taken for the wire to extend

D work done on the wire

37 A uranium atom with a charge of +2*e* has a nucleon number of 235 and a proton number of 92.

e is the elementary charge.

What is the total number of protons, neutrons and electrons in this charged atom?

A 235 **B** 325 **C** 327 **D** 329

2 In this experiment, you will investigate the behaviour of paper on water.

You have been provided with two sheets of tracing paper.

(a) • On one of the sheets of tracing paper, draw two identical rectangles as shown in Fig. 2.1 where c = 4.0 cm and d = 6.0 cm. The orientation of the rectangles must be as shown in Fig. 2.1.

• Add labels A and B to the rectangles, as shown in Fig. 2.1.

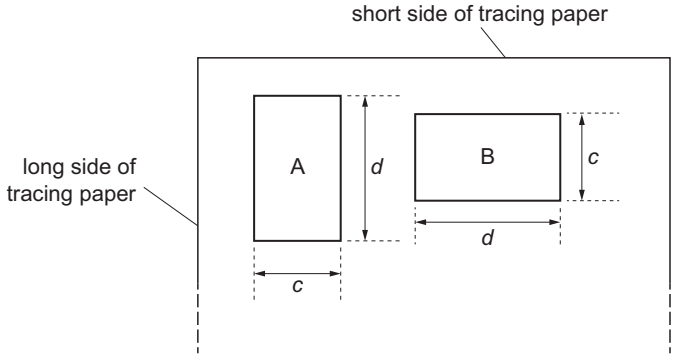


Fig. 2.1

• Use the scissors to cut out the rectangles.

• Take measurements to determine the average value of d.

d = ... cm [1]

(b) (i) • When A is placed flat on the surface of the water in one of the bowls, the shape will curl up as shown in Fig. 2.2. Two edges of the paper will curl and then meet.

Fig. 2.2

The time between placing A on the water and the two edges meeting is T_A.

- Place A flat on the water.
- Determine T_A.

T_A = ...

- Remove A from the water and place it in the empty bowl.

[2]

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

percentage uncertainty = ... % [1]

(c) (i) • Repeat the procedure in **(b)(i)** for B. The time between placing B on the water and the two edges meeting is T_B.

T_B = ...

- Remove B from the water.
- Compare your values of T_A and T_B. Record the longer time.

longer time = ...

[1]

(ii) The quantity W is given by

$$W = \frac{\text{longer time}}{\text{shorter time}}.$$

Calculate W.

W = ... [1]

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

.....

.....

..... [1]

(d) Repeat **(a)**, **(b)(i)**, **(c)(i)** and **(c)(ii)** using new rectangles with c = 4.0 cm and d = 9.0 cm.

d = ... cm

T_A = ...

T_B = ...

longer time = ...

W = ...

[3]

(e) It is suggested that the relationship between W and d is

$$W^2 = kd$$

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 20%.

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]

2 A student investigates an electrical circuit.

The circuit is set up as shown in Fig. 2.1.

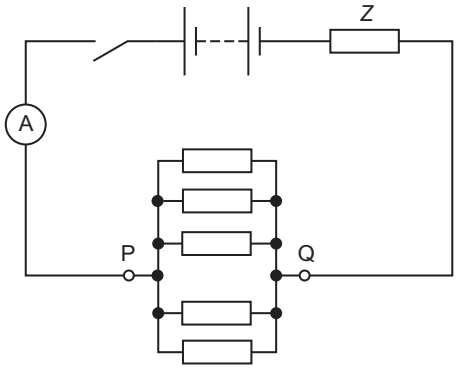


Fig. 2.1

A battery of negligible internal resistance is connected to a resistor of resistance Z. Five resistors, each of resistance R, are connected in parallel between P and Q.

The switch is closed. The total current I in the circuit is measured using the ammeter.

The experiment is then repeated by changing the number n of resistors, each of resistance R, connected in parallel between P and Q.

It is suggested that I and n are related by the equation

$$E = I\left(\frac{R}{n} + Z\right)$$

where E is the electromotive force (e.m.f.) of the battery.

(a) A graph is plotted of $\frac{1}{I}$ on the y-axis against $\frac{1}{n}$ on the x-axis.

Determine expressions for the gradient and y-intercept.

gradient = ...

y-intercept = ...
[1]

(b) Values of n, $\frac{1}{n}$ and I are given in Table 2.1.

Table 2.1

n	$\frac{1}{n}$	I / μA	$\frac{1}{I}$ / $10^3 A^{-1}$
5	0.200	455 ± 5	
6	0.167	525 ± 5	
7	0.143	580 ± 5	
8	0.125	635 ± 5	
9	0.111	685 ± 5	
11	0.0909	765 ± 5	

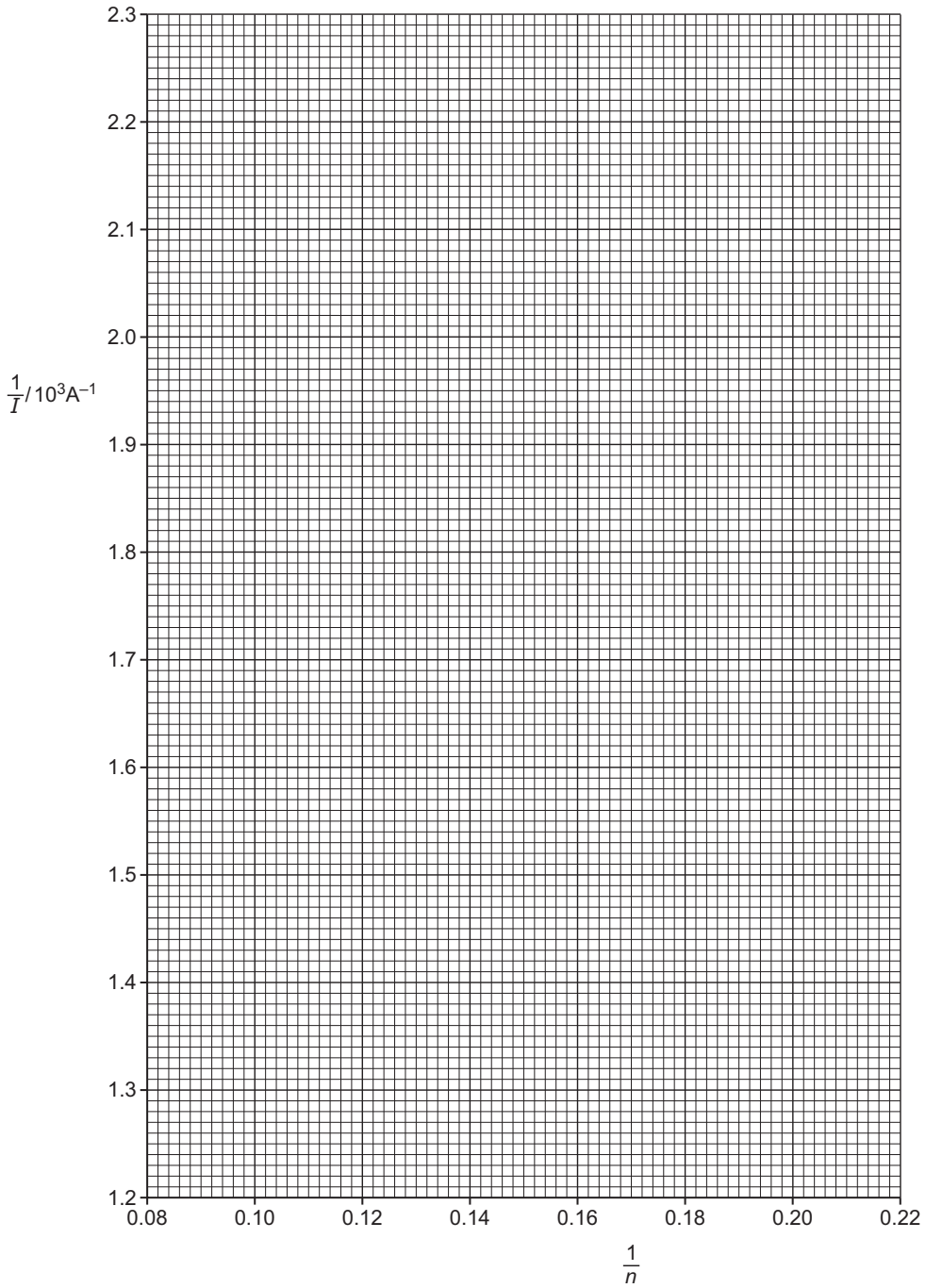
Calculate and record values of $\frac{1}{I}$ / $10^3 A^{-1}$ in Table 2.1. Include the absolute uncertainties in $\frac{1}{I}$.
[2]

(c) **(i)** Plot a graph of $\frac{1}{I}$ / $10^3 A^{-1}$ against $\frac{1}{n}$. Include error bars for $\frac{1}{I}$. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Label both lines. [2]

(iii) Determine the gradient of the line of best fit. Include the absolute uncertainty in your answer.

gradient = ... [2]



(iv) Determine the *y*-intercept of the line of best fit. Include the absolute uncertainty in your answer.

y-intercept = ... [2]

(d) The e.m.f. E of the battery is determined twice during the experiment. The values obtained are 5.6 V and 6.0 V.

(i) Using your answers to **(a)**, **(c)(iii)** and **(c)(iv)**, determine the values of R and Z. Include appropriate units.

R = ...

Z = ...
[2]

(ii) Determine the percentage uncertainty in your value of R.

percentage uncertainty = ... % [1]

(e) The experiment is repeated with 20 resistors, each of resistance R, connected in parallel between P and Q. Determine the total current I in the circuit.

I = ... A [1]

[Total: 15]

1 A ball is dropped on to an inclined thin metal sheet, as shown in Fig. 1.1.

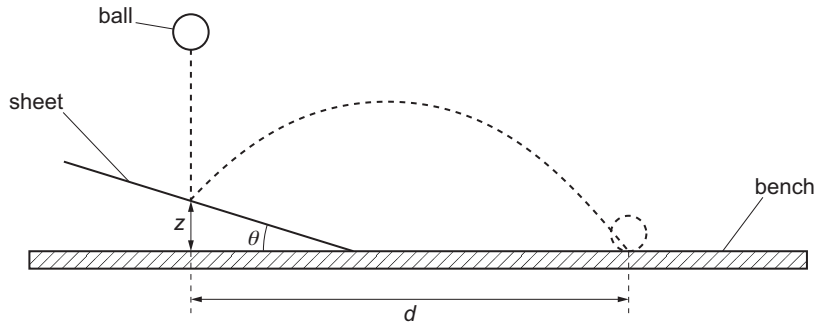


Fig. 1.1 (not to scale)

The angle between the sheet and the horizontal bench is θ. The height of the point of contact of the ball and the sheet is z. The horizontal distance travelled by the ball between its points of contact with the sheet and the bench is d, as shown in Fig. 1.1.

It is suggested that d is related to θ by the relationship

$$d = \frac{Pv^2 \sin 4\theta}{g} + Q\sqrt{z}$$

where v is the speed of the ball as it makes contact with the sheet, g is the acceleration of free fall, and P and Q are constants.

Plan a laboratory experiment to test the relationship between d and θ.

Draw a diagram showing the arrangement of your equipment.

Explain how the results could be used to determine values for P and Q.

In your plan you should include:

- the procedure to be followed
- the measurements to be taken
- the control of variables
- the analysis of the data
- any safety precautions to be taken.

Diagram

[15]