A LEVEL

Physics Paper 2

Topical Pastpaper Questions

2016 - 2020

For Examinations to be held in 2022 and Onwards

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Preface

A Level Physics Paper 2 Topical Pastpaper Questions provide complete practice and revision for students taking A Level Physics (9702) Examination to be held in 2022 and onwards.

It has been an established fact that the questions from past papers provide the students with the best practice. They are able to apply what they have learnt and therefore, can judge their knowledge of the subject.

This book contains

- **218 Questions** carefully selected from 2016 to 2020 past papers including Feb/March series.
- The topics are listed according to new syllabus for 2022 and onwards.
- The questions and parts from abandoned topics have been removed.
- **Answer Key** is provided at the end of the book for reference.

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Acknowledgement

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Contents

Data

acceleration of free fall	g	$= 9.81\ \mathrm{m\,s^{-2}}$
speed of light in free space	c	$= 3.00 \times 10^{8}\ \mathrm{m\,s^{-1}}$
elementary charge	e	$= 1.60 \times 10^{-19}\ \mathrm{C}$
unified atomic mass unit	$1\ \mathrm{u}$	$= 1.66 \times 10^{-27}\ \mathrm{kg}$
rest mass of proton	m_p	$= 1.67 \times 10^{-27}\ \mathrm{kg}$
rest mass of electron	m_e	$= 9.11 \times 10^{-31}\ \mathrm{kg}$
Avogadro constant	N_A	$= 6.02 \times 10^{23}\ \mathrm{mol^{-1}}$
molar gas constant	R	$= 8.31\ \mathrm{J\,K^{-1}\,mol^{-1}}$
Boltzmann constant	k	$= 1.38 \times 10^{-23}\ \mathrm{J\,K^{-1}}$
gravitational constant	G	$= 6.67 \times 10^{-11}\ \mathrm{N\,m^{2}\,kg^{-2}}$
permittivity of free space	ε_0	$= 8.85 \times 10^{-12}\ \mathrm{F\,m^{-1}}$
	$(\frac{1}{4\pi\varepsilon_0}$	$= 8.99 \times 10^{9}\ \mathrm{m\,F^{-1}})$
Planck constant	h	$= 6.63 \times 10^{-34}\ \mathrm{J\,s}$
Stefan–Boltzmann constant	σ	$= 5.67 \times 10^{-8}\ \mathrm{W\,m^{-2}\,K^{-4}}$

Formulae

uniformly accelerated motion	s	$= ut + \frac{1}{2}at^2$
	v^2	$= u^2 + 2as$
hydrostatic pressure	Δp	$= \rho g \Delta h$
upthrust	F	$= \rho g V$
Doppler effect for sound waves	f_o	$= \frac{f_\mathrm{s} v}{v \pm v_\mathrm{s}}$
electric current	I	$= Anvq$
resistors in series	R	$= R_1 + R_2 + \ldots$
resistors in parallel	$\frac{1}{R}$	$= \frac{1}{R_1} + \frac{1}{R_2} + \ldots$

1 Physical Qunatities and Units

2016

(F/M/2016/P22/Q.1)

1 The speed v of a transverse wave on a uniform string is given by the expression

$$v = \sqrt{\frac{Tl}{m}}$$

where T is the tension in the string, l is its length and m is its mass.

An experiment is performed to determine the speed v of the wave. The measurements are shown in Fig. 1.1.

quantity	measurement	uncertainty
T	1.8 N	± 5%
l	126 cm	± 1%
m	5.1 g	± 2%

Fig. 1.1

(a) State an appropriate instrument to measure the length l.

.... [1]

(b) **(i)** Use the data in Fig. 1.1 to calculate the speed v.

v = ... m s^{-1} [2]

(ii) Use your answer in **(b)(i)** and the data in Fig. 1.1 to determine the value of v, with its absolute uncertainty, to an appropriate number of significant figures.

v = ... ± ....m s^{-1} [3]

[Total: 6]

(M/J/2016/P21/Q.1)

2 **(a)** Make estimates of

(i) the mass, in kg, of a wooden metre rule,

mass = ... kg [1]

(ii) the volume, in cm^3, of a cricket ball or a tennis ball.

volume = ... cm^3 [1]

(b) A metal wire of length *L* has a circular cross-section of diameter *d*, as shown in Fig. 1.1.

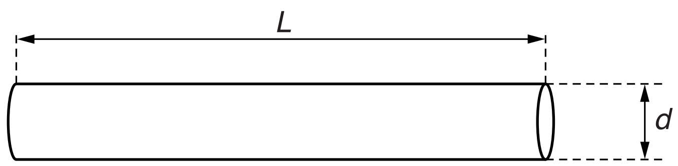


Fig. 1.1

The volume *V* of the wire is given by the expression

$$V = \frac{\pi d^2 L}{4}.$$

The diameter, length and mass *M* are measured to determine the density of the metal of the wire. The measured values are:

$d = 0.38 \pm 0.01$ mm,
$L = 25.0 \pm 0.1$ cm,
$M = 0.225 \pm 0.001$ g.

Calculate the density of the metal, with its absolute uncertainty. Give your answer to an appropriate number of significant figures.

density = ... ± .... $kg\,m^{-3}$ [5]

[Total: 7]

(M/J/2016/P23/Q.1)

3 **(a)** A list of quantities that are either scalars or vectors is shown in Fig. 1.1.

quantity	scalar	vector
distance	✓	
energy		
momentum		
power		
time		
weight		

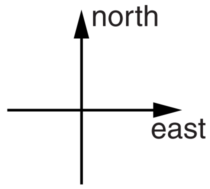
Fig. 1.1

Complete Fig. 1.1 to indicate whether each quantity is a scalar or a vector.

One line has been completed as an example. [2]

(b) A girl runs 120 m due north in 15 s. She then runs 80 m due east in 12 s.

(i) Sketch a vector diagram to show the path taken by the girl. Draw and label her resultant displacement R.



[1]

(ii) Calculate, for the girl,

1. the average speed,

average speed = ... $m s^{-1}$ [1]

2. the magnitude of the average velocity *v* and its angle with respect to the direction of the initial path.

magnitude of *v* = ... $m s^{-1}$

angle = ...° [3]

[Total: 7]

(M/J/2016/P23/Q.2)

4 **(a)** Describe the effects, one in each case, of systematic errors and random errors when using a micrometer screw gauge to take readings for the diameter of a wire.

systematic errors: ....

....

random errors: ....

....
[2]

(b) Distinguish between precision and accuracy when measuring the diameter of a wire.

precision: ....

....

accuracy: ....

....
[2]

[Total: 4]

(O/N/2016/P21/Q.1)

5 **(a)** Define *density*.

....

....[1]

(b) The mass m of a metal sphere is given by the expression

$$m = \frac{\pi d^3 \rho}{6}$$

where ρ is the density of the metal and d is the diameter of the sphere.

Data for the density and the mass are given in Fig. 1.1.

quantity	value	uncertainty
ρ m	$8100\,kg\,m^{-3}$ 7.5 kg	± 5% ± 4%

Fig. 1.1

(i) Calculate the diameter d.

d = ... m [1]

(ii) Use your answer in **(i)** and the data in Fig. 1.1 to determine the value of d, with its absolute uncertainty, to an appropriate number of significant figures.

d = ... ± .... m [3]

[Total: 5]

(O/N/2016/P22/Q.1)

6 **(a)** **(i)** Define *pressure*.

....

....[1]

(ii) Show that the SI base units of pressure are $\text{kg}\,\text{m}^{-1}\,\text{s}^{-2}$.

[1]

(b) Gas flows through the narrow end (nozzle) of a pipe. Under certain conditions, the mass *m* of gas that flows through the nozzle in a short time *t* is given by

$$\frac{m}{t} = kC\sqrt{\rho P}$$

where *k* is a constant with no units,
C is a quantity that depends on the nozzle size,
ρ is the density of the gas arriving at the nozzle,
P is the pressure of the gas arriving at the nozzle.

Determine the base units of *C*.

base units ....[3]

[Total: 5]

2017

(F/M/2017/P22/Q.1)

7 **(a)** Complete Fig. 1.1 by putting a tick (✓) in the appropriate column to indicate whether the listed quantities are scalars or vectors.

quantity	scalar	vector
acceleration		
force		
kinetic energy		
momentum		
power		
work		

Fig. 1.1 [2]

(b) A floating sphere is attached by a cable to the bottom of a river, as shown in Fig. 1.2.

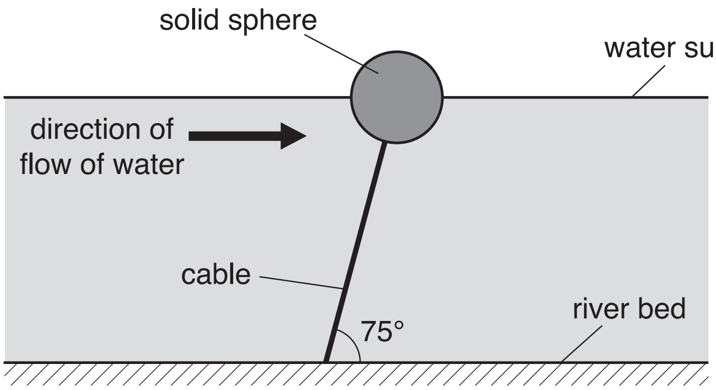


Fig. 1.2

The sphere is in equilibrium, with the cable at an angle of 75° to the horizontal. Assume that the force on the sphere due to the water flow is in the horizontal direction.

The radius of the sphere is 23 cm. The sphere is solid and is made from a material of density 82 kg m^{-3}.

(i) Show that the weight of the sphere is 41 N.

[2]

(ii) The tension in the cable is 290 N.
Determine the upthrust acting on the sphere.

upthrust = ... N [2]

(iii) Explain the origin of the upthrust acting on the sphere.

....

....

....[1]

[Total: 7]

(M/J/2017/P21/Q.1)

8 **(a)** Determine the SI base units of stress.
Show your working.

base units ....[2]

(b) A beam PQ is clamped so that the beam is horizontal. A mass *M* of 500 g is hung from end Q and the beam bends slightly, as illustrated in Fig. 1.1.

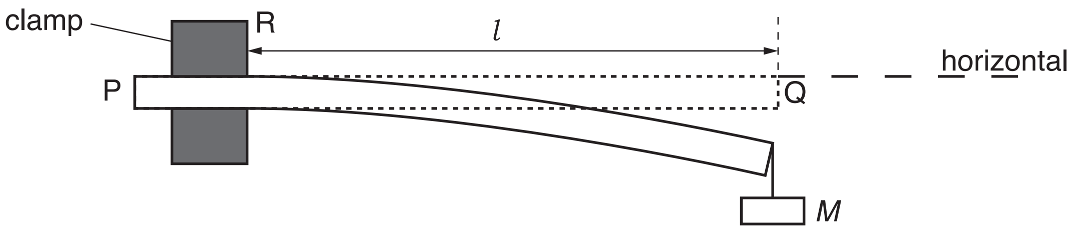


Fig. 1.1

The length l of the beam from the edge of the clamp R to end Q is 60.0 cm. The width *b* of the beam is 30.0 mm and the thickness *d* of the beam is 5.00 mm. The material of the beam has Young modulus *E*.

The mass *M* is made to oscillate vertically. The time period *T* of the oscillations is 0.58 s.

The period T is given by the expression

$$T = 2\pi \sqrt{\frac{4Ml^3}{Ebd^3}}.$$

(i) Determine E in GPa.

E = ...GPa [3]

(ii) The quantities used to determine E should be measured with accuracy and with precision.

1. Explain the difference between accuracy and precision.

accuracy: ....

....

precision: ....

....
[2]

2. In a particular experiment, the quantities l and T are measured with the same percentage uncertainty. State and explain which of these two quantities contributes more to the uncertainty in the value of E.

....

....

....[1]

[Total: 8]

(M/J/2017/P22/Q.1)

9 **(a)** State two SI base units other than kilogram, metre and second.

1. ....

2. ....
[1]

(b) Determine the SI base units of resistivity.

base units ....[3]

(c) **(i)** A wire of cross-sectional area 1.5 mm^2 and length 2.5 m has a resistance of 0.030 Ω. Calculate the resistivity of the material of the wire in nΩ m.

resistivity = ...nΩ m [3]

(ii) **1.** State what is meant by *precision*.

....

....

2. Explain why the precision in the value of the resistivity is improved by using a micrometer screw gauge rather than a metre rule to measure the diameter of the wire.

....

....

....

[2]

[Total: 9]

(M/J/2017/P23/Q.1)

10 (a) Two forces, with magnitudes 5.0 N and 12 N, act from the same point on an object. Calculate the magnitude of the resultant force *R* for the forces acting

(i) in opposite directions,

R = ... N [1]

(ii) at right angles to each other.

R = ... N [1]

(b) An object X rests on a smooth horizontal surface. Two horizontal forces act on X as shown in Fig. 1.1.

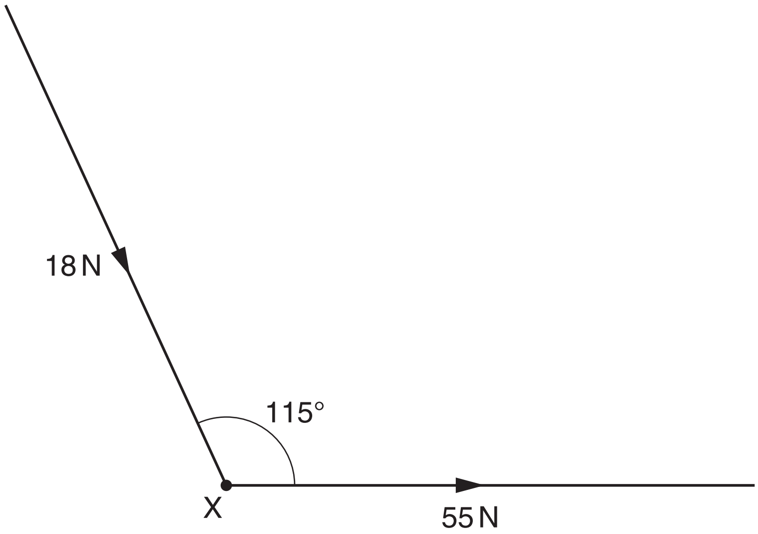


Fig. 1.1 (not to scale)

A force of 55 N is applied to the right. A force of 18 N is applied at an angle of 115° to the direction of the 55 N force.

(i) Use the resolution of forces or a scale diagram to show that the magnitude of the resultant force acting on X is 65 N.

[2]

(ii) Determine the angle between the resultant force and the 55 N force.

angle = ... ° [2]

(c) A third force of 80 N is now applied to X in the opposite direction to the resultant force in **(b)**.
The mass of X is 2.7 kg.
Calculate the magnitude of the acceleration of X.

acceleration = ...m s^{-2} [3]

[Total: 9]

(O/N/2017/P21/Q.1)

11 **(a)** The drag force F_D acting on a sphere moving through a fluid is given by the expression

$$F_D = K\rho v^2$$

where K is a constant,
ρ is the density of the fluid
and v is the speed of the sphere.

Determine the SI base units of K.

base units ....[3]

(b) A ball of weight 1.5 N falls vertically from rest in air. The drag force F_D acting on the ball is given by the expression in **(a)**. The ball reaches a constant (terminal) speed of 33 m s^{-1}.

Assume that the upthrust acting on the ball is negligible and that the density of the air is uniform.

For the instant when the ball is travelling at a speed of 25 m s^{-1}, determine

(i) the drag force F_D on the ball,

F_D = ... N [2]

(ii) the acceleration of the ball.

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

(c) Describe the acceleration of the ball in **(b)** as its speed changes from zero to 33 m s^{-1}.

....

....

....

....[3]

[Total: 10]

(O/N/2017/P22/Q.1)

12 One end of a wire is connected to a fixed point. A load is attached to the other end so that the wire hangs vertically.

The diameter d of the wire and the load F are measured as

$d = 0.40 \pm 0.02$ mm,
$F = 25.0 \pm 0.5$ N.

(a) For the measurement of the diameter of the wire, state

(i) the name of a suitable measuring instrument,

....[1]

(ii) how random errors may be reduced when using the instrument in **(i)**.

....

....

....[2]

(b) The stress σ in the wire is calculated by using the expression

$$\sigma = \frac{4F}{\pi d^2}.$$

(i) Show that the value of σ is $1.99 \times 10^8\,\mathrm{N\,m^{-2}}$.

[1]

(ii) Determine the percentage uncertainty in σ.

percentage uncertainty = ...% [2]

(iii) Use the information in **(b)(i)** and your answer in **(b)(ii)** to determine the value of σ, with its absolute uncertainty, to an appropriate number of significant figures.

σ = ... ± .... $\mathrm{N\,m^{-2}}$ [2]

[Total: 8]

(O/N/2017/P23/Q.1)

13 (a) (i) Define *power*.

....

....[1]

(ii) Show that the SI base units of power are $kg\,m^2\,s^{-3}$.

[1]

(b) All bodies radiate energy. The power P radiated by a body is given by

$$P = kAT^4$$

where T is the thermodynamic temperature of the body,
A is the surface area of the body
and k is a constant.

(i) Determine the SI base units of k.

base units ....[2]

(ii) On Fig. 1.1, sketch the variation with T^2 of P. The quantity A remains constant.

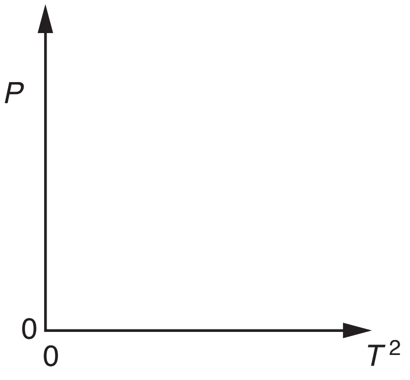


Fig. 1.1

[1]

[Total: 5]

2018

(M/J/2018/P21/Q.1)

14 (a) State what is meant by a *scalar* quantity and by a *vector* quantity.

scalar: ....

....

vector: ....

....
[2]

(b) Complete Fig. 1.1 to indicate whether each of the quantities is a vector or a scalar.

quantity	vector or scalar
power	
temperature	
momentum	

Fig. 1.1

[2]

(c) An aircraft is travelling in wind. Fig. 1.2 shows the velocities for the aircraft in still air and for the wind.

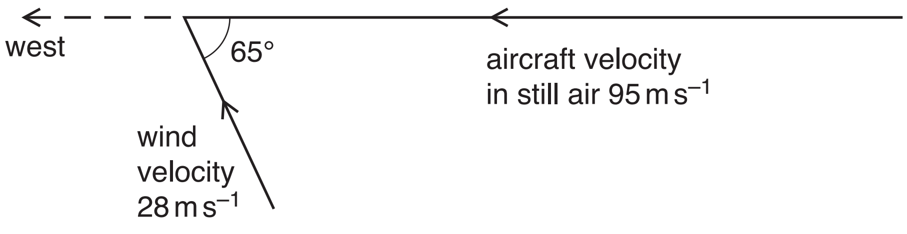


Fig. 1.2

The velocity of the aircraft in still air is 95 m s^{-1} to the west.
The velocity of the wind is 28 m s^{-1} from 65° south of east.

(i) On Fig. 1.2, draw an arrow, labelled R, in the direction of the resultant velocity of the aircraft.

[1]

(ii) Determine the magnitude of the resultant velocity of the aircraft.

magnitude of velocity = ... $m\,s^{-1}$ [2]

[Total: 7]

(M/J/2018/P22/Q.1)

15 (a) Define *force*.

....[1]

(b) State the SI base units of force.

....[1]

(c) The force F between two point charges is given by

$$F = \frac{Q_1 Q_2}{4\pi r^2 \varepsilon}$$

where Q_1 and Q_2 are the charges,
r is the distance between the charges,
ε is a constant that depends on the medium between the charges.

Use the above expression to determine the base units of ε.

base units ....[2]

[Total: 4]

(M/J/2018/P23/Q.1)

16 **(a)** An analogue voltmeter is used to take measurements of a constant potential difference across a resistor.

For these measurements, describe **one** example of

(i) a systematic error,

....

....[1]

(ii) a random error.

....

....[1]

(b) The potential difference across a resistor is measured as 5.0 V ± 0.1 V. The resistor is labelled as having a resistance of 125 Ω ± 3%.

(i) Calculate the power dissipated by the resistor.

power = ... W [2]

(ii) Calculate the percentage uncertainty in the calculated power.

percentage uncertainty = ... % [2]

(iii) Determine the value of the power, with its absolute uncertainty, to an appropriate number of significant figures.

power = ... ± .... W [2]

[Total: 8]

(O/N/2018/P22/Q.1)

17 A golfer strikes a ball so that it leaves horizontal ground with a velocity of $6.0\,m\,s^{-1}$ at an angle θ to the horizontal, as illustrated in Fig. 1.1.

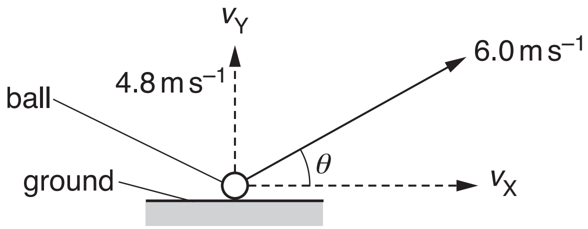


Fig. 1.1 (not to scale)

The magnitude of the initial vertical component v_Y of the velocity is $4.8\,m\,s^{-1}$.
Assume that air resistance is negligible.

(a) Show that the magnitude of the initial horizontal component v_X of the velocity is $3.6\,m\,s^{-1}$.

[1]

(b) The ball leaves the ground at time $t = 0$ and reaches its maximum height at $t = 0.49\,s$.

On Fig. 1.2, sketch separate lines to show the variation with time t, until the ball returns to the ground, of

(i) the vertical component v_Y of the velocity (label this line Y), [2]

(ii) the horizontal component v_X of the velocity (label this line X). [2]

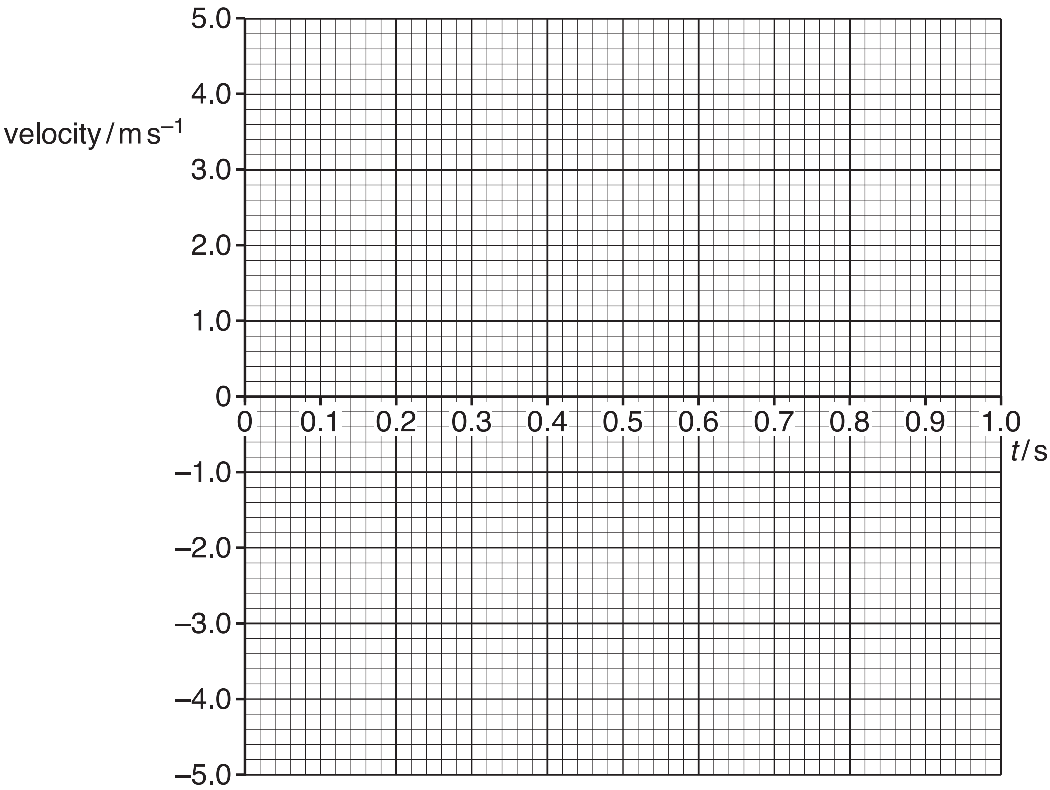


Fig. 1.2