Topical Past Papers

AS & A Level Physics (9702) Paper 2

[AS Level Structured Questions]

Exam Series: May/June 2015 – May/June 2025

Format Type B:
Each question is followed by its answer scheme

Introduction

Each Topical Past Paper Questions Workbook contains a comprehensive collection of hundreds of questions and corresponding answer schemes, presented in worksheet format. The questions are carefully arranged according to their respective chapters and topics, which align with the latest IGCSE or AS/A Level subject content. Here are the key features of these resources:

1. The workbook covers a wide range of topics, which are organized according to the latest syllabus content for Cambridge IGCSE or AS/A Level exams.
2. Each topic includes numerous questions, allowing students to practice and reinforce their understanding of key concepts and skills.
3. The questions are accompanied by detailed answer schemes, which provide clear explanations and guidance for students to improve their performance.
4. The workbook's format is user-friendly, with worksheets that are easy to read and navigate.
5. This workbook is an ideal resource for students who want to familiarize themselves with the types of questions that may appear in their exams and to develop their problem-solving and analytical skills.

Overall, Topical Past Paper Questions Workbooks are a valuable tool for students preparing for IGCSE or AS/A Level exams, providing them with the opportunity to practice and refine their knowledge and skills in a structured and comprehensive manner. To provide a clearer description of this book's specifications, here are some key details:

- Title: Cambridge AS & A Level Physics (9702) Paper 2 Topical Past Paper Questions
- Subtitle: Exam Practice Worksheets With Answer Scheme
- Examination board: Cambridge Assessment International Education (CAIE)
- Subject code: 9702
- Years covered: May/June 2015 – May/June 2025
- Paper: 2
- Number of pages: 1227
- Number of questions: 486

Contents

Chapter 1

Physical quantities and units

1.1 SI units

1. 9702_m19_qp_22 Q: 1

(a) The ampere, metre and second are SI base units.

State **two** other SI base units.

1. .....

2. .....

[2]

(b) The average drift speed v of electrons moving through a metal conductor is given by the equation:

$$v = \frac{\mu F}{e}$$

where e is the charge on an electron
F is a force acting on the electron
and μ is a constant.

Determine the SI base units of μ.

SI base units .....[3]

[Total: 5]

Answer:

	Answer	Mark
(a)	kilogram / kg	B1
	kelvin / K	B1
(b)	units for v: $m\,s^{-1}$ and units for F: $kg\,m\,s^{-2}$	C1
	units for e: $A\,s$	C1
	units for μ: $m\,s^{-1}\,A\,s\,/\,kg\,m\,s^{-2}$ = $A\,kg^{-1}\,s^{2}$	A1

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1.2 Errors and uncertainties

2. 9702_m25_qp_22 Q: 1

(a) Explain what is meant by the accuracy of a measured value.

.....

..... [1]

(b) Two solid cubes, A and B, are measured to determine the density of their materials.

Table 1.1 shows the measurements for cube A.

Table 1.1

quantity	measurement
length of side	(1.53 ± 0.01) cm
mass	(31.3 ± 0.5) g

(i) Show that the calculated density of the material of cube A is $8.7 \times 10^3\,\text{kg m}^{-3}$.

[2]

(ii) Calculate the percentage uncertainty in the density of the material of cube A.

percentage uncertainty = ...% [2]

(iii) The density of the material of cube B is determined to be $9.2 \times 10^3\,\text{kg m}^{-3} \pm 6\%$.

State and explain whether cube A and cube B could be made from the same material.

.....

.....

.....

..... [2]

[Total: 7]

Answer:

Question	Answer	Marks
(a)	how close the (measured) value is to the true value (of the quantity)	**A1**
(b)(i)	(ρ =) m / V	**C1**
	= $31.3 \times 10^{-3} / (1.53 \times 10^{-2})^3 = 8.7 \times 10^3$ (kg m^{-3})	**A1**
(b)(ii)	(0.5 / 31.3) or (0.01 / 1.53) % uncertainty = $(0.016 \times 100) + 3 \times (0.0065 \times 100)$	**C1**
	= 4%	**A1**
(b)(iii)	The ranges (of the densities of A and B) overlap **or** the (calculated) density of A is within the range of the density of B **or** the difference in densities is within the uncertainty (of B)	**M1**
	(so) they could be the same	**A1**

3. 9702_w24_qp_21 Q: 1

(a) Define density.

.....

..... [1]

(b) Fig. 1.1 shows a cuboidal glass block.

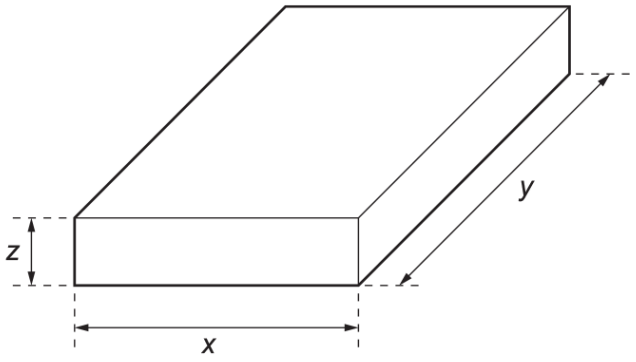


Fig. 1.1 (not to scale)

A student measures the mass m of the block and the side lengths x, y and z. The measurements are shown in Table 1.1.

Table 1.1

quantity	measurement
m	(0.243 ± 0.001) kg
x	(5.41 ± 0.01) cm
y	(11.09 ± 0.01) cm
z	(1.62 ± 0.01) cm

(i) Determine the density of the glass.

density = ... $kg\,m^{-3}$ [2]

(ii) Calculate the percentage uncertainty in the density.

percentage uncertainty = ...% [3]

(c) The true value of the density of the glass is different from the answer in **(b)(i)** because of a systematic error in the measurements.

Suggest **one** possible cause of this systematic error.

.....

.....

..... [1]

[Total: 7]

Answer:

Question	Answer	Marks
(a)	mass per unit volume	**B1**
(b)(i)	density = $0.243 / (0.0541 \times 0.1109 \times 0.0162)$	**C1**
	= 2500 kg m^{-3}	**A1**
(b)(ii)	(0.001 / 0.243) **or** (0.01 / 5.41) **or** (0.01 / 11.09) **or** (0.01 / 1.62)	**C1**
	$(\Delta\rho / \rho) = (\Delta m / m) + (\Delta x / x) + (\Delta y / y) + (\Delta z / z)$ = (0.001 / 0.243) + (0.01 / 5.41) + (0.01 / 11.09) + (0.01 / 1.62) (= 0.013)	**C1**
	percentage uncertainty in ρ = 0.013×100 = 1.3% (allow 1 s.f. answer of 1%)	**A1**
(c)	zero error (on calipers / balance) **or** incorrect calibration (of calipers / balance)	**B1**

4. 9702_w23_qp_21 Q: 1

(a) Compare scalar and vector quantities.

.....

.....

..... [2]

(b) The radius of a small sphere is determined from a measurement of the volume of the sphere. The sphere is submerged in water, displacing some of the water into a measuring cylinder as shown in Fig. 1.1.

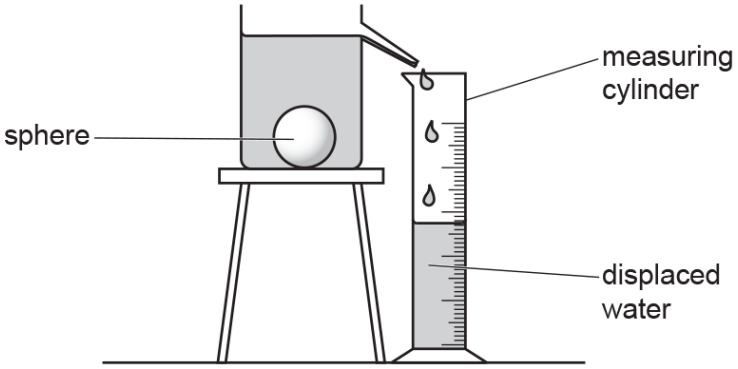


Fig. 1.1 (not to scale)

The measured volume of displaced water is $(28.0 \pm 0.5)\,cm^3$.

Calculate:

(i) the radius, in cm, of the sphere

radius = ... cm [1]

(ii) the percentage uncertainty in the radius of the sphere.

percentage uncertainty = ... % [2]

[Total: 5]

Answer:

Question	Answer	Mark
(a)	scalar and vector have magnitude	**B1**
	vector has direction (and scalar does not have direction)	**B1**
(b)(i)	$r = [(3 \times 28) / 4\pi]^{1/3}$ $= 1.9$ cm	**A1**
(b)(ii)	percentage uncertainty in $V = (0.5 / 28) \times 100$ $(= 1.79\%)$	**C1**
	percentage uncertainty in $r = 1.79 / 3$ $= 0.6\%$	**A1**

5. 9702_w23_qp_23 Q: 1

(a) Table 1.1 lists some physical quantities. Complete the table by placing a tick (✓) next to the scalar quantities.

Table 1.1

acceleration	
charge	
momentum	
power	
upthrust	

[1]

(b) A uniform cylinder has diameter D, length L and mass M.
The density ρ of the cylinder is given by

$$\rho = \frac{4M}{\pi D^2 L}.$$

Table 1.2 shows the data obtained from an experiment to determine the density of the cylinder.

Table 1.2

quantity	measurement	percentage uncertainty
D	(26.2 ± 0.1) mm	.....%
L	(162 ± 1) mm	.....%
M	(247 ± 1) g	0.4%

(i) Calculate the percentage uncertainties in D and L. Write your answers in Table 1.2.

[1]

(ii) Calculate the density of the cylinder. Give your answer to three significant figures.

density = ... kg m^{-3} [2]

(iii) Calculate the percentage uncertainty in the density.

percentage uncertainty = ...% [2]

[Total: 6]

Answer:

Question	Answer	Marks
(a)	charge **and** power only ticked	**B1**
(b)(i)	$\%D = 0.4\%$ **and** $\%L = 0.6\%$	**A1**
(b)(ii)	$\rho = (4 \times 0.247) / [\pi \times (26.2 \times 10^{-3})^2 \times 0.162]$	**C1**
	$\rho = 2.83 \times 10^3$ kg m^{-3}	**A1**
(b)(iii)	percentage uncertainty = $0.4 + (2 \times 0.4) + 0.6$	**C1**
	= 1.8%	**A1**

6. 9702_w22_qp_21 Q: 1

(a) The boxes in Fig. 1.1 contain terms on the left-hand side and examples of these terms on the right-hand side.

Draw a line between each term on the left and the correct example on the right.

base quantity	coulomb
base unit	electric current
derived quantity	force
derived unit	kilogram

Fig. 1.1

[2]

(b) A set of experimental measurements is described as precise and not accurate.

State what is meant by:

(i) precise

.....

..... [1]

(ii) not accurate.

.....

..... [1]

(c) An object of mass m travels with speed v in a circle of radius r. The force F acting on the object is given by

$$F = \frac{mv^2}{r}.$$

The percentage uncertainties of three of the quantities are given in Table 1.1.

Table 1.1

quantity	percentage uncertainty
F	±3%
m	±4%
r	±5%

The value of v is determined from F, m and r.

(i) Calculate the percentage uncertainty in v.

percentage uncertainty = ... % [2]

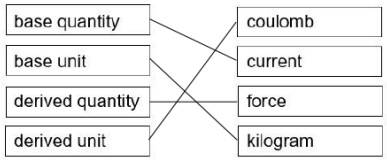
(ii) The value of v is $15.0\,m\,s^{-1}$.

Calculate the absolute uncertainty in v.

absolute uncertainty = ... $m\,s^{-1}$ [1]

[Total: 7]

Answer:

Question	Answer	Marks
(a)	 any two joined correctly	C1
	all four joined correctly	A1
(b)(i)	the measurements have a small range	B1
(b)(ii)	(average of the) measurements not close to the true value	B1
(c)(i)	percentage uncertainty = (3 + 5 + 4) / 2	C1
	= 6%	A1
(c)(ii)	absolute uncertainty = (6 / 100) × 15.0 = 0.9 m s^{-1}	A1

7. 9702_w22_qp_23 Q: 1

The rate of flow Q of a liquid along a narrow pipe of length L and radius r is given by

$$Q = \frac{\alpha r^4}{L}$$

where α is a constant.

An experiment is carried out to determine the value of α. The data from the experiment are shown in Table 1.1.

Table 1.1

quantity	value	percentage uncertainty
Q	$2.72 \times 10^{-8}\,m^3\,s^{-1}$	±3%
r	$7.1 \times 10^{-5}\,m$	±2%
L	$2.5 \times 10^{-2}\,m$	±4%

(a) Use information in Table 1.1 to show that the SI base unit of α is s^{-1}.

[1]

(b) Show that the percentage uncertainty in α is 15%.

[1]

(c) Calculate α with its absolute uncertainty. Give your answer to an appropriate number of significant figures.

α = (..... ± .....) × $10^7\,s^{-1}$ [3]

[Total: 5]

Answer:

Question	Answer	Marks
(a)	(SI base unit of α =) $m^3 s^{-1} \times m / m^4 = s^{-1}$	A1
(b)	(percentage uncertainty =) 3 + 4 + 2 × 4 = 15 (%)	A1
(c)	$\alpha = QL / r^4$ $= 2.72 \times 10^{-8} \times 2.5 \times 10^{-2} / (7.1 \times 10^{-5})^4$ $= 2.7 \times 10^7$	C1
	absolute uncertainty $= 0.15 \times [2.7 \times 10^7]$ $= 0.4 \times 10^7$	C1
	$\alpha = (2.7 \pm 0.4) \times 10^7 s^{-1}$	A1

8. 9702_w21_qp_22 Q: 1

(a) A unit may be stated with a prefix that represents a power-of-ten multiple or submultiple.

Complete Table 1.1 to show the name and symbol of each prefix and the corresponding power-of-ten multiple or submultiple.

Table 1.1

prefix	power-of-ten multiple or submultiple
kilo (k)	10^3
tera (T)	
( )	10^{-12}

[2]

(b) In the following list, underline all the units that are SI base units.

ampere coulomb metre newton [1]

(c) The potential difference V between the two ends of a uniform metal wire is given by

$$V = \frac{4\rho LI}{\pi d^2}$$

where d is the diameter of the wire,
I is the current in the wire,
L is the length of the wire,
and ρ is the resistivity of the metal.

For a particular wire, the percentage uncertainties in the values of some of the above quantities are listed in Table 1.2.

Table 1.2

quantity	percentage uncertainty
d	±3.0%
I	±2.0%
L	±2.5%
V	±3.5%

The quantities listed in Table 1.2 have values that are used to calculate ρ as $4.1 \times 10^{-7}\,\Omega\,\text{m}$.

For this value of ρ, calculate:

(i) the percentage uncertainty

percentage uncertainty = ...% [2]

(ii) the absolute uncertainty.

absolute uncertainty = ... Ω m [1]

[Total: 6]

Answer:

Question	Answer	Marks
(a)	10^{12}	B1
	pico (p)	B1
(b)	ampere and metre both underlined (and no other units underlined)	B1
(c)(i)	percentage uncertainty = 3.5 + (3.0 × 2) + 2.5 + 2.0	C1
	= 14%	A1
(c)(ii)	absolute uncertainty = $4.1 \times 10^{-7} \times 14 / 100$	A1
	$= 6 \times 10^{-8}\,\Omega\,\text{m}$	

9. 9702_m20_qp_22 Q: 1

(a) Length, mass and temperature are all SI base quantities.

State **two** other SI base quantities.

1. .....

2. .....
[2]

(b) The acceleration of free fall g may be determined from an oscillating pendulum using the equation

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

where l is the length of the pendulum and T is the period of oscillation.

In an experiment, the measured values for an oscillating pendulum are

$l = 1.50\,\text{m} \pm 2\%$
and $T = 2.48\,\text{s} \pm 3\%$.

(i) Calculate the acceleration of free fall g.

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

(ii) Determine the percentage uncertainty in g.

percentage uncertainty = ... % [2]

(iii) Use your answers in **(b)(i)** and **(b)(ii)** to determine the absolute uncertainty of the calculated value of g.

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

[Total: 6]

Answer:

	Answer	Mark
(a)	time (electric) current *allow* amount of substance *allow* luminous intensity *any two of the above quantities, 1 mark each*	**B2**
(b)(i)	$g = (4\pi^2 \times 1.50) / (2.48^2)$ $= 9.63\ \text{m s}^{-2}$	**A1**
(b)(ii)	percentage uncertainty = 2 + (3 × 2) or fraction uncertainty = 0.02 + (0.03 × 2)	**C1**
	percentage uncertainty = 8%	**A1**
(b)(iii)	absolute uncertainty = 0.08 × 9.6 $= 0.8\ \text{m s}^{-2}$	**A1**

10. 9702_s19_qp_22 Q: 1

(a) The diameter d of a cylinder is measured as 0.0125 m ± 1.6%.

Calculate the absolute uncertainty in this measurement.

absolute uncertainty = ... m [1]

(b) The cylinder in **(a)** stands on a horizontal surface. The pressure p exerted on the surface by the cylinder is given by

$$p = \frac{4W}{\pi d^2}.$$

The measured weight W of the cylinder is 0.38 N ± 2.8%.

(i) Calculate the pressure p.

p = ... N m^{-2} [1]

(ii) Determine the absolute uncertainty in the value of p.

absolute uncertainty = ... N m^{-2} [2]

[Total: 4]

Answer:

	Answer	Mark
(a)	absolute uncertainty $= (1.6 / 100) \times 0.0125$ $= 2 \times 10^{-4}$ m	A1
(b)(i)	$p = (4 \times 0.38) / (\pi \times 0.0125^2)$ $= 3100$ N m^{-2}	A1
(b)(ii)	percentage uncertainty $= 2.8 + (2 \times 1.6)$ (= 6%) **or** fractional uncertainty $= 0.028 + (2 \times 0.016)$ (= 0.06)	C1
	absolute uncertainty $= 0.06 \times 3100$ $= 190$ N m^{-2} (*allow to 1 significant figure*)	A1

11. 9702_w17_qp_22 Q: 1

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 1.99×10^8 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 = ... ± ..... $N\,m^{-2}$ [2]

[Total: 8]

Answer:

	Answer	Mark
(a)(i)	micrometer (screw gauge)/digital calipers	B1
(a)(ii)	take several readings (and average)	M1
	along the wire **or** around the circumference	A1
(b)(i)	$\sigma = 4 \times 25 / [\pi \times (0.40 \times 10^{-3})^2] = 1.99 \times 10^8\ N\,m^{-2}$ **or** $\sigma = 25 / [\pi \times (0.20 \times 10^{-3})^2] = 1.99 \times 10^8\ N\,m^{-2}$	A1
(b)(ii)	$\%F = 2\%$ **and** $\%d = 5\%$ **or** $\Delta F/F = \frac{0.5}{25}$ **and** $\Delta d/d = \frac{0.02}{0.4}$	C1
	$\%\sigma = 2\% + (2 \times 5\%)$ **or** $\%\sigma = [0.02 + (2 \times 0.05)] \times 100$ $\%\sigma = 12\%$	A1
(b)(iii)	absolute uncertainty $= (12/100) \times 1.99 \times 10^8$ $= 2.4 \times 10^7$	C1
	$\sigma = 2.0 \times 10^8 \pm 0.2 \times 10^8\ N\,m^{-2}$ **or** $2.0 \pm 0.2 \times 10^8\ N\,m^{-2}$	A1

12. 9702_m16_qp_22 Q: 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]

Answer:

(a) metre rule / tape measure B1

(b) **(i)** $v = [(1.8 \times 126 \times 10^{-2}) / 5.1 \times 10^{-3}]^{1/2}$ C1
$= 21.1\,(\text{m s}^{-1})$ A1

(ii) percentage uncertainty = 4% **or** fractional uncertainty = 0.04 C1
$\Delta v = 0.04 \times 21.1$
$= 0.84$ C1
$v = 21.1 \pm 0.8\,(\text{m s}^{-1})$ A1

13. 9702_s16_qp_23 Q: 2

(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]

Answer:

(a) systematic: the reading is larger or smaller than (or varying from) the true reading by a constant amount B1

random: scatter in readings about the true reading B1 [2]

(b) precision: the size of the smallest division (on the measuring instrument)
or
0.01 mm for the micrometer B1

accuracy: how close (diameter) value is to the true (diameter) value B1 [2]

1.3 Scalars and vectors

14. 9702_s21_qp_23 Q: 1

(a) A property of a vector quantity, that is not a property of a scalar quantity, is direction. For example, velocity has direction but speed does not.

(i) State **two** other scalar quantities and **two** other vector quantities.

scalar quantities: ..... and .....

vector quantities: ..... and .....
[2]

(ii) State **two** properties that are possessed by both scalar and vector physical quantities.

1. .....

2. .....
[2]

(b) A ship at sea is travelling with a velocity of $13\,m\,s^{-1}$ in a direction 35° east of north in still water, as shown in Fig. 1.1.

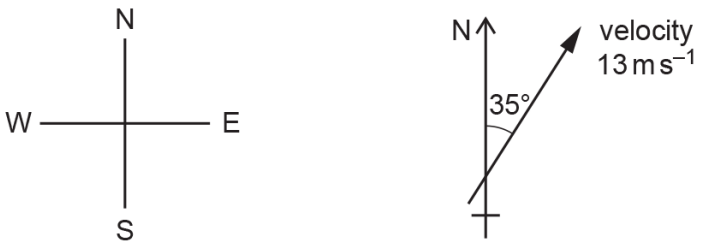


Fig. 1.1

(i) Determine the magnitudes of the components of the velocity of the ship in the north and the east directions.

north component of velocity = ... $m\,s^{-1}$

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

5

(ii) The ship now experiences a tidal current. The water in the sea moves with a velocity of $2.7\,m\,s^{-1}$ to the west.

Calculate the resultant velocity component of the ship in the east direction.

resultant east component of velocity = ... $m\,s^{-1}$ [1]

(iii) Use your answers in **(b)(i)** and **(b)(ii)** to determine the magnitude of the resultant velocity of the ship.

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

(iv) Use your answers in **(b)(i)** and **(b)(ii)** to determine the angle between north and the resultant velocity of the ship.

angle = ...° [2]

[Total: 11]

Answer:

Question	Answer	Marks
(a)(i)	two correct scalar quantities e.g. time, mass, distance, temperature	**B1**
	two correct vector quantities e.g. force, acceleration, velocity, displacement	**B1**
(a)(ii)	magnitude	**B1**
	unit	**B1**
(b)(i)	north component of velocity = 11 m s^{-1}	**A1**
	east component of velocity = 7.5 m s^{-1}	**A1**
(b)(ii)	velocity = 7.5 – 2.7 = 4.8 m s^{-1}	**A1**
(b)(iii)	velocity = $\sqrt{(11^2 + 4.8^2)}$	**C1**
	= 12 m s^{-1}	**A1**
(b)(iv)	angle = $\tan^{-1}$ (4.8 / 11)	**C1**
	= 24°	**A1**

Chapter 2

Kinematics

2.1 Equations of motion

15. 9702_s25_qp_21 Q: 1

(a) Define acceleration.

.....

..... [1]

(b) In an experiment, two objects A and B are released from the side of a building, as shown in Fig. 1.1.

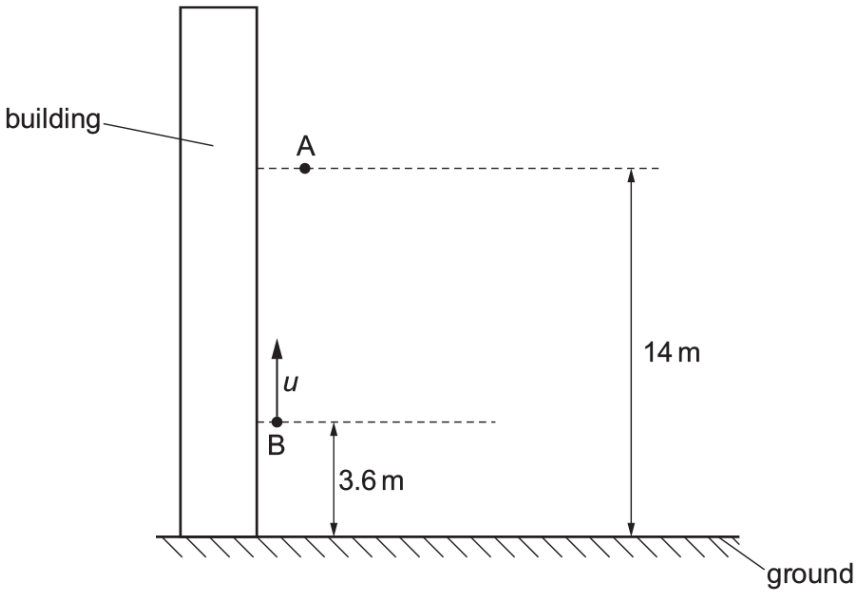


Fig. 1.1 (not to scale)

Object A is released from rest at a height of 14 m above the horizontal ground.
Object B is released with an initial upwards vertical velocity u at a height of 3.6 m above the ground.
Both objects take the same time to reach the ground and they do not collide with each other.
Air resistance is negligible.

(i) Calculate the time taken for object A to reach the ground.

time = ... s [2]

(ii) Use your answer in **(b)(i)** to calculate u.

u = ... $m\,s^{-1}$ [2]

(c) In a second experiment, object B is released from the same height and given the same initial speed as in **(b)** but at a release angle θ to the vertical, as shown in Fig. 1.2.

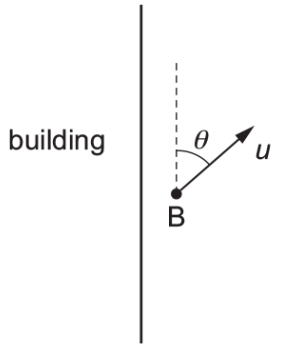


Fig. 1.2

(i) State and explain whether the time taken for object B to reach the ground is less than, the same as or greater than the time in **(b)(i)**.

.....

.....

..... [2]

(ii) By considering energy, state and explain the effect of the change in release angle on the speed at which B reaches the ground.

.....

.....

..... [2]

[Total: 9]

Answer:

Question	Answer	Marks
(a)	rate of change of velocity	**B1**
(b)(i)	$s = ut + \frac{1}{2}at^2$ **and** $u = 0$ or $s = \frac{1}{2}at^2$ $t = \sqrt{(2 \times 14 / 9.81)}$	**C1**
	$t = 1.7$ **s**	**A1**
	OR $v = \sqrt{(0^2 + 2 \times 9.81 \times 14)}$ $v = 17$ (m s^{-1}) $17 = (0 + 9.81) \times t$ **or** $17 = 9.81 \times t$ or $14 = \frac{1}{2} \times (0 + 17) \times t$ **or** $14 = \frac{1}{2} \times 17 \times t$	**(C1)**
	$t = 1.7$ **s**	**(A1)**
(b)(ii)	$s = ut + \frac{1}{2}at^2$ $u = (3.6 - \frac{1}{2} \times 9.81 \times 1.7^2) / 1.7$	**C1**
	$u = (-) 6.2$ m s^{-1}	**A1**
	OR $v = (3.6 + \frac{1}{2} \times 9.81 \times 1.7^2) / 1.7$ $v = 10$ (m s^{-1}) $10 = u + 9.81 \times 1.7$ or $10^2 = u^2 + (2 \times 9.81 \times 3.6)$ or $3.6 = \frac{1}{2} \times (u + 10) \times 1.7$	**(C1)**
	$u = (-) 6.2$ m s^{-1}	**(A1)**

Question	Answer	Marks
(c)(i)	Less time (as it reaches a lower height)	**B1**
	(because) the initial vertical (component of the) velocity is smaller (than in part **(b)**)	**B1**
(c)(ii)	The (total) initial energy is the same (as in part **(b)**)	**B1**
	change in gravitational potential energy is same, so speed is the same	**B1**

16. 9702_s25_qp_23 Q: 1

(a) Define velocity.

.....

..... [1]

(b) In an experiment, two objects A and B are released from the side of a building, as shown in Fig. 1.1.

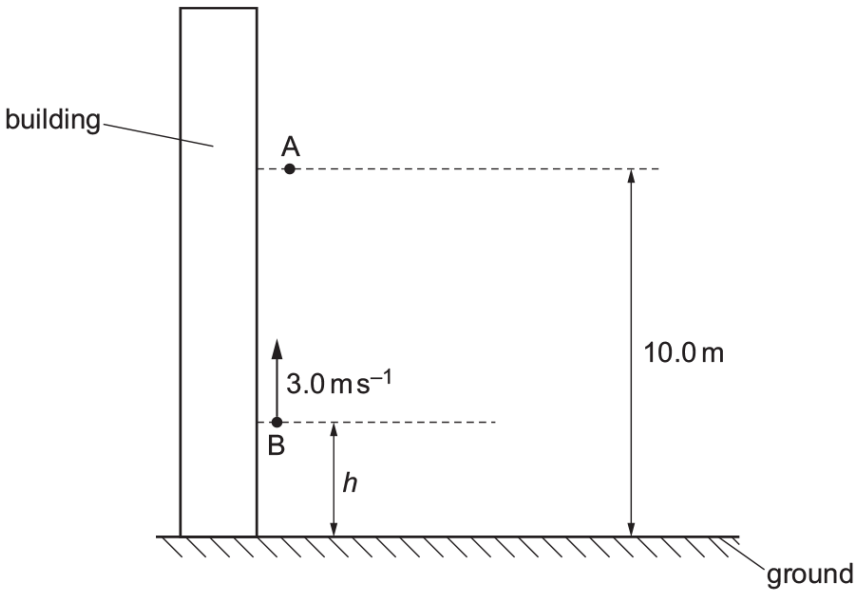


Fig. 1.1 (not to scale)

Object A is released from rest at a height of 10.0 m above horizontal ground.
Object B is released with an initial upward velocity of 3.0 m s^{-1} at a height h above the ground.
Both objects take the same time to reach the ground and they do not collide with each other.
Air resistance is negligible.

Calculate h.

h = ... m [3]

(c) In a second experiment, object B is released from the same height as in **(b)** but with a speed of $6.0\,m\,s^{-1}$ at an angle of 60° to the vertical, as shown in Fig. 1.2.

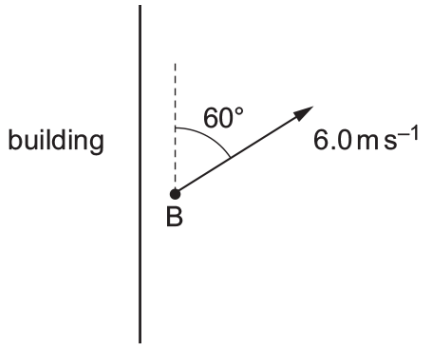


Fig. 1.2

(i) State and explain whether the time taken for object B to reach the ground is less than, the same as, or greater than the time taken in the first experiment.

.....

.....

..... [2]

(ii) By considering energy, state and explain whether the speed at which object B reaches the ground is less than, the same as, or greater than in the first experiment.

.....

.....

..... [2]

[Total: 8]

Answer:

Question	Answer	Marks
(a)	Rate of change of displacement	**B1**
(b)	For object A: $s = ut + \frac{1}{2}at^2$ so $t = \sqrt{\frac{2\times 10}{9.81}}$ =1.4	**C1**
	Then for object B: $s = ut + \frac{1}{2}at^2$ $h = -(3\times 1.4) + (0.5 \times 9.81 \times 1.4^2)$	**C1**
	= 5.7 m	**A1**
	OR $h = -(3\times 1.4) + 10$	**(C1)**
	= 5.7 m	**(A1)**
(c)(i)	time taken (to reach the ground is) same	**B1**
	The initial vertical (component of the) velocity is the same (as in part **(1b)**)	**B1**
(c)(ii)	The (total) initial energy is greater (than in part **(1b)**)	**B1**
	change in gravitational potential energy is same, so speed is greater	**B1**

17. 9702_s24_qp_21 Q: 2

(a) Define velocity.

.....

..... [1]

(b) A student throws a ball over a vertical wall of height *h*, as shown in Fig. 2.1.

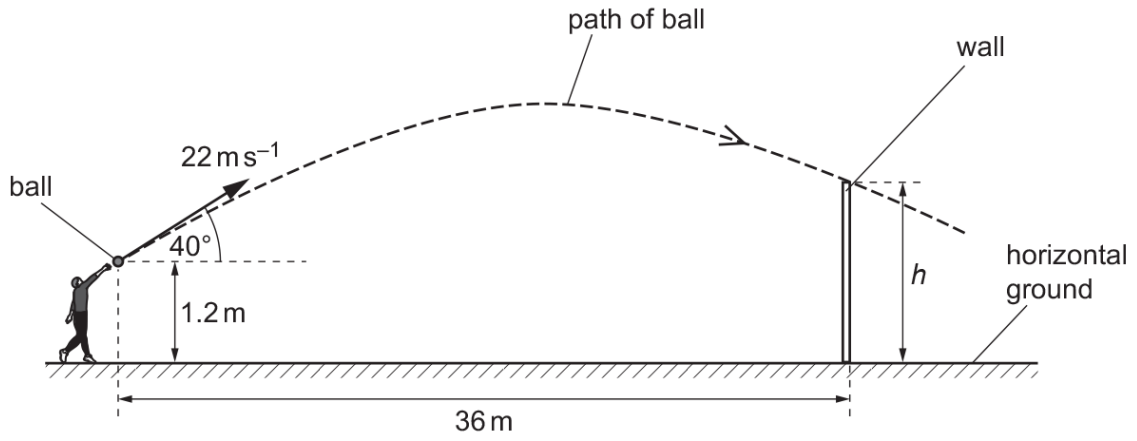


Fig. 2.1 (not to scale)

The ball leaves the hand of the student at a height of 1.2 m above the horizontal ground.
The ball has an initial velocity of 22 m s^{-1} at an angle of 40° to the horizontal.
The wall is a horizontal distance of 36 m from where the student releases the ball.

Air resistance is negligible.

(i) Determine the time taken for the ball to reach the wall.

time taken = ... s [2]

(ii) Calculate the vertical component u of the initial velocity of the ball.

u = ...m s^{-1} [1]

(iii) The ball just goes over the wall.

Calculate the height h of the wall.

h = ... m [3]

[Total: 7]

Answer:

Question	Answer	Marks
(a)	change in displacement / time (taken)	**B1**
(b)(i)	horizontal velocity = 22 × cos 40°	**C1**
	time taken = 36 / (22 × cos 40°) = 2.1 s	**A1**
(b)(ii)	u = 22 × sin 40° = 14 m s^{-1}	**A1**
(b)(iii)	s = ut + ½ at^2 = (14 × 2.1) + (½ × −9.81 × 2.1^2)	**C1**
	= 7.8 (m)	**C1**
	(therefore) height of wall = 7.8 + 1.2 = 9.0 m	**A1**

Question	Answer	Marks
(b)(iii)	**or**	
	other methods possible e.g. time to maximum height = (0 – 14) / –9.81 (= 1.43 s) time from maximum height to wall = 2.1 – 1.43 (= 0.67 s) maximum height above release = (14 × 1.43) + (½ × −9.81 × 1.43^2) = 9.99 (m)	**(C1)**
	height from maximum to wall = 0.5 × 9.81 × 0.67^2 (= 2.2 m) height above release = 9.99 – 2.2 = 7.8 (m)	**(C1)**
	height of wall = 1.2 + 7.8 = 9.0 m	**(A1)**

18. 9702_s24_qp_23 Q: 2

(a) Define displacement from a point.

.....

..... [1]

(b) An object is projected horizontally at a speed of $6.0\,m\,s^{-1}$ from a slope, as shown in Fig. 2.1.

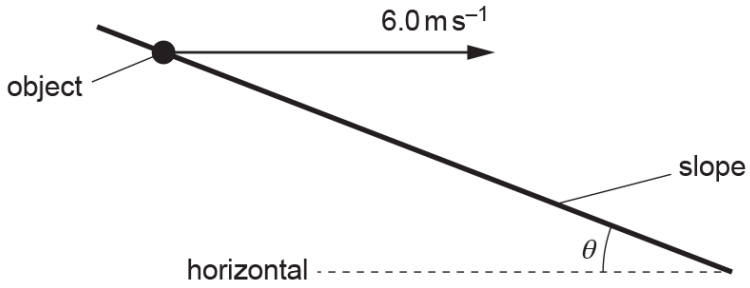


Fig. 2.1 (not to scale)

The slope is at an angle θ to the horizontal. Air resistance is negligible.

The object lands on the slope a time of 0.71 s later and stops without rolling or bouncing.

(i) Determine the horizontal distance travelled by the object.

distance = ... m [1]

(ii) Determine the vertical distance travelled by the object.

distance = ... m [2]

(iii) Use your answers in **(b)(i)** and **(b)(ii)** to calculate θ.

θ = ... ° [2]

(iv) Determine the magnitude of the displacement of the object from its original position.

displacement = ... m [2]

(v) By considering energy, calculate the speed of the object just before it lands.

speed = ... $m\,s^{-1}$ [3]

[Total: 11]

Answer:

Question	Answer	Marks
(a)	distance (from the point) in a straight line in a given direction	**B1**
(b)(i)	distance = speed × time = 6.0 × 0.71 = 4.3 m	**A1**
(b)(ii)	$s = ut + ½ at^2$ $= ½ \times 9.81 \times 0.71^2$	**C1**
	= 2.5 m	**A1**
(b)(iii)	$\tan \theta = 2.5 / 4.3$ **or** hypotenuse $= \sqrt{(4.3^2 + 2.5^2)}$ (= 4.97 m) $\cos \theta = 4.3 / 4.97$ **or** $\sin \theta = 2.5 / 4.97$	**C1**
	$\theta = 30°$	**A1**

Question	Answer	Marks
(b)(iv)	displacement $= \sqrt{(4.3^2 + 2.5^2)}$	**C1**
	= 4.9 m or 5.0 m	**A1**
	or	
	displacement = 2.5 / sin 30° **or** displacement = 4.3 / cos 30°	**(C1)**
	= 5.0 m	**(A1)**
(b)(v)	KE = $½mv^2$ **or** GPE = mgh	**C1**
	initial KE + loss in GPE = final KE $(½ \times m \times 6.0^2) + (m \times 9.81 \times 2.5) = (½ \times m \times v^2)$	**C1**
	$v = 9.2$ m s^{-1}	**A1**

19. 9702_w24_qp_23 Q: 1

(a) Define acceleration.

.....

..... [1]

(b) A small aircraft is flying horizontally at a speed of $42\,m\,s^{-1}$ at a height of 63 m above horizontal ground, as shown in Fig. 1.1.

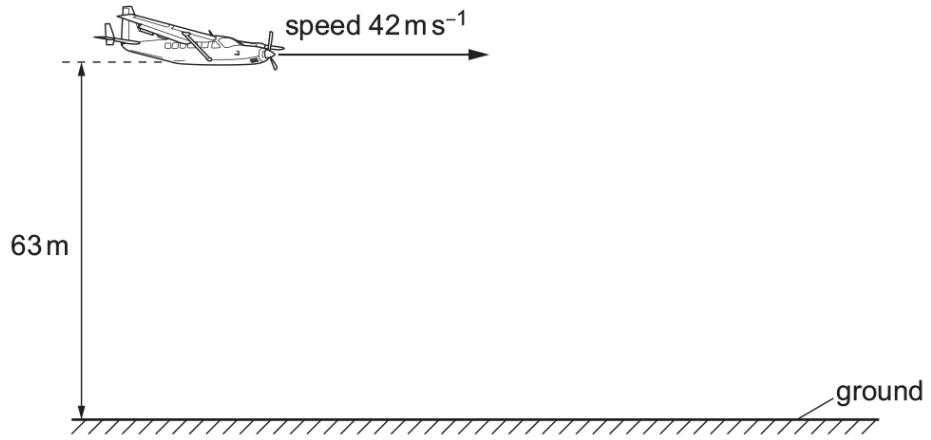


Fig. 1.1

The aircraft drops a small parcel. The parcel is released from the aircraft at the instant shown in Fig. 1.1. Air resistance is negligible.

(i) On Fig. 1.1, draw a line to show the path of the parcel as it falls from the aircraft to the ground. [1]

(ii) Calculate the time taken from the instant of release to the instant the parcel reaches the ground.

time = ... s [2]

(iii) Calculate the vertical component of the velocity of the parcel immediately before it reaches the ground.

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

(iv) Determine the speed at which the parcel reaches the ground.

speed = ... $m\,s^{-1}$ [2]

[Total: 7]

Answer:

Question	Answer	Marks
(a)	rate of change of velocity	**B1**
(b)(i)	curved path from aircraft to ground, starting horizontal at aircraft and then with increasing negative gradient as it moves towards the ground	**B1**
(b)(ii)	$s = ut + \frac{1}{2}at^2$ $63 = \frac{1}{2} \times 9.81 \times t^2$	**C1**
	time = 3.6 s	**A1**
(b)(iii)	$v^2 = 2 \times 9.81 \times 63$ **or** $v = 0 + (9.81 \times 3.6)$ **or** $63 = (v \times 3.6) - (\frac{1}{2} \times 9.81 \times 3.6^2)$ **or** $63 = \frac{1}{2} \times (0 + v) \times 3.6$ v = 35 $m\,s^{-1}$	**A1**
(b)(iv)	$speed^2 = 35^2 + 42^2$	**C1**
	speed = 55 $m\,s^{-1}$	**A1**

20. 9702_m23_qp_22 Q: 1

(a) Underline **all** the SI base units in the following list.

ampere coulomb current kelvin newton [1]

(b) A toy car moves in a horizontal straight line. The displacement s of the car is given by the equation

$$s = \frac{v^2}{2a}$$

where a is the acceleration of the car and v is its final velocity.

State **two** conditions that apply to the motion of the car in order for the above equation to be valid.

1 .....

2 .....
[2]

(c) An experiment is performed to determine the acceleration of the car in **(b)**. The following measurements are obtained:

$s = 3.89\,\text{m} \pm 0.5\%$
$v = 2.75\,\text{m s}^{-1} \pm 0.8\%$.

(i) Calculate the acceleration a of the car.

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

(ii) Determine the percentage uncertainty, to two significant figures, in a.

percentage uncertainty = ...% [2]

(iii) Use your answers in **(c)(i)** and **(c)(ii)** to determine the absolute uncertainty in the calculated value of a.

absolute uncertainty = ... $m\,s^{-2}$ [1]

[Total: 7]

Answer:

Question	Answer	Marks
(a)	only ampere and kelvin underlined	**B1**
(b)	initial speed / velocity is zero	**B1**
	(non-zero magnitude of) acceleration is constant / uniform (and in a straight line)	**B1**
(c)(i)	$a = 2.75^2 / (2 \times 3.89)$ $= 0.97\ m\,s^{-2}$	**A1**
(c)(ii)	percentage uncertainty = $(2 \times 0.8) + 0.5$	**C1**
	$= 2.1\%$	**A1**
(c)(iii)	absolute uncertainty = $(2.1 / 100) \times 0.97$ $= 0.02\ m\,s^{-2}$	**A1**

21. 9702_s23_qp_23 Q: 1

A well has a depth of 36 m from ground level to the surface of the water in the well, as shown in Fig. 1.1.

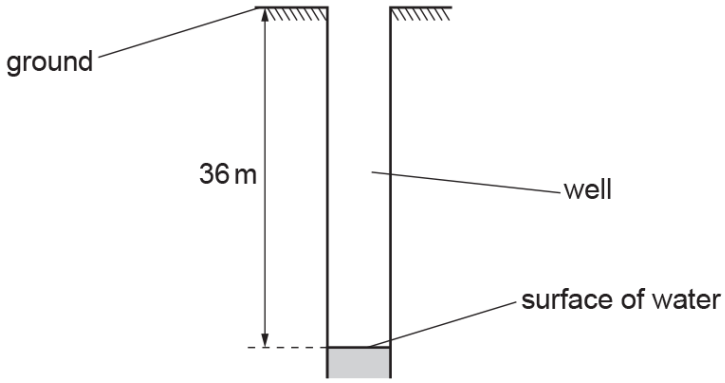


Fig. 1.1 (not to scale)

A student wishes to find the depth of the well. The student plans to drop a stone down the well and record the time taken from releasing the stone to hearing the splash made by the stone as it enters the water.

(a) Assume that air resistance is negligible and that the stone is released from rest.

Calculate the time taken for the stone to fall from ground level to the surface of the water.

time = ... s [2]

(b) The time recorded by the student using a stop-watch is not equal to the time in **(a)**.

Suggest **three** possible reasons, other than the effect of air resistance, for this difference.

1 .....

.....

2 .....

.....

3 .....

.....

[3]

(c) The student repeats the experiment three times and uses the results to calculate the depth of the well. The values are shown in Table 1.1.

Table 1.1

	1st experiment	2nd experiment	3rd experiment
depth/m	54.4	53.9	54.1

The true depth of the well is 36.0 m. Explain why these results may be described as precise but not accurate.

.....

.....

.....

..... [2]

[Total: 7]

Answer:

Question	Answer	Marks
(a)	t = $\sqrt{(2s / g)}$ = $\sqrt{[(2 \times 36) / 9.81]}$	C1
	= 2.7 s	A1
(b)	• reaction time between hearing the splash and stopping the stop-watch • the sound (of the splash) takes time to reach the student **or** the stone hits the water at a different time to the sound being heard **or** the sound (of the splash) has to travel to the student • the student might not let go of the stone from ground level • the student might not let go of the stone and start the stop-watch at the same time • stop-watch may not be properly calibrated / has a zero error • (local value of) g is not (exactly) 9.81 (m s^{-2}) • stone given initial velocity / initial velocity not zero • stone does not fall (exactly) vertically / in a straight line *Any three points, 1 mark each*	B3
(c)	precise: results are close together / have little scatter	B1
	not accurate: the values are not close to / 50% different / (very) different from the true value	B1

22. 9702_w23_qp_21 Q: 3

A trolley A moves along a horizontal surface at a constant velocity towards another trolley B which is moving at a lower constant speed in the same direction. Fig. 3.1 shows the trolleys at time $t = 0$.

Fig. 3.1

Table 3.1 shows data for the trolleys.

Table 3.1

trolley	mass / kg	initial speed / m s^{-1}
A	0.25	0.48
B	0.75	0.12

The two trolleys collide elastically and then separate. Resistive forces are negligible.

Fig. 3.2 shows the variation with time t of the velocity v for trolley B.

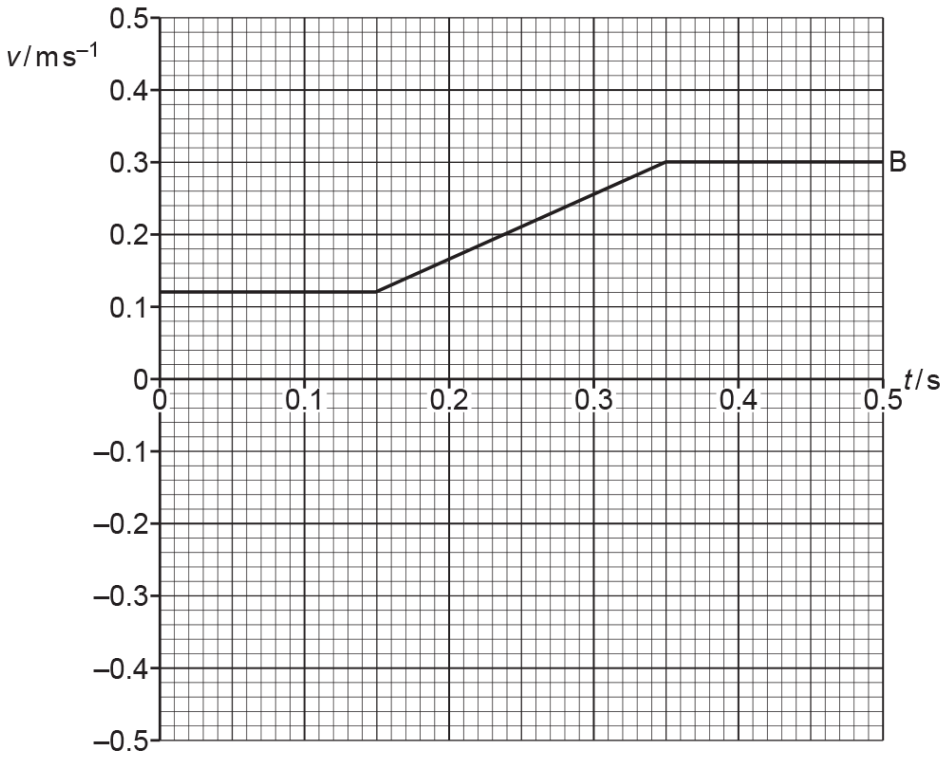


Fig. 3.2

(a) State what is represented by the area under a velocity–time graph.

..... [1]

(b) Use Table 3.1 and Fig. 3.2 to determine:

(i) the acceleration of trolley B during the collision

acceleration of B = ... $m\,s^{-2}$ [2]

(ii) the magnitude and direction of the final velocity of trolley A.

magnitude = ... $m\,s^{-1}$

direction .....
[3]

(c) On Fig. 3.2, sketch the variation of the velocity of trolley A with time t from $t = 0$ to $t = 0.50\,s$. [3]

[Total: 9]

Answer:

Question	Answer	Mark
(a)	displacement	**A1**
(b)(i)	a = gradient **or** $a = \Delta v / (\Delta)t$ **or** $a = (v - u) / t$	**C1**
	e.g. $a = (0.30 - 0.12) / (0.35 - 0.15)$ $a = 0.90\ \text{m s}^{-2}$	**A1**
(b)(ii)	$(0.25 \times 0.48) + (0.75 \times 0.12) = (0.25\ v) + (0.75 \times 0.30)$ **or** $(0.48 - 0.12) = (0.30 - v)$ **or** $(½ \times 0.25 \times 0.48^2) + (½ \times 0.75 \times 0.12^2) = (½ \times 0.25 \times v^2) + (½ \times 0.75 \times 0.30^2)$	**C1**
	$v = (-)0.060\ \text{m s}^{-1}$	**A1**
	direction: to the left / from the right / opposite to (its) initial velocity / opposite to (initial / final) velocity of B	**B1**
(c)	sketch: horizontal line from (0, 0.48) to (0.15, 0.48)	**B1**
	horizontal line from (0.35, –0.06) to (0.5, –0.06)	**B1**
	straight line between (0.15, 0.48) and (0.35, –0.06)	**B1**