Topical Past Paper Questions Worksheets

AS & A Level Physics (9702) Paper 2

Exam Series: May/June 2015 – May/June 2023

Format Type A:
Answers to all questions are provided as an appendix

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Introduction

Each Topical Past Paper Questions Compilation 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 2023
- Paper: 3
- Number of pages: 881
- Number of questions: 380

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]

1.2 Errors and uncertainties

2. 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]

3. 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]

4. 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 $4.1 \times 10^{-7}\,\Omega\,m$.

For this value of ρ, calculate:

(i) the percentage uncertainty

percentage uncertainty = ...% [2]

(ii) the absolute uncertainty.

absolute uncertainty = ... $\Omega\,m$ [1]

[Total: 6]

5. 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 m ± 2%
and T = 2.48 s ± 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]

6. 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 = ... $\mathrm{N\,m^{-2}}$ [1]

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

absolute uncertainty = ... $\mathrm{N\,m^{-2}}$ [2]

[Total: 4]

7. 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

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

(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 $1.99 \times 10^8\,\text{N}\,\text{m}^{-2}$.

[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]

---

8. 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]

9. 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]

1.3 Scalars and vectors

10. 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 $13\,\mathrm{m\,s^{-1}}$ in a direction 35° east of north in still water, as shown in Fig. 1.1.

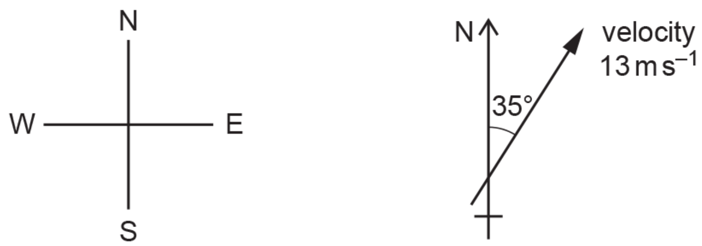


Fig. 1.1

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

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

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

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

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

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

Chapter 2

Kinematics

2.1 Equations of motion

11. 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:

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

(i) Calculate the acceleration *a* of the car.

a = ... $\text{m}\,\text{s}^{-2}$ [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]

12. 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.

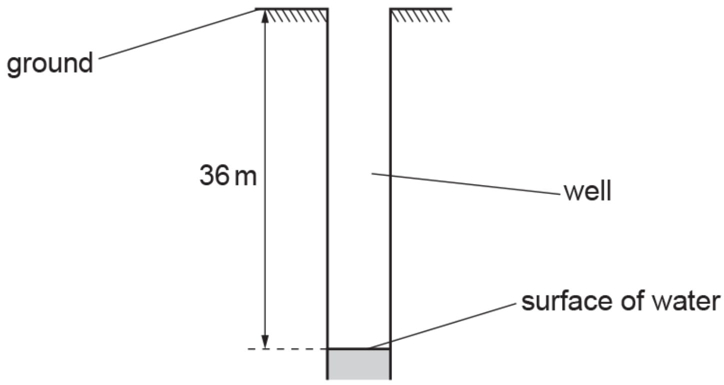


Fig. 1.1 (not to scale)

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]

13. 9702_s22_qp_22 Q: 3

A man standing on a wall throws a small ball vertically upwards with a velocity of $5.6\,m\,s^{-1}$. The ball leaves his hand when it is at a height of 3.1 m above the ground, as shown in Fig. 3.1.

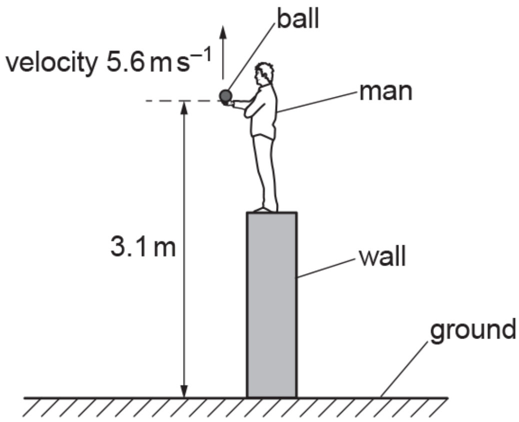


Fig. 3.1 (not to scale)

Assume that air resistance is negligible.

(a) Show that the ball reaches a maximum height above the ground of 4.7 m.

[2]

(b) The man does not catch the ball as it falls.

Calculate the time taken for the ball to fall from its maximum height to the ground.

time taken = ... s [2]

(c) The ball leaves the man's hand at time $t = 0$ and hits the ground at time $t = T$.

On Fig. 3.2, sketch a graph to show the variation of the velocity v of the ball with time t from $t = 0$ to $t = T$. Numerical values of v and t are not required. Assume that v is positive in the upward direction.

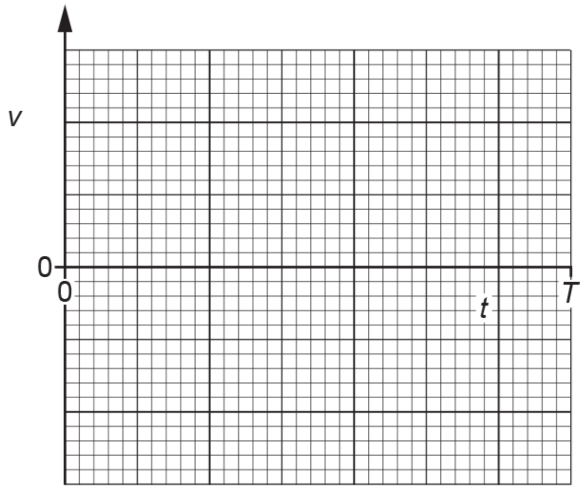


Fig. 3.2

[3]

(d) State what is represented by the gradient of the graph in **(c)**.

.... [1]

(e) The man now throws a second ball with the same velocity and from the same height as the first ball. The mass of the second ball is greater than that of the first ball. Assume that air resistance is still negligible.

For the first and second balls, compare:

(i) the magnitudes of their accelerations

.... [1]

(ii) the speeds with which they hit the ground.

.... [1]

[Total: 10]

14. 9702_s20_qp_23 Q: 1

(a) State **one** similarity and **one** difference between *distance* and *displacement*.

similarity: ....

....

difference: ....

....
[2]

(b) A student takes several measurements of the same quantity. This set of measurements has high precision, but low accuracy.

Describe what is meant by:

(i) *high precision*

....

.... [1]

(ii) *low accuracy*.

....

.... [1]

[Total: 4]

15. 9702_w20_qp_22 Q: 1

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

Table 1.1

quantity	scalar	vector
acceleration		
density		
temperature		
momentum		

[2]

(b) A toy train moves along a straight section of track. Fig. 1.1 shows the variation with time *t* of the distance *d* moved by the train.

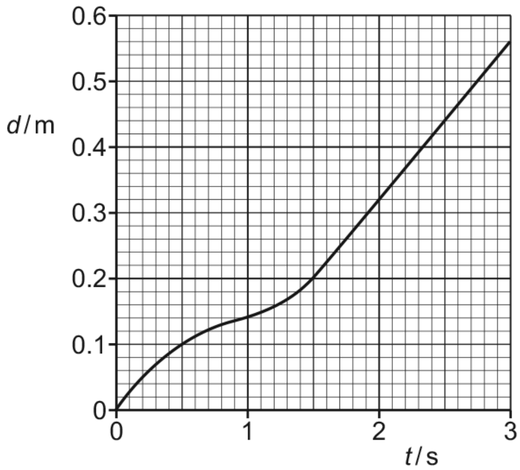


Fig. 1.1

(i) Describe qualitatively the motion of the train between time $t = 0$ and time $t = 1.0$ s.

....

.... [1]

(ii) Determine the speed of the train at time $t = 2.0\,s$.

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

(c) The straight section of track in **(b)** is part of the loop of track shown in Fig. 1.2.

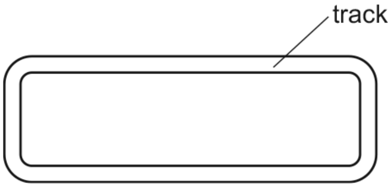


Fig. 1.2

The train completes exactly one lap of the loop.

State and explain the average velocity of the train over the one complete lap.

....

....

.... [1]

[Total: 6]

16. 9702_s19_qp_21 Q: 1

(a) Define *velocity*.

....

....[1]

(b) The speed v of a sound wave through a gas of pressure P and density ρ is given by the equation

$$v = \sqrt{\frac{kP}{\rho}}$$

where k is a constant that has no units.

An experiment is performed to determine the value of k. The data from the experiment are shown in Fig. 1.1.

quantity	value	uncertainty
v	$3.3 \times 10^2\,\mathrm{m\,s^{-1}}$	± 3%
P	$9.9 \times 10^4\,\mathrm{Pa}$	± 2%
ρ	$1.29\,\mathrm{kg\,m^{-3}}$	± 4%

Fig. 1.1

(i) Use data from Fig. 1.1 to calculate k.

k = ... [2]

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

k = ... ± .... [3]

[Total: 6]

17. 9702_m18_qp_22 Q: 1

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

quantity	**vector or scalar**
acceleration	
speed	
power	

Fig. 1.1

[2]

(b) A ball is projected with a horizontal velocity of $1.1\,\mathrm{m\,s^{-1}}$ from point A at the edge of a table, as shown in Fig. 1.2.

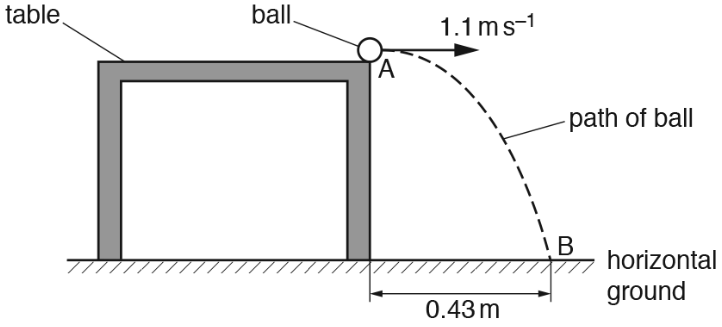


Fig. 1.2

The ball lands on horizontal ground at point B which is a distance of 0.43 m from the base of the table. Air resistance is negligible.

(i) Calculate the time taken for the ball to fall from A to B.

time = ... s [1]

(ii) Use your answer in **(b)(i)** to determine the height of the table.

height = ... m [2]

(iii) The ball leaves the table at time $t = 0$.

For the motion of the ball between A and B, sketch graphs on Fig. 1.3 to show the variation with time t of

1. the acceleration a of the ball,

2. the vertical component s_v of the displacement of the ball from A.

Numerical values are not required.

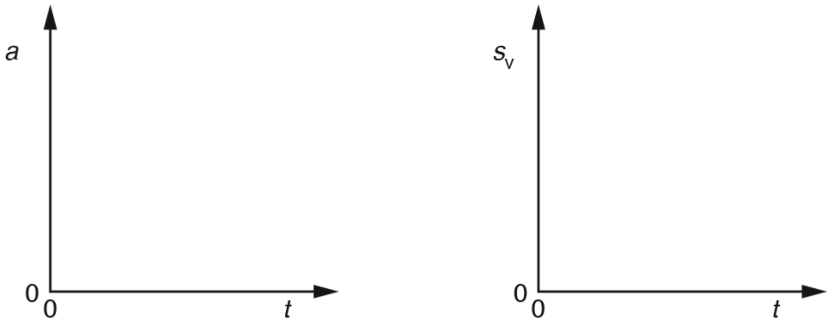


Fig. 1.3

[2]

(c) A ball of greater mass is projected from the table with the same velocity as the ball in **(b)**. Air resistance is still negligible.

State and explain the effect, if any, of the increased mass on the time taken for the ball to fall to the ground.

....

....[1]

[Total: 8]

18. 9702_w17_qp_21 Q: 2

The variation with time t of the velocity v of two cars P and Q is shown in Fig. 2.1.

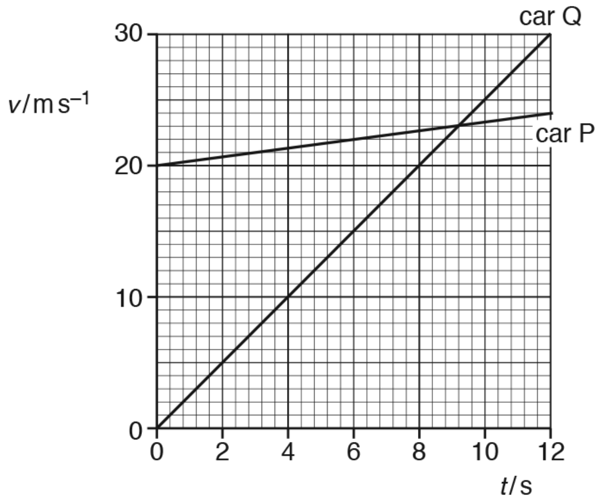


Fig. 2.1

The cars travel in the same direction along a straight road.
Car P passes car Q at time $t = 0$.

(a) The speed limit for cars on the road is 100 km h^{-1}. State and explain whether car Q exceeds the speed limit.

.... [1]

(b) Calculate the acceleration of car P.

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

(c) Determine the distance between the two cars at time $t = 12$ s.

distance = ... m [3]

(d) From time $t = 12$ s, the velocity of each car remains constant at its value at $t = 12$ s.

Determine the time t at which car Q passes car P.

t = ... s [2]

[Total: 8]

19. 9702_s16_qp_21 Q: 2

A ball is thrown from a point P with an initial velocity u of 12 m s^{-1} at 50° to the horizontal, as illustrated in Fig. 2.1.

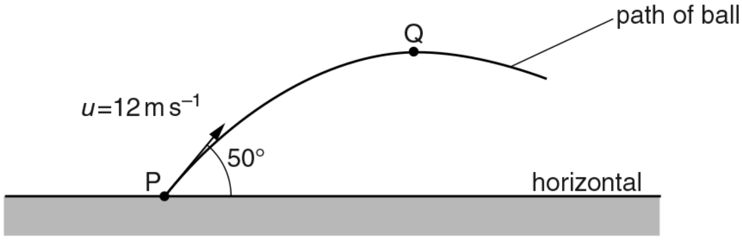


Fig. 2.1

The ball reaches maximum height at Q.

Air resistance is negligible.

(a) Calculate

(i) the horizontal component of u,

horizontal component = ... m s^{-1} [1]

(ii) the vertical component of u.

vertical component = ... m s^{-1} [1]

(b) Show that the maximum height reached by the ball is 4.3 m.

[2]

(c) Determine the magnitude of the displacement PQ.

displacement = ... m [4]

[Total: 8]

20. 9702_s16_qp_23 Q: 1

(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		

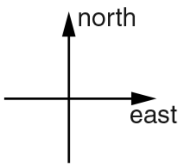
Fig. 1.1

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.



(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]

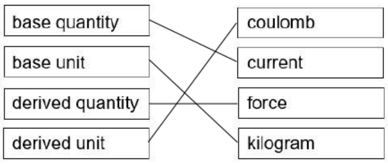
Appendix A

Answers

1. 9702_m19_ms_22 Q: 1

	Answer	Mark
(a)	kilogram / kg	**B1**
	kelvin / K	**B1**
(b)	units for *v*: m s^{-1} <u>and</u> 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**

2. 9702_w22_ms_21 Q: 1

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**

3. 9702_w22_ms_23 Q: 1

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

4. 9702_w21_ms_22 Q: 1

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 $= 4.1 \times 10^{-7} \times 14 / 100$ $= 6 \times 10^{-8}\ \Omega\,m$	A1

5. 9702_m20_ms_22 Q: 1

	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)	$g = (4\pi^2 \times 1.50) / (2.48^2)$ $= 9.63\ m\,s^{-2}$	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 $= 0.8\ m\,s^{-2}$	A1

6. 9702_s19_ms_22 Q: 1

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

7. 9702_w17_ms_22 Q: 1

	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
	%σ = 2% + (2 × 5%) **or** %σ = [0.02 + (2 × 0.05)] × 100 %σ = 12%	A1
(b)(iii)	absolute uncertainty = (12 / 100) × 1.99×10^8 = 2.4×10^7	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

8. 9702_m16_ms_22 Q: 1

(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 (m s^{-1}) A1

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

9. 9702_s16_ms_23 Q: 2

(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]

10. 9702_s21_ms_23 Q: 1

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**

11. 9702_m23_ms_22 Q: 1

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 × 0.8) + 0.5	**C1**
	= 2.1%	**A1**
(c)(iii)	absolute uncertainty = (2.1 / 100) × 0.97 = 0.02 $m\,s^{-2}$	**A1**

12. 9702_s23_ms_23 Q: 1

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

13. 9702_s22_ms_22 Q: 3

Question	Answer	Marks
(a)	$v^2 = u^2 + 2as$ $s = 5.6^2 / (2 \times 9.81)$	C1
	(max height =) $3.1 + 5.6^2 / (2 \times 9.81) = 4.7$ (m)	A1
(b)	$s = ut + \frac{1}{2}at^2$ $4.7 = \frac{1}{2} \times 9.81 \times t^2$	C1
	$t = 0.98$ s	A1
(c)	line drawn from a non-zero speed at $t = 0$ to a greater speed at $t = T$	B1
	a single sloping straight line drawn from $t = 0$ to $t = T$	B1
	line starts with a positive non-zero value of v and ends with a negative non-zero value of v	B1
(d)	acceleration (of the ball)	B1
(e)(i)	(magnitudes of accelerations are) equal / same	B1
(e)(ii)	(speeds are) equal / same	B1

14. 9702_s20_ms_23 Q: 1

	Answer	Mark
(a)	similarity: both have magnitude	B1
	difference: distance is a scalar/does not have direction **or** displacement is a vector/has direction	B1
(b)(i)	the measurements have a small range	B1
(b)(ii)	the (average of the) measurements is not close to the true value	B1

15. 9702_w20_ms_22 Q: 1

	Answer	Mark
(a)	density and temperature indicated as scalars	B1
	acceleration and momentum indicated as vectors	B1
(b)(i)	decelerates **or** speed/velocity decreases	B1
(b)(ii)	speed = $(\Delta)d / (\Delta)t$ **or** gradient	C1
	= e.g. (0.56 – 0.20) / 1.5 = 0.24 m s^{-1}	A1
(c)	displacement is zero (so) average velocity is zero	B1

16. 9702_s19_ms_21 Q: 1

	Answer	Mark
(a)	(velocity =) change in displacement / time (taken)	B1
(b)(i)	k = [1.29 × (3.3 × 10^2)^2] / 9.9 × 10^4	C1
	= 1.4	A1
(b)(ii)	percentage uncertainty = (3 × 2) + 4 + 2 (= 12%) **or** fractional uncertainty = (0.03 × 2) + 0.04 + 0.02 (= 0.12)	C1
	Δk = 0.12 × 1.42 = 0.17 (*allow to 1 significant figure*)	C1
	k = 1.4 ± 0.2	A1

17. 9702_m18_ms_22 Q: 1

	Answer	Mark
(a)	acceleration: vector speed: scalar power: scalar *All three correct scores 2 marks. Only two correct scores 1 mark.*	B2
(b)(i)	time = 0.43 / 1.1 = 0.39 s	A1
(b)(ii)	$s = ut + ½at^2$ = ½ × 9.81 × 0.39^2	C1
	= 0.75 m	A1
(b)(iii)	1 horizontal line at a non-zero value of a.	B1
	2 curved line from origin with increasing gradient.	B1
(c)	acceleration (of free fall) is unchanged / not dependent on mass <u>and</u> so no effect (on time taken).	A1

18. 9702_w17_ms_21 Q: 2

	Answer	Mark
(a)	$30\,m\,s^{-1} = 108\,km\,h^{-1}$ **or** $100\,km\,h^{-1} = 28\,m\,s^{-1}$ **and** so exceeds speed limit	**B1**
(b)	acceleration = gradient **or** $\Delta v/(\Delta)t$ **or** $(v-u)/t$	**C1**
	e.g. acceleration = (24 – 20) / 12 [other points on graph line may be used] $= 0.33\,m\,s^{-2}$	**A1**
(c)	distance travelled by Q = ½ × 12 × 30 (= 180 m)	**C1**
	distance travelled by P = ½ × (20 + 24) × 12 (= 264 m)	**C1**
	distance between cars = 264 – 180 = 84 m	**A1**
(d)	$30 - 24 = 6\,m\,s^{-1}$ 'extra' time T = 84/6 (= 14 s) **or** 180 + 30T = 264 + 24T 'extra' time T = 84/6 (= 14 s)	**C1**
	t = 12 + 14 = 26 s	**A1**

19. 9702_s16_ms_21 Q: 2

(a) (i) horizontal component (= 12 cos 50°) = $7.7\,m\,s^{-1}$ A1 [1]

(ii) vertical component (= 12 sin 50° or 7.7 tan 50°) = $9.2\,m\,s^{-1}$ A1 [1]

(b) $v^2 = u^2 + 2as$ <u>and</u> $v = 0$ or $mgh = ½mv^2$ or $s = v^2\sin^2\theta/2g$ C1

$9.2^2 = 2 \times 9.81 \times h$ hence h = 4.3 (4.31) m A1 [2]

alternative methods using time to maximum height of 0.94 s:

$s = ut + ½at^2$ and t = 0.94 (s) (C1)
$s = 9.2 \times 0.94 - ½ \times 9.81 \times 0.94^2$ hence s = 4.3 m (A1)

or
$s = vt - ½at^2$ and t = 0.94 (s) (C1)
$s = ½ \times 9.81 \times 0.94^2$ hence s = 4.3 m (A1)

or
$s = ½(u + v)t$ and t = 0.94 (s) (C1)
$s = ½ \times 9.2 \times 0.94$ hence s = 4.3 m (A1)

(c) t (= 9.2 / 9.81) = 0.94 (0.938) s C1

horizontal distance = 0.938 × 7.7 (= 7.23 m) C1

displacement = $[4.3^2 + 7.23^2]^{1/2}$ C1

= 8.4 m A1 [4]

20. 9702_s16_ms_23 Q: 1

(a)	scalars: energy, power and time	A1	
	vectors: momentum and weight	A1	[2]
(b) (i)	triangle with right angles between 120 m and 80 m, arrows in correct direction and result displacement from start to finish arrow in correct direction and labelled R	B1	[1]
(ii) 1.	average speed (= 200 / 27) = 7.4 m s^{-1}	A1	[1]
2.	resultant displacement (= $[120^2 + 80^2]^{1/2}$) = 144 (m)	C1	
	average velocity (= 144 / 27) = 5.3(3) m s^{-1}	A1	
	direction (= $\tan^{-1}$ 80 / 120) = 34° (33.7)	A1	[3]

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21. 9702_s15_ms_21 Q: 2

(a)	speed = distance / time and velocity = displacement / time	B1	
	speed is a scalar as distance has no direction **and** velocity is a vector as displacement has direction	B1	[2]
(b) (i)	constant acceleration or linear/uniform increase in velocity until 1.1 s	B1	
	rebounds or bounces or changes direction	B1	
	decelerates to zero velocity at the same acceleration as initial value	B1	[3]
(ii)	$a = (v - u) / t$ or use of gradient implied	C1	
	= (8.8 + 8.8) / 1.8 or appropriate values from line or = (8.6 + 8.6) / 1.8	B1	
	= 9.8 (9.78) m s^{-2} or = 9.6 m s^{-2}	A1	[3]
(iii)	**1.** distance = first area above graph + second area below graph	C1	
	= (1.1 × 10.8) / 2 + (0.9 × 8.8) / 2 (= 5.94 + 3.96)	C1	
	= 9.9 m	A1	[3]
	2. displacement = first area above graph – second area below graph	C1	
	= (1.1 × 10.8) / 2 – (0.9 × 8.8) / 2		
	= 2.0 (1.98) m	A1	[2]
(iv)	correct shape with straight lines and all lines above the time axis or all below	M1	
	correct times for zero speeds (0.0, 1.15 s, 2.1 s) and peak speeds (10.8 m s^{-1} at 1.1 s and 8.8 m s^{-1} at 1.2 s and 3.0 s)	A1	[2]
