



Surname _____

Other Names _____

Centre Number _____

Candidate Number _____

Candidate Signature _____

I declare this is my own work.

AS

PHYSICS

Paper 2

7407/2

Time allowed: 1 hour 30 minutes

You are advised to spend about 35 minutes on Section C

At the top of the page, write your surname and other names, your centre number, your candidate number and add your signature.

[Turn over]



For this paper you must have:

- a pencil and a ruler
- a scientific calculator
- a Data and Formulae Booklet
- a protractor.

INSTRUCTIONS

- Use black ink or black ball-point pen.
- Answer ALL questions.
- You must answer the questions in the spaces provided. Do not write on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.



INFORMATION

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- You are expected to use a scientific calculator where appropriate.
- A Data and Formulae Booklet is provided as a loose insert.

DO NOT TURN OVER UNTIL TOLD TO DO SO



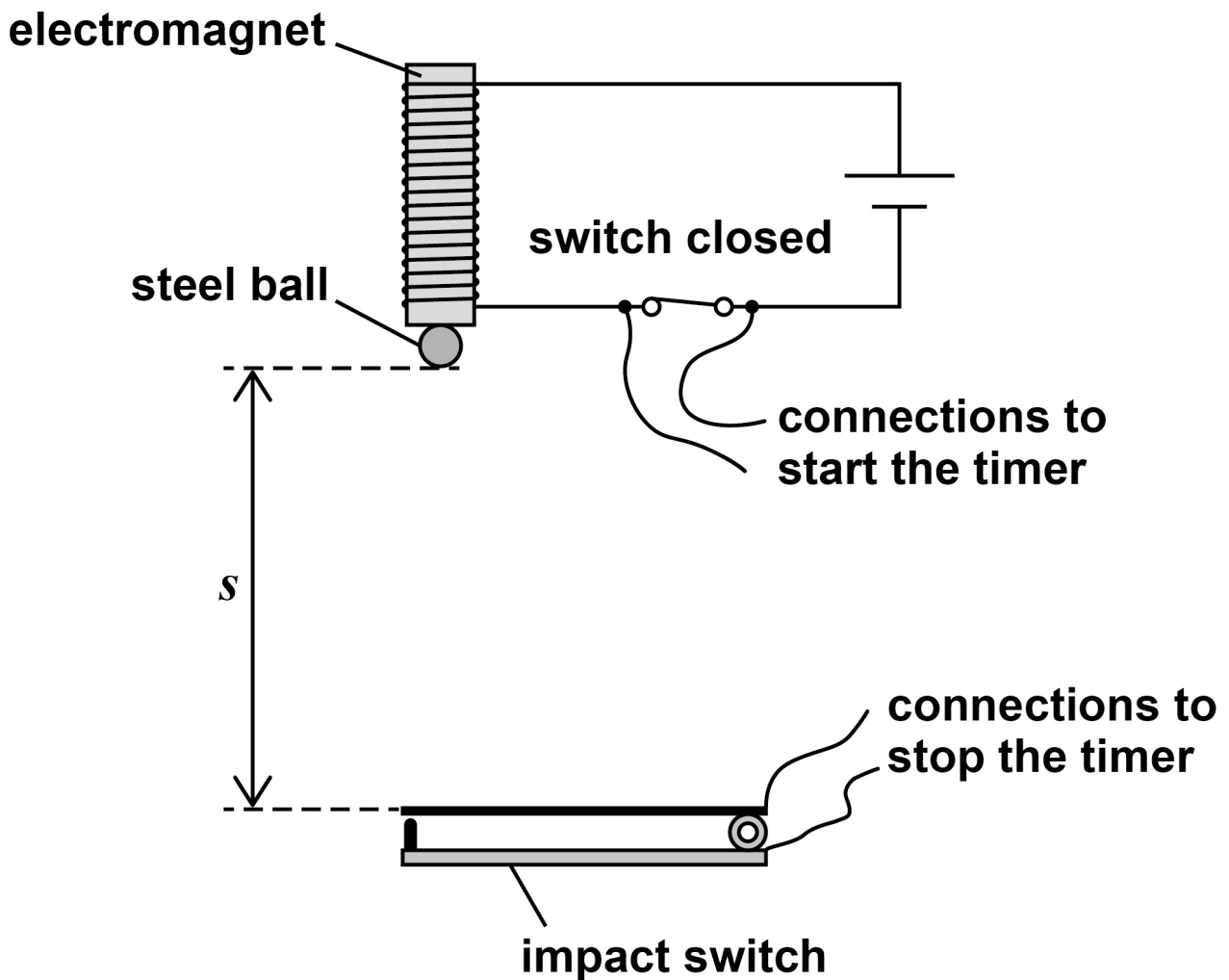
SECTION A

Answer ALL questions in this section.

0	1
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FIGURE 1 shows apparatus used to determine the acceleration g due to gravity by a free-fall method.

FIGURE 1



When the switch is opened a timer starts and a steel ball is released from rest.

The ball falls vertically onto an impact switch and this stops the timer.

The timer displays the time t for the ball to fall through the vertical distance s shown in FIGURE 1, on the opposite page.

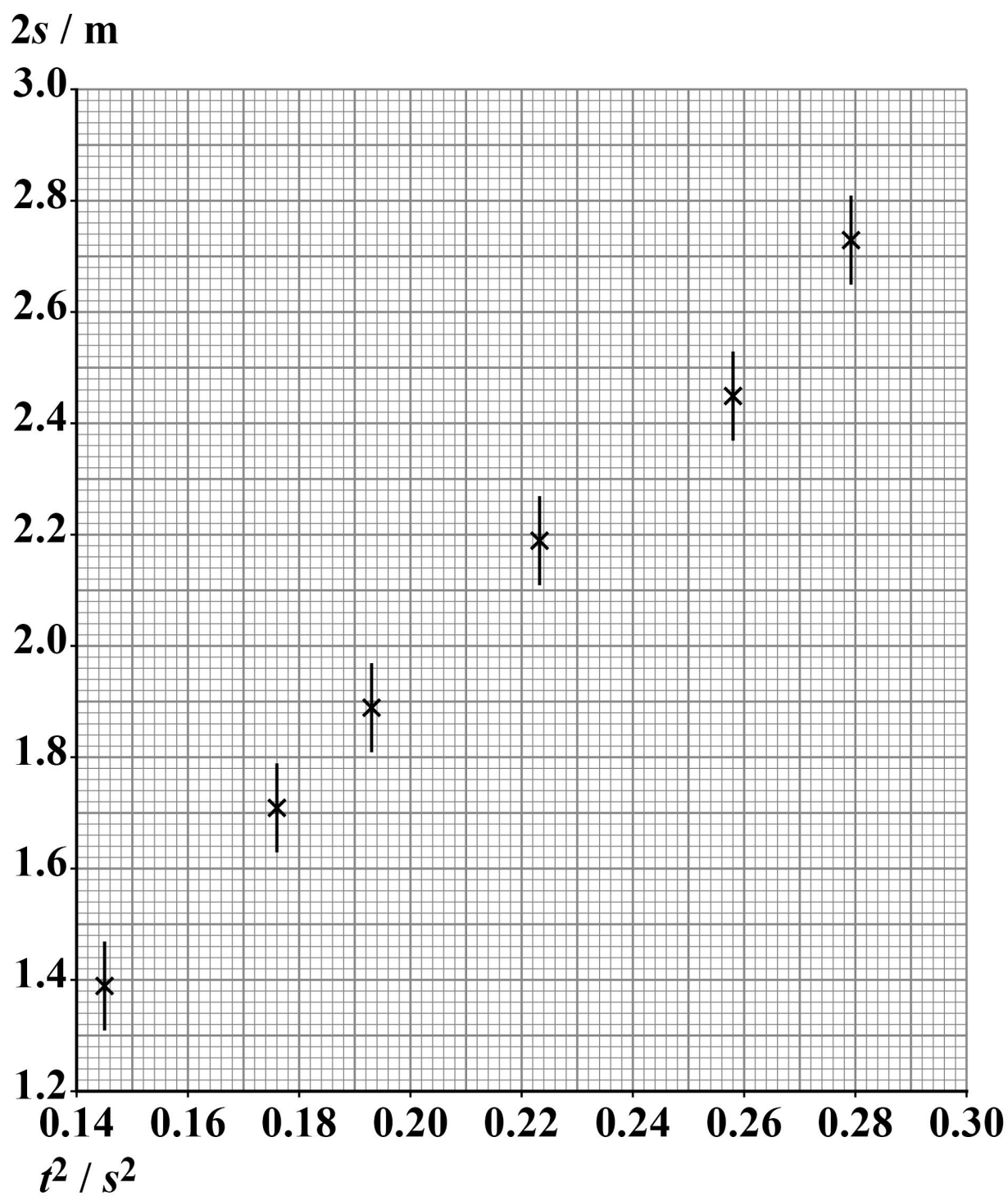
A student obtains values of t for different values of s .

The student plots the graph of $2s$ against t^2 shown in FIGURE 2, on page 6.

[Turn over]



FIGURE 2



0	1	.	1
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The student has used an absolute uncertainty in s to draw the vertical error bars in FIGURE 2.

Deduce the student's absolute uncertainty in s . [1 mark]

absolute uncertainty in s = _____ m

[Turn over]



0	1	.	2
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Determine

- the maximum gradient $G_{\max}$ of a straight line that passes through all the error bars
- the minimum gradient $G_{\min}$ of a straight line that passes through all the error bars.

[3 marks]

$G_{\max} =$ _____

$G_{\min} =$ _____



0	1	.	3
---	---	---	---

It can be shown that $2s = gt^2$.

Determine a value for g using $G_{\max}$ and $G_{\min}$. [2 marks]

$g =$ _____ m s^{-2}

[Turn over]



0	1	.	4
---	---	---	---

Determine the percentage uncertainty in your value for g . [2 marks]

percentage uncertainty = _____ %



A fault develops in the apparatus.

When the switch is opened there is now a 30 ms delay before the ball is released.

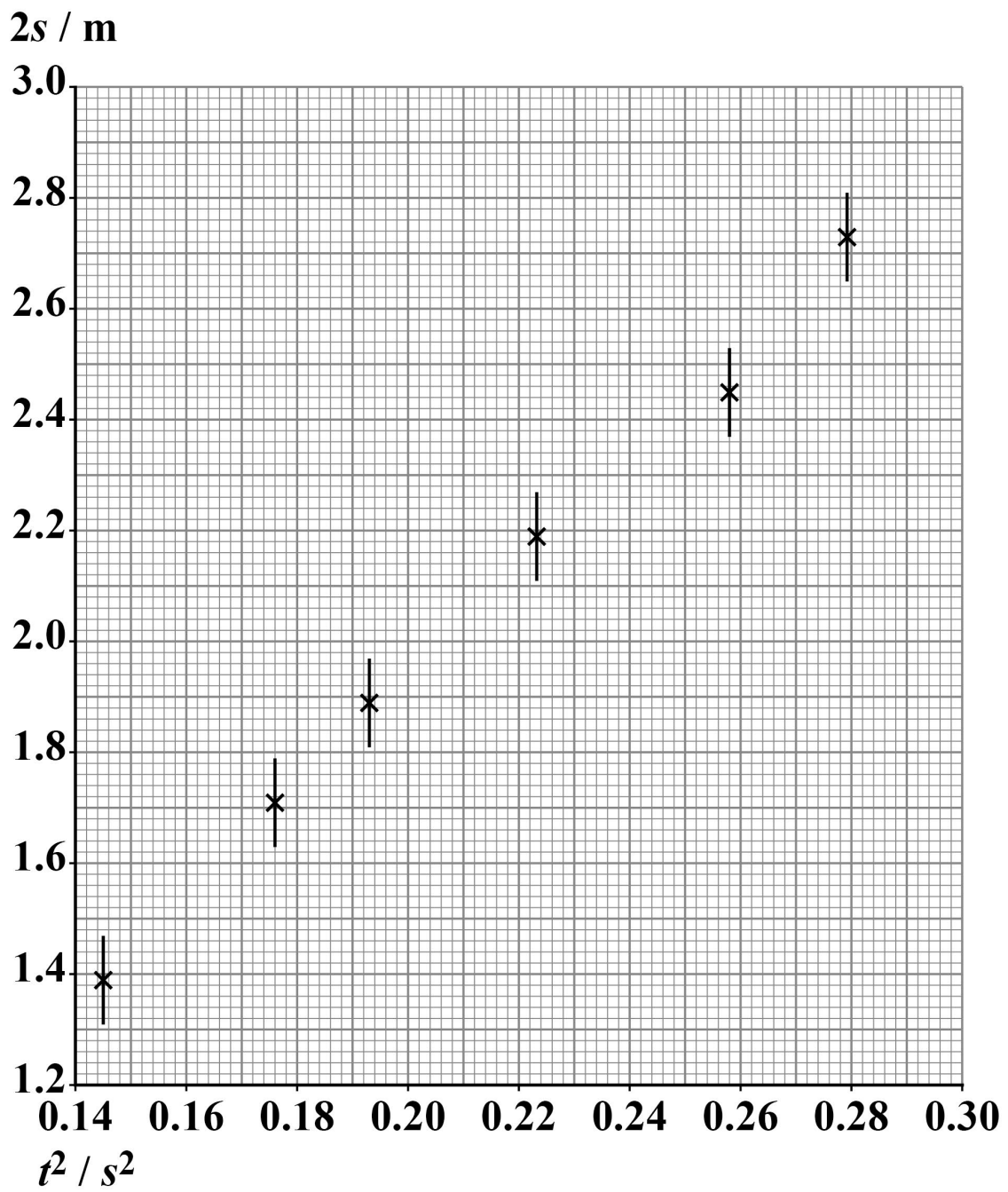
01.5

State the type of error produced by this fault. [1 mark]

[Turn over]



REPEAT OF FIGURE 2



0	1	.	6
---	---	---	---

A graph of $2s$ against t^2 is produced using results from the faulty apparatus.

Describe how this graph is different from the graph in FIGURE 2. [1 mark]

[Turn over]

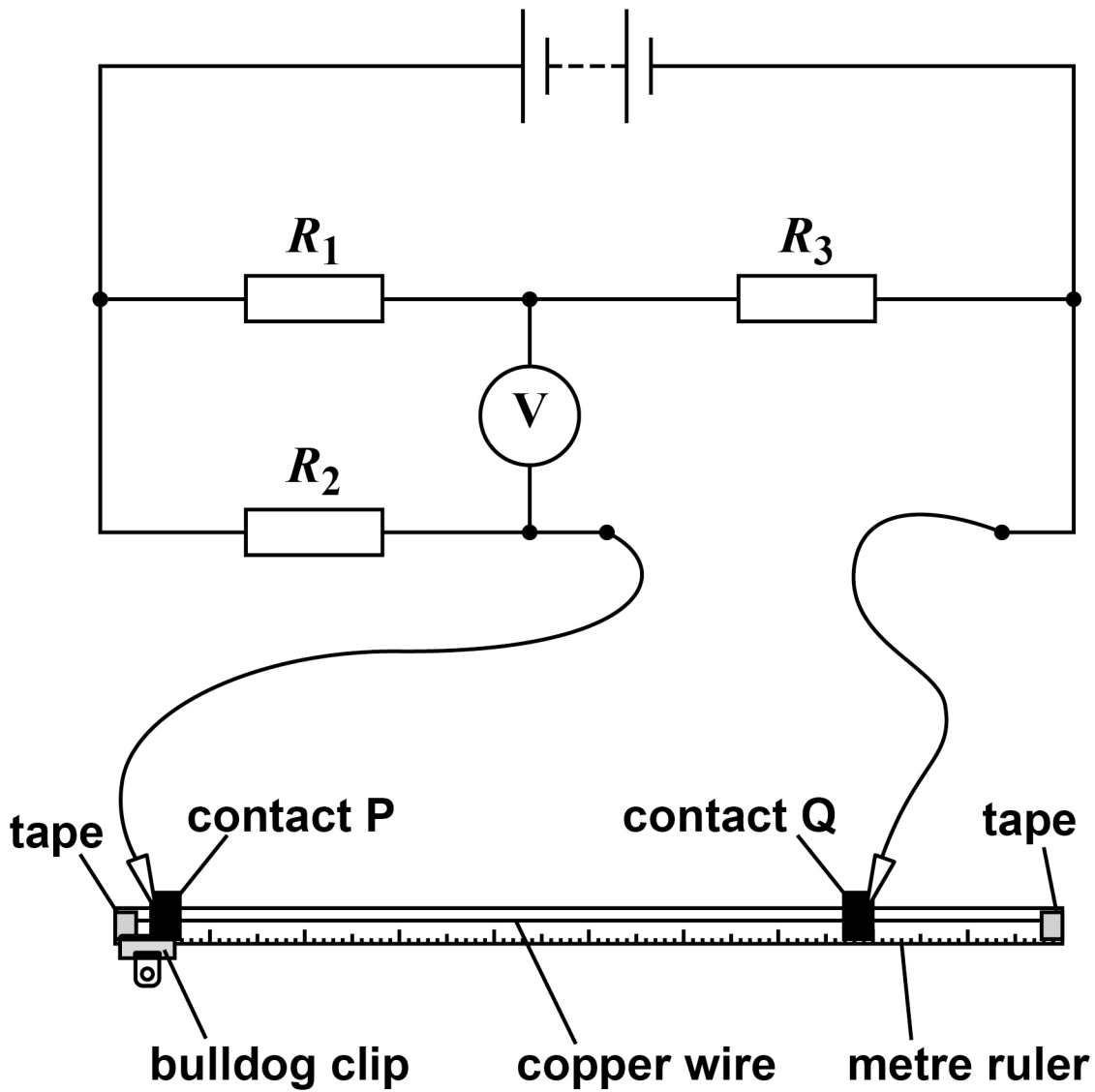
10



02

FIGURE 3 shows a circuit used to find the resistance per unit length of a copper wire.

FIGURE 3



The copper wire is fixed with tape to a metre ruler that has 2 mm graduations.

Contact P is placed on the wire close to one end of the ruler and held firmly in place using a bulldog clip.

When contact Q is placed on the wire as shown in FIGURE 3, on the opposite page, the voltmeter shows a non-zero reading.

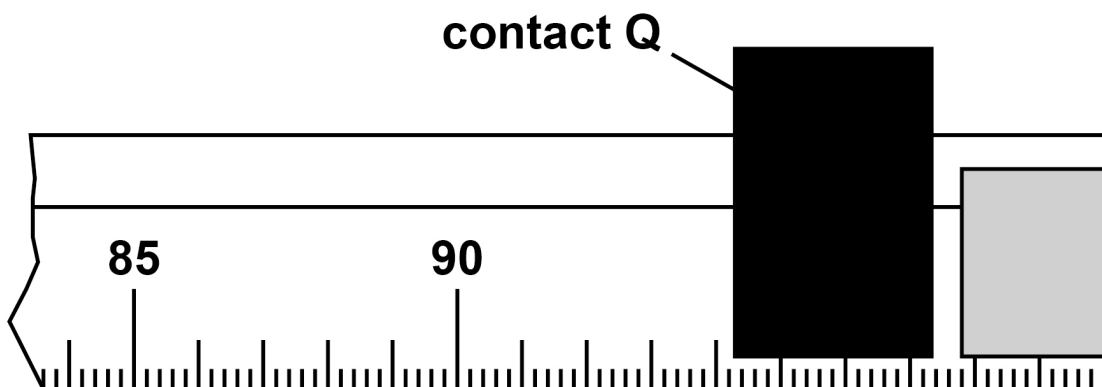
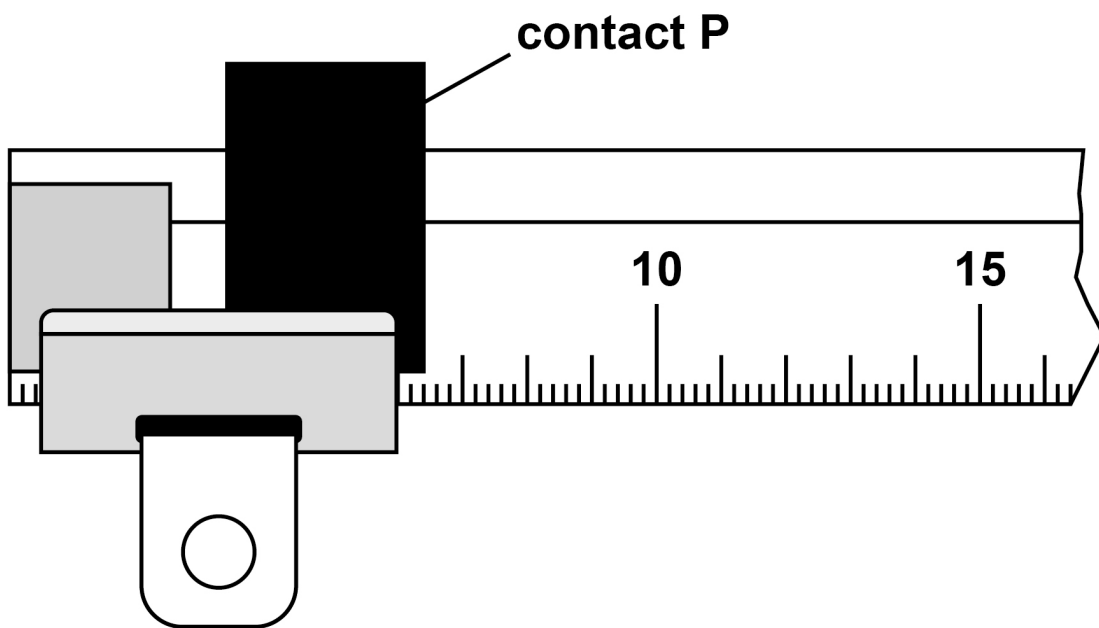
Q is moved along the wire until the voltmeter reading is zero.

FIGURE 4, on page 16, shows enlarged views of the position of P and the new position of Q.

[Turn over]



FIGURE 4



0	2	.	1
---	---	---	---

Determine, in m, the length x of copper wire between P and Q. [1 mark]

$x =$ _____ m

[Turn over]



02.2

When the voltmeter reading is zero:

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

where R_4 is the resistance of the copper wire between P and Q.

Determine, in $\Omega \text{ m}^{-1}$, the resistance per unit length of the copper wire.

$$R_1 = 2.2 \text{ M}\Omega$$

$$R_2 = 3.9 \text{ k}\Omega$$

$$R_3 = 75 \text{ }\Omega$$

[2 marks]

resistance per unit length = _____ $\Omega \text{ m}^{-1}$



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[Turn over]



0	2	.	3
---	---	---	---

The diameter d of the copper wire is approximately 0.4 mm.

Suggest:

- a suitable measuring instrument to accurately determine d
- how to reduce the effect of random error on the result for d .

[3 marks]



[Turn over]



02.4

Determine the resistivity ρ of copper.

diameter d of the copper wire = 0.38 mm [2 marks]

$\rho =$ _____ $\Omega \text{ m}$

The copper wire is replaced with a constantan wire of diameter 0.38 mm.

$\frac{\text{resistivity of constantan}}{\text{resistivity of copper}} = 30$



02.5

Suggest ONE change to the circuit to make the voltmeter read zero for the same value of x as in Question 02.1, on page 17. [1 mark]

02.6

Calculate, in mm, the diameter of a constantan wire that has the SAME resistance per unit length as the copper wire. [1 mark]

diameter = _____ mm

[Turn over]



SECTION B

Answer ALL questions in this section.

0	3
---	---

A student buys a portable loudspeaker that is powered by its own internal battery. The battery in the loudspeaker is initially uncharged.



0	3	.	1
---	---	---	---

The battery is connected to a charger that maintains a constant potential difference of 5.0 V across the battery. It takes 2.6 hours for the battery to become fully charged. The average current in the battery during this time is 2.0 A .

The battery is disconnected from the charger. The fully-charged battery operates the loudspeaker for 12 hours before it is completely discharged.

Calculate the average output power of the battery during these 12 hours. [2 marks]

average output power = _____ W

[Turn over]



03.2

A mobile phone transmits data to the loudspeaker using microwaves. The data are processed at the loudspeaker to produce sound waves.

Microwaves and sound waves travel at different speeds.

Describe TWO other differences between microwaves and sound waves. [2 marks]

1

2



0	3	.	3
---	---	---	---

A second loudspeaker receives the same data from the mobile phone. The two loudspeakers act as coherent sources of sound waves.

State the TWO conditions required for the sources to be coherent. [2 marks]

1

2

[Turn over]

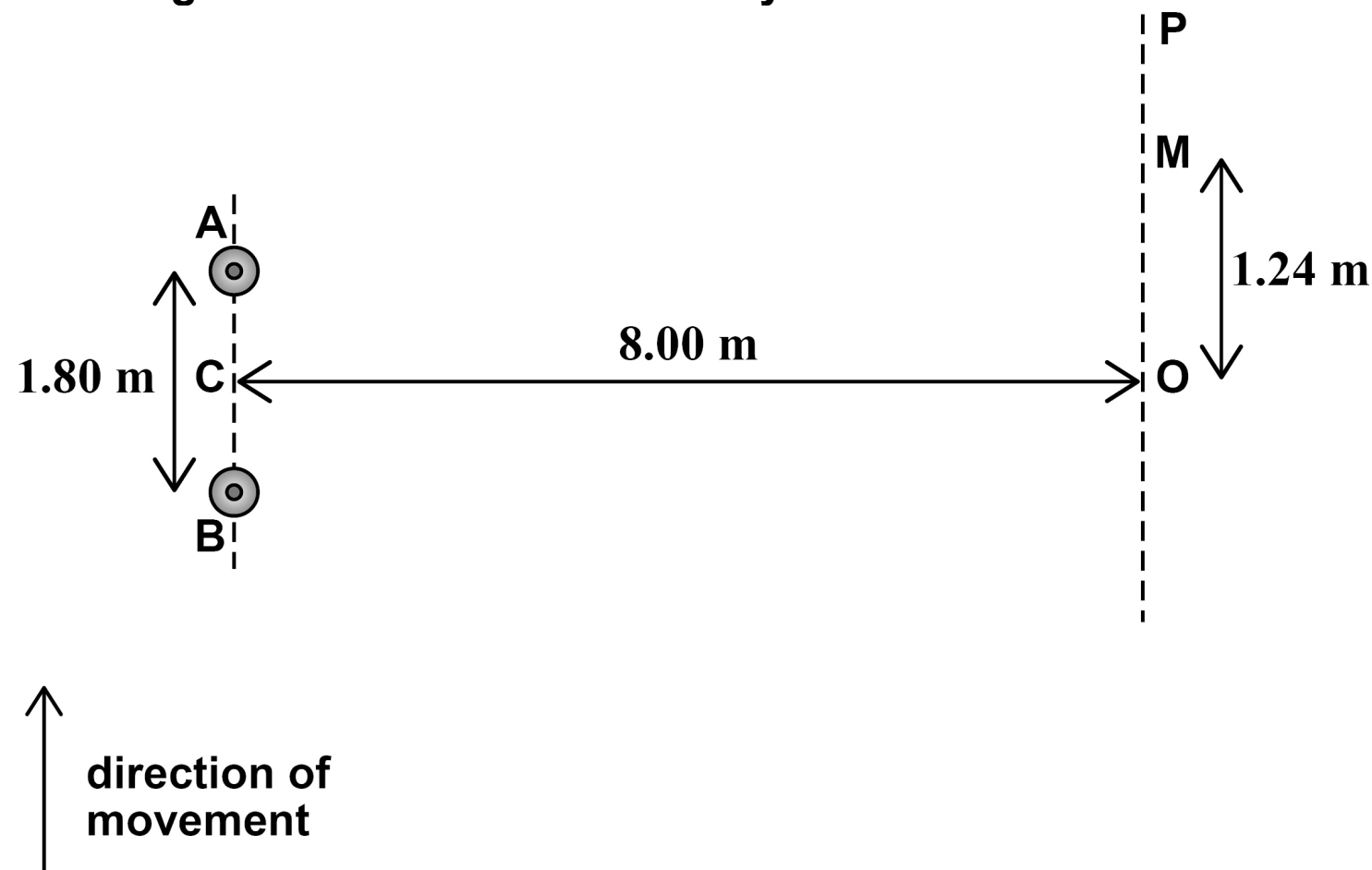




FIGURE 5 shows two loudspeakers A and B that act as coherent point sources of sound of a single frequency.

FIGURE 5

The diagram is not drawn accurately.





C is the midpoint between A and B.

Distances OA and OB are equal.

OP is perpendicular to CO.

The student uses a sound-level meter to measure the intensity of the sound. The meter detects a maximum intensity at O.

The student moves the meter along OP. The intensity decreases and reaches a first minimum at M. The intensity then increases as the meter moves towards P.

The student records the following distances:

AB = 1.80 m

CO = 8.00 m

OM = 1.24 m.

[Turn over]



03.4

Show that the difference between the path lengths *AM* and *BM* is approximately 0.3 m. [2 marks]



31

03.5

The speed of sound is 340 m s^{-1} .

Determine the frequency of the sound waves. [2 marks]

frequency = _____ Hz

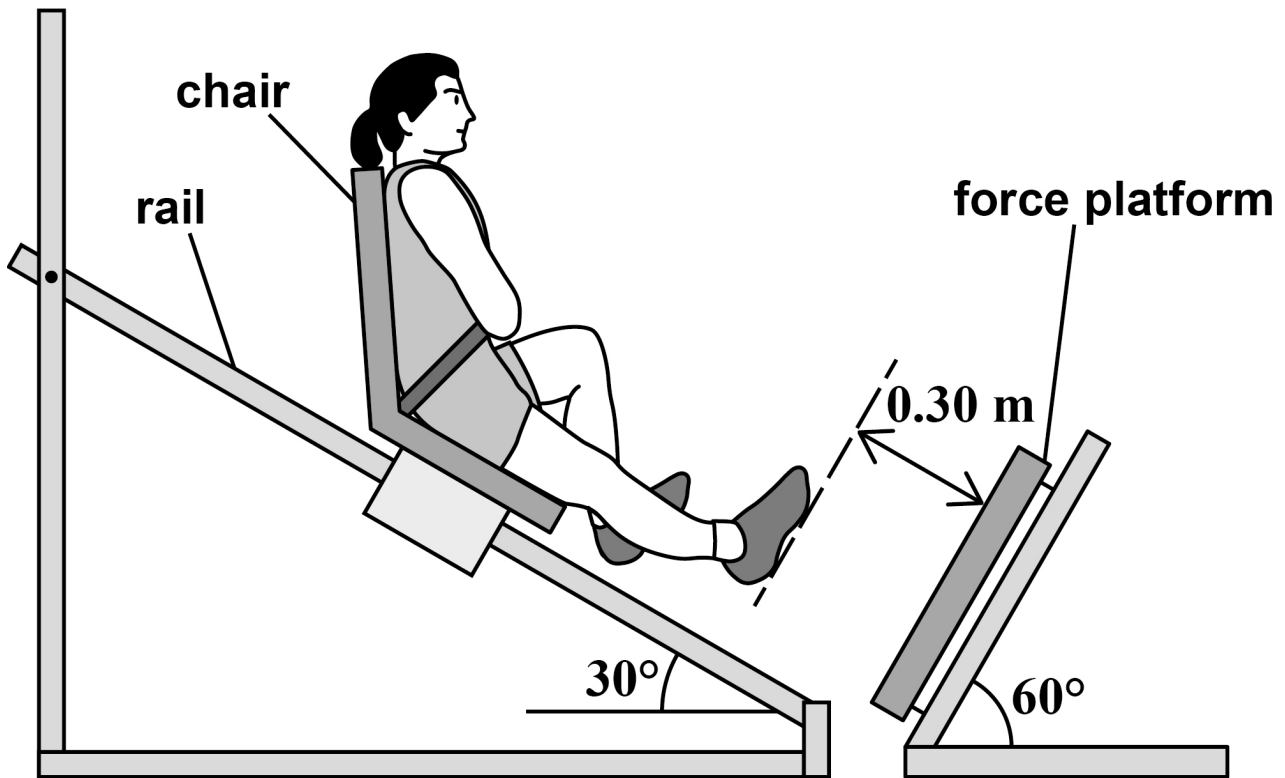
[Turn over]

10

04

FIGURE 6 shows apparatus used to measure the force exerted by an athlete during a single-leg jump.

FIGURE 6



In **FIGURE 6**, the athlete is strapped into a chair and held at rest halfway along a rail.

The chair is then released to slide down the rail. The athlete keeps her right leg extended until her right foot makes contact with a force platform.

Friction between the rail and the chair is negligible.

initial distance between right foot and platform = 0.30 m

angle between rail and floor = 30°

angle between platform and floor = 60°



04.1

Show that the athlete and chair accelerate towards the platform at approximately 5 m s^{-2} . [1 mark]

04.2

Calculate the speed of the athlete when her right foot makes initial contact with the platform. [2 marks]

speed = _____ m s^{-1}

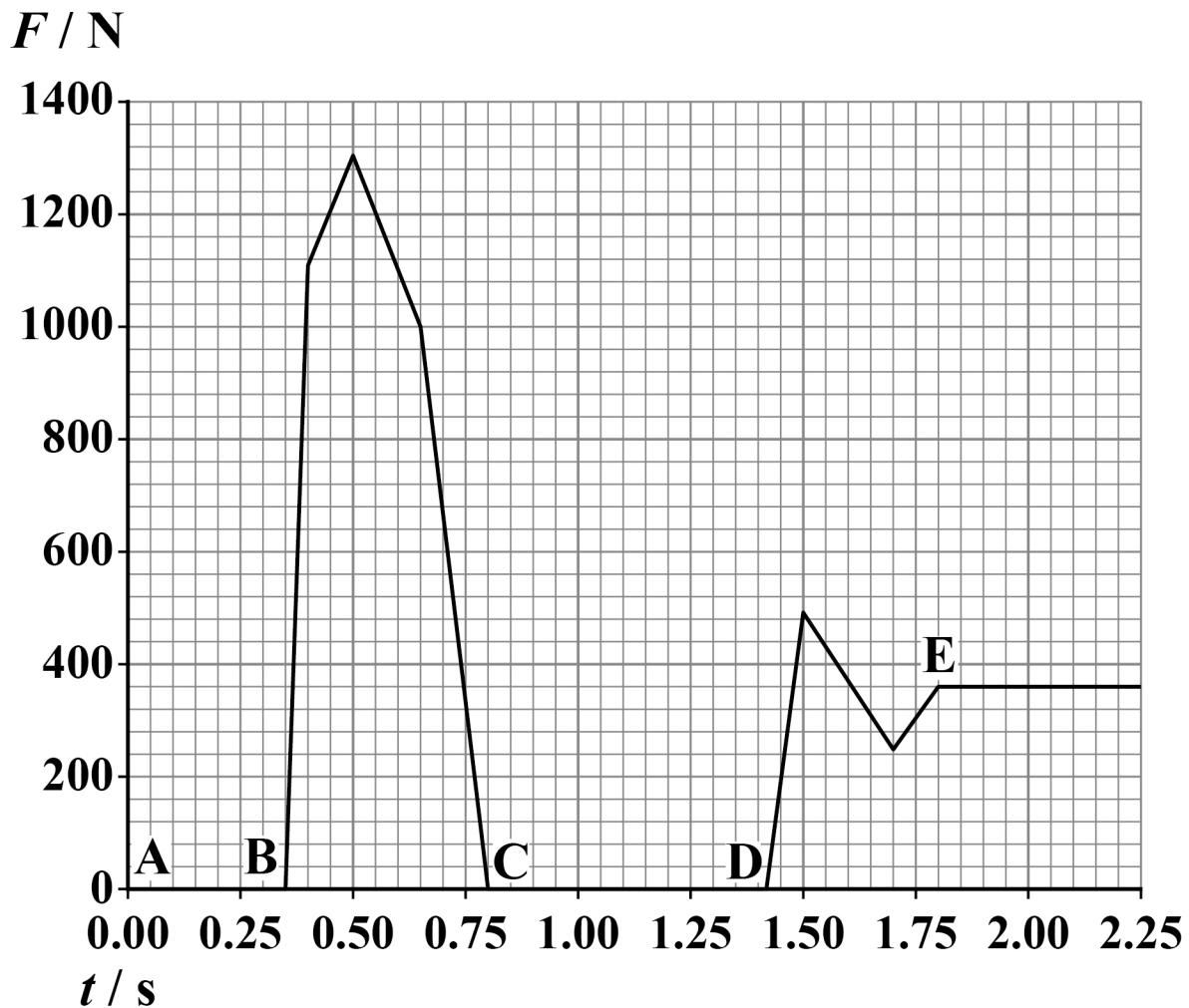
[Turn over]



After her right foot makes contact with the platform, she uses her right leg to stop moving and then push herself back up the rail. She slides down the rail again, lands on the platform with both feet and comes to rest.

FIGURE 7 shows the variation of force F on the platform with time t during the full motion.

FIGURE 7



The sequence below describes what happens at the five instances A, B, C, D and E shown in FIGURE 7.

- A: athlete and chair are released at $t = 0.00$ s
- B: right foot of athlete contacts the platform with leg fully extended
- C: right foot loses contact with the platform
- D: athlete lands on the platform with both feet
- E: athlete and chair come to rest

0	4	.	3
---	---	---	---

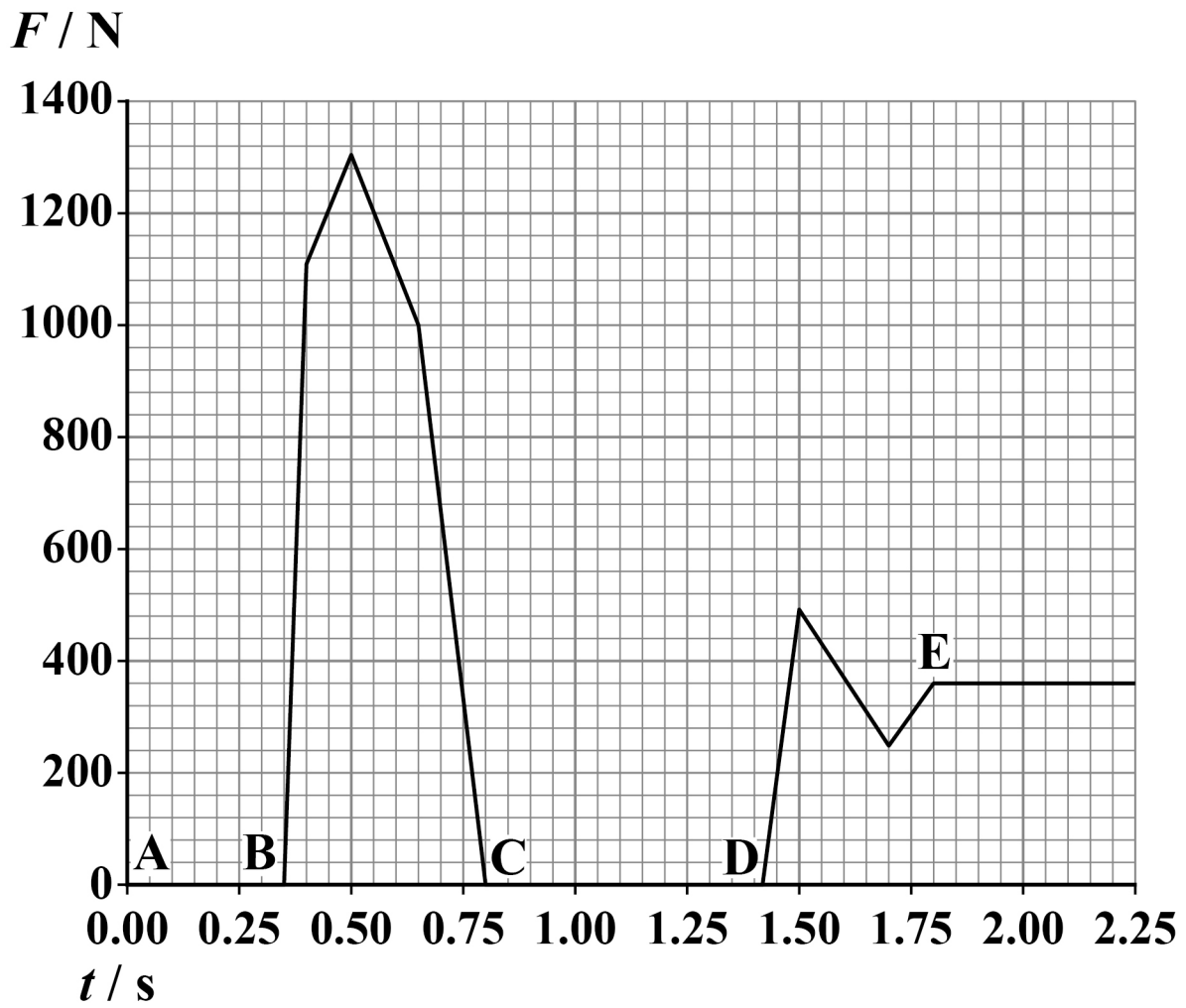
Determine the impulse provided by the force platform between B and C. [2 marks]

impulse = _____ N s

[Turn over]



REPEAT OF FIGURE 7



0	4	.	4
---	---	---	---

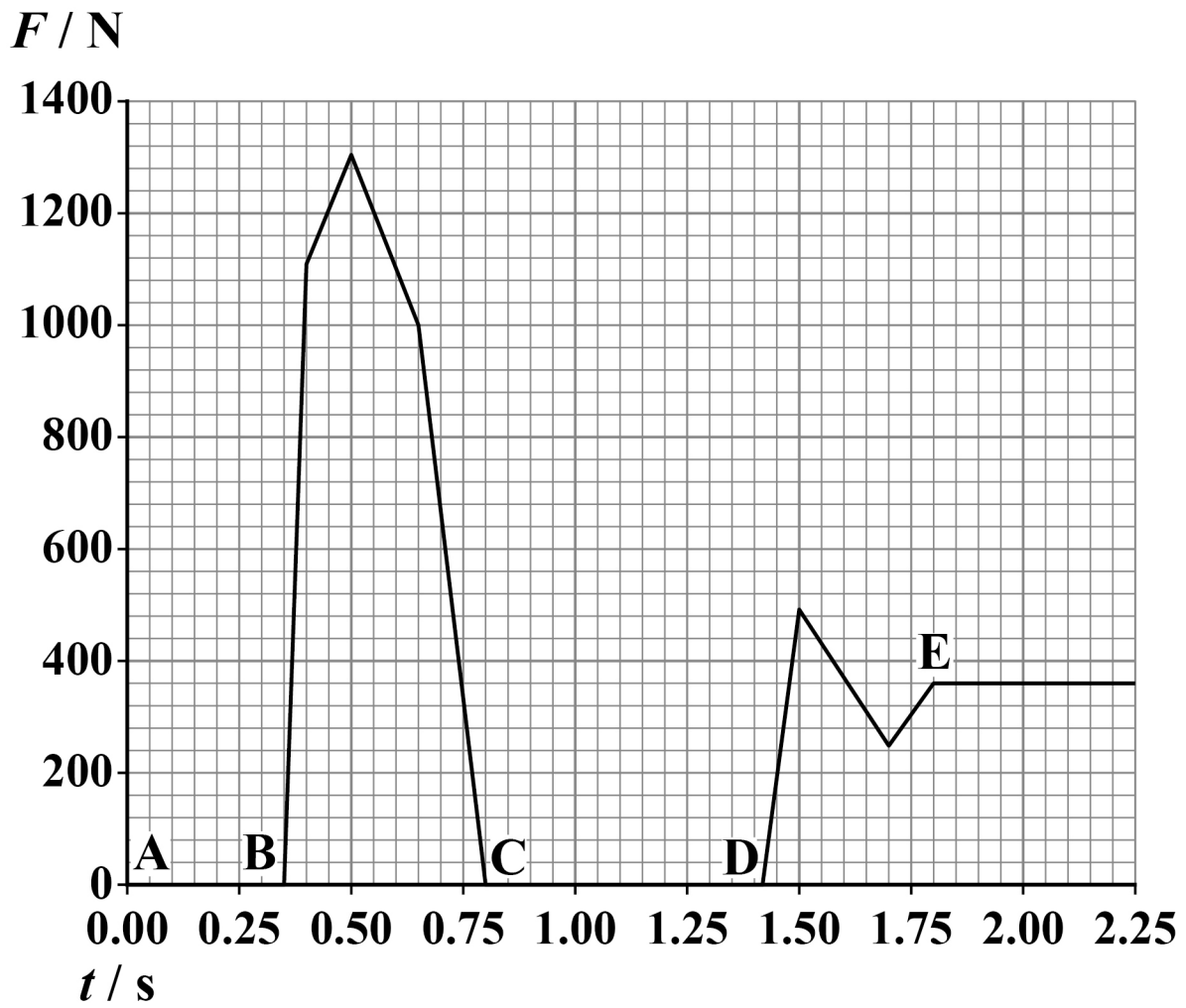
Determine the distance travelled by the athlete between C and D. [3 marks]

distance travelled = _____ m

[Turn over]



REPEAT OF FIGURE 7



0	4	.	5
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Determine, using FIGURE 7, on the opposite page, the combined mass of the athlete and chair. [2 marks]

mass = _____ kg

[Turn over]

10



SECTION C

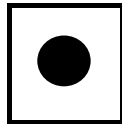
Each of Questions 05 to 34 is followed by four responses, A, B, C and D.

For each question select the best response.

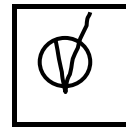
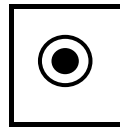
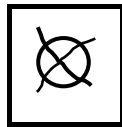
Only ONE answer per question is allowed.

For each question, completely fill in the circle alongside the appropriate answer.

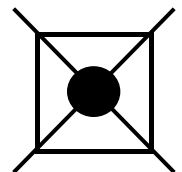
CORRECT METHOD



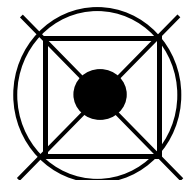
WRONG METHODS



If you want to change your answer you must cross out your original answer as shown.



If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown.



You may do your working in the blank space around each question but this will not be marked. Do NOT use additional sheets for this working.



05

Which row has the largest value for

$$\frac{\text{specific charge of the particle in column X}}{\text{specific charge of the particle in column Y}}?$$

 [1 mark]

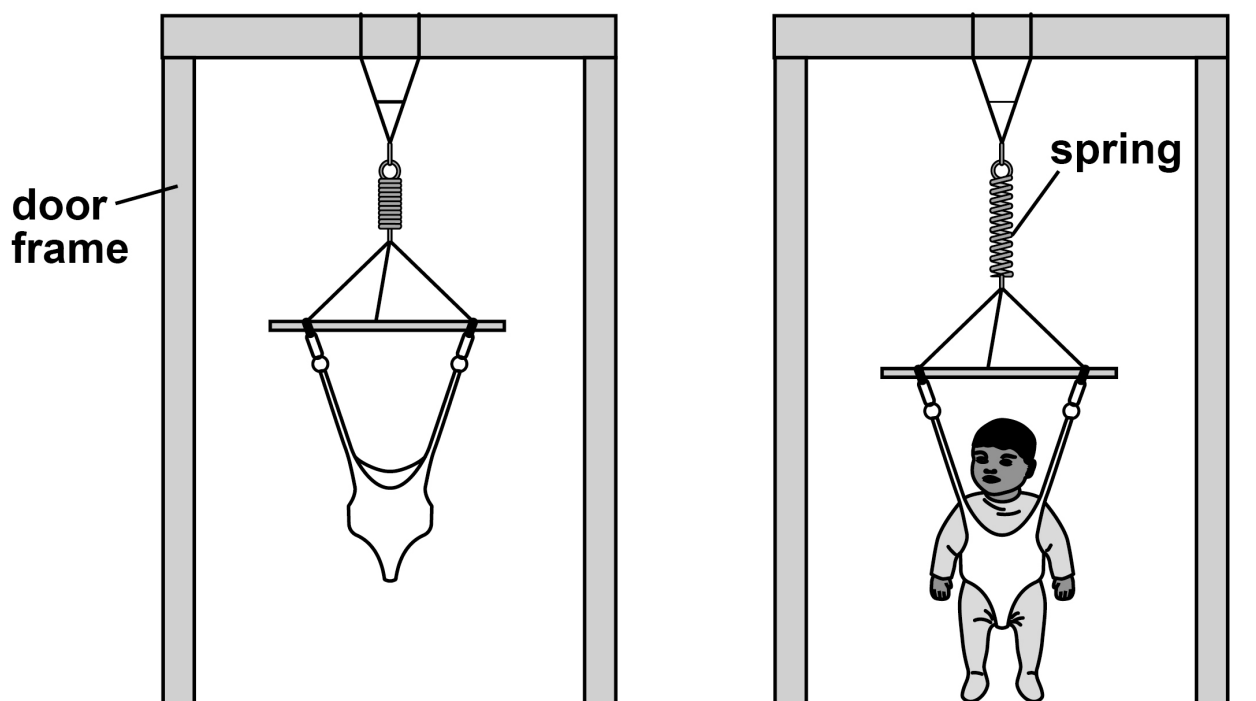
		X	Y
☐	A	electron	alpha particle
☐	B	alpha particle	electron
☐	C	electron	proton
☐	D	proton	alpha particle

[Turn over]



06

A baby bouncer consists of an inextensible harness attached to a spring.



The stiffness of the spring is in the range:

- ☐ A $1\text{--}10\text{ N m}^{-1}$
- ☐ B $10\text{--}100\text{ N m}^{-1}$
- ☐ C $100\text{--}1000\text{ N m}^{-1}$
- ☐ D $1000\text{--}10\,000\text{ N m}^{-1}$

[1 mark]



0	7
---	---

Which row only contains SI fundamental base units?
[1 mark]

☐

A A, kg, N, s

☐

B A, K, mol, s

☐

C C, kg, m, mol

☐

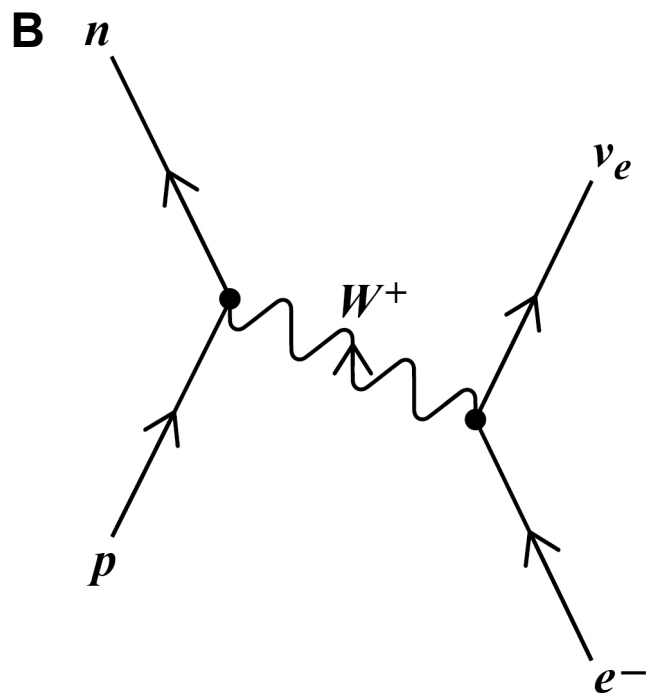
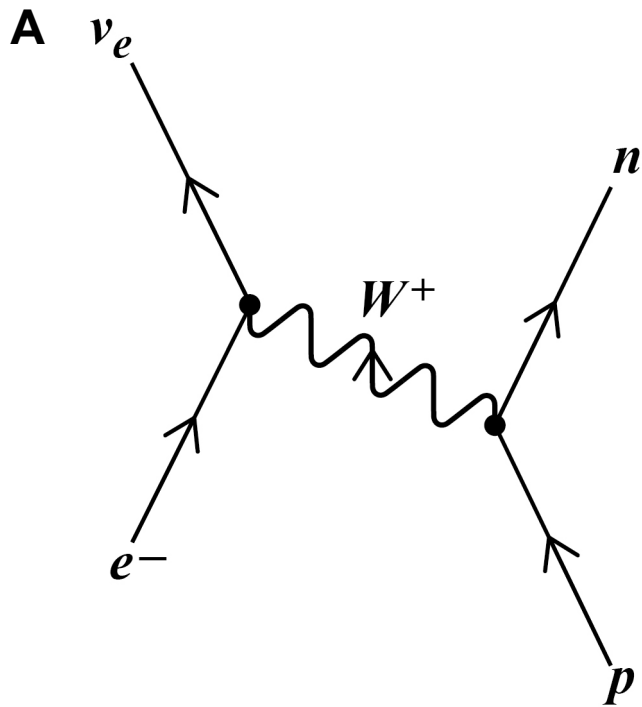
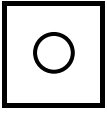
D J, K, m, s

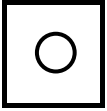
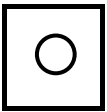
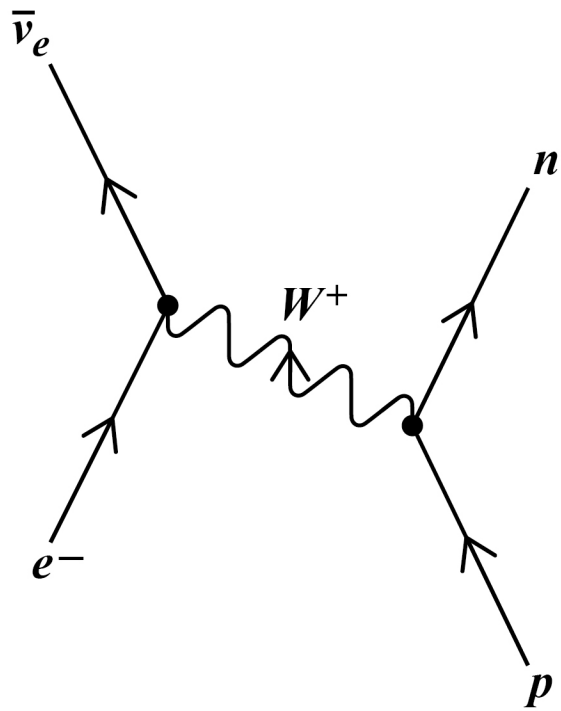
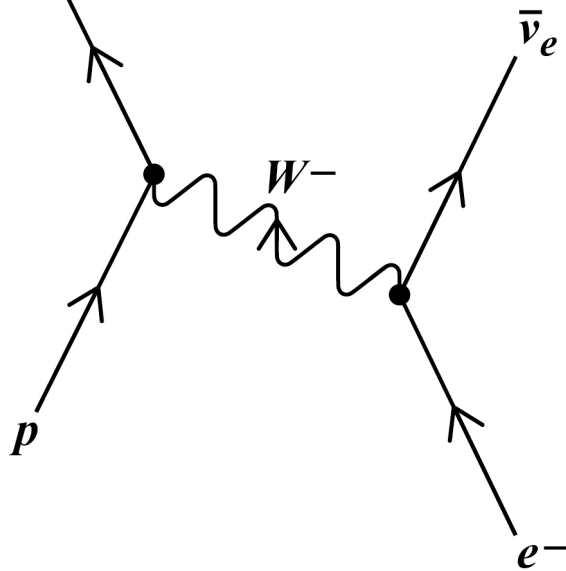
[Turn over]



0	8
---	---

Which diagram represents the process of electron capture? [1 mark]



**C****D****[Turn over]**

09

Which row is correct? [1 mark]

	Name of particle	Classification	Quark structure
☐ A	antineutron	meson	$\bar{u}\bar{u}\bar{d}$
☐ B	positive kaon	baryon	$\bar{u}s$
☐ C	antiproton	baryon	$\bar{u}\bar{u}\bar{d}$
☐ D	positive pion	meson	$\bar{u}d$



1	0
---	---

An alpha particle and a nucleus of boron ${}^{10}_5\text{B}$ interact to form an unstable nucleus and a free neutron.

The unstable nucleus decays by positron emission to form a nucleus of nuclide X.

What is X? [1 mark]

☐

A ${}^{13}_5\text{B}$

☐

B ${}^{13}_6\text{C}$

☐

C ${}^{13}_7\text{N}$

☐

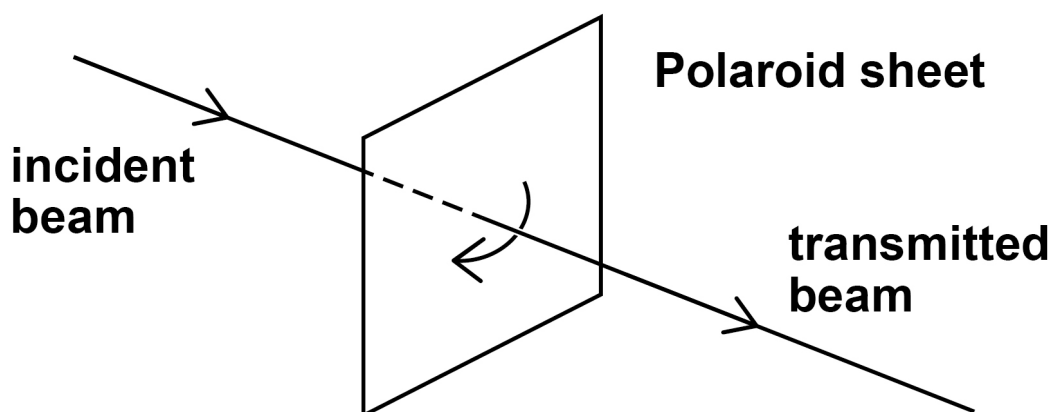
D ${}^{13}_8\text{O}$

[Turn over]



1	1
---	---

A narrow beam of light is incident on a sheet of Polaroid material. The intensity of the transmitted beam is a maximum.



The Polaroid sheet is rotated about the beam by 90° and the intensity of the transmitted beam decreases to zero.

Which row explains this observation? [1 mark]

		Nature of incident beam	Action of Polaroid material as it is rotated
☐	A	unpolarised	polarises the incident beam
☐	B	unpolarised	absorbs the incident beam
☐	C	polarised	absorbs the incident beam
☐	D	polarised	changes the plane of polarisation of the incident beam

[Turn over]

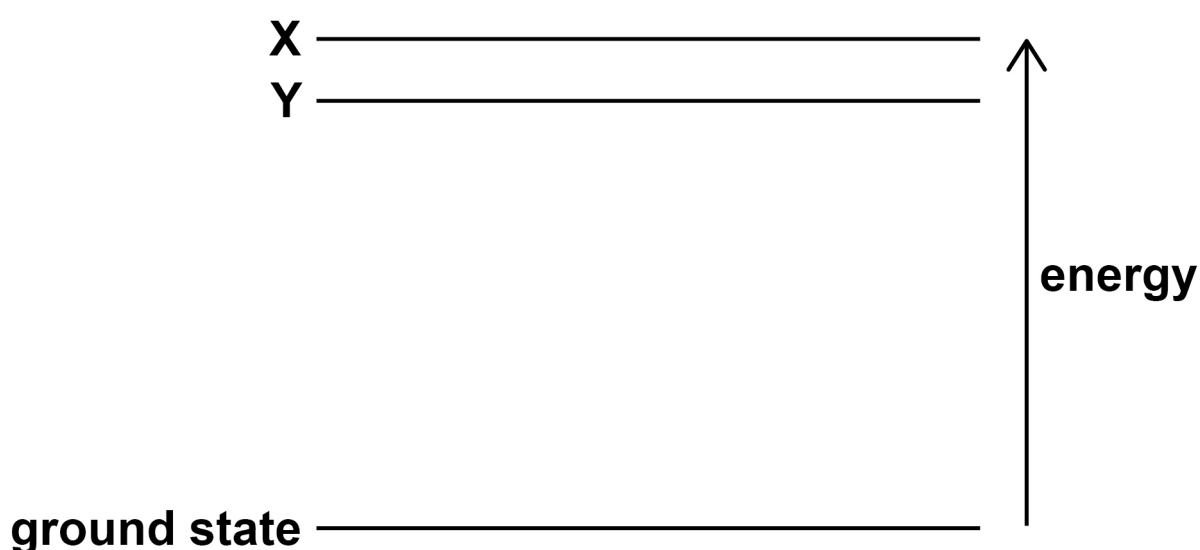


1	2
---	---

The diagram shows the ground state and two higher-energy states X and Y of an atom.

A transition from X to the ground state produces a photon of wavelength 147 nm.

A transition from Y to the ground state produces a photon of wavelength 160 nm.



What is the energy difference between X and Y? [1 mark]

☐ A $1.5 \times 10^{-17} \text{ J}$

☐ B $1.4 \times 10^{-18} \text{ J}$

☐ C $1.2 \times 10^{-18} \text{ J}$

☐ D $1.1 \times 10^{-19} \text{ J}$



1	3
---	---

Which provides evidence for discrete atomic energy levels? [1 mark]

☐

A β^+ decay

☐

B electron diffraction

☐

C line spectra

☐

D the photoelectric effect

[Turn over]



14

A mass M hangs in equilibrium from a vertical spring that obeys Hooke's law.

M is pulled down by 10 cm and then released to oscillate about the equilibrium position.

M returns to the equilibrium position for the first time 0.50 s after release.

Which row gives the amplitude and the period of the oscillations? [1 mark]

		Amplitude / cm	Period / s
☐	A	10	1.0
☐	B	10	2.0
☐	C	20	2.0
☐	D	20	1.0



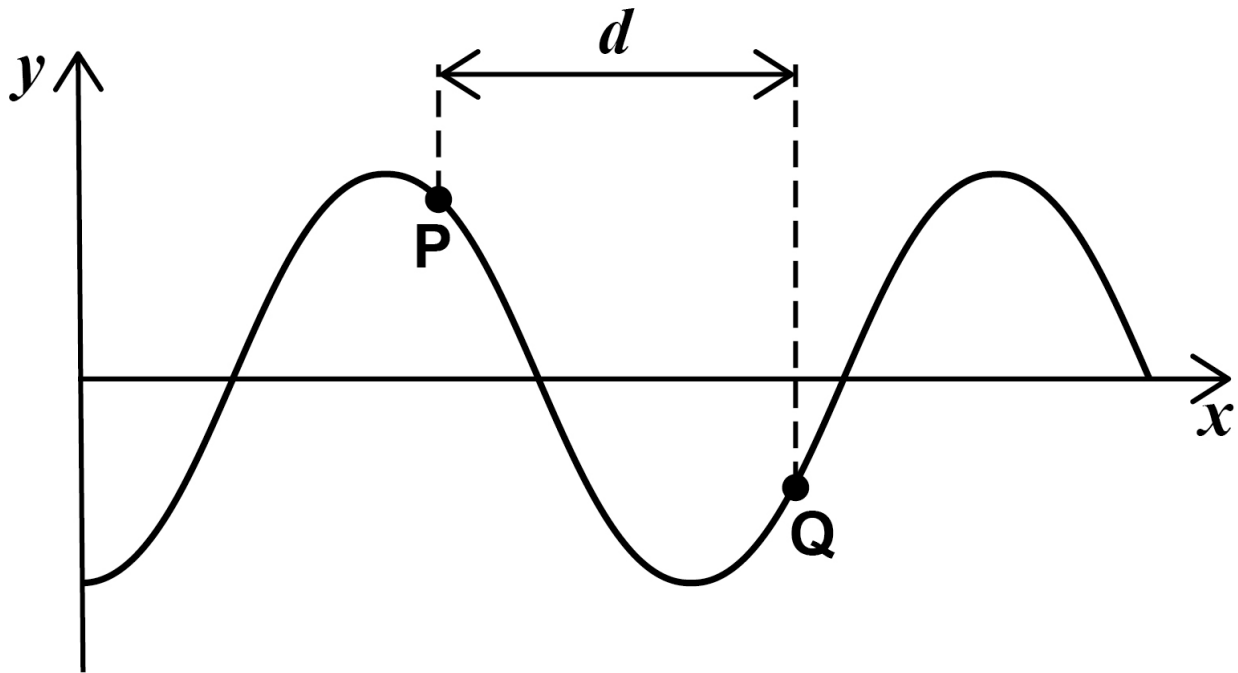
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[Turn over]



1	5
---	---

Two points P and Q on a progressive wave are separated by distance d .



The phase difference between P and Q is θ rad.

What is the wavelength? [1 mark]

☐

A $\frac{\theta d}{2\pi}$

☐

B θd

☐

C $\frac{2\pi d}{\theta}$

☐

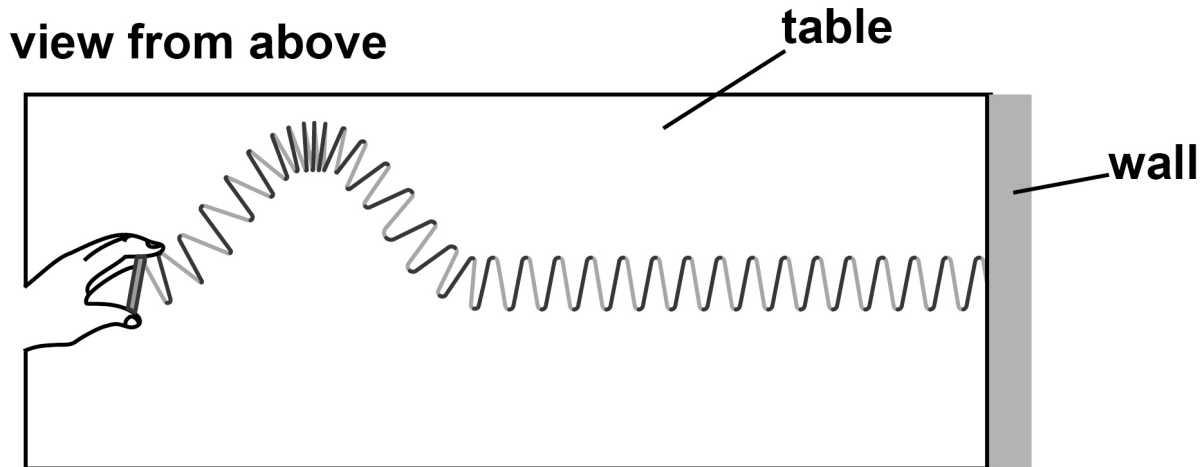
D $\frac{d}{\theta}$

[Turn over]



1	6
---	---

A long spring is used to demonstrate wave motion. The spring lies horizontally on a table. One end of the spring is attached to a wall.



The free end of the spring is quickly moved to one side and then back to the centre, creating a pulse.

This movement takes 0.40 s.

The pulse travels 4.0 m along the spring in a time of 2.0 s.

What is the length of the pulse? [1 mark]

☐

A 0.8 m

☐

B 1.6 m

☐

C 2.0 m

☐

D 10.0 m



1	7
---	---

A stretched wire vibrates between two fixed points. The frequency of the first harmonic of the vibrating wire is 300 Hz.

Without making any other change, the tension in the wire is doubled.

What is the frequency of the new first harmonic of the wire? [1 mark]

☐

A 150 Hz

☐

B 420 Hz

☐

C 600 Hz

☐

D 1200 Hz

[Turn over]



1	8
---	---

A stationary wave forms on a uniform string.

Which statement is correct? [1 mark]

☐

A The amplitude of oscillations is a maximum at the nodes.

☐

B The distance between two adjacent nodes equals one wavelength.

☐

C The oscillations at two adjacent antinodes are in antiphase.

☐

D The time period of oscillating sections varies along the string.



1	9
---	---

Monochromatic visible light is incident normally on a plane transmission diffraction grating that has 4.8×10^5 lines m^{-1} .

First-order maxima are observed at angles of 16° to the central maximum.

How many maxima in total can be observed? [1 mark]

☐

A 3

☐

B 4

☐

C 5

☐

D 7

[Turn over]



20

Which combination produces the smallest modal dispersion in an optical fibre? [1 mark]

		Refractive index of core	Refractive index of cladding
☐	A	1.5	1.4
☐	B	1.4	1.5
☐	C	1.5	1.3
☐	D	1.3	1.5



2	1
---	---

Which is a scalar quantity? [1 mark]

☐

A force

☐

B kinetic energy

☐

C momentum

☐

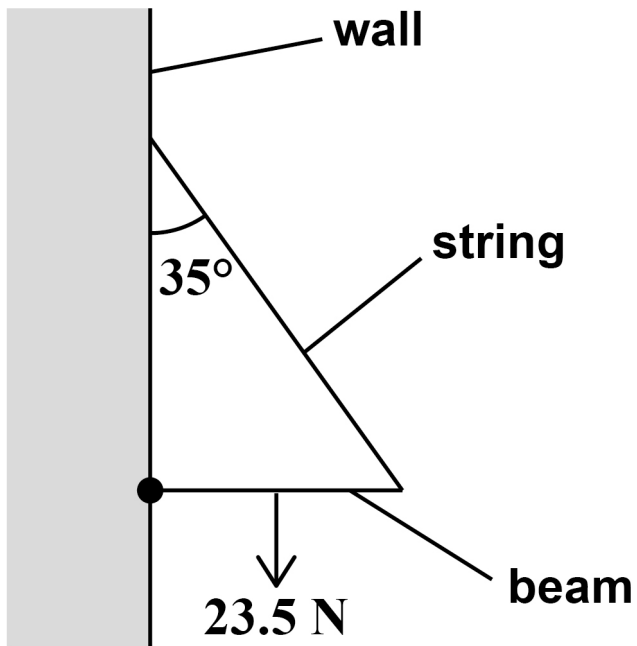
D velocity

[Turn over]



2	2
---	---

A uniform beam of weight 23.5 N is attached by a hinge to a vertical wall and supported by a string. The string makes an angle of 35° to the wall.



What is the tension in the string? [1 mark]

☐

A 14 N

☐

B 21 N

☐

C 29 N

☐

D 41 N



23

Which description of a couple and its unit is correct?
[1 mark]

	Description	Unit
☐ A	consists of two equal parallel forces	N m^{-1}
☐ B	produces translational motion	N m
☐ C	consists of two equal and opposite forces	N m
☐ D	produces rotational motion	N m^{-1}

[Turn over]



2	4
---	---

P and Q are two balls of the same diameter. P has a greater mass than Q.

Both balls are projected at the same time from the top of a tall building that stands on horizontal ground. Both balls are projected with the same horizontal velocity.

P reaches the ground after time t_P and at a horizontal distance d_P from the building.

Q reaches the ground after time t_Q and at a horizontal distance d_Q from the building.

The air is still and air resistance is NOT negligible.

Which row is correct? [1 mark]

		Time	Horizontal distance
☐	A	$t_P = t_Q$	$d_P = d_Q$
☐	B	$t_P = t_Q$	$d_P > d_Q$
☐	C	$t_P < t_Q$	$d_P = d_Q$
☐	D	$t_P < t_Q$	$d_P > d_Q$



2	5
---	---

A firework rocket moves vertically upwards.
 The rocket's fuel burns at a steady rate to produce a constant thrust.
 The mass of the rocket decreases with time.

Ignore the effects of air resistance on the rocket.

Which row shows the acceleration of the rocket before, and the acceleration immediately after, the fuel has been used up? [1 mark]

		Acceleration before	Acceleration immediately after
☐	A	increasing upwards	constant downwards
☐	B	increasing upwards	decreasing upwards
☐	C	constant upwards	constant downwards
☐	D	decreasing upwards	constant downwards

[Turn over]



2	6
---	---

Object P has a mass of 7500 kg and travels at 12 m s^{-1} .
Object Q has a mass of 2500 kg and travels at 20 m s^{-1}
in the same direction as P.
P and Q collide and remain together after the collision.

What is the total kinetic energy of P and Q
immediately after the collision? [1 mark]

☐

A 70 kJ

☐

B 140 kJ

☐

C 980 kJ

☐

D 2.0 MJ



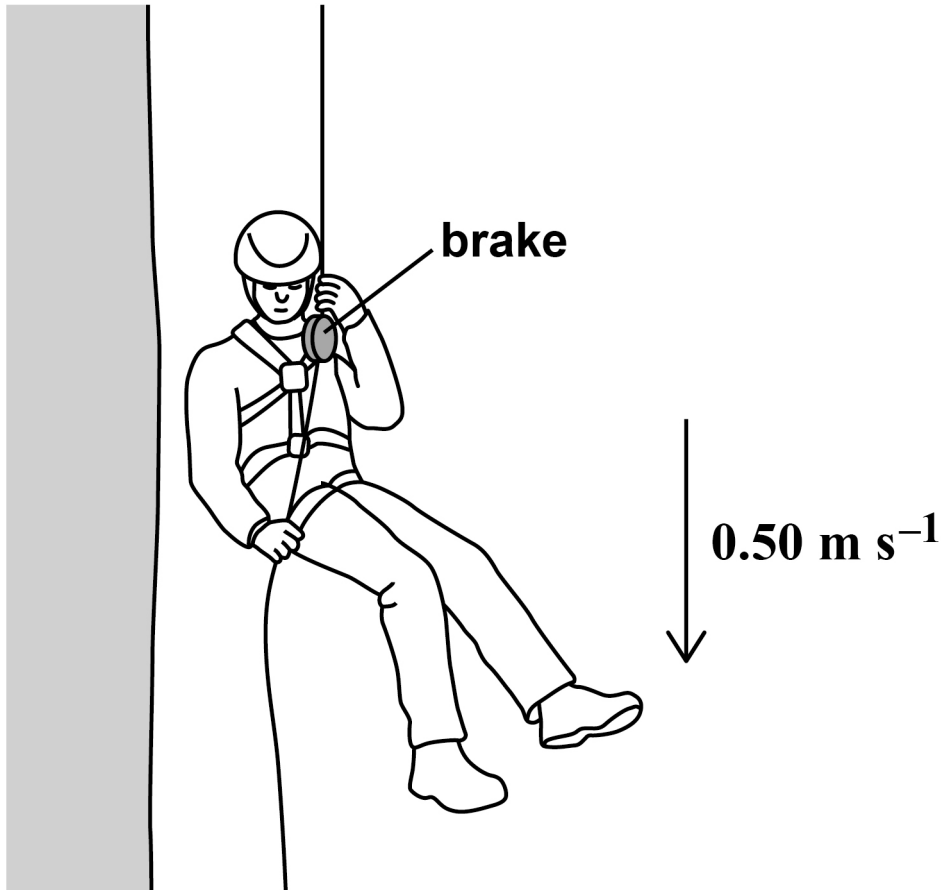
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[Turn over]



2	7
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A climber wears a harness attached to a rope. The rope passes through a brake. There is friction between the rope and the brake.



The climber uses the brake to descend at a steady speed of 0.50 m s^{-1} .

The combined mass of the climber, the harness and the brake is 60 kg .



What is the rate of energy transfer to the brake and rope? [1 mark]

☐

A 15 W

☐

B 29 W

☐

C 150 W

☐

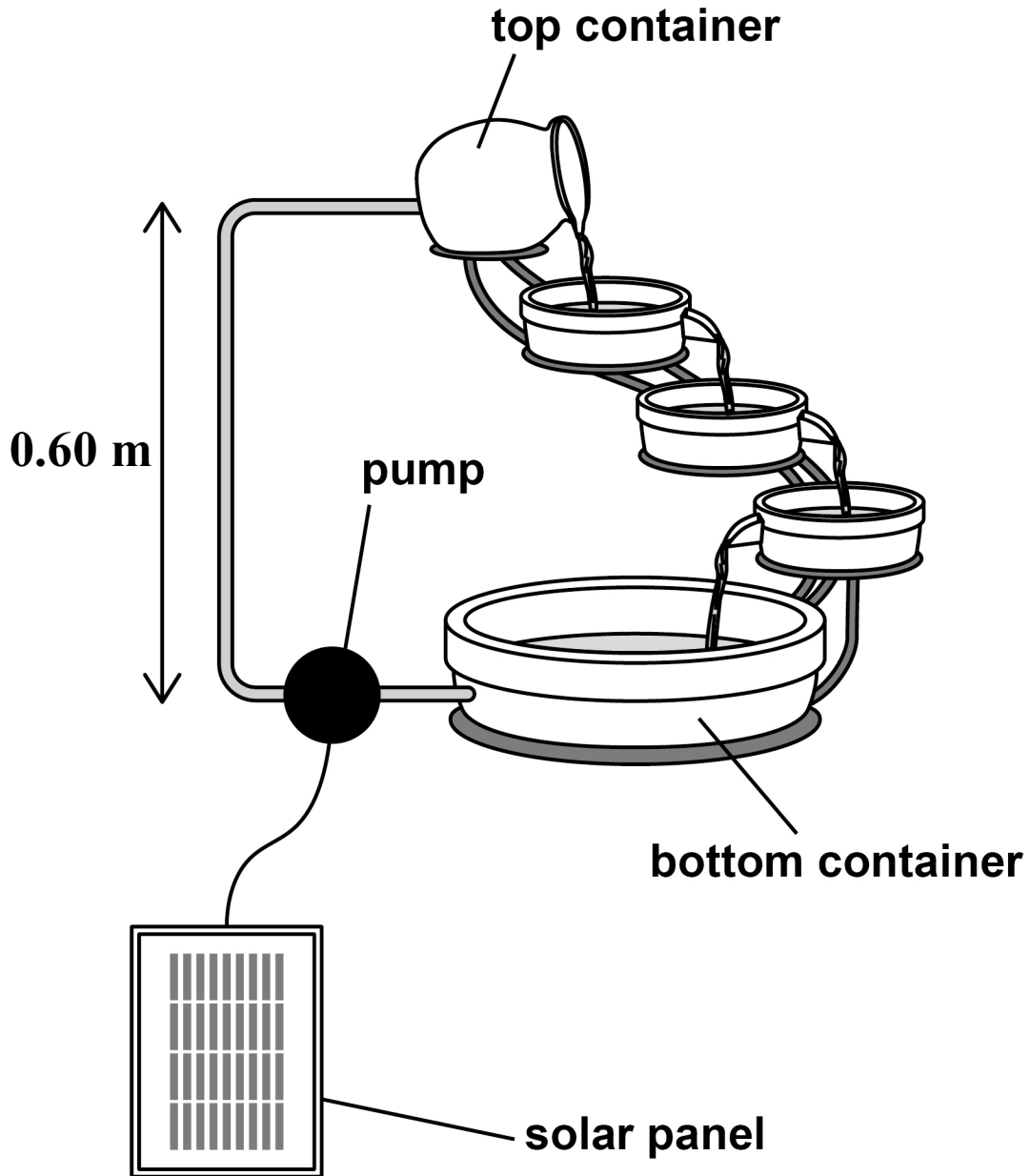
D 290 W

[Turn over]



2	8
---	---

A solar panel powers a pump for a water feature.



Solar energy is incident on the solar panel at a rate of 1.5 W.

Water from the bottom container is continually pumped through a vertical height of 0.60 m to the top container.

The overall efficiency of the solar panel and the pump is 20%.

What mass of water can be pumped into the top container each second? [1 mark]

☐

A 5 g

☐

B 50 g

☐

C 100 g

☐

D 250 g

[Turn over]



29

A wire is made from a material of Young modulus E .
The wire obeys Hooke's law.

The wire has an unstretched length L and a
cross-sectional area A .

When a force is applied to the wire, the extension of the
wire is e .

What is the elastic strain energy stored in the wire?
[1 mark]

☐

A $\frac{AEe^2}{2L}$

☐

B $\frac{L}{2Ae}$

☐

C $\frac{Ae^2}{2EL}$

☐

D $\frac{AEL}{2e}$



3	0
---	---

As the temperature of a copper wire increases, its resistance

☐

A remains constant.

☐

B increases.

☐

C decreases.

☐

D remains constant at first and then decreases.

[1 mark]

[Turn over]



3	1
---	---

A $12\ \Omega$ resistor is connected across the terminals of a cell that has an emf of $2.0\ \text{V}$ and an internal resistance of $4.0\ \Omega$.

What is the terminal pd? [1 mark]

☐

A $0.50\ \text{V}$

☐

B $0.75\ \text{V}$

☐

C $1.30\ \text{V}$

☐

D $1.50\ \text{V}$



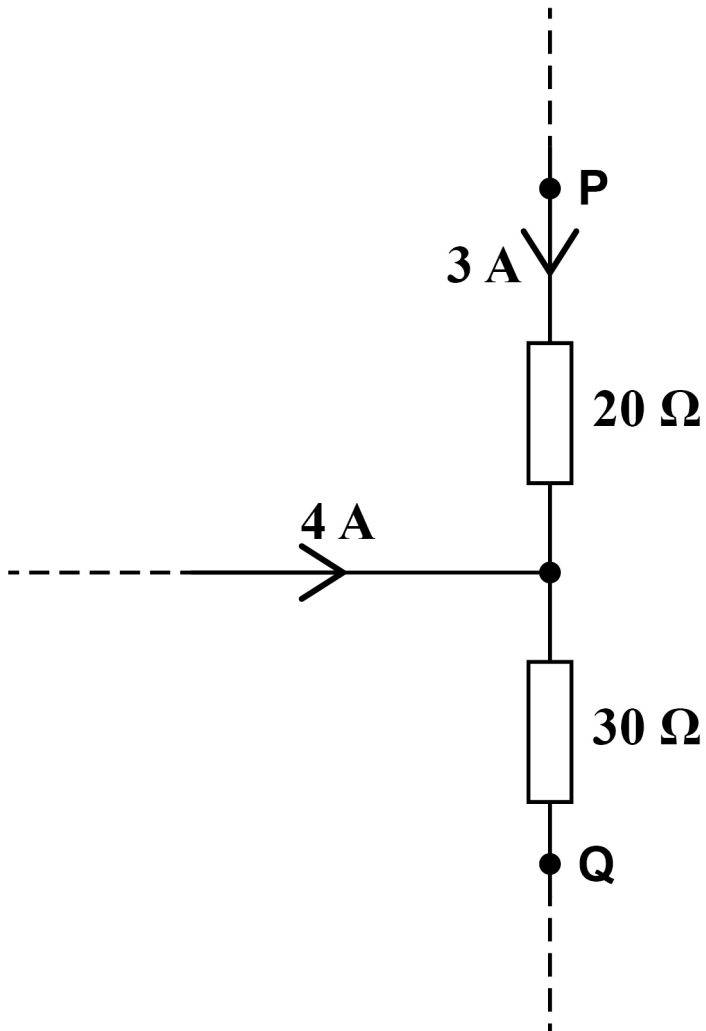
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[Turn over]



3	2
---	---

The diagram shows the currents in part of a circuit.



What is the potential difference between points P and Q? [1 mark]

☐

A 60 V

☐

B 70 V

☐

C 180 V

☐

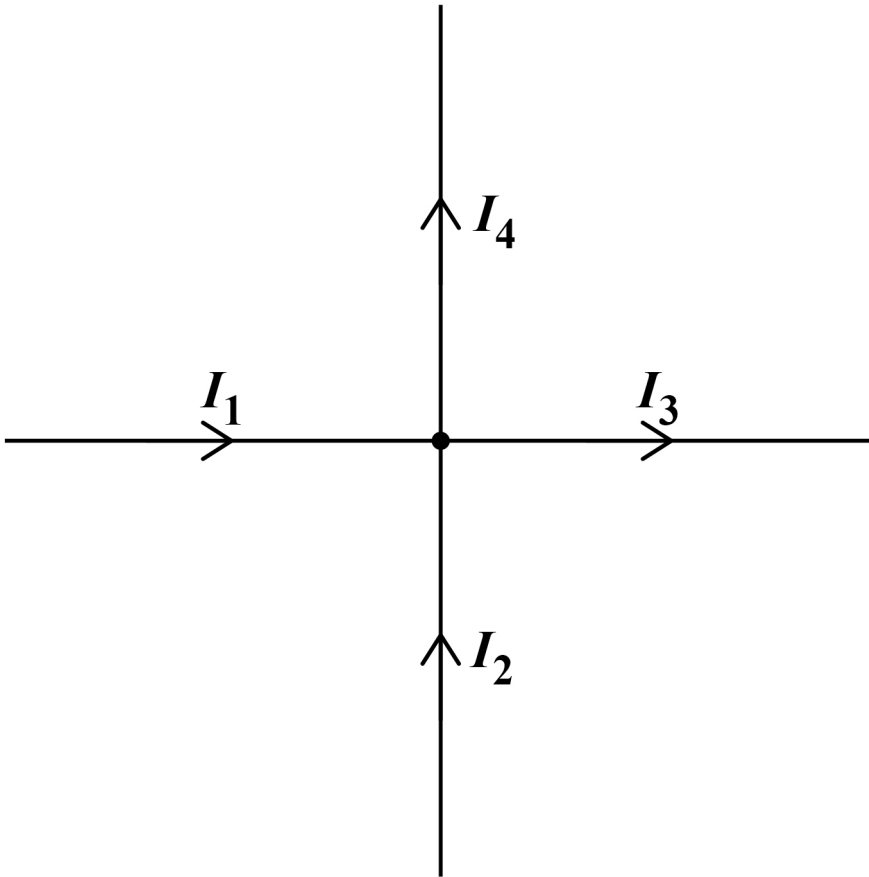
D 270 V

[Turn over]



3	3
---	---

The currents in the four wires obey the relationship
 $I_1 + I_2 + I_3 + I_4 = 0$



This relationship is an expression of the law of conservation of

☐

A charge.

☐

B energy.

☐

C potential difference.

☐

D power.

[1 mark]

[Turn over]



3	4
---	---

A practical power supply provides a steady current I for a time t to an external circuit.

The emf of the power supply during t is equivalent to

☐

A the energy dissipated in the external circuit.

☐

B the energy dissipated in the whole circuit.

☐

C the energy dissipated in the whole circuit, divided by the product It .

☐

D the potential difference across the terminals of the power supply.

[1 mark]

END OF QUESTIONS

30



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Question	Mark
1	
2	
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5–34	
TOTAL	

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