AQA

Please write clearly in block capitals.

Centre number		Candidate number	

Surname ____________________

Forename(s) ____________________

Candidate signature ____________________

I declare this is my own work.

AS
PHYSICS

Paper 2

Time allowed: 1 hour 30 minutes
You are advised to spend about 35 minutes on Section C

Materials
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.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or 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.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5–34	
TOTAL	

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ANSWER IN THE SPACES PROVIDED

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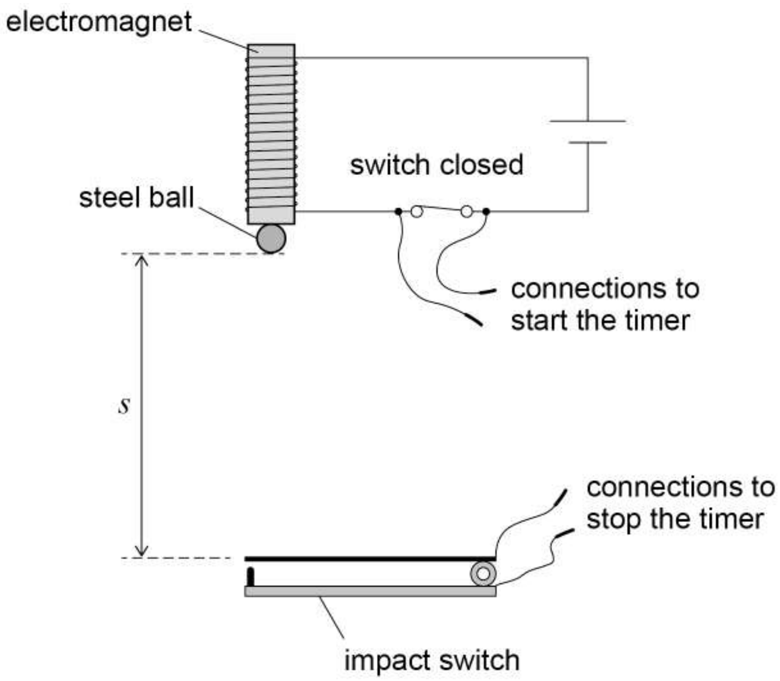
Section A

Answer **all** questions in this section.

0 1 **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**.

Question 1 continues on the next page

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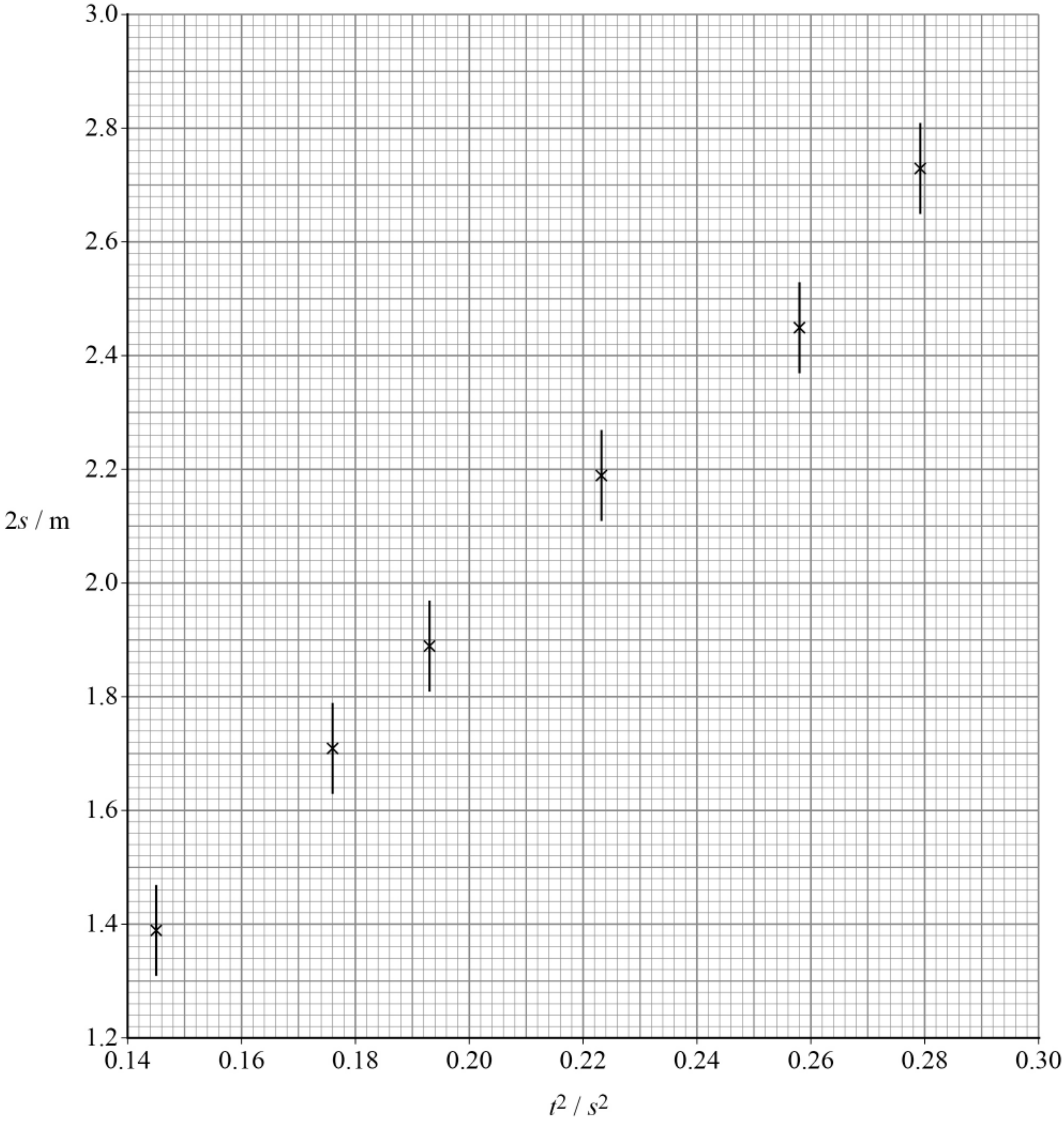
A student obtains values of t for different values of s.

The student plots the graph of $2s$ against t^2 shown in **Figure 2**.

Figure 2



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0 1 . 1 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

0 1 . 2 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} = ____________________

Question 1 continues on the next page

Turn over ►

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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}

0 1 . 4 Determine the percentage uncertainty in your value for g.

[2 marks]

percentage uncertainty = ______________________ %

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A fault develops in the apparatus.
When the switch is opened there is now a 30 ms delay before the ball is released.

0 1 . 5 State the type of error produced by this fault.

[1 mark]

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]

10

Turn over for the next question

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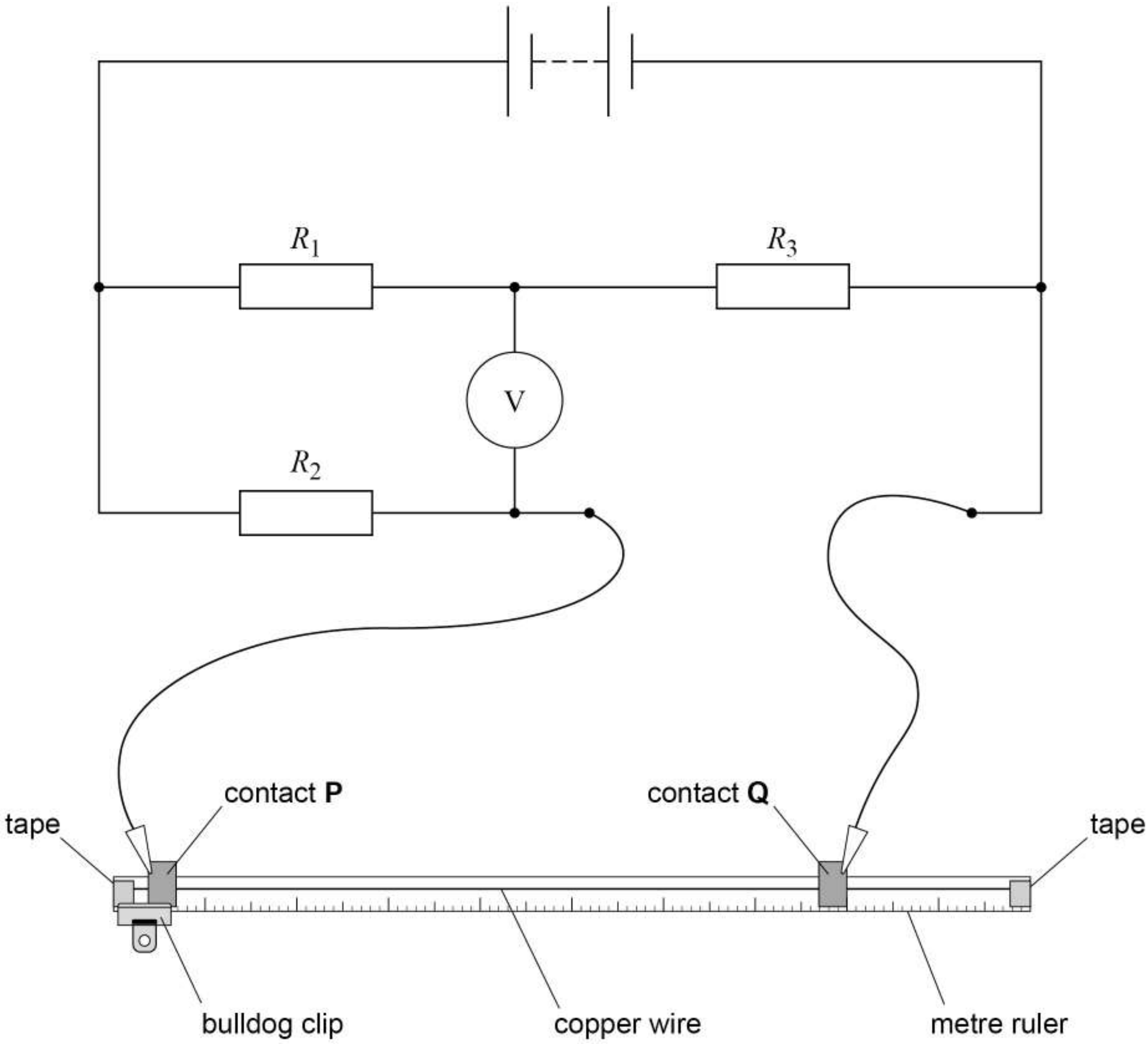
0 2 **Figure 3** shows a circuit used to find the resistance per unit length of a copper wire.

Figure 3

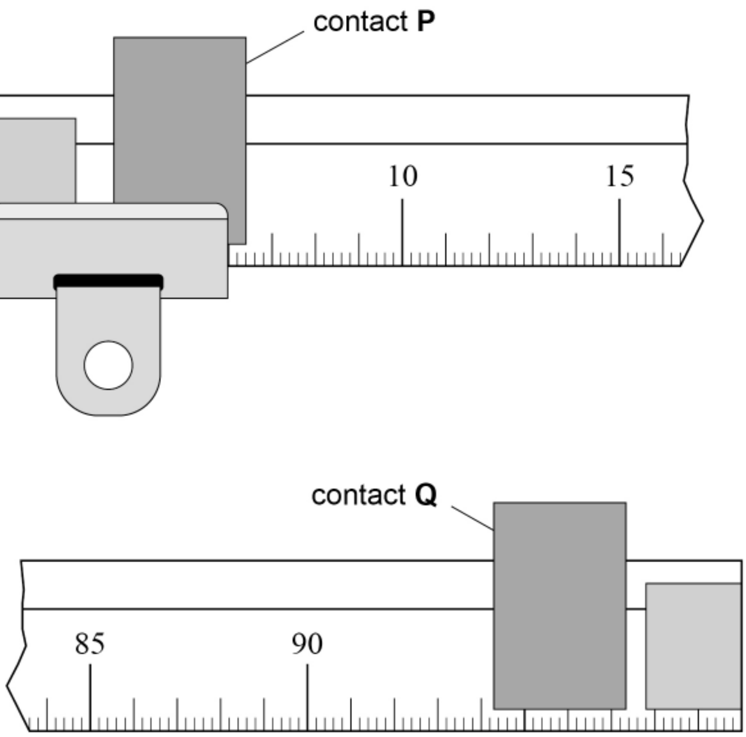


The copper wire is fixed with tape to a metre ruler that has $2\ \mathrm{mm}$ graduations.
Contact **P** is placed on the wire close to one end of the ruler and held firmly in place using a bulldog clip.
When contact **Q** is placed on the wire as shown in **Figure 3** the voltmeter shows a non-zero reading.

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

Figure 4 shows enlarged views of the position of **P** and the new position of **Q**.

Figure 4



0 2 . 1 Determine, in m, the length x of copper wire between **P** and **Q**.

[1 mark]

x = ____________________ m

Question 2 continues on the next page

Turn over ►

Do not write outside the box

0 2 . 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 $\Omega\ \mathrm{m}^{-1}$, the resistance per unit length of the copper wire.

$R_1 = 2.2\ \mathrm{M\Omega}$
$R_2 = 3.9\ \mathrm{k\Omega}$
$R_3 = 75\ \Omega$

[2 marks]

resistance per unit length = ____________________ $\Omega\ \mathrm{m}^{-1}$

0 2 . 3 The diameter d of the copper wire is approximately $0.4\ \mathrm{mm}$.

Suggest:

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

[3 marks]

Do not write outside the box

0 2 . 4 Determine the resistivity ρ of copper.

diameter d of the copper wire $= 0.38$ mm

[2 marks]

$\rho =$ ____________________ Ω m

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

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

0 2 . 5 Suggest **one** change to the circuit to make the voltmeter read zero for the same value of x as in Question **02.1**.

[1 mark]

____

____

____

0 2 . 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

10

END OF SECTION A

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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 $5.0\ \mathrm{V}$ 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 $2.0\ \mathrm{A}$.

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

0 3 . 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 ____

____

Question 3 continues on the next page

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 ____

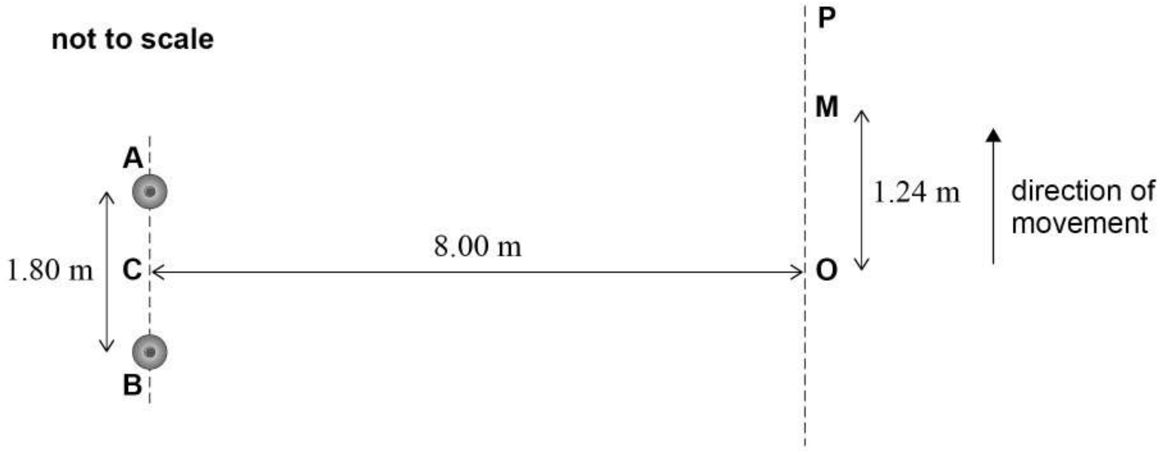
____

2 ____

____

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

Figure 5



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.

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0 3 . 4 Show that the difference between the path lengths **AM** and **BM** is approximately $0.3\ \text{m}$.

[2 marks]

0 3 . 5 The speed of sound is $340\ \text{m s}^{-1}$.

Determine the frequency of the sound waves.

[2 marks]

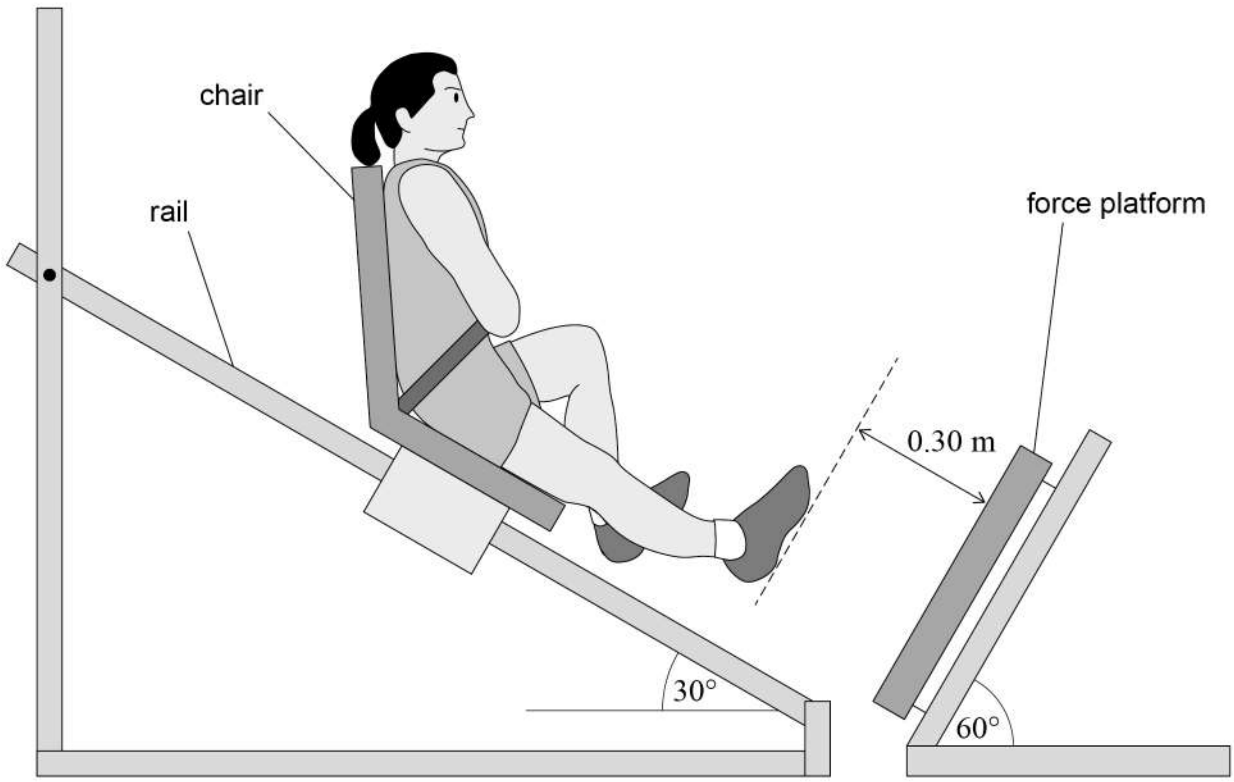
frequency = ____________________ Hz

10

Turn over for the next question

0 4 **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°

0 4 . 1 Show that the athlete and chair accelerate towards the platform at approximately $5\ \mathrm{m\ s^{-2}}$.

[1 mark]

Do not write outside the box

0 4 . 2 Calculate the speed of the athlete when her right foot makes initial contact with the platform.

[2 marks]

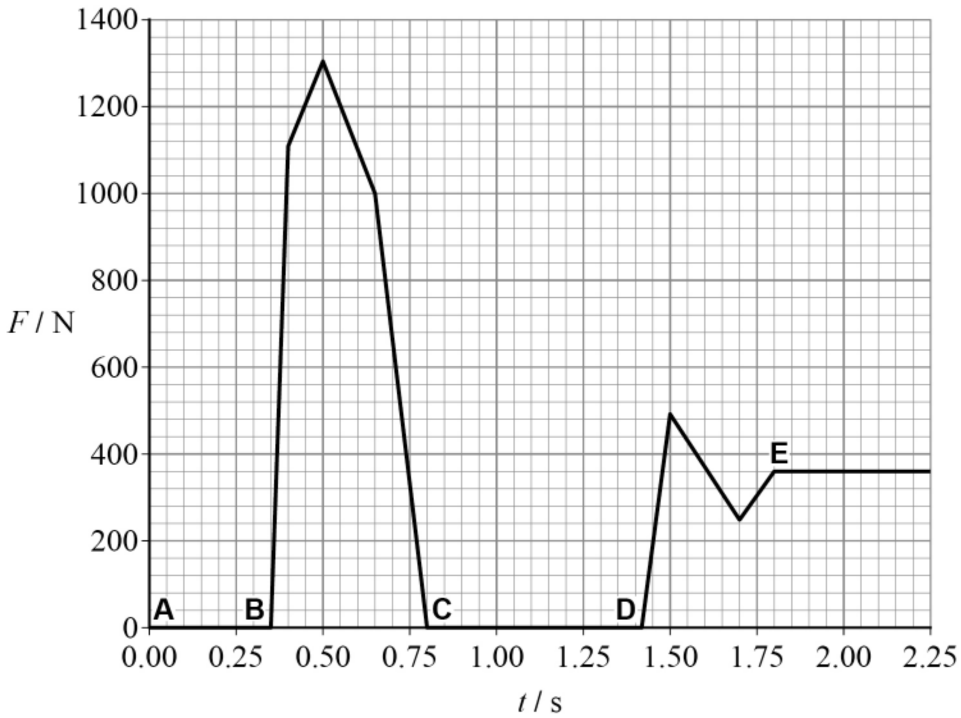
speed = ______________________ $m\ s^{-1}$

Question 4 continues on the next page

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

Do not write outside the box

0 4 . 4 Determine the distance travelled by the athlete between **C** and **D**.

[3 marks]

distance travelled = ____________________ m

0 4 . 5 Determine, using **Figure 7**, the combined mass of the athlete and chair.

[2 marks]

mass = ____________________ kg

10

END OF SECTION B

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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.

0 5 Which row has the largest value for

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

[1 mark]

	X	**Y**	
A	electron	alpha particle	⬭
B	alpha particle	electron	⬭
C	electron	proton	⬭
D	proton	alpha particle	⬭

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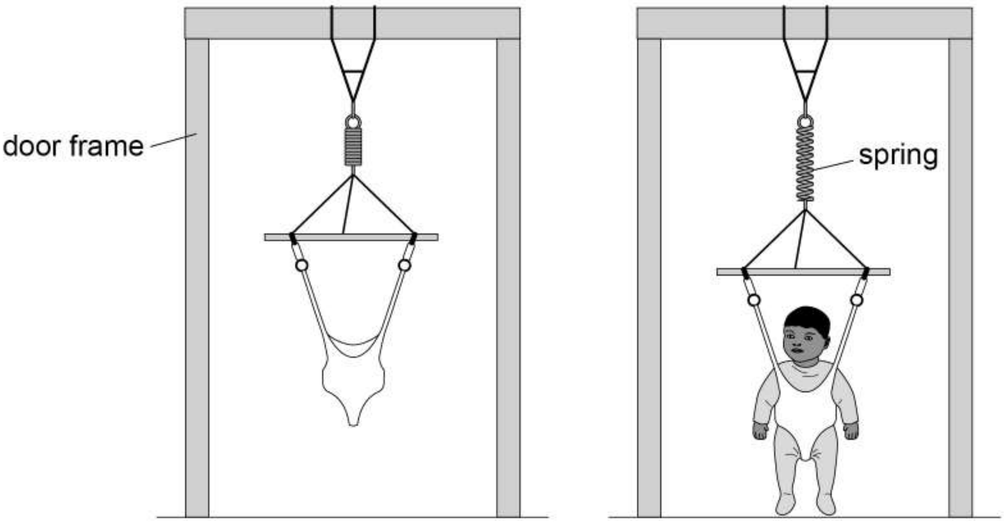
0 6 A baby bouncer consists of an inextensible harness attached to a spring.



The stiffness of the spring is in the range:

[1 mark]

A 1–10 N m^{-1} ⬭

B 10–100 N m^{-1} ⬭

C 100–1000 N m^{-1} ⬭

D 1000–10 000 N m^{-1} ⬭

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 ⬭

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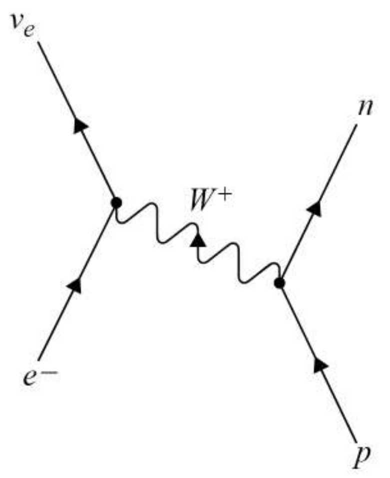
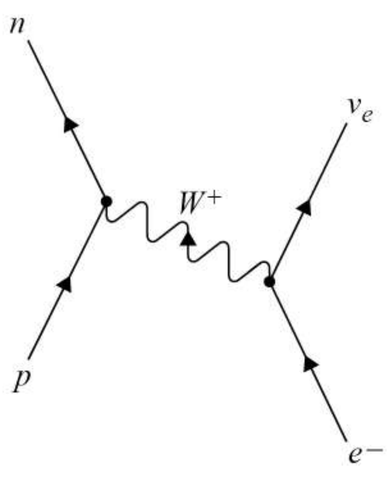
0 8 Which diagram represents the process of electron capture?

[1 mark]

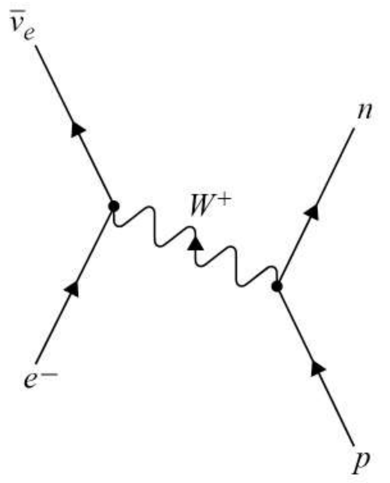
A



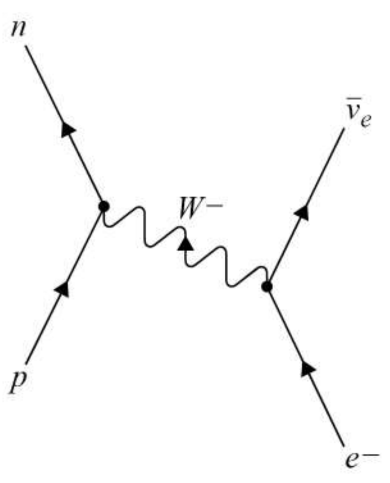
B



C



D



A ⬭

B ⬭

C ⬭

D ⬭

Do not write outside the box

0 9 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 $^{10}_{5}\mathrm{B}$ 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 $^{13}_{5}\mathrm{B}$ ⬭

B $^{13}_{6}\mathrm{C}$ ⬭

C $^{13}_{7}\mathrm{N}$ ⬭

D $^{13}_{8}\mathrm{O}$ ⬭

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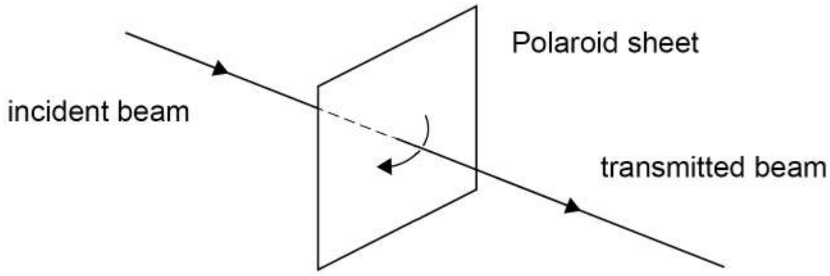
1 1 A narrow beam of light is incident on a sheet of Polaroid material. The intensity of the transmitted beam is a maximum.



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?

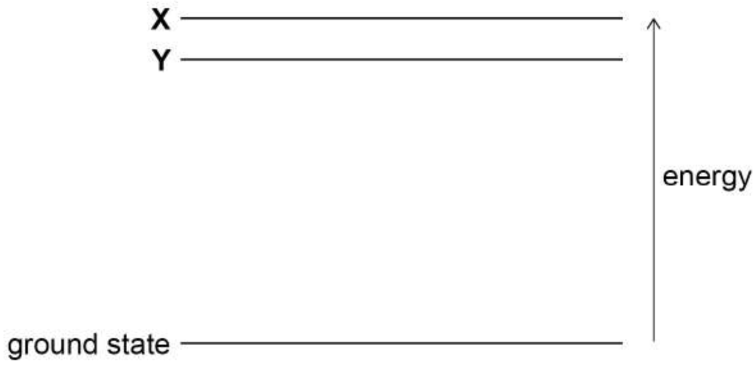
[1 mark]

	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	⬭

Do not write outside the box

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 1.5×10^{-17} J ⬭

B 1.4×10^{-18} J ⬭

C 1.2×10^{-18} J ⬭

D 1.1×10^{-19} 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 ►

Do not write outside the box

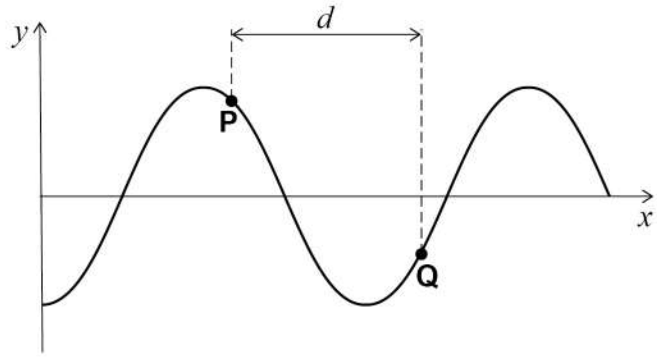
1 4 A mass **M** hangs in equilibrium from a vertical spring that obeys Hooke's law.
M is pulled down by 10 cm and then released to oscillate about the equilibrium position.
M returns to the equilibrium position for the first time 0.50 s after release.

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	⬭

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 $\frac{\theta d}{2\pi}$ ◯

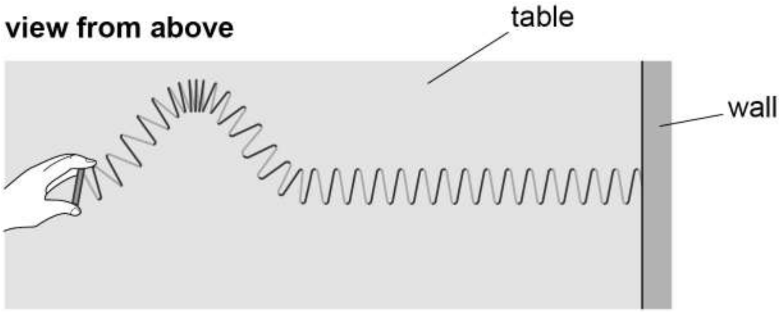
B θd ◯

C $\frac{2\pi d}{\theta}$ ◯

D $\frac{d}{\theta}$ ◯

Turn over for the next question

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 ○

Do not write outside the box

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 ⬭

2 0 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	⬭

Do not write outside the box

2 1 Which is a scalar quantity?

[1 mark]

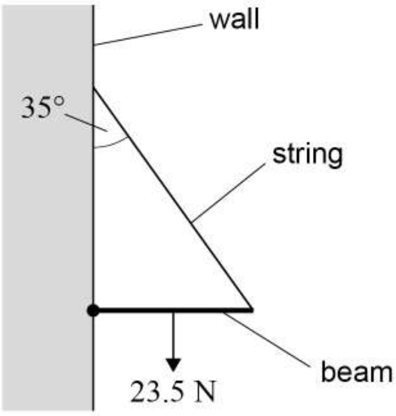
A force ⬭

B kinetic energy ⬭

C momentum ⬭

D velocity ⬭

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 ⬭

Do not write outside the box

2 3 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	$N\ m^{-1}$	⬭

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	$t_P < t_Q$	$d_P > d_Q$	⬭

Turn over ►

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	⬭

2 6 Object **P** has a mass of $7500\ \mathrm{kg}$ and travels at $12\ \mathrm{m\ s^{-1}}$.
Object **Q** has a mass of $2500\ \mathrm{kg}$ and travels at $20\ \mathrm{m\ s^{-1}}$ 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]

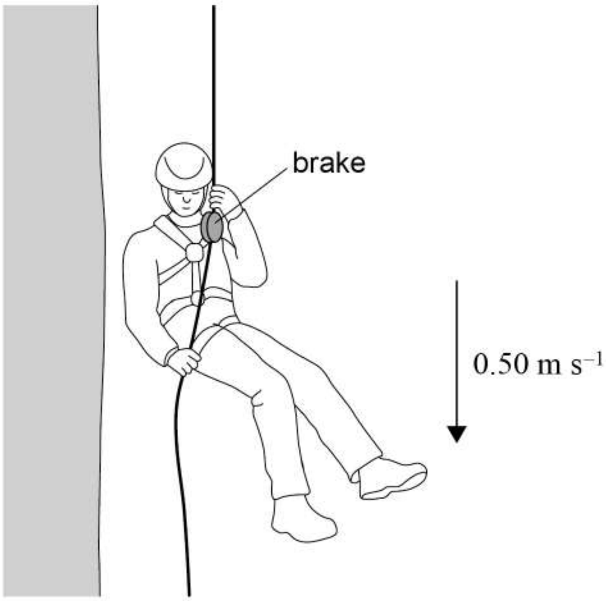
A 70 kJ ⬭

B 140 kJ ⬭

C 980 kJ ⬭

D 2.0 MJ ⬭

2 7 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 $0.50\ \text{m s}^{-1}$.
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

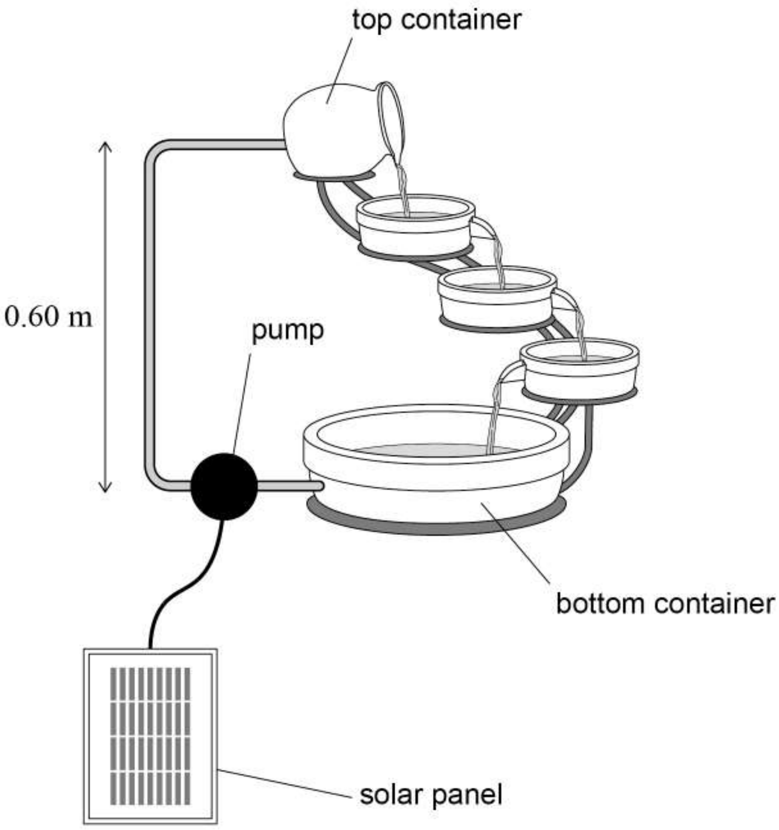
C 150 W

D 290 W

Turn over for the next question

Do not write outside the box

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 ⬭

2 9 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

[1 mark]

A remains constant. ⬭

B increases. ⬭

C decreases. ⬭

D remains constant at first and then decreases. ⬭

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]

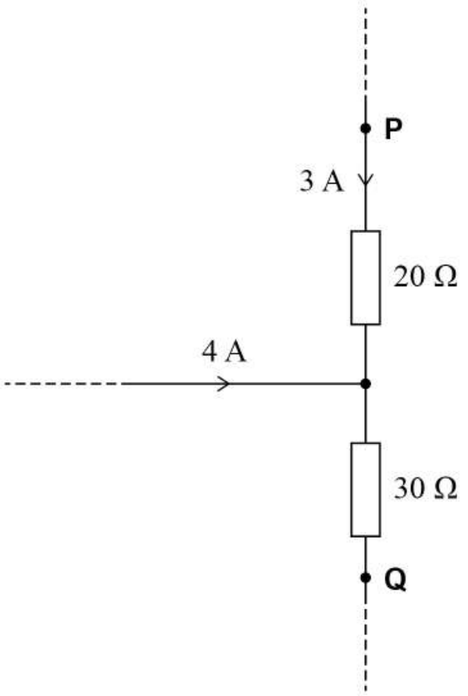
A $0.50\ \text{V}$ ⬭

B $0.75\ \text{V}$ ⬭

C $1.30\ \text{V}$ ⬭

D $1.50\ \text{V}$ ⬭

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

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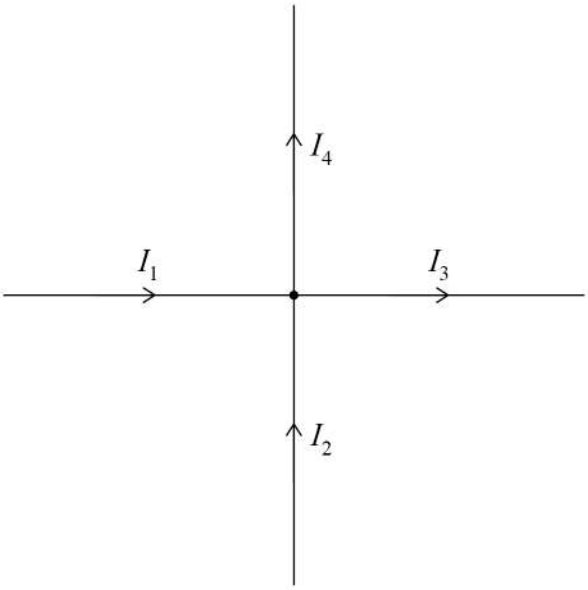
3 3 The currents in the four wires obey the relationship $I_1 + I_2 + I_3 + I_4 = 0$



This relationship is an expression of the law of conservation of

[1 mark]

A charge. ⬭

B energy. ⬭

C potential difference. ⬭

D power. ⬭

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

[1 mark]

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. ⬭

30

END OF QUESTIONS

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