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	
6–35	
TOTAL	

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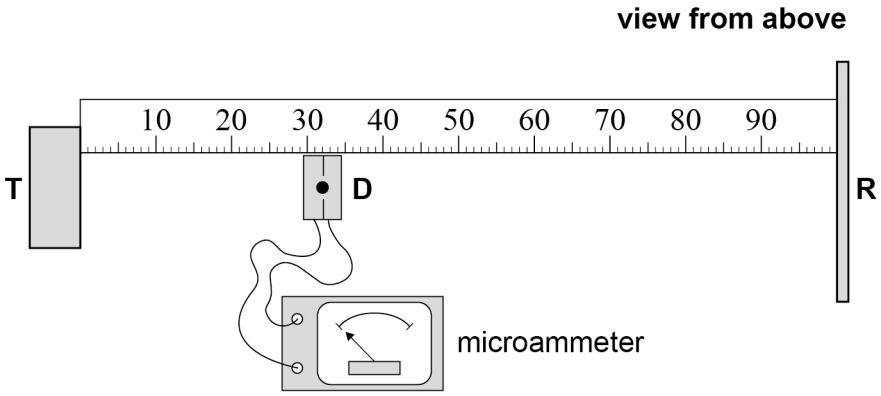
Section A

Answer **all** questions in this section.

0 1 A student investigates stationary waves using microwaves.

Figure 1 shows a metre ruler fixed to a bench. The student places a microwave transmitter **T** at one end of the ruler and a vertical metal reflector **R** at the other end. **R** is at a right angle to the ruler.

Figure 1



The student places a microwave detector **D** approximately one-third of the distance from **T** to **R**. When **T** is switched off, the microammeter connected to **D** reads zero.

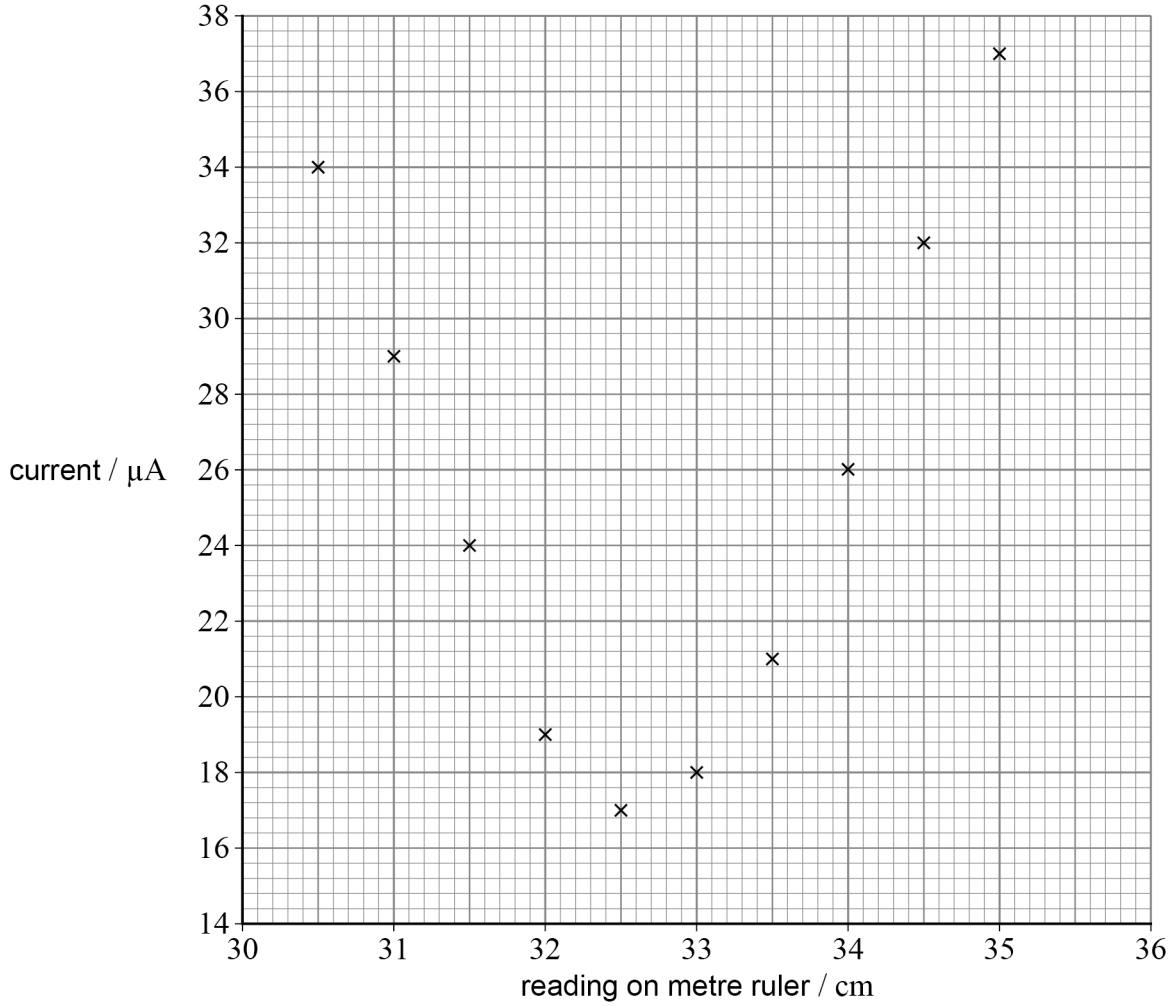
When **T** is switched on, stationary waves are produced between **T** and **R**, and the microammeter registers a current. When the student moves **D** along the ruler, the size of the current changes between maximum and minimum values.

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The student measures the current at different positions of **D** along the ruler to identify a position **P** of the minimum current.

Figure 2 is a plot of the measurements taken near **P**.

Figure 2



0 1 . 1 Draw a line of best fit for these data.

[2 marks]

0 1 . 2 State a value for the position of **P**.

[1 mark]

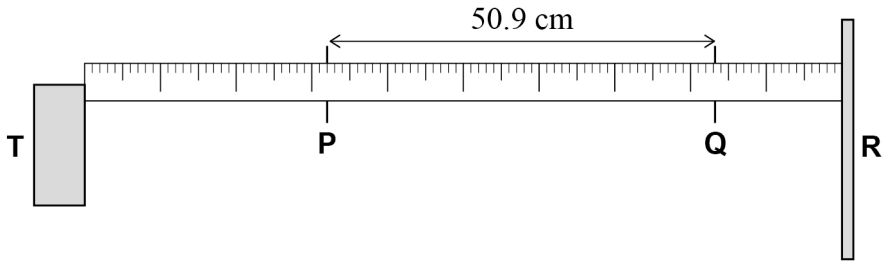
position of **P** = _____ cm

Question 1 continues on the next page

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The student moves **D** along the metre ruler towards **R** and observes a series of maximum and minimum readings on the microammeter. He identifies **Q** as the position of the **8th minimum** current from **P**. He measures the distance **PQ** to be 50.9 cm, as shown in **Figure 3**.

Figure 3



0 1 . 3 The absolute uncertainty in identifying any minimum current is ± 0.2 cm.

Determine the percentage uncertainty in the distance **PQ**.

[2 marks]

percentage uncertainty in **PQ** = _____ %

0 1 . 4 Deduce the frequency of the microwaves produced by **T**.

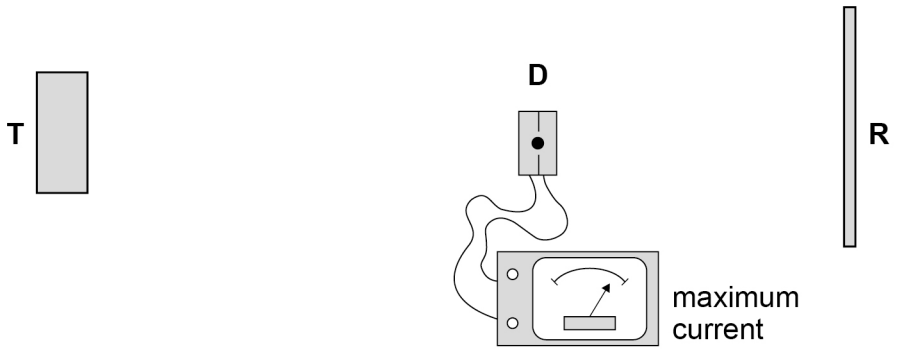
[3 marks]

frequency = _____ Hz

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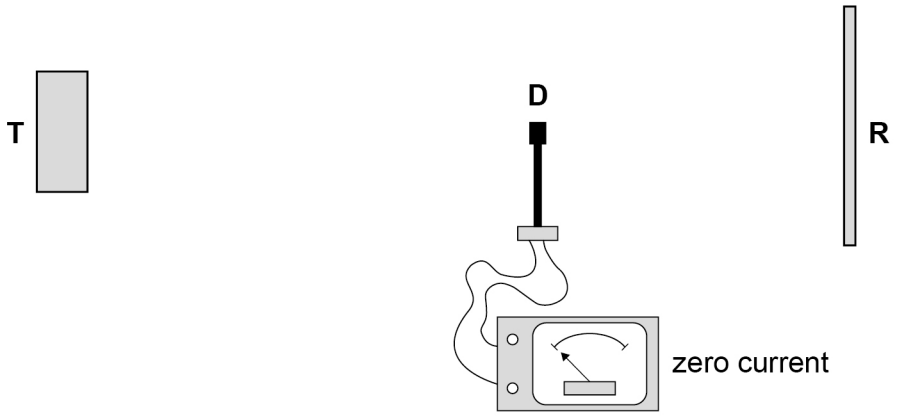
0 1 . 5 **Figure 4** shows **D** placed at a position where the current is a maximum.

Figure 4



The student rotates **D** by $90°$, without changing its distance from **T**, to the position shown in **Figure 5**. The current is now zero.

Figure 5



State the property of microwaves that is shown by this change in current.

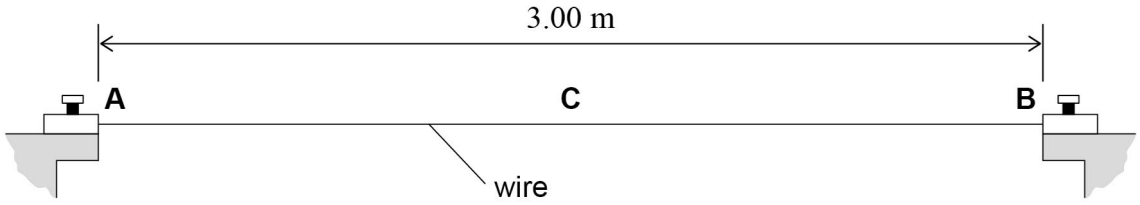
[1 mark]

9

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0 2 A student does an experiment to determine the Young modulus of a metal.
Figure 6 shows a wire made from the metal clamped at points **A** and **B** so that the wire is horizontal. The horizontal distance between **A** and **B** = 3.00 m.
C is the mid-point on the wire between **A** and **B**.

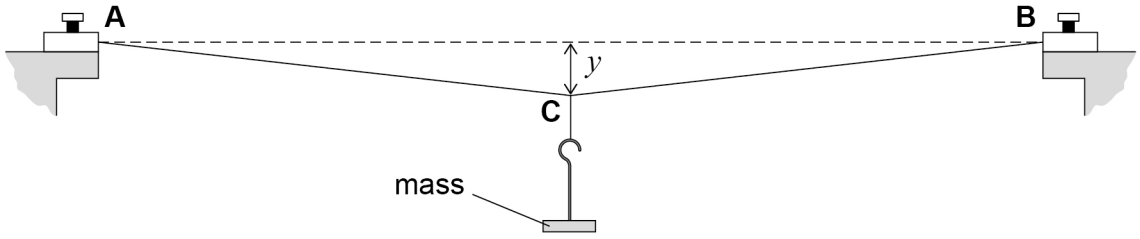
Figure 6



A mass of weight W is suspended at **C** to extend the wire. **Figure 7** shows that **C** moves vertically downwards by a distance y.

Figure 7

not to scale



Do not write outside the box

0 2 . 1 When W is 1.0 N, y is 6.34 cm.

Show that the wire extends by approximately 3 mm.

[1 mark]

0 2 . 2 Calculate the tension in the wire when W is 1.0 N.

[2 marks]

tension = _____ N

Question 2 continues on the next page

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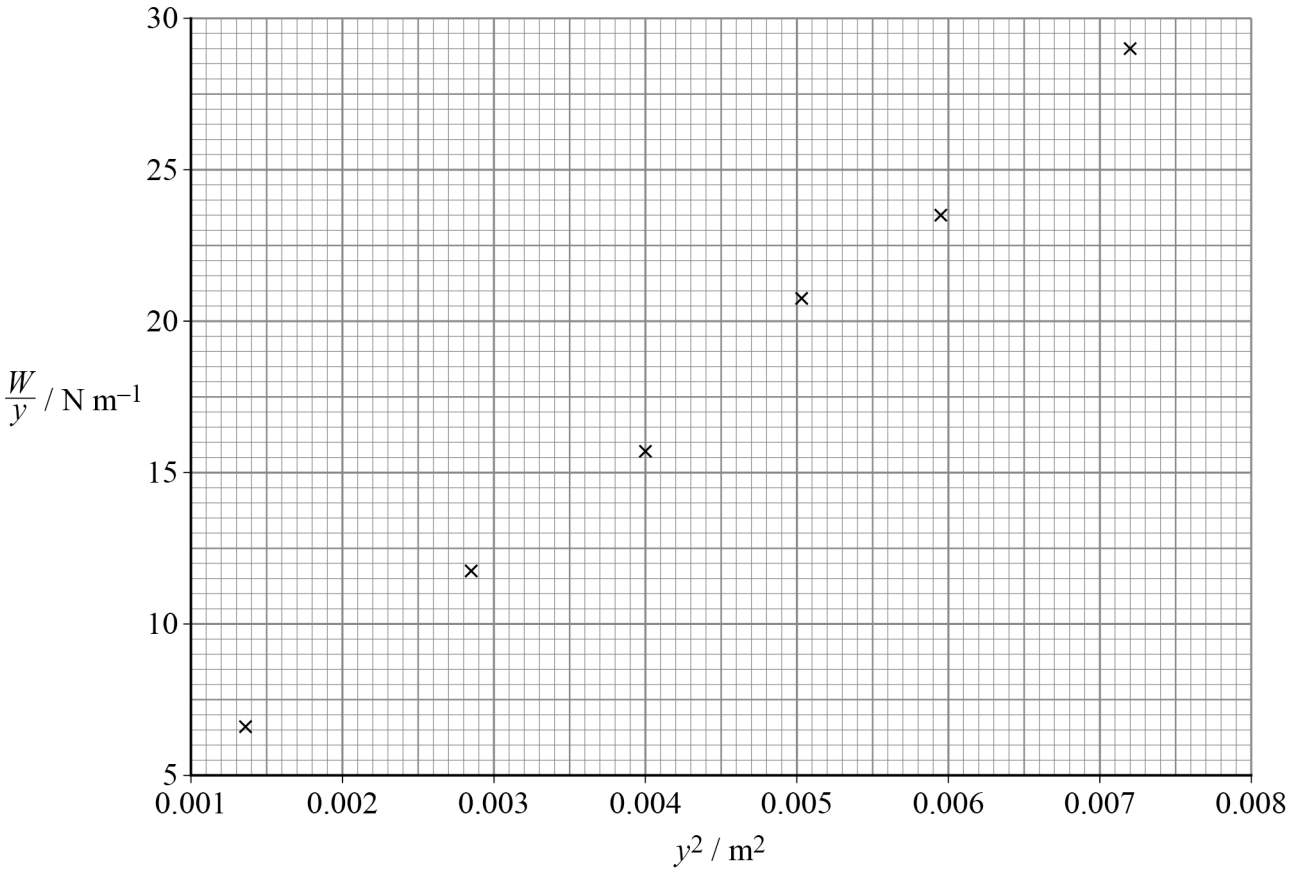
It can be shown that

$$\frac{W}{y} = \frac{EAy^2}{x^3} + k$$

where E = Young modulus of the metal
$A = 1.11 \times 10^{-7}$ m^2
$x = 1.50$ m
k = a constant.

A student measures y for different values of W and plots the graph shown in **Figure 8**.

Figure 8



Do not write outside the box

0 2 . 3 Determine E using **Figure 8**.

[4 marks]

$E =$ _____ Pa

0 2 . 4 Deduce the fundamental base units for k.

[1 mark]

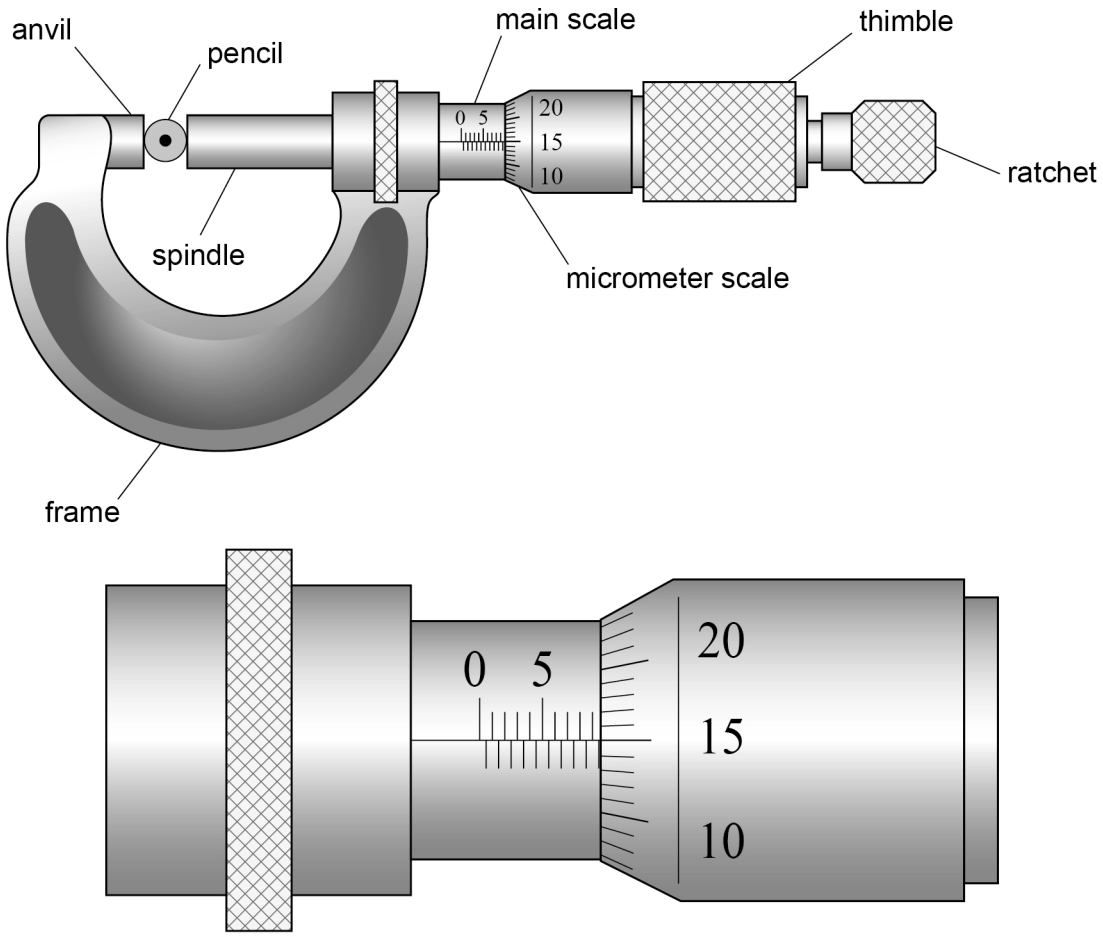
fundamental base units for $k =$ _____

8

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0 3 **Figure 9** shows a micrometer screw gauge used to measure the diameter of a pencil.

Figure 9



main scale and micrometer scale
shown enlarged

Do not write outside the box

0 3 . 1 State the reading on the micrometer.

[1 mark]

reading = _____ unit = _____

0 3 . 2 The micrometer has a zero error.

Describe how to determine an accurate measurement for the diameter of the pencil using this micrometer.

[2 marks]

_____

_____

_____

_____

_____

_____

_____

3

END OF SECTION A

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Section B

Answer **all** questions in this section.

0 4 **Figure 10** shows a conveyor used to raise concrete blocks on a building site. The blocks do not slip on the belt at any time.

Figure 10

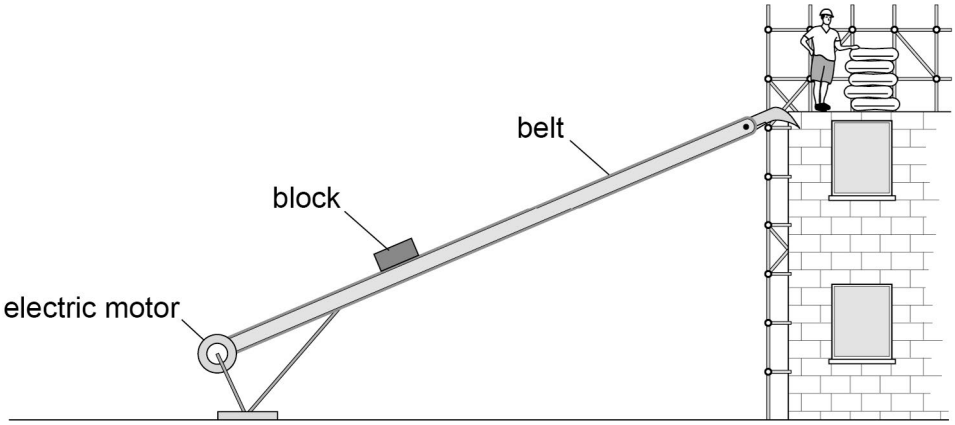
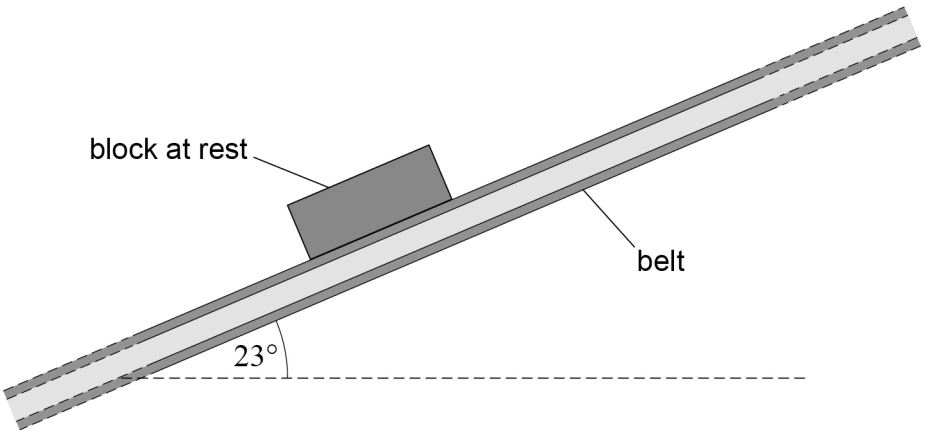


Figure 11 shows an enlarged view of one block on the belt. The belt is inclined at $23°$ to the horizontal. The mass of the block is $19\ \text{kg}$.

Figure 11



The belt exerts a frictional force F on the block when the block is at rest.

0 4 . 1 Draw an arrow on **Figure 11** to show the line of action of F.

[1 mark]

Do not write outside the box

0 4 . 2 Show that the magnitude of F is approximately $70\ \text{N}$.

[1 mark]

0 4 . 3 The belt is driven by an electric motor. When the motor is switched on, the belt and the block accelerate uniformly from rest to a speed of $0.32\ \text{m s}^{-1}$ in a time of $0.50\ \text{s}$.

Calculate the magnitude of the frictional force of the belt on the block during this acceleration.

[3 marks]

frictional force = _____ N

Question 4 continues on the next page

Do not write outside the box

0 4 . 4 The motor is connected to a $110\ \text{V}$ dc supply that has negligible internal resistance. The maximum operating current in the motor is $5.0\ \text{A}$.

The efficiency of the motor and drive system of the conveyor is 28%. The belt travels at $0.32\ \text{m s}^{-1}$ and is $8.0\ \text{m}$ long.

Deduce the maximum number of blocks that can be moved on the belt at one time.

[4 marks]

maximum number of blocks = _____

9

Do not write outside the box

0 5 . 1 A light emitting diode (LED) emits blue light with a wavelength of $440\ \text{nm}$.
The rate of photon emission is $3.0 \times 10^{16}\ \text{s}^{-1}$.

Show that the power output of the LED is approximately $0.014\ \text{W}$.

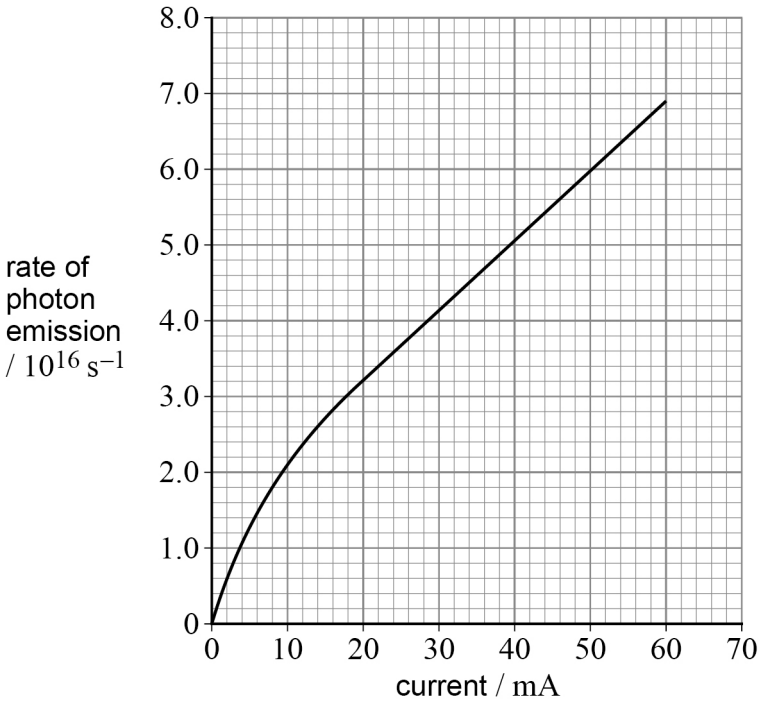
[2 marks]

Question 5 continues on the next page

Do not write outside the box

0 5 . 2 A different LED emits red light with a wavelength of $660\ \text{nm}$.
Figure 12 shows how the rate of photon emission varies with current up to the maximum operating current of this LED.

Figure 12



A student claims that the red LED can have twice the power output of the blue LED.

Deduce whether the student's claim is correct.

[3 marks]

Do not write outside the box

0 5 . 3 The student has paint that fluoresces when light of any wavelength is incident on it. She coats the blue LED and the red LED with the paint.

Compare the wavelengths of light emitted by the paint on each LED.

In your answer you should also explain the processes that cause the paint to fluoresce.

[6 marks]

11

END OF SECTION B

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Section C

Each of Questions **06** to **35** 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 6 An atom of oxygen-15 $\left({}^{15}_{8}\mathrm{O}\right)$ gains two electrons to form an ion.

What is the specific charge of the ion?

[1 mark]

A $-1.3 \times 10^{7}\ \mathrm{C\ kg^{-1}}$ ⬭

B $-2.4 \times 10^{7}\ \mathrm{C\ kg^{-1}}$ ⬭

C $-5.1 \times 10^{7}\ \mathrm{C\ kg^{-1}}$ ⬭

D $-6.4 \times 10^{7}\ \mathrm{C\ kg^{-1}}$ ⬭

0 7 Which is an exchange particle for the weak interaction?

[1 mark]

A lepton ⬭

B photon ⬭

C pion ⬭

D $\mathrm{W^{+}}$ ⬭

Do not write outside the box

0 8 A particular baryon has a quark structure dss and decays by the weak interaction.

What are possible decay products of this baryon?

The quark structure of Λ^0 is uds.

[1 mark]

A $\Lambda^0 + \pi^-$ ⬭

B $n + \pi^-$ ⬭

C $\Lambda^0 + e^-$ ⬭

D $K^+ + K^0$ ⬭

0 9 A muon and an antimuon annihilate to produce the minimum number of photons.

What is the maximum wavelength of the photons?

[1 mark]

A 5.9×10^{-15} m ⬭

B 1.2×10^{-14} m ⬭

C 5.9×10^{-9} m ⬭

D 1.2×10^{-8} m ⬭

1 0 An electron has speed v. The electron's kinetic energy is doubled.

What is the new speed of the electron?

[1 mark]

A $\frac{v}{\sqrt{2}}$ ⬭

B $\sqrt{2}v$ ⬭

C $2v$ ⬭

D $4v$ ⬭

Do not write outside the box

1 1 An object of mass m is accelerated from rest to a velocity v by a constant resultant force F.

What is the work done on the object during this acceleration?

[1 mark]

A $\frac{Fv}{2}$ ⬭

B Fv ⬭

C mv^2 ⬭

D $\frac{mv^2}{2}$ ⬭

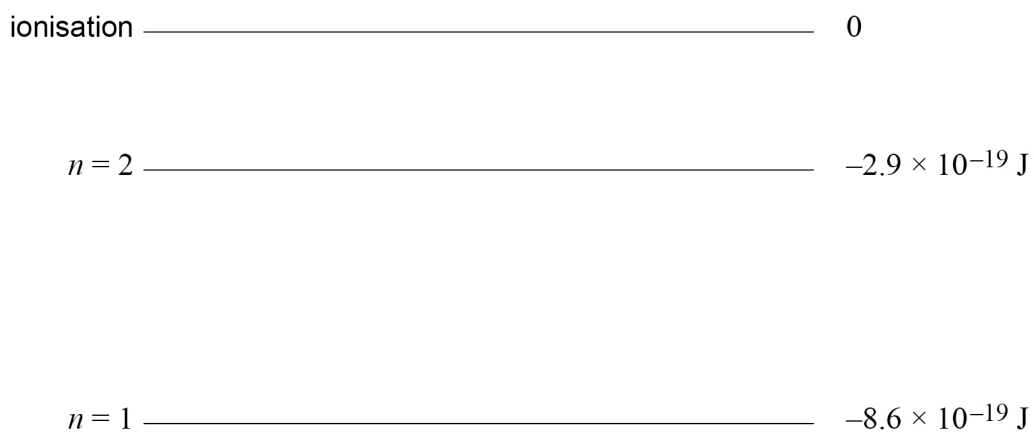
1 2 Which row describes the nature of the strong nuclear force between two nucleons at separations of 0.25 fm, 2.0 fm and 8.0 fm?

[1 mark]

	At a separation of 0.25 fm	**At a separation of 2.0 fm**	**At a separation of 8.0 fm**	
A	attractive	repulsive	negligible	⬭
B	repulsive	attractive	attractive	⬭
C	negligible	repulsive	attractive	⬭
D	repulsive	attractive	negligible	⬭

Do not write outside the box

1 3 Some energy levels of a lithium atom are shown below.



A free electron with kinetic energy 6.0×10^{-19} J collides with a stationary lithium atom in its $n = 1$ energy level. The lithium atom is excited to the $n = 2$ energy level.

What is the kinetic energy of the free electron after the collision?

[1 mark]

A 0.3×10^{-19} J ⬭

B 2.6×10^{-19} J ⬭

C 3.1×10^{-19} J ⬭

D 5.7×10^{-19} J ⬭

1 4 What are the products when a free neutron decays?

[1 mark]

A $p + e^- + \nu_e$ ⬭

B $p + e^+ + \bar{\nu}_e$ ⬭

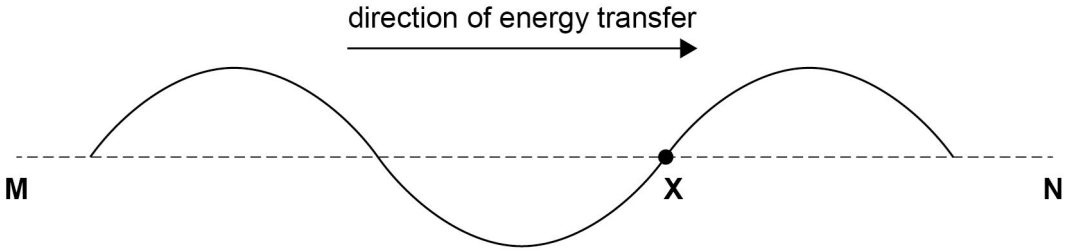
C $p + e^- + \bar{\nu}_e$ ⬭

D $p + e^+ + \nu_e$ ⬭

Do not write outside the box

1 5 A progressive wave travels along a rope in the direction **M** to **N**.

X marks a point on the rope.



The wave has a frequency of $5.0\ \text{Hz}$, a wavelength of $1.0\ \text{m}$ and an amplitude of $0.20\ \text{m}$.

Where will **X** be after $0.15\ \text{s}$?

[1 mark]

A below **MN** by $0.20\ \text{m}$ ⬭

B above **MN** by $0.20\ \text{m}$ ⬭

C nearer **N** by $0.15\ \text{m}$ ⬭

D nearer **N** by $0.75\ \text{m}$ ⬭

1 6 What is true for an inelastic collision between two isolated objects?

[1 mark]

A Both total momentum and total kinetic energy are conserved. ⬭

B Neither total momentum nor total kinetic energy is conserved. ⬭

C Only total kinetic energy is conserved. ⬭

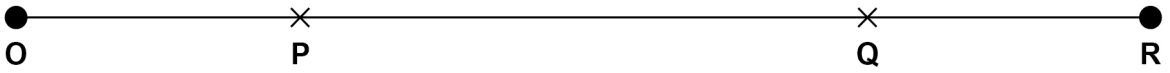
D Only total momentum is conserved. ⬭

Do not write outside the box

1 7 The diagram shows a string stretched between two fixed points **O** and **R** which are 120 cm apart.

P and **Q** are points on the string.

OP = 30 cm
OQ = 90 cm



At a certain frequency the string vibrates at its first harmonic.

P and **Q** oscillate in phase.

The frequency is gradually increased.

What is the next harmonic at which **P** and **Q** will oscillate in phase?

[1 mark]

A second ⬭

B third ⬭

C fourth ⬭

D fifth ⬭

Turn over for the next question

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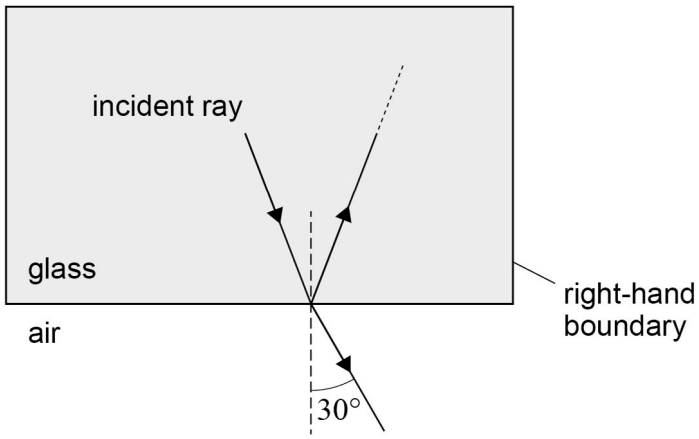
1 8 A ray of light is incident on the internal boundary of a rectangular glass block in air.

Part of the light refracts out of the block at an angle of 30°.

Some of the remaining light reflects within the block to become incident on the right-hand boundary.

refractive index of glass = 1.48

not to scale



What is the angle of incidence of the ray at the right-hand boundary?

[1 mark]

A 20° ⬭

B 42° ⬭

C 48° ⬭

D 70° ⬭

Do not write outside the box

1 9 In a Young's double-slit experiment, monochromatic light is incident on two narrow slits and the resulting interference pattern is observed on a screen.

Which change **decreases** the fringe separation?

[1 mark]

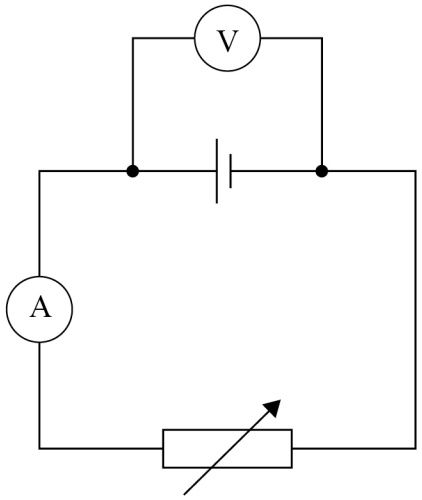
A decreasing the separation between the two slits ⬭

B increasing the distance between the slits and the screen ⬭

C using monochromatic light of higher frequency ⬭

D using monochromatic light of longer wavelength ⬭

2 0 In the circuit shown, the cell has an emf of $12\ \text{V}$ and an internal resistance which is not negligible.



When the resistance of the variable resistor is $10\ \Omega$ the voltmeter reads $10\ \text{V}$ and the ammeter reads $1.0\ \text{A}$.

The resistance of the variable resistor is changed to $5\ \Omega$.

What is the new reading on the ammeter?

[1 mark]

A $1.4\ \text{A}$ ⬭

B $1.7\ \text{A}$ ⬭

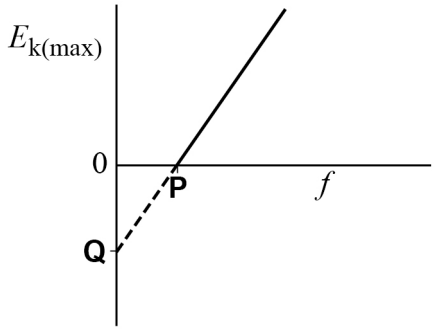
C $2.0\ \text{A}$ ⬭

D $2.4\ \text{A}$ ⬭

Turn over ►

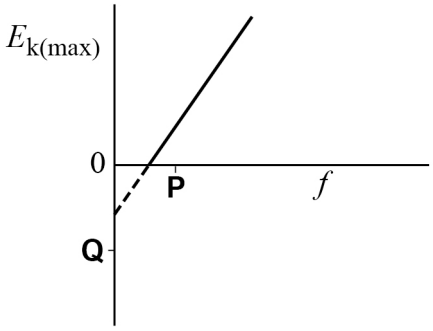
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2 1 The graph shows how the maximum kinetic energy $E_{k(max)}$ of photoelectrons emitted from a metal surface varies with the frequency f of the incident radiation.
P is the intercept on the f axis. **Q** is the intercept on the $E_{k(max)}$ axis.

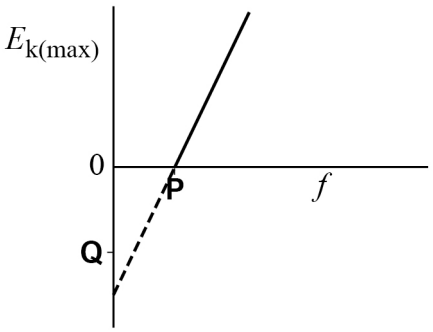


Which graph shows the variation of $E_{k(max)}$ with f for a metal with a greater work function?
[1 mark]

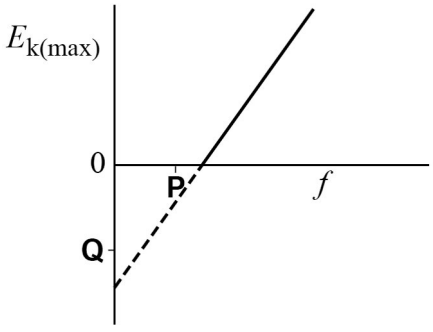
A



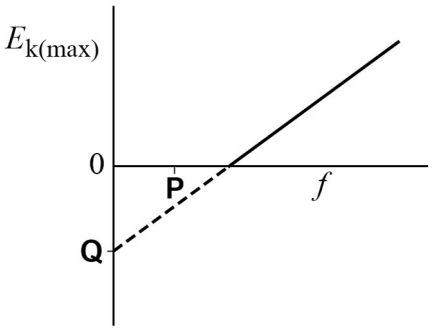
B



C



D



A ⬭

B ⬭

C ⬭

D ⬭

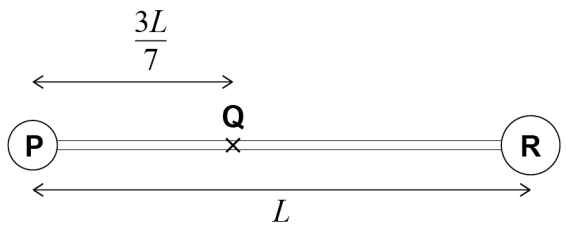
Do not write outside the box

2 2 **P** and **R** are uniform spheres of mass $3\ \text{kg}$ and $4\ \text{kg}$ respectively.
P and **R** are joined by a rod of negligible mass.
The distance between their centres is L.
The centre of mass of this system is at **Q**.

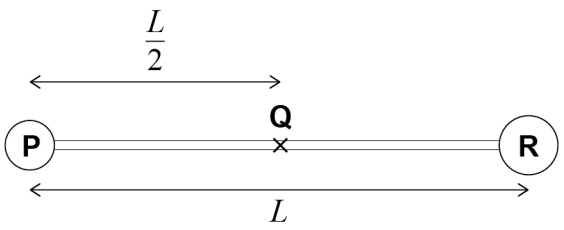
Which diagram shows the position of the centre of mass?

[1 mark]

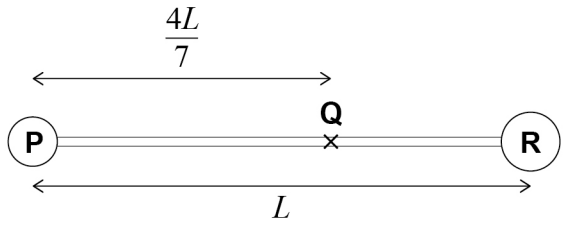
A



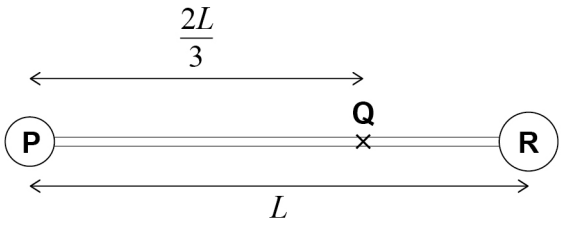
B



C



D



A ⬭

B ⬭

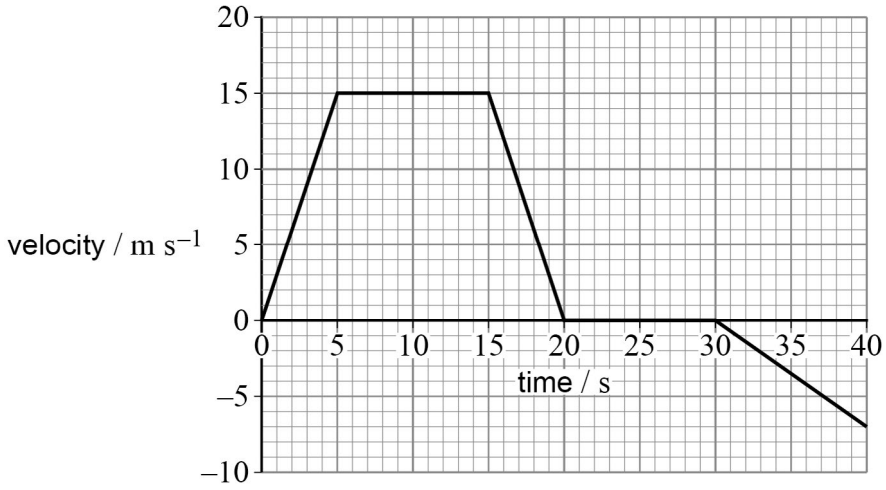
C ⬭

D ⬭

Turn over for the next question

Do not write outside the box

2 3 A vehicle travels on a straight road, starting at time $t = 0$
The graph shows how its velocity varies with time.



What is the distance of the vehicle from its start position when $t = 40$ s?

[1 mark]

A 115 m ⬭

B 190 m ⬭

C 260 m ⬭

D 370 m ⬭

2 4 A suitcase weighing 200 N is placed on a weighing scale in a lift.
The scale reads 180 N when the lift is moving.

The lift is

[1 mark]

A moving down at a constant velocity. ⬭

B moving down with a decreasing velocity. ⬭

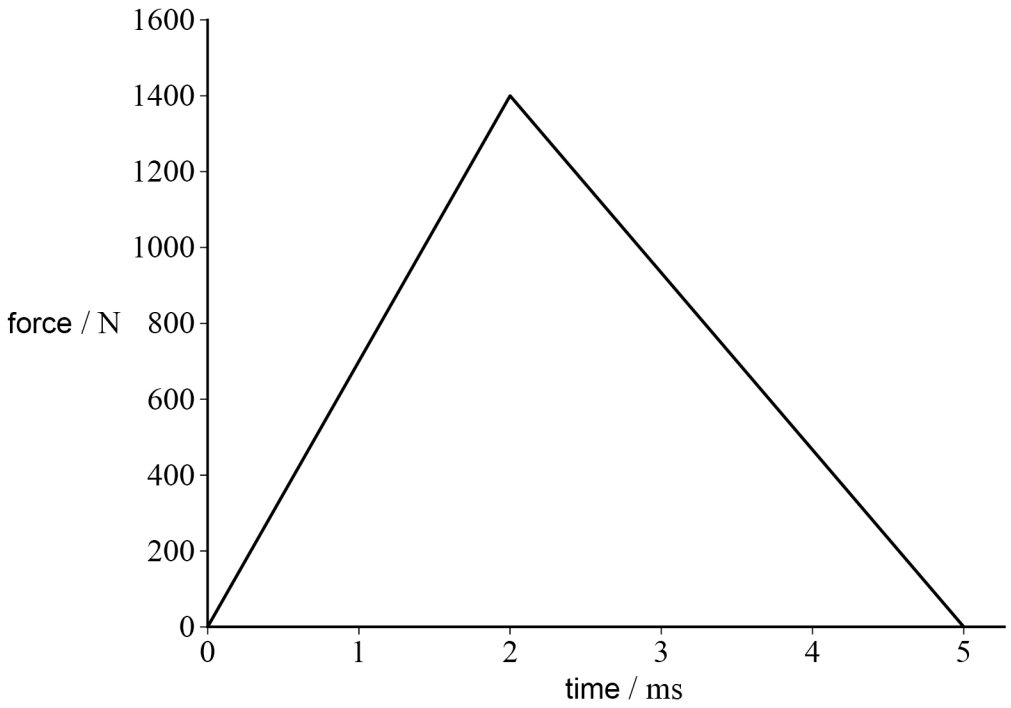
C moving up at a constant velocity. ⬭

D moving up with a decreasing velocity. ⬭

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2 5 A stationary ball is free to move. The ball is hit with a bat.

The graph shows how the force of the bat on the ball changes with time.



The ball has a mass of 0.044 kg.

What is the speed of the ball immediately after being hit?

[1 mark]

A 13 m s^{-1} ⬭

B 60 m s^{-1} ⬭

C 80 m s^{-1} ⬭

D 160 m s^{-1} ⬭

Turn over for the next question

Do not write outside the box

2 6 A mass m is added to a vertical spring that is initially unextended, as shown in **Diagram 1**.

The mass is then lowered until it hangs stationary on the spring, as shown in **Diagram 2**.

The extension of the spring is now ΔL.

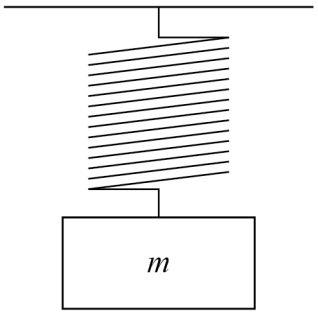


Diagram 1

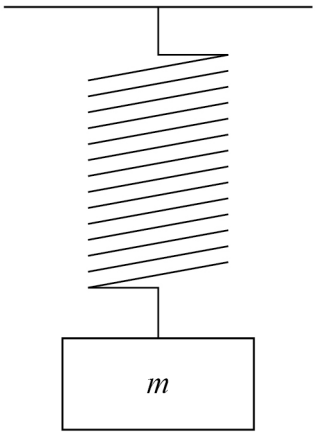


Diagram 2

How much energy is transferred from the mass–spring system?

[1 mark]

A $\frac{mg\Delta L}{2}$ ⬭

B $mg\Delta L$ ⬭

C $\frac{3mg\Delta L}{2}$ ⬭

D $2mg\Delta L$ ⬭

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Questions **27** and **28** are about three spheres **X**, **Y** and **Z**.

The relative mass and relative diameter of each sphere are given in the table.

	X	**Y**	**Z**
relative mass	1	5	1
relative diameter	1	1	5

Each sphere is dropped from rest and accelerates to its terminal speed.

2 7 What is true about the accelerations of the spheres at the instant they are released?

[1 mark]

A The acceleration of **X** is less than that of **Y**. ⬭

B The acceleration of **X** is greater than that of **Z**. ⬭

C The acceleration of **X** is the same as that of **Y**. ⬭

D The acceleration of **Y** is less than that of **Z**. ⬭

2 8 What is true about the terminal speeds?

[1 mark]

A The terminal speed of **X** is greater than that of **Y**. ⬭

B The terminal speed of **X** is the same as that of **Y**. ⬭

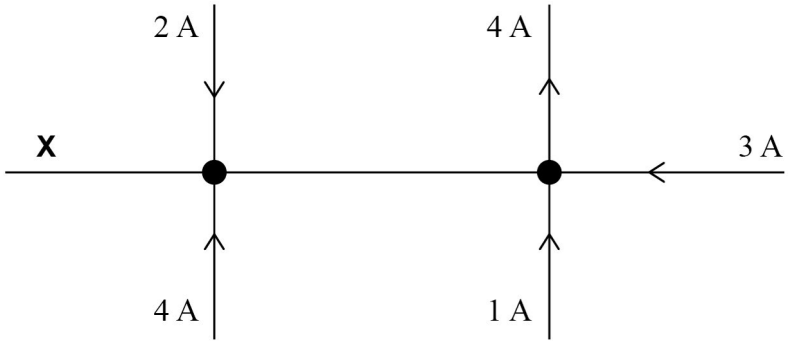
C The terminal speed of **Y** is greater than that of **Z**. ⬭

D The terminal speed of **X** is less than that of **Z**. ⬭

Turn over for the next question

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2 9 The diagram shows the currents in a set of wires.



What is the magnitude of the current at **X**?

[1 mark]

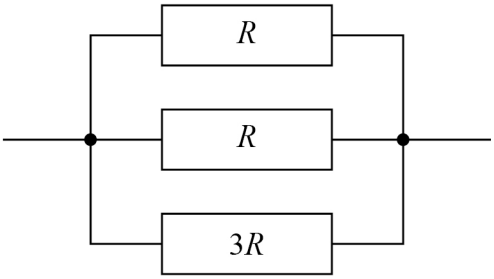
A zero ⬭

B 2 A ⬭

C 3 A ⬭

D 6 A ⬭

3 0 Resistors of resistance R, R and $3R$ are connected as shown.



What is the resistance of the arrangement?

[1 mark]

A $\frac{3R}{7}$ ⬭

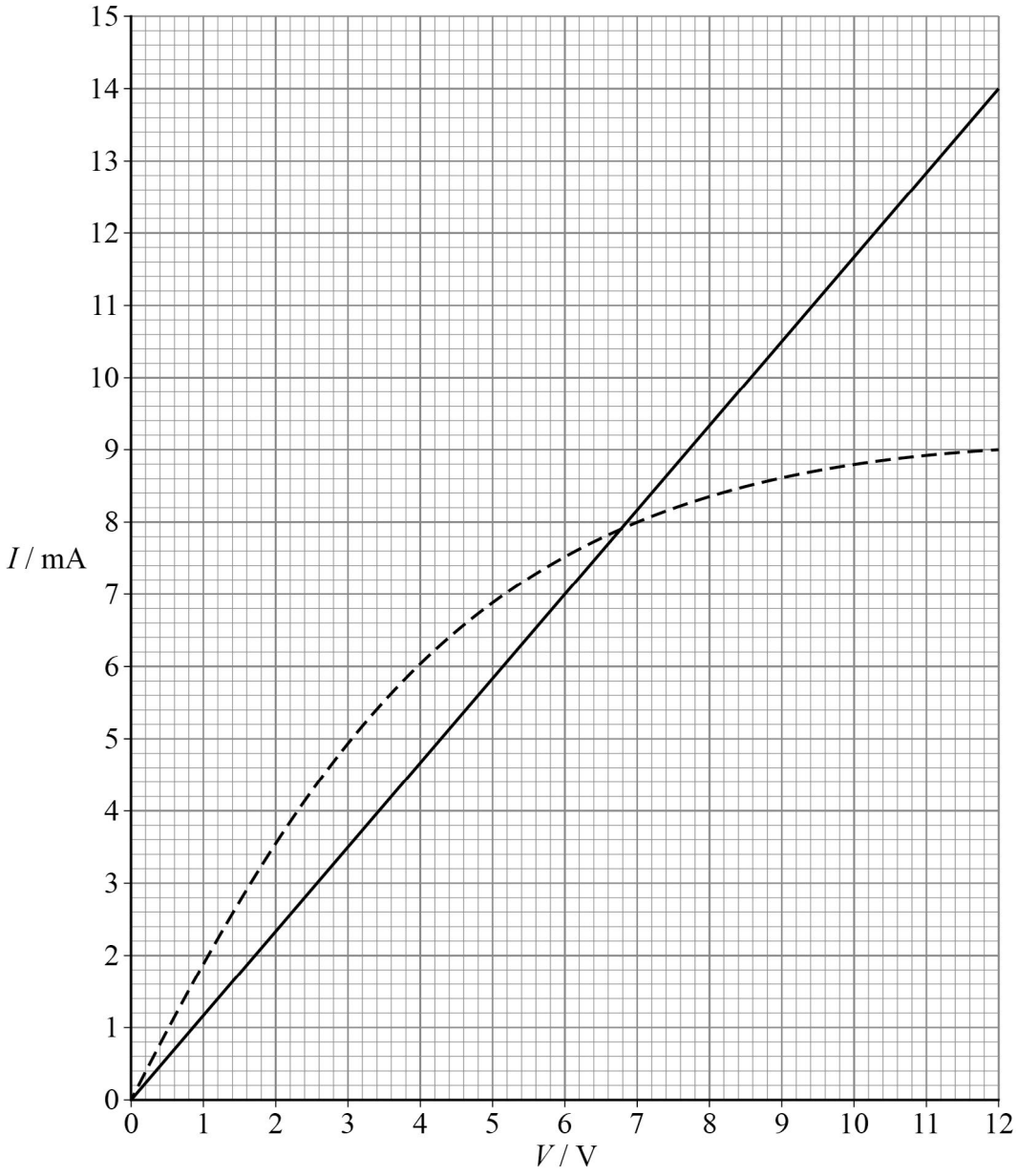
B $\frac{7R}{3}$ ⬭

C $\frac{5R}{6}$ ⬭

D $\frac{6R}{5}$ ⬭

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3 1 The graph shows the current–voltage (I–V) characteristics for two components.



The two components are connected in parallel with a 12 V battery that has negligible internal resistance.

What is the current in the battery?

[1 mark]

A 7.9 mA ⬭

B 14.5 mA ⬭

C 15.8 mA ⬭

D 23.0 mA ⬭

Turn over ►

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3 2 A wire is made from a material of density ρ.
The wire has a mass m and an initial length L.
When the tensile force in the wire is F the extension of the wire is ΔL.

What is the Young modulus of the material?

[1 mark]

A $\frac{F\rho L^2}{m\Delta L}$ ⬭

B $\frac{FL^2}{m\rho\Delta L}$ ⬭

C $\frac{F\rho}{m\Delta L}$ ⬭

D $\frac{FmL^2}{\rho\Delta L}$ ⬭

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3 3 Measurements are taken to determine the resistivity of a uniform metal wire.
The table shows the quantities measured and their percentage uncertainties.

Quantity	Percentage uncertainty
potential difference across wire	0.3%
current in wire	5.0%
diameter of wire	4.0%
length of wire	0.2%

What is the percentage uncertainty in the calculated value for the resistivity of the metal of the wire?

[1 mark]

A 1.6% ⬭

B 9.5% ⬭

C 13.5% ⬭

D 21.5% ⬭

3 4 Superconductors are used to

[1 mark]

A increase the strength of electricity cables. ⬭

B make light dependent resistors. ⬭

C produce strong magnetic fields. ⬭

D increase the rate of heat energy transfer. ⬭

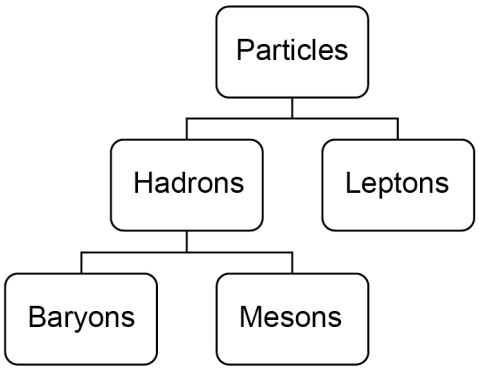
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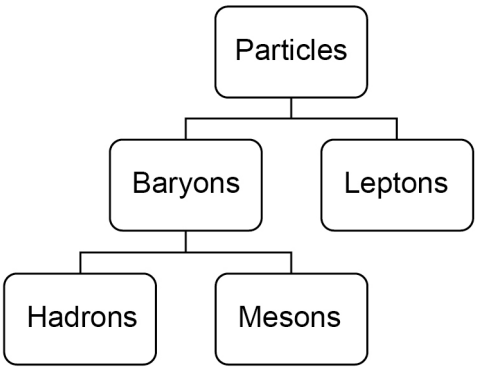
3 5 Which shows the classification of particles?

[1 mark]

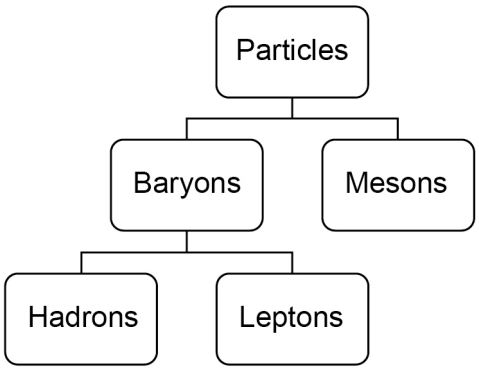
A



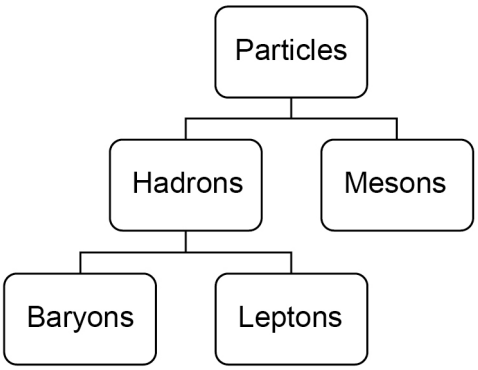
B



C



D



A ⬭

B ⬭

C ⬭

D ⬭

30

END OF QUESTIONS

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