AQA

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

AS
PHYSICS

Paper 2

Thursday 8 June 2017 Afternoon Time allowed: 1 hour 30 minutes

Materials
For this paper you must have:
- a pencil and a ruler
- a scientific calculator
- a Data and Formulae booklet.

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.
- 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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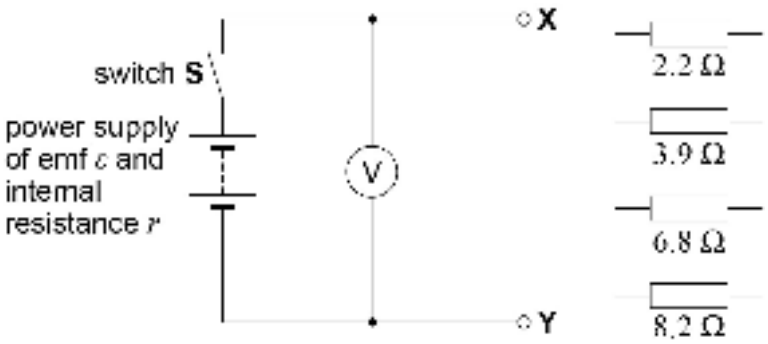
Section A

Answer **all** questions in this section.

0 1 This question is about an experiment to determine the internal resistance of a power supply.

A student is given the circuit and the four resistors of known resistance shown in **Figure 1**.

Figure 1



The student can change the external resistance R of the circuit between terminals **X** and **Y**. This is done by connecting different combinations of **two** resistors in series or in parallel between **X** and **Y**.
This method can produce **12 different values** for R.

0 1 . 1 Calculate the largest value of R that the student can obtain using **two** resistors.
[1 mark]

largest value of R = _____ Ω

0 1 . 2 Calculate the smallest value of R that the student can obtain using **two** resistors.
[2 marks]

smallest value of R = _____ Ω

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0 1 . 3 With switch **S** closed (in the on position) and no resistors connected between **X** and **Y** the voltmeter reading V is 1.62 V.

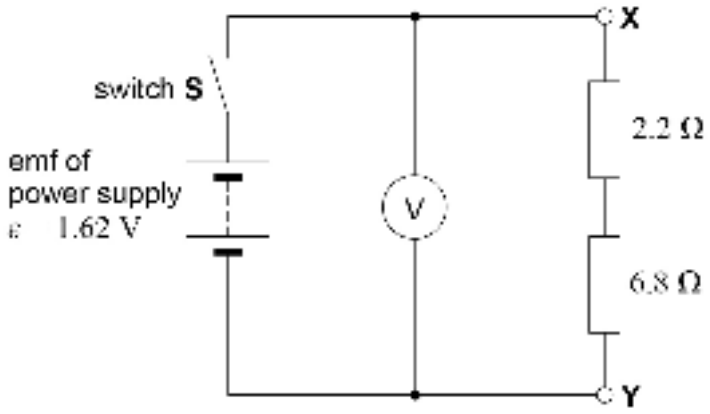
The student concludes that this voltmeter reading equals the emf ε of the power supply.

State why the student's conclusion that $\varepsilon = 1.62$ V was correct.

[1 mark]

0 1 . 4 **Figure 2** shows one particular combination and arrangement of two resistors that the student could use.

Figure 2



When **S** is closed the voltmeter reading V is 1.14 V.

Explain why V is less than 1.62 V when **S** is closed.

[1 mark]

Question 1 continues on the next page

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0 1 . 5 It can be shown that

$$\varepsilon - V = r \times \frac{V}{R}$$

where r is the internal resistance of the power supply.

Determine $(\varepsilon - V)$ and $\frac{V}{R}$ for this circuit using the data given in question **01.4**.

[1 mark]

$(\varepsilon - V)$ = _____ V

$\frac{V}{R}$ = _____ V Ω^{-1}

0 1 . 6 The student obtains values of V for five further different values of R.
These data were used to produce the graph of $(\varepsilon - V)$ against $\frac{V}{R}$ in **Figure 3**.

Plot the point you determined in question **01.5** on **Figure 3** and add a suitable best-fit line.

[1 mark]

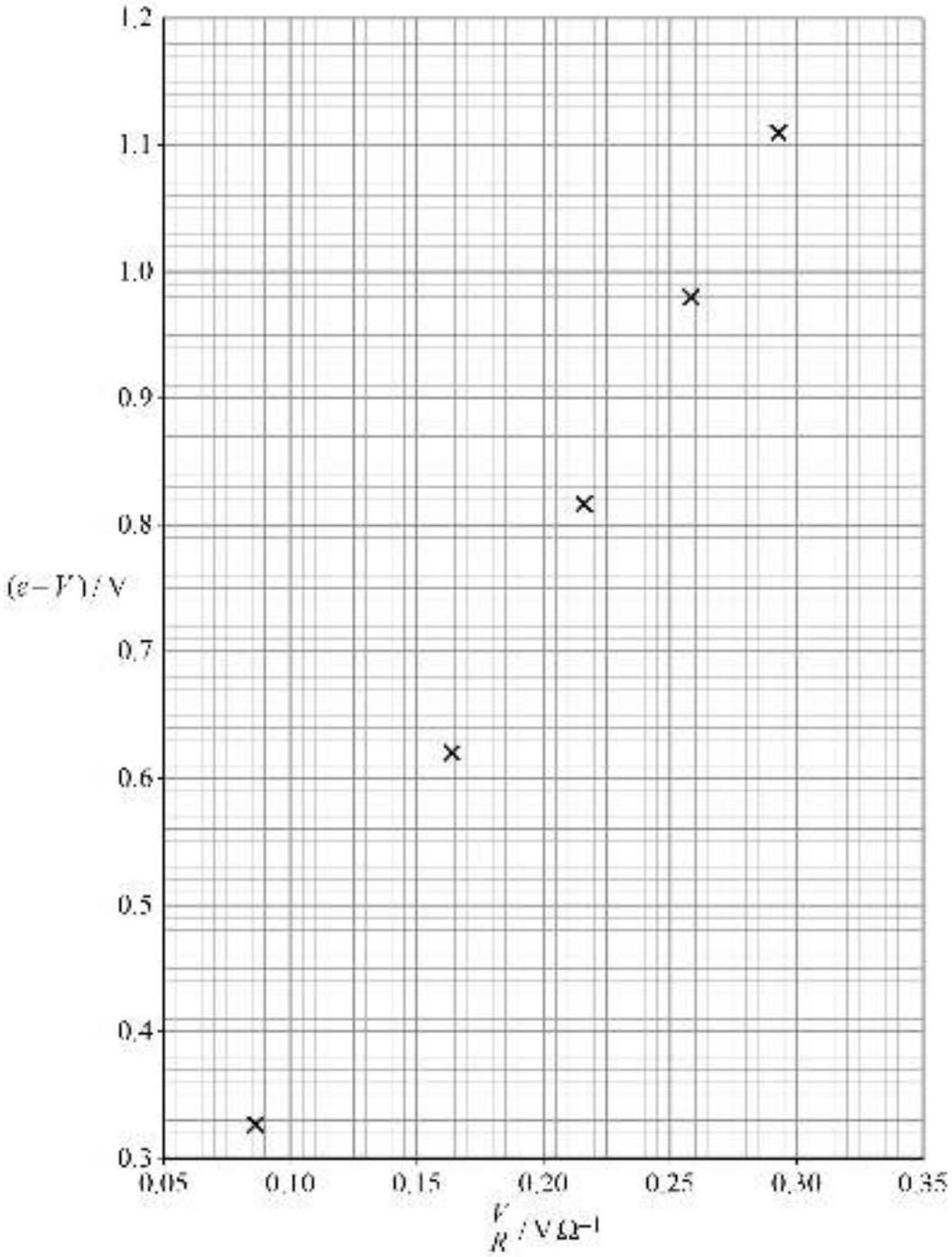
0 1 . 7 Use **Figure 3** to determine r.

[2 marks]

r = _____ Ω

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Figure 3

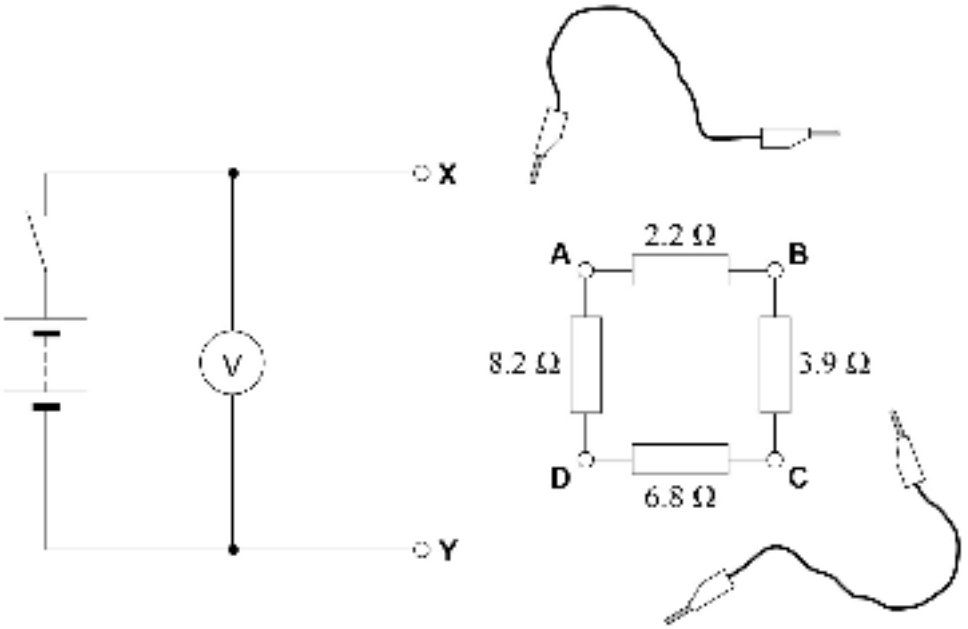


Question 1 continues on the next page

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0 1 . 8 **Figure 4** shows a different method for varying the resistance R described in question **01** on page 2.

Figure 4



The four resistors are connected in a loop with sockets **A**, **B**, **C** and **D** at each junction. Two leads are used to connect the resistor loop to **X** and **Y**.

Discuss whether this method is an improvement over the method described in question **01**. In your answer, you should refer to the number of different values that can be obtained for R.

[2 marks]

11

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Turn over for the next question

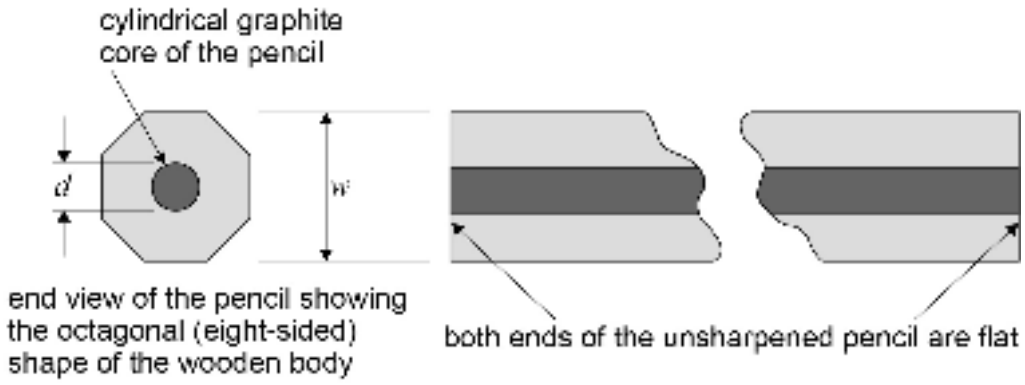
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ANSWER IN THE SPACES PROVIDED

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0 2 A pencil, unsharpened at both ends, has a cylindrical graphite core of uniform diameter d surrounded by an octagonal (eight-sided) wooden body.

Figure 5 shows an end view and a cross-sectional slice along the length of the pencil.

Figure 5



0 2 . 1 A student used a micrometer to measure the width w at several points along the length of the pencil.

Explain why the student used this procedure to determine a value for w.

[1 mark]

Do not write outside the box

0 2 . 2 The student's results are shown in **Table 1**.

Table 1

w_1 / mm	w_2 / mm	w_3 / mm	w_4 / mm	w_5 / mm
7.23	7.10	7.06	7.20	7.16

Determine the percentage uncertainty in the result the student obtains for w.

[2 marks]

percentage uncertainty = _____ %

0 2 . 3 The cross-sectional area A of the end of the pencil is given by

$$A = 0.83\,w^2$$

The volume of the cylindrical core is known to be 9.0% of the volume of the unsharpened pencil.
The cylindrical core of the graphite has a diameter d.

Determine d.

[2 marks]

d = _____ mm

Question 2 continues on the next page

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0 2 . 4 A student investigates the rate at which a similar pencil wears away through use.

The student measures the length of the pencil using a sliding vernier scale placed alongside a fixed scale. The fixed scale has a precision of 1 mm.

Figure 6 shows the vernier scale in the zero position.

Figure 7 shows the pencil (which is now sharpened) placed next to the fixed scale.

The position of the vernier scale is adjusted so that the length of the pencil can be read.

Read and record the length of the pencil shown in **Figure 7**.

[1 mark]

length of pencil = _____ mm

0 2 . 5 The pencil is then removed from the scale and is used to draw 20 lines on a sheet of paper. Each line has a length 25 cm.

The pencil is then replaced next to the fixed scale and the vernier scale adjusted so the new length of the pencil can be read, as shown in **Figure 8**.

Read and record the new length of the pencil shown in **Figure 8**.

[1 mark]

new length of pencil = _____ mm

0 2 . 6 $L_{1/2}$ is the length of the line that could be drawn which would cause the original length of the pencil to be halved.

Calculate $L_{1/2}$.
Ignore any decrease in length as a result of sharpening the pencil.

[2 marks]

$L_{1/2}$ = _____ m

9

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Figure 6

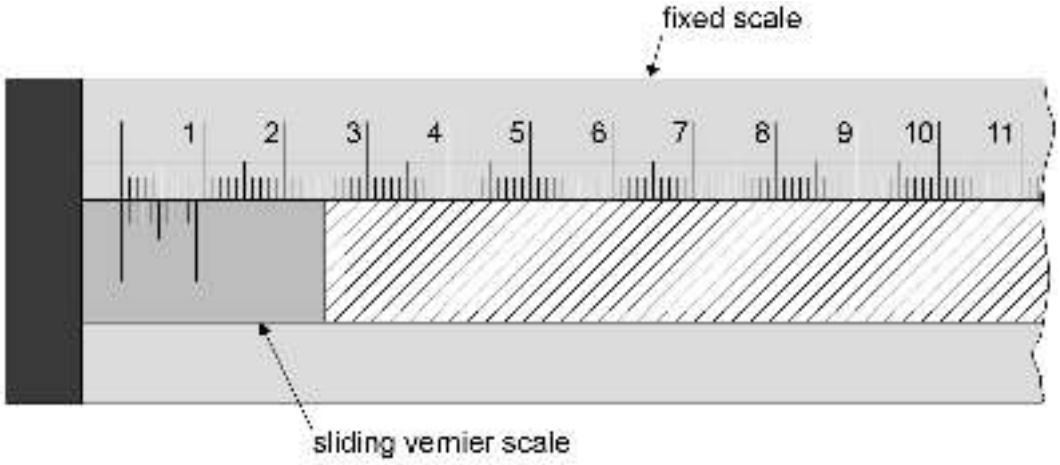


Figure 7

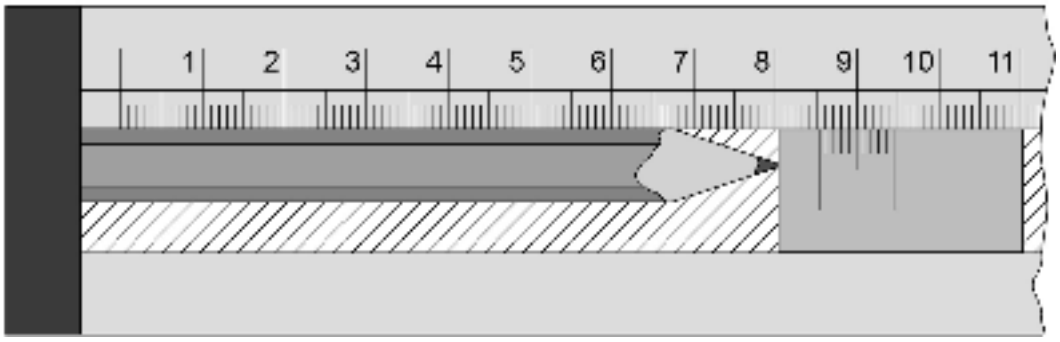
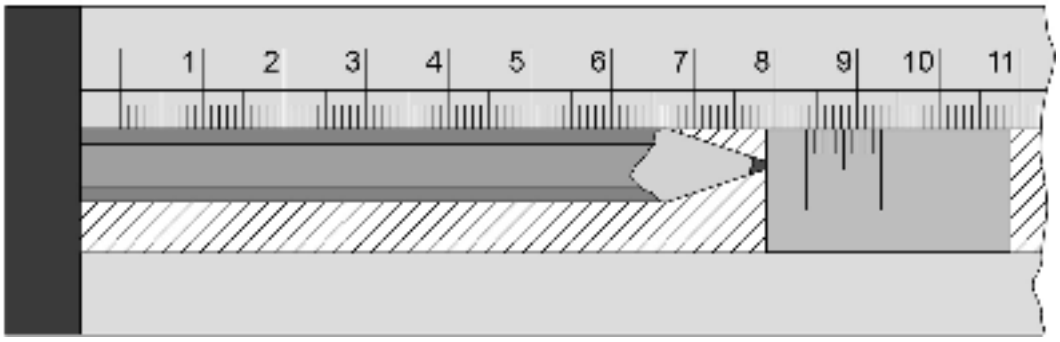


Figure 8



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Section B

Answer **all** questions in this section.

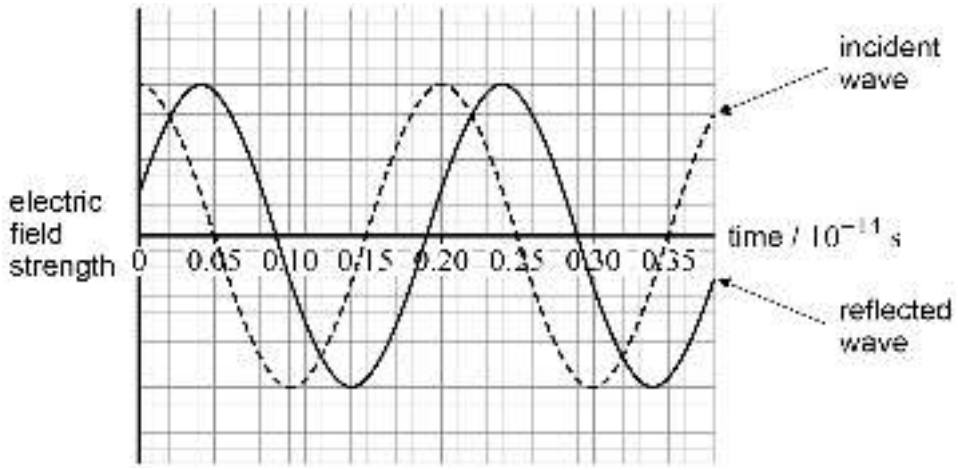
0 3 A gravimeter is an instrument used to measure the acceleration due to gravity. The gravimeter measures the distance fallen by a free-falling mirror in a known time.

To do this, monochromatic light is reflected normally off the mirror, creating interference between the incident and reflected waves. The mirror is released from rest and falls, causing a change in the phase difference between the incident and reflected waves at a detector.

At the point of release of the mirror, the waves are in phase, resulting in a maximum intensity at the detector. The next maximum is produced at the detector when the mirror has fallen through a distance equal to half a wavelength of the light. The gravimeter records the number of maxima detected in a known time as the mirror falls. These data are used by the gravimeter to compute the acceleration of the free-falling mirror.

Figure 9 illustrates the phase relationship between the incident and reflected waves at the detector for one position of the mirror.

Figure 9



Do not write outside the box

0 3 . 1 Show that the wavelength of the light is 600 nm.

[3 marks]

0 3 . 2 Determine the phase difference, in rad, between the incident and reflected waves shown in **Figure 9**.

[2 marks]

phase difference = _____ rad

Question 3 continues on the next page

Do not write outside the box

0 3 . 3 A maximum is detected each time the mirror travels a distance equal to half a wavelength of the light.

In one measurement 2.37×10^5 maxima are recorded as the mirror is released from rest and falls for 0.120 s.

Using an appropriate equation of motion, calculate the acceleration due to gravity that the gravimeter computes from these data.

State your answer to 3 significant figures.

wavelength of the light = 600 nm

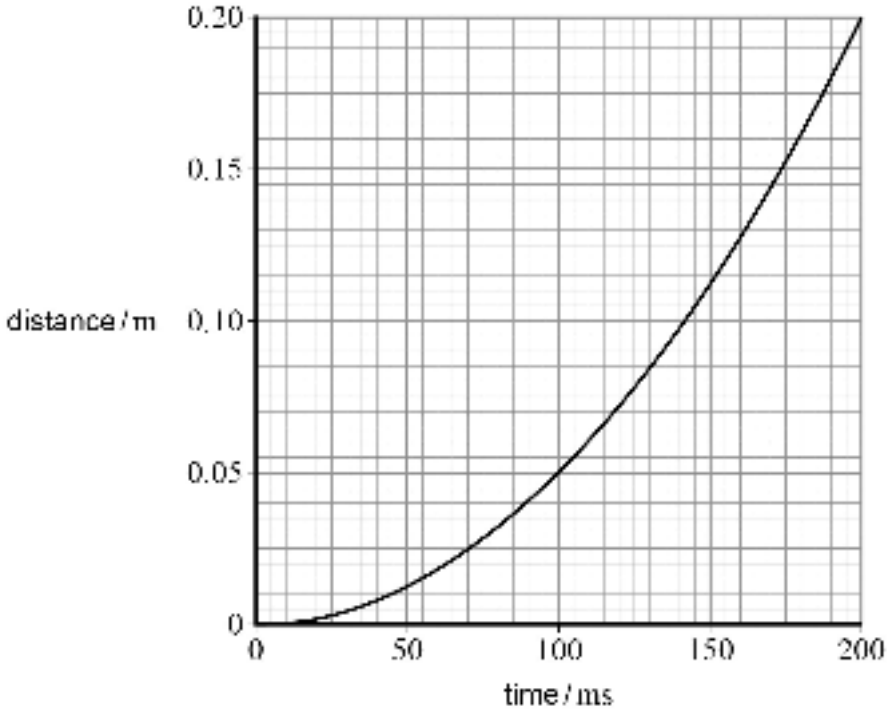
[3 marks]

acceleration due to gravity = _____ m s^{-2}

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0 3 . 4 **Figure 10** is a graph that the gravimeter could produce to show how the distance travelled by the mirror varies with time as it falls.

Figure 10



Determine the gradient of the line when the time is 0.12 s.

[2 marks]

gradient = _____

0 3 . 5 State what this gradient represents.

[1 mark]

_____

11

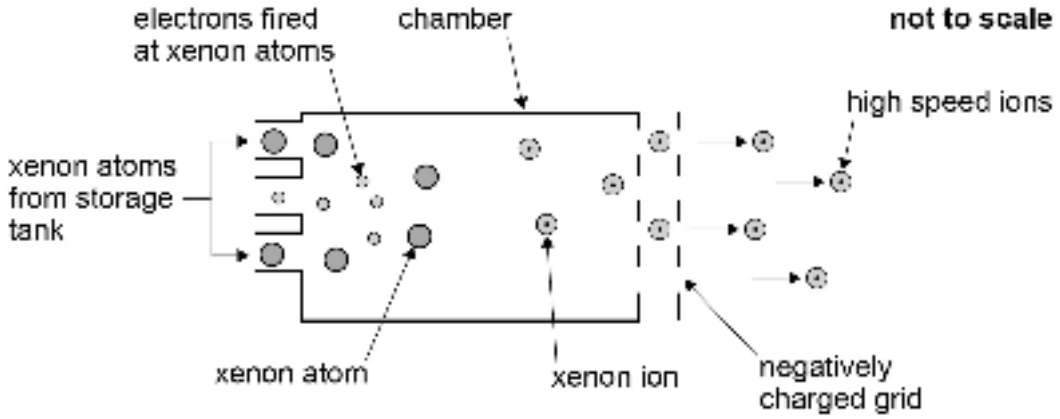
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0 4 **Figure 11** represents an ion propulsion unit used on a spacecraft launched in 1998.

Atoms of xenon-131 ($^{131}_{54}\mathrm{Xe}$) were injected from a storage tank into a chamber where they became ionised due to collisions with electrons.

A negatively charged grid attracted the xenon ions, accelerating them out of the back of the ion propulsion unit and causing the spacecraft to be propelled forward.

Figure 11



0 4 . 1 The mass of a Xe^{+} ion is 2.18×10^{-25} kg.

Calculate the specific charge of a Xe^{+} ion.

Give an appropriate unit for your answer.

[2 marks]

specific charge = _____ unit _____

Do not write outside the box

0 4 . 2 The storage tank contained $79\ \text{kg}$ of xenon. When the ion propulsion unit was switched on it had an average power output of $2.1\ \text{kW}$.

Each xenon ion gained $1300\ \text{eV}$ of energy as it was accelerated and ejected out of the propulsion unit.

Calculate the energy, in J, gained by each xenon ion.

[1 mark]

energy = _____ J

0 4 . 3 Determine the length of time the ion propulsion unit operated before all of the $79\ \text{kg}$ of xenon was used up.

mass of xenon atom = $2.18 \times 10^{-25}\ \text{kg}$

[3 marks]

time = _____ s

Question 4 continues on the next page

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0 4 . 4 Ion propulsion units could use helium ions instead of xenon ions.

An ion of helium-4 (He^+) has a much higher specific charge than an ion of xenon-131 (Xe^+). Both ions would gain $1300\ eV$ of kinetic energy in being accelerated and ejected from an ion propulsion unit.

Suggest whether helium ions or xenon ions are better to use as a propellant in future space programmes. In your answer you should compare the relative speeds and momentum changes of the ions.

[3 marks]

9

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Section C

Each of Questions **5** 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 answer completely fill in the circle alongside the appropriate answer.

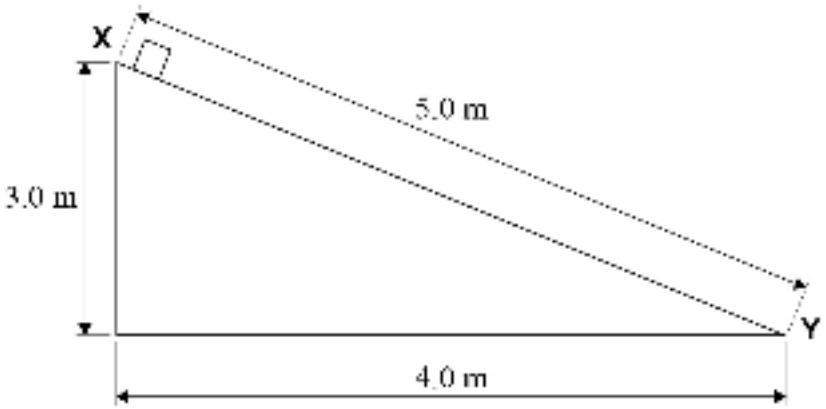
CORRECT METHOD  WRONG METHODS 

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.

0 5 A mass of $2.5\ \text{kg}$ is released from rest at **X** and slides down a ramp, of height $3.0\ \text{m}$, to point **Y** as shown.



When the mass reaches **Y** at the bottom of the ramp it has a velocity of $5.0\ \text{m s}^{-1}$.

What is the average frictional force between the mass and the ramp?

[1 mark]

A 8.5 N 

B 10.6 N 

C 14.7 N 

D 24.5 N 

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0 6 Which row shows the correct interactions experienced by a hadron or a lepton?

[1 mark]

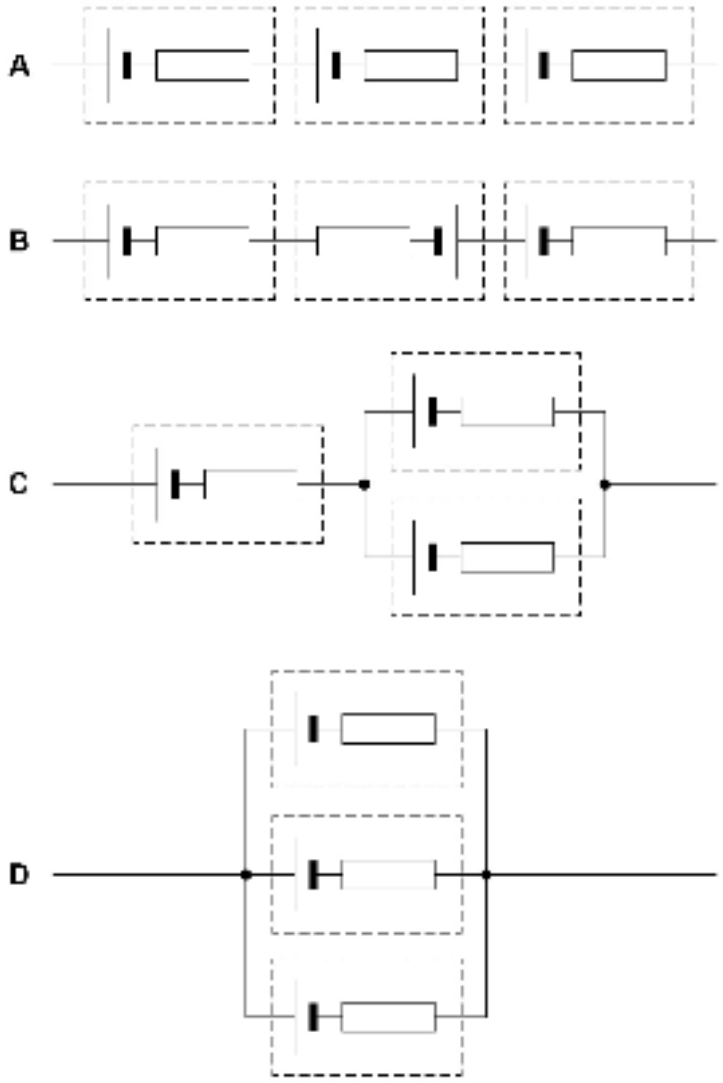
	Particle	Strong interaction	Weak interaction	
A	Hadron	Yes	Yes	⬭
B	Lepton	Yes	Yes	⬭
C	Hadron	Yes	No	⬭
D	Lepton	Yes	No	⬭

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0 7 Three cells each have an emf $\varepsilon = 1.5\ \text{V}$ and an internal resistance $r = 0.6\ \Omega$.

Which combination of these cells will deliver a total emf of $1.5\ \text{V}$ and a maximum current of $7.5\ \text{A}$?

[1 mark]



A ⬭

B ⬭

C ⬭

D ⬭

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0 8 When a nucleus of the radioactive isotope $^{65}_{28}\mathrm{Ni}$ decays, a β^- particle and an electron antineutrino are emitted.

How many protons and neutrons are there in the resulting daughter nucleus?

[1 mark]

	Number of protons	Number of neutrons	
A	28	65	⬭
B	29	65	⬭
C	29	36	⬭
D	30	35	⬭

0 9 A bullet of mass $10\ \mathrm{g}$ is fired with a velocity of $100\ \mathrm{m\ s^{-1}}$ from a stationary rifle of mass $4.0\ \mathrm{kg}$. Consider the rifle and bullet to be an isolated system.

What are the recoil velocity of the rifle and the total momentum of the rifle and bullet just after firing?

[1 mark]

	Recoil velocity / m s^{-1}	Total momentum / kg m s^{-1}	
A	0.25	0	⬭
B	0.25	1.0	⬭
C	0.40	0	⬭
D	0.40	1.0	⬭

1 0 Which row correctly shows electromagnetic radiations in order of decreasing wavelength?

[1 mark]

A gamma > ultraviolet > microwave ⬭

B ultraviolet > gamma > microwave ⬭

C microwave > ultraviolet > gamma ⬭

D gamma > microwave > ultraviolet ⬭

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1 1 Which statement is correct about the properties of an unpolarised electromagnetic wave as it passes through a polariser?

[1 mark]

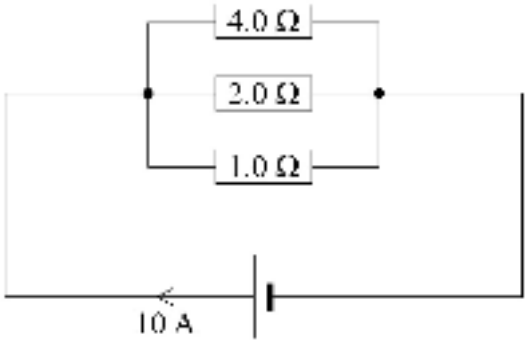
A The wave remains unchanged. ⬭

B The wave does not pass through the polariser. ⬭

C The wave's electric field oscillates along the direction of travel. ⬭

D The intensity of the wave is reduced. ⬭

1 2 The current in the cell is $10\ \text{A}$ as shown.



What is the current in the $2.0\ \Omega$ resistor?

[1 mark]

A 0.35 A ⬭

B 2.86 A ⬭

C 3.50 A ⬭

D 7.14 A ⬭

Turn over for the next question

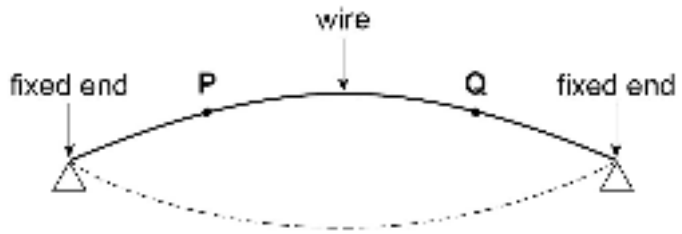
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1 3 What interactions are involved in the production of a strange particle and its decay into non-strange particles?

[1 mark]

	Production	Decay	
A	strong	weak	⬭
B	strong	strong	⬭
C	weak	strong	⬭
D	weak	weak	⬭

1 4 A uniform wire, fixed at both ends, is plucked in the middle so that it vibrates at the first harmonic as shown.



What is the phase difference between the oscillations of the particles at **P** and **Q**?

[1 mark]

A zero ⬭

B $\frac{\pi}{4}$ rad ⬭

C $\frac{\pi}{2}$ rad ⬭

D $\frac{3\pi}{4}$ rad ⬭

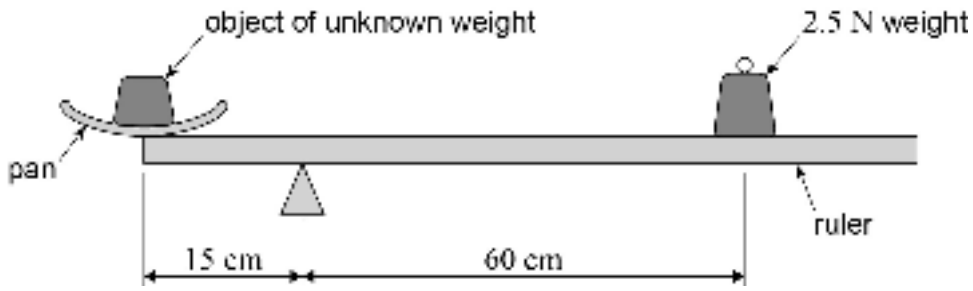
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1 5 Which row correctly states whether momentum, mass and velocity are scalar or vector quantities?

[1 mark]

	Momentum	**Mass**	**Velocity**	
A	scalar	scalar	vector	⬭
B	vector	scalar	scalar	⬭
C	scalar	vector	scalar	⬭
D	vector	scalar	vector	⬭

1 6 The diagram shows a uniform metre ruler of weight 1.5 N pivoted 15 cm from one end for use as a simple balance.



A scale pan of weight 0.5 N is placed at the end of the ruler and an object of unknown weight is placed in the pan. The ruler moves to a steady horizontal position when a weight of 2.5 N is added at a distance of 60 cm from the pivot as shown.

What is the weight of the object?

[1 mark]

A 9.5 N ⬭

B 10.0 N ⬭

C 13.0 N ⬭

D 13.5 N ⬭

Turn over ►

Do not write outside the box

1 7 What is the name given to a material that breaks without deformation when a force is applied to it?

[1 mark]

A Plastic ⬭

B Brittle ⬭

C Stiff ⬭

D Elastic ⬭

1 8 A battery of negligible internal resistance and an emf of $12\ \text{V}$ is connected in series with a heating element. The heating element has a resistance of $6.5\ \Omega$ when in operation.

What is the energy transferred by the heating element when operating for 5 minutes?

[1 mark]

A $111\ \text{J}$ ⬭

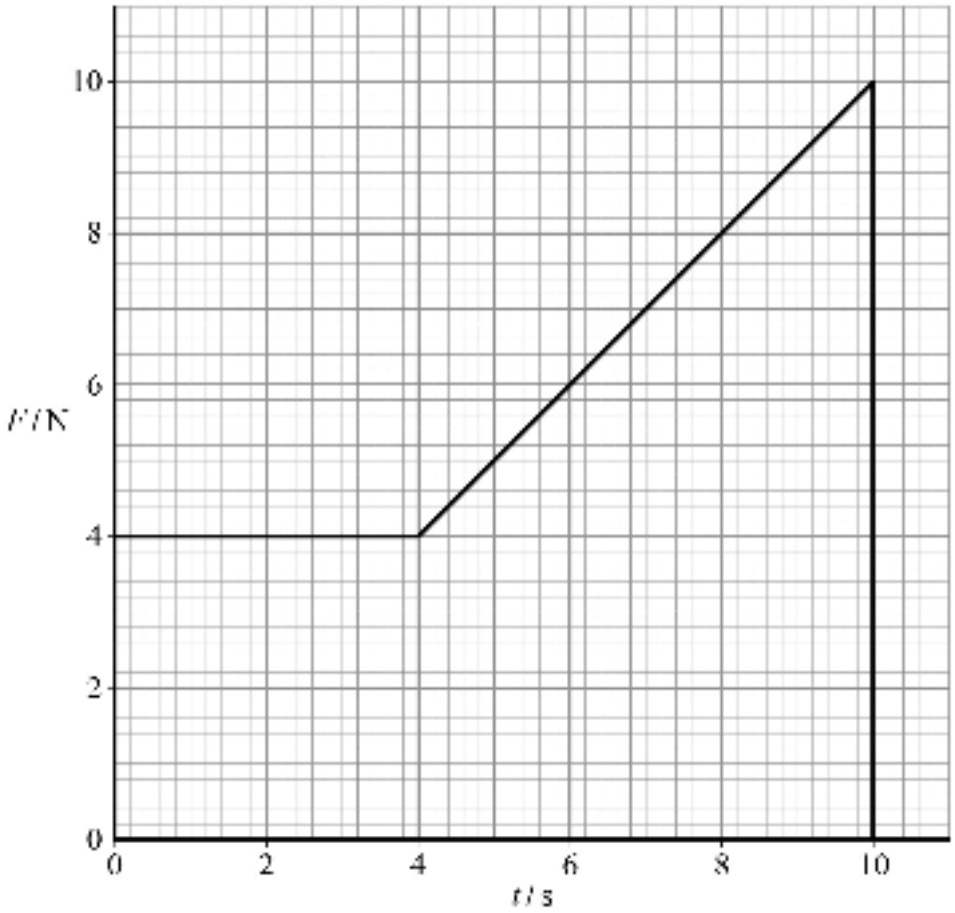
B $390\ \text{J}$ ⬭

C $6650\ \text{J}$ ⬭

D $23\ 400\ \text{J}$ ⬭

Do not write outside the box

1 9 The graph shows how the force F applied to an object varies with time t.



What is the momentum gained by the object from $t = 0$ to $t = 10$ s?

[1 mark]

A 18 kg m s^{-1} ⬭

B 32 kg m s^{-1} ⬭

C 40 kg m s^{-1} ⬭

D 58 kg m s^{-1} ⬭

Turn over for the next question

Do not write outside the box

2 0 When light of a certain frequency greater than the threshold frequency of a metal is directed at the metal, photoelectrons are emitted from the surface.
The power of the light incident on the metal surface is doubled.

Which row shows the effect on the maximum kinetic energy and the number of photoelectrons emitted per second?

[1 mark]

	Maximum kinetic energy	**Number of photoelectrons emitted per second**	
A	remains unchanged	remains unchanged	⬭
B	doubles	remains unchanged	⬭
C	remains unchanged	doubles	⬭
D	doubles	doubles	⬭

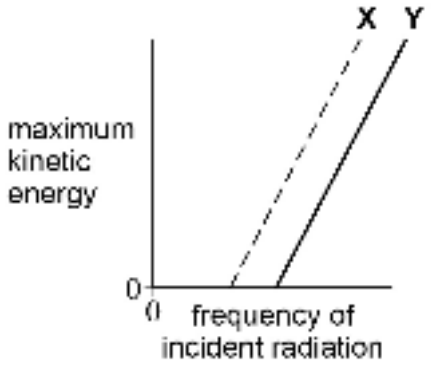
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2 1 Line **X** on the graphs below shows how the maximum kinetic energy of emitted photoelectrons varies with the frequency of incident radiation for a particular metal.

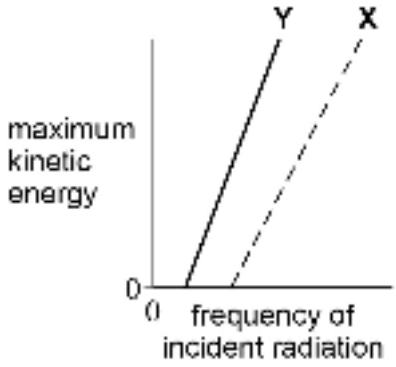
Which graph shows the results for a metal **Y** that has a higher work function than **X**?

[1 mark]

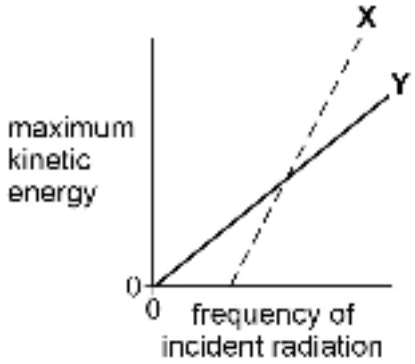
A



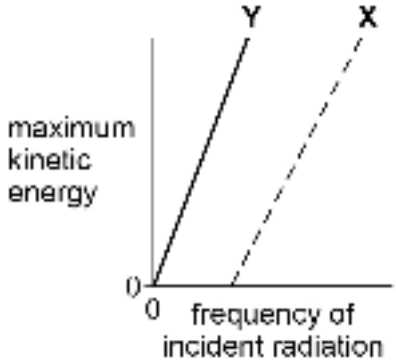
B



C



D



A ⬭

B ⬭

C ⬭

D ⬭

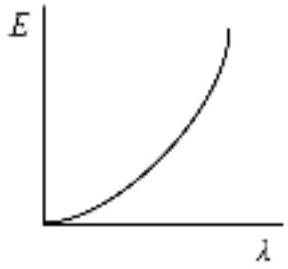
Turn over for the next question

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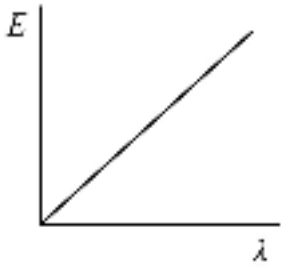
2 2 Which graph best shows the relationship between photon energy E and wavelength λ of a photon of electromagnetic radiation?

[1 mark]

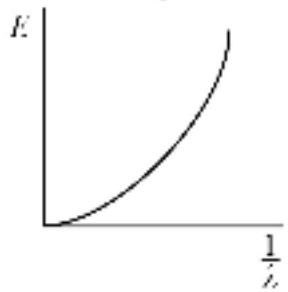
A



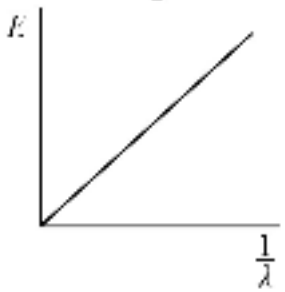
B



C



D



A ⬭

B ⬭

C ⬭

D ⬭

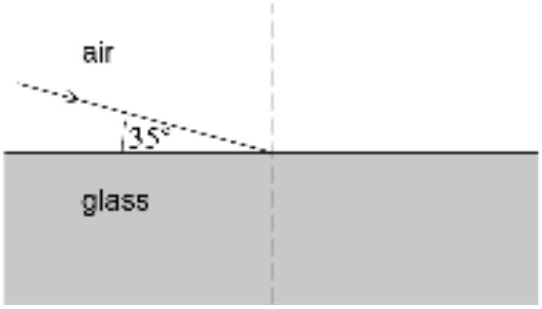
2 3 Which row shows the change in velocity, frequency and wavelength of an electromagnetic wave as it travels from an optically less dense to an optically more dense medium?

[1 mark]

	Velocity	**Frequency**	**Wavelength**	
A	decreases	decreases	unchanged	⬭
B	increases	unchanged	increases	⬭
C	decreases	unchanged	decreases	⬭
D	increases	increases	unchanged	⬭

Do not write outside the box

2 4 The diagram shows a ray of light travelling in air and incident on a glass block of refractive index 1.5



What is the angle of refraction in the glass?

[1 mark]

A 22.5° ⬭

B 23.3° ⬭

C 33.1° ⬭

D 59.4° ⬭

2 5 Intensity maxima are produced on a screen when a parallel beam of monochromatic light is incident on a diffraction grating. Light of a longer wavelength can be used or the distance from the diffraction grating to the screen can be increased.

Which row gives the change in appearance of the maxima when these changes are made independently?

[1 mark]

	Longer wavelength	**Distance from grating to screen increased**	
A	closer together	more widely spaced	⬭
B	more widely spaced	more widely spaced	⬭
C	more widely spaced	closer together	⬭
D	closer together	closer together	⬭

Do not write outside the box

2 6 What **cannot** be used as a unit for the Young modulus?

[1 mark]

A $\mathrm{N\ m^{-2}}$ ⬭

B Pa ⬭

C $\mathrm{kg\ m^{-2}\ s^{-2}}$ ⬭

D $\mathrm{kg\ m^{-1}\ s^{-2}}$ ⬭

2 7 Light of wavelength $500\ \mathrm{nm}$ is passed through a diffraction grating which has 400 lines per mm.

What is the angular separation between the two second-order maxima?

[1 mark]

A $11.5°$ ⬭

B $23.1°$ ⬭

C $23.6°$ ⬭

D $47.2°$ ⬭

2 8 Two identical balls, **X** and **Y**, are at the same height and a horizontal distance of $25\ \mathrm{cm}$ apart.

X is projected horizontally with a velocity of $0.10\ \mathrm{m\ s^{-1}}$ towards **Y** at the same time that **Y** is released from rest. Both **X** and **Y** move freely in the absence of air resistance.

What is the distance between the balls $1.0\ \mathrm{s}$ later?

[1 mark]

A $0.15\ \mathrm{m}$ ⬭

B $0.25\ \mathrm{m}$ ⬭

C $2.4\ \mathrm{m}$ ⬭

D $4.9\ \mathrm{m}$ ⬭

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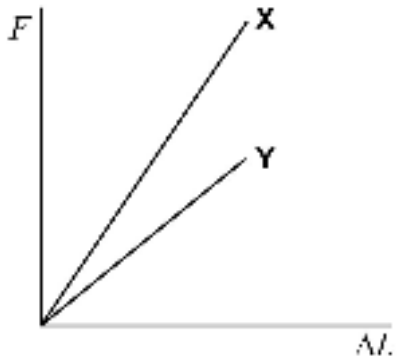
2 9 Two bodies of different masses undergo an elastic collision in the absence of any external force.

Which row gives the effect on the total kinetic energy of the masses and the magnitudes of the forces exerted on the masses during the collision?

[1 mark]

	Total kinetic energy	Magnitudes of forces	
A	remains unchanged	same on both masses	⬭
B	remains unchanged	greater on the smaller mass	⬭
C	decreases	same on both masses	⬭
D	decreases	greater on the smaller mass	⬭

3 0 Two separate wires **X** and **Y** have the same original length and cross-sectional area. The graph shows the extension ΔL produced in **X** and **Y** when the tensile force F applied to the wires is increased up to the point where they break.



Which statement is **incorrect**?

[1 mark]

A For a given extension more energy is stored in **X** than in **Y**. ⬭

B The Young modulus of the material of wire **Y** is greater than that of wire **X**. ⬭

C Both wire **X** and wire **Y** obey Hooke's law. ⬭

D Wire **X** has a greater breaking stress than wire **Y**. ⬭

Do not write outside the box

3 1 Which statement about superconductors is correct?

[1 mark]

A When a material becomes a superconductor, its resistivity is almost zero. ⬭

B The temperature at which a material becomes a superconductor is called the critical temperature. ⬭

C When current passes through a superconductor the pd across it becomes a maximum. ⬭

D Copper is a superconductor at room temperature. ⬭

3 2 A wire has a resistance R.

What is the resistance when both the length and radius of the wire are doubled?

[1 mark]

A $\frac{R}{4}$ ⬭

B $\frac{R}{2}$ ⬭

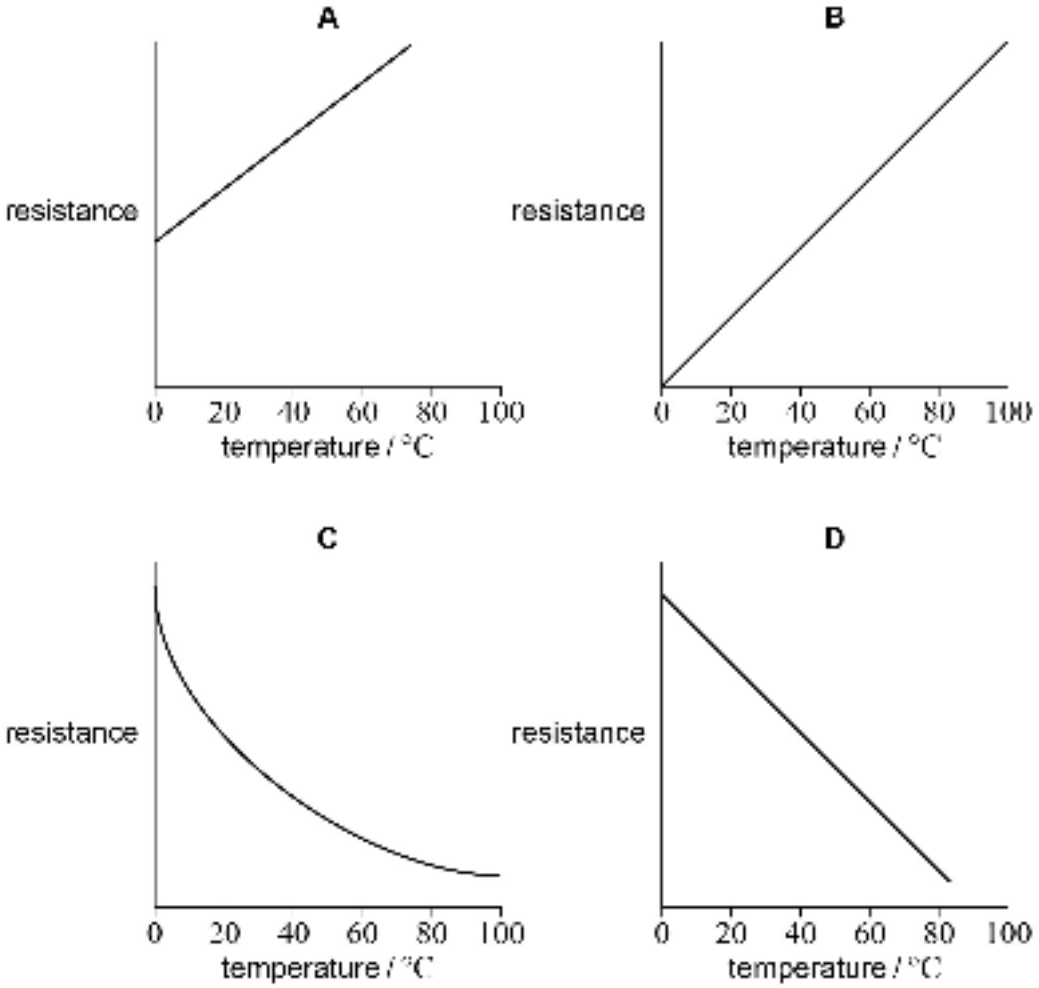
C $2R$ ⬭

D $4R$ ⬭

Do not write outside the box

3 3 Which graph shows the variation of the resistance with temperature for an ntc thermistor?

[1 mark]



A ⬭

B ⬭

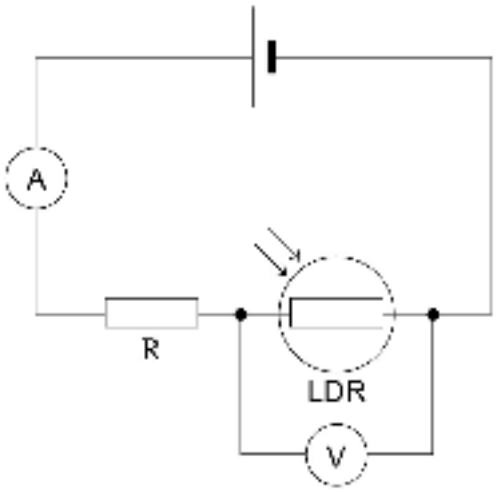
C ⬭

D ⬭

Turn over for the next question

Do not write outside the box

3 4 The figure shows a light dependent resistor (LDR) and fixed resistor R connected in series across a cell. The internal resistance of the cell is negligible.



Which row shows how the readings on the ammeter and the voltmeter change when the light intensity incident on the LDR is increased?

[1 mark]

	Ammeter reading	**Voltmeter reading**	
A	decreases	increases	⬭
B	decreases	decreases	⬭
C	increases	increases	⬭
D	increases	decreases	⬭

END OF QUESTIONS

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