AQA

SPECIMEN MATERIAL

AS
PHYSICS
(7407/2)

Paper 2

Specimen 2014 Morning Time allowed: 1 hour 30 minutes

Materials
For this paper you must have:
- a pencil
- a ruler
- a calculator
- a data and formulae booklet.

Instructions
- Answer **all** questions.
- Show all your working.

Information
- The maximum mark for this paper is 70.

Please write clearly, in block capitals, to allow character computer recognition.

Centre number Candidate number

Surname

Forename(s)

Candidate signature

Section A

Answer **all** questions in this section.

0 1 A student has a diffraction grating that is marked 3.5×10^3 lines per m.

0 1 . 1 Calculate the percentage uncertainty in the number of lines per metre suggested by this marking.

[1 mark]

percentage uncertainty = ____________________ %

0 1 . 2 Determine the grating spacing.

[2 marks]

grating spacing = ______________________ mm

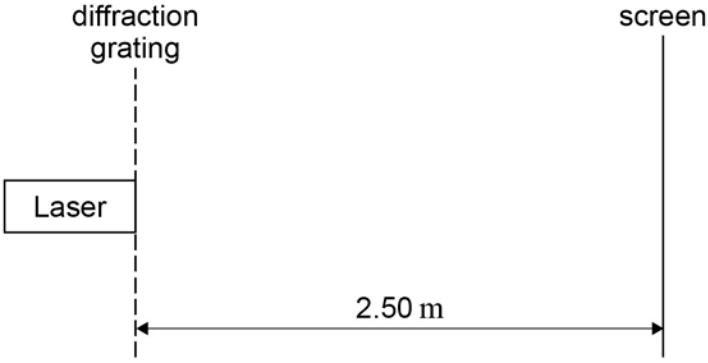
0 1 . 3 State the absolute uncertainty in the value of the spacing.

[1 mark]

absolute uncertainty = ___________________ mm

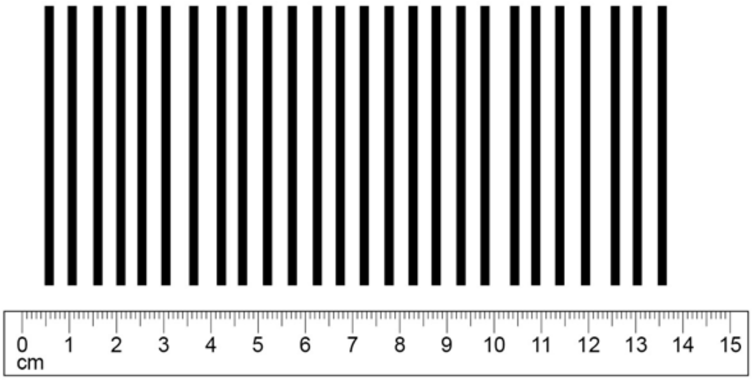
0 1 . 4 The student sets up the apparatus shown in **Figure 1** in an experiment to confirm the value marked on the diffraction grating.

Figure 1



The laser has a wavelength of 628 nm. **Figure 2** shows part of the interference pattern that appears on the screen. A ruler gives the scale.

Figure 2



Use **Figure 2** to determine the spacing between two adjacent maxima in the interference pattern. Show all your working clearly.

[1 mark]

spacing = ____________________ mm

0 1 . 5 Calculate the number of lines per metre on the grating.

[2 marks]

number of lines = ____________________

0 1 . 6 State and explain whether the value for the number of lines per m obtained in part 1.5 is in agreement with the value stated on the grating.

[2 marks]

____

____

____

0 1 . 7 State **one** safety precaution that you would take if you were to carry out the experiment that was performed by the student.

[1 mark]

____

____

____

0 2 **Data analysis question**

Capillary action can cause a liquid to rise up a hollow tube. **Figure 3** shows water that has risen to a height h in a narrow glass tube because of capillary action.

Figure 3

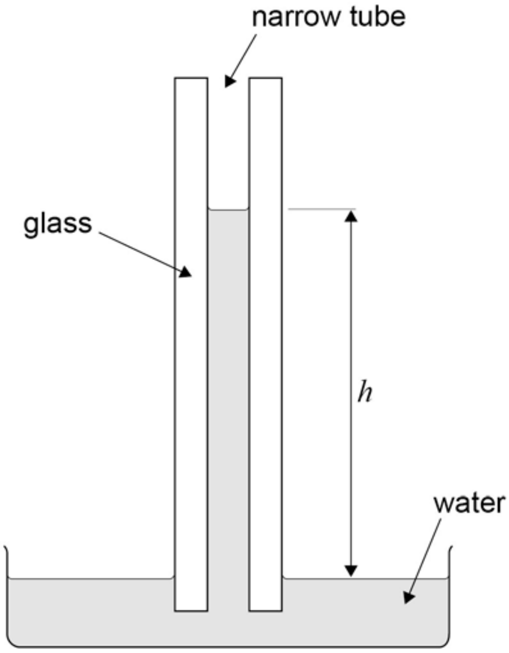
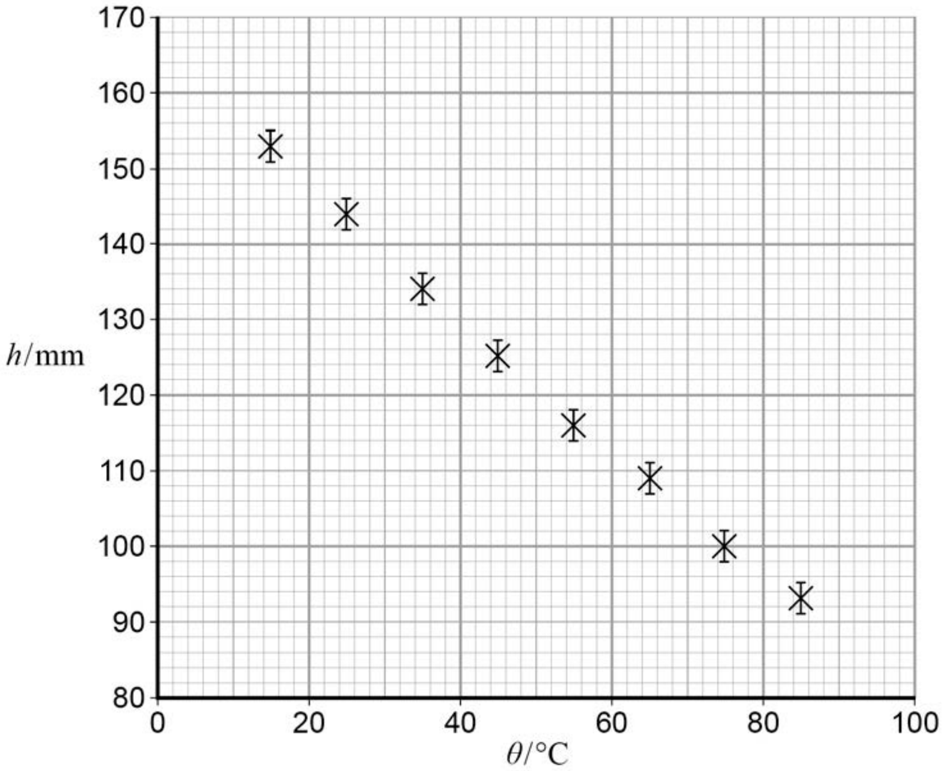


Figure 4 shows the variation of h with temperature θ for this particular tube.

Figure 4



The uncertainty in the measurement of h is shown by the error bars. Uncertainties in the measurements of temperature are negligible.

0 2 . 1 Draw a best-fit straight line for these data (**Figure 4**).

[1 mark]

0 2 . 2 It is suggested that the relationship between h and θ is

$$h = h_0 - (h_0 k)\theta$$

where h_0 and k are constants.
Determine h_0.

[1 mark]

h_0 = ____________________ mm

0 2 . 3 Show that the value of $h_0 k$ is about 0.9 $\mathrm{mm\,K^{-1}}$.

[3 marks]

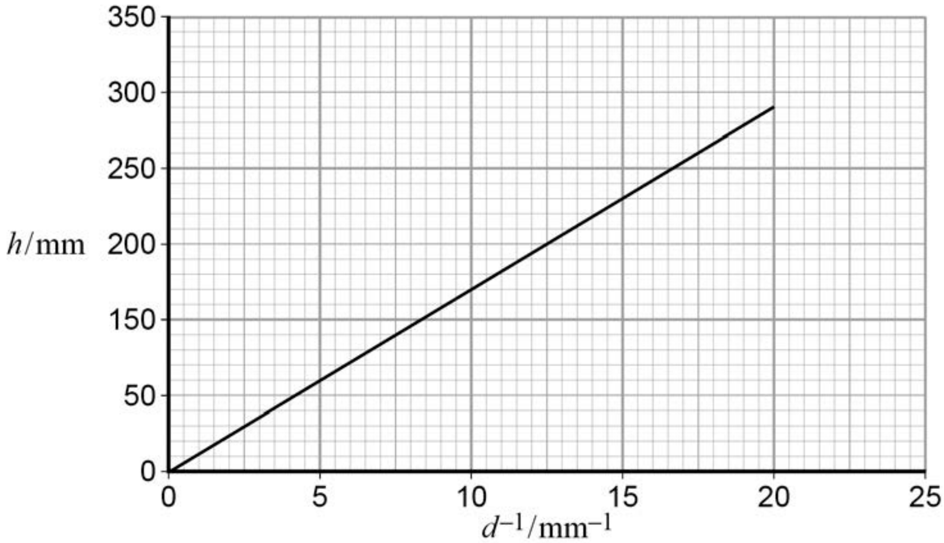
0 2 . 4 Determine k. State a unit for your answer.

[2 marks]

k = ________________________ unit ____________________

0 2 . 5 A similar experiment is carried out at constant temperature with tubes of varying internal diameter d. **Figure 5** shows the variation of h with $\frac{1}{d}$ at a constant temperature.

Figure 5



It is suggested that capillary action moves water from the roots of a tree to its leaves.

The gradient of **Figure 5** is 14.5 mm^2.

The distance from the roots to the top leaves of the tree is 8.0 m.

Calculate the internal diameter of the tubes required to move water from the roots to the top leaves by capillary action.

[2 marks]

0 2 . 6 Comment on the accuracy of your answer for the internal tube diameter in part 2.5.

[1 mark]

Section B

Answer **all** questions in this section.

These questions are about ultrasound

Read the passage and then answer questions 3.1 – 3.6

The term **ultrasound** refers to vibrations in a material that occur at frequencies too high to be detected by a human ear. When ultrasound waves move through a solid, both longitudinal and transverse vibrations may be involved. For the longitudinal vibrations in a solid, the speed c of the ultrasound wave is given by

$$c = \sqrt{\frac{E}{\rho}}$$

where E is the Young modulus of the material and ρ is the density. Values for c and ρ are given in **Table 1**.

Table 1

Substance	c / m s^{-1}	ρ / kg m^{-3}
glass	5100	2500
sea water	1400	1000

Ultrasound waves, like electromagnetic radiation, can travel through the surface between two materials. When all the energy is transmitted from one material to the other, the materials are said to be **acoustically matched**. This happens when ρc is the same for both materials.

0 3 . 1 Calculate the magnitude of the Young modulus for glass.

[1 mark]

Young modulus = ____________________

0 3 . 2 State your answer to 3.1 in terms of SI fundamental units.

[1 mark]

0 3 . 3 The passage states that 'when ultrasound waves move through a solid both longitudinal and transverse vibrations may be involved'.

State the difference between longitudinal and transverse waves.

[2 marks]

____

____

____

____

0 3 . 4 Show that when two materials are acoustically matched, the ratio of their Young moduli is equal to the ratio of their speeds of the ultrasound waves.

[2 marks]

0 3 . 5 The wave speed in a material X is twice that in material Y. X and Y are acoustically matched.

Determine the ratio of the densities of X and Y.

[1 mark]

X = ________________ Y = ________________

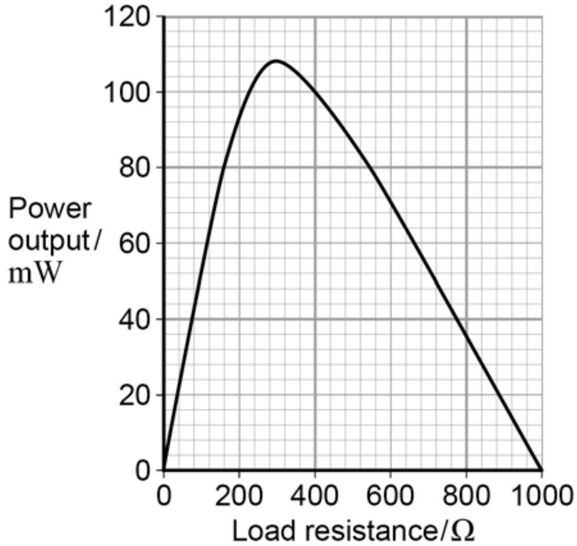
0 3 . 6 Ultrasound waves obey the same laws of reflection and refraction as electromagnetic waves.

Using data from **Table 1**, discuss the conditions for which total internal reflection can occur when ultrasound waves travel between glass and sea water.

[3 marks]

0 4 **Figure 6** shows data for the variation of the power output of a photovoltaic cell with load resistance. The data were obtained by placing the cell in sunlight. The intensity of the energy from the Sun incident on the surface of the cell was constant.

Figure 6



0 4 . 1 Use data from **Figure 6** to calculate the current in the load at the peak power.

[3 marks]

Question 4 continues on the next page

0 4 . 2 The intensity of the Sun's radiation incident on the cell is 730 $\mathrm{W\,m^{-2}}$. The active area of the cell has dimensions of 60 mm × 60 mm.

Calculate, at the peak power, the ratio $\frac{electrical\ energy\ delivered\ by\ the\ cell}{energy\ arriving\ at\ the\ cell\ from\ the\ Sun}$

[3 marks]

0 4 . 3 The average wavelength of the light incident on the cell is 500 nm. Estimate the number of photons incident on the active area of the cell every second.

[2 marks]

0 4 . 4 The measurements of the data in **Figure 6** were carried out when the rays from the sun were incident at 90° to the surface of the panel. A householder wants to generate electrical energy using a number of solar panels to produce a particular power output.

Identify **two** pieces of information scientists could provide to inform the production of a suitable system.

[2 marks]

END OF SECTION A

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.

0 5 In which of the following do both quantities have the same unit?

[1 mark]

A Electrical resistivity and electrical resistance.
B Work function Planck constant
C Pressure and the Young modulus.
D Acceleration and rate of change of momentum.

0 6 What are the numbers of hadrons, baryons and mesons in an atom of ${}^{7}_{3}\mathrm{Li}$?

[1 mark]

	hadrons	**baryons**	**mesons**	
A	7	3	3	
B	7	4	4	
C	7	7	0	
D	10	7	0	

0 7 Electron capture can be represented by the following equation.

$$p + e^- \rightarrow \mathrm{X} + \mathrm{Y}$$

Which row correctly identifies **X** and **Y**?

[1 mark]

	X	Y	
A	p	K^-	⬭
B	e^-	e^+	⬭
C	n	ν_e	⬭
D	n	π^0	⬭

0 8 A calcium ion is formed by removing two electrons from an atom of $^{40}_{20}\mathrm{Ca}$. What is the specific charge of the calcium ion?

[1 mark]

A 3.2×10^{-19} C kg^{-1} ⬭
B 2.9×10^{-18} C kg^{-1} ⬭
C 4.8×10^{6} C kg^{-1} ⬭
D 4.8×10^{7} C kg^{-1} ⬭

0 9 Electrons and protons in two beams are travelling at the same speed. The beams are diffracted by objects of the same size.
Which correctly compares the de Broglie wavelength λ_e of the electrons with the de Broglie wavelength λ_p of the protons and the width of the diffraction patterns that are produced by these beams?

[1 mark]

	comparison of de Broglie wavelength	diffraction pattern	
A	$\lambda_e > \lambda_p$	electron beam width > proton beam width	⬭
B	$\lambda_e < \lambda_p$	electron beam width > proton beam width	⬭
C	$\lambda_e > \lambda_p$	electron beam width < proton beam width	⬭
D	$\lambda_e < \lambda_p$	electron beam width < proton beam width	⬭

1 0 The intensity of a monochromatic light source is increased. Which of the following is correct?

[1 mark]

	Energy of an emitted photon	Number of photons emitted per second	
A	increases	increases	⬭
B	increases	unchanged	⬭
C	unchanged	increases	⬭
D	unchanged	unchanged	⬭

1 1 Which of the following is **not** true?

[1 mark]

A Each meson consists of a single quark and a single antiquark. ⬭

B Each baryon consists of three quarks. ⬭

C The magnitude of the charge on every quark is $\frac{1}{3}$. ⬭

D A particle consisting of a single quark has not been observed. ⬭

1 2 Two points on a progressive wave are one-eighth of a wavelength apart. The distance between them is 0.5 m, and the frequency of the oscillation is 10 Hz. What is the minimum speed of the wave?

[1 mark]

A 0.2 $\mathrm{m\ s^{-1}}$ ⬭

B 10 $\mathrm{m\ s^{-1}}$ ⬭

C 20 $\mathrm{m\ s^{-1}}$ ⬭

D 40 $\mathrm{m\ s^{-1}}$ ⬭

1 3 Which of the following waves **cannot** be polarised?

[1 mark]

A radio ⬭

B ultrasonic ⬭

C microwave ⬭

D ultraviolet ⬭

1 4 A diffraction pattern is formed by passing monochromatic light through a single slit. If the width of the single slit is reduced, which of the following is true?

[1 mark]

	Width of central maximum	Intensity of central maximum	
A	unchanged	decreases	○
B	increases	increases	○
C	increases	decreases	○
D	decreases	decreases	○

1 5 A light source emits light which is a mixture of two wavelength, λ_1 and λ_2. When the light is incident on a diffraction grating it is found that the fifth order of light of wavelength λ_1 occurs at the same angle as the fourth order for light of wavelength λ_2. If λ_1 is 480 nm what is λ_2?

[1 mark]

A 400 nm ○
B 480 nm ○
C 600 nm ○
D 750 nm ○

1 6 Which of the following is correct for a stationary wave?

[1 mark]

A Between two nodes the amplitude of the wave is constant. ○

B The two waves producing the stationary wave must always be 180° out of phase. ○

C The separation of the nodes for the second harmonic is double the separation of nodes for the first harmonic. ○

D Between two nodes all parts of the wave vibrate in phase. ○

1 7 Sound waves cross a boundary between two media X and Y. The frequency of the waves in X is 400 Hz. The speed of the waves in X is 330 $\mathrm{m\,s^{-1}}$ and the speed of the waves in Y is 1320 $\mathrm{m\,s^{-1}}$. What are the correct frequency and wavelength in Y?

[1 mark]

	Frequency / Hz	**Wavelength / m**	
A	100	0.82	⬭
B	400	0.82	⬭
C	400	3.3	⬭
D	1600	3.3	⬭

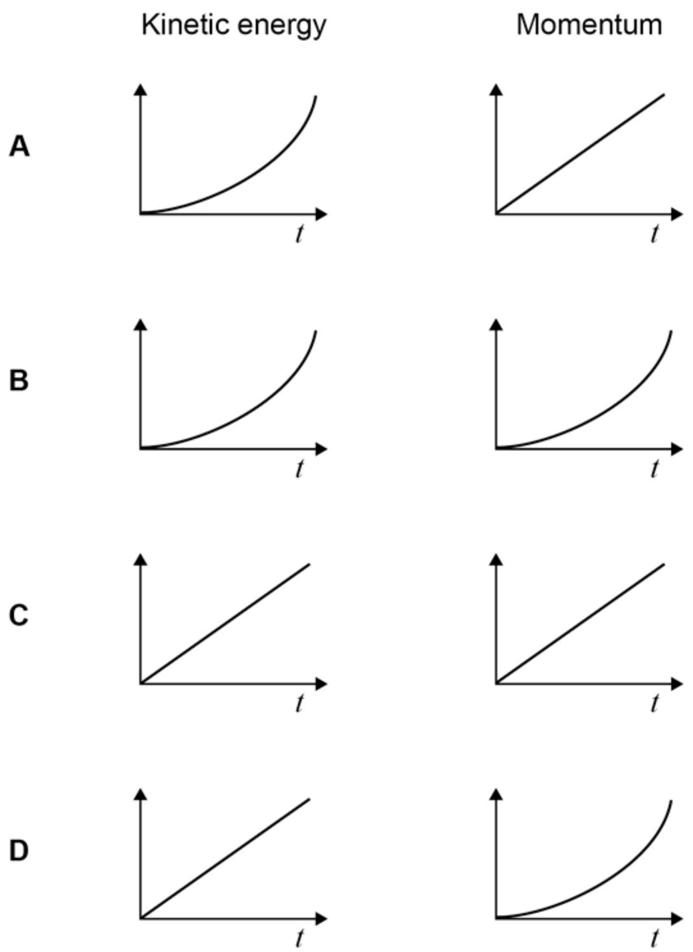
1 8 Which of the following is a scalar quantity?

[1 mark]

A velocity ⬭
B kinetic energy ⬭
C force ⬭
D momentum ⬭

1 9 A object is accelerated from rest by a constant force F for a time t. Which graphs represent the variation of time with the change in the kinetic energy and the change in momentum of the object?

[1 mark]



A ○
B ○
C ○
D ○

2 0 An object is dropped from a cliff. How far does the object fall in the third second? Assume that $g = 10\ \mathrm{m\ s^{-2}}$.

[1 mark]

A 10 m ○
B 20 m ○
C 25 m ○
D 45 m ○

2 1 A body falls freely, with negligible air resistance. What quantity of the body is its rate of change of momentum?

[1 mark]

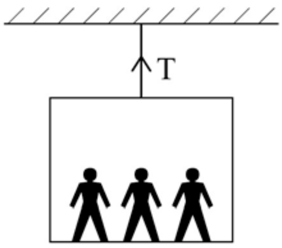
A mass
B power
C kinetic energy
D weight

2 2 A firework rocket is fired vertically into the air and explodes at its highest point. What are the changes to the total kinetic energy of the rocket and the total momentum of the rocket as a result of the explosion?

[1 mark]

	total kinetic energy of rocket	**total momentum of rocket**	
A	unchanged	unchanged	
B	unchanged	increased	
C	increased	unchanged	
D	increased	increased	

2 3 A lift and its passengers with a total mass of 500 kg accelerates upwards at $2\ \mathrm{m\ s^{-2}}$ as shown. Assume that $g = 10\ \mathrm{m\ s^{-2}}$.



What is the tension in the cable?

[1 mark]

A 1000 N
B 4000 N
C 5000 N
D 6000 N

2 4 Which of the following is **not** a unit of power?

[1 mark]

A $\mathrm{N\,m\,s^{-1}}$ ⬭

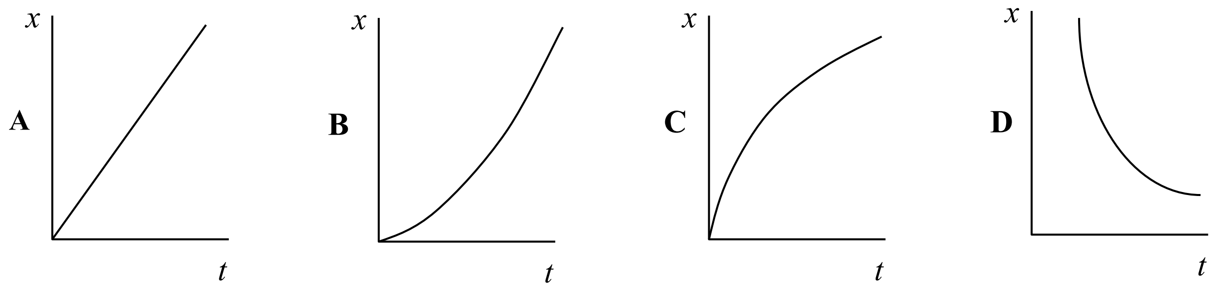
B $\mathrm{kg\,m^{2}\,s^{-3}}$ ⬭

C $\mathrm{J\,s^{-1}}$ ⬭

D $\mathrm{kg\,m^{-1}\,s^{-1}}$ ⬭

2 5 A car accelerates uniformly from rest along a straight road. Which graph shows the variation of displacement x of the car with time t?

[1 mark]



A ⬭

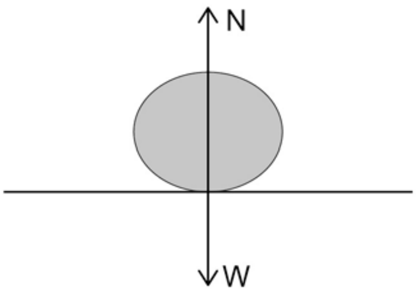
B ⬭

C ⬭

D ⬭

Turn over for the next question

2 6 The diagram shows the two forces, N and W, acting on a ball which is at rest on a table.

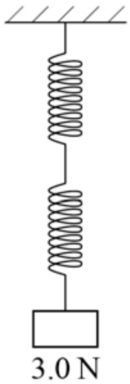


N and W are equal in magnitude. Which law indicates that N and W are equal in magnitude?

[1 mark]

A conservation of momentum ⬭
B Newton's first law ⬭
C conservation of energy ⬭
D Newton's third law ⬭

2 7 A load of 3.0 N is attached to a spring of negligible mass and spring constant 15 N m^{-1}.

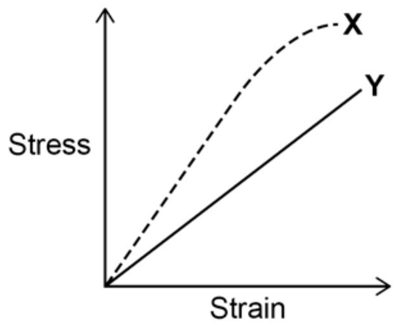


What is the energy stored in the spring?

[1 mark]

A 0.3 J ⬭
B 0.6 J ⬭
C 0.9 J ⬭
D 1.2 J ⬭

2 8 The diagram shows how the stress varies with strain for metal specimens X and Y which are different. Both specimens were stretched until they broke.



Which of the following is incorrect?

[1 mark]

A X is stiffer than Y

B X has a higher value of the Young modulus

C X is more brittle than Y

D Y has a lower maximum tensile stress than X

2 9 Three identical cells, each of internal resistance R, are connected in series with an external resistor of resistance R. The current in the external resistor is I. If one of the cells is reversed in the circuit, what is the new current in the external resistor?

[1 mark]

A $\frac{I}{3}$

B $\frac{4I}{9}$

C $\frac{I}{2}$

D $\frac{2I}{3}$

Turn over for the next question

3 0 In a cathode ray tube 7.5×10^{15} electrons strike the screen in 40 s. What current does this represent?
Charge of the electron is 1.6×10^{-19} C.

[1 mark]

A 1.3×10^{-16} A ○
B 5.3×10^{-15} A ○
C 3.0×10^{-5} A ○
D 1.2×10^{-3} A ○

3 1 A cylindrical conductor of length l, diameter D, and resistivity ρ has a resistance R.

What is the resistance of another cylindrical conductor of length l, diameter $\frac{D}{2}$, and resistivity ρ?

[1 mark]

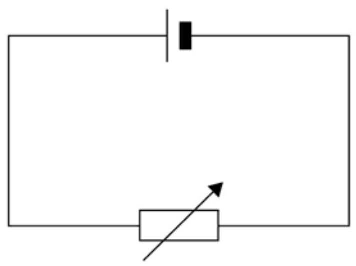
A $8R$ ○

B $4R$ ○

C $2R$ ○

D R ○

3 2 The cell in the circuit has an emf of 2.0 V. When the variable resistor has a resistance of 4.0 Ω, the potential difference (pd) across the terminals of the cell is 1.0 V.

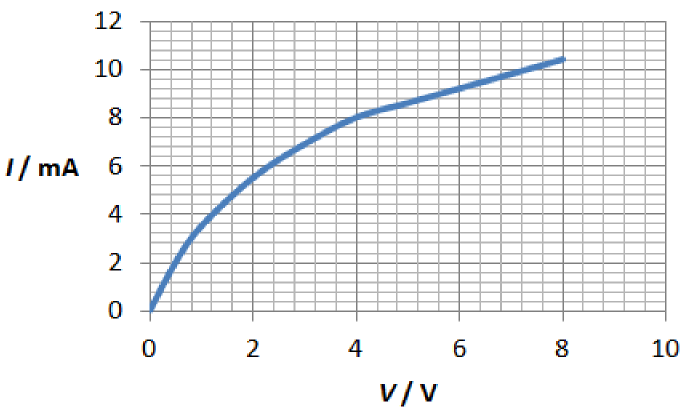


What is the pd across the terminals of the cell when the resistance of the variable resistor is 12 Ω?

[1 mark]

A 0.25 V ○
B 0.75 V ○
C 1.33 V ○
D 1.50 V ○

3 3 The graph shows the current–voltage (I–V) characteristics of a filament lamp.



What is the resistance of the filament when the potential difference (pd) across it is 4.0 V?

[1 mark]

A 500 Ω

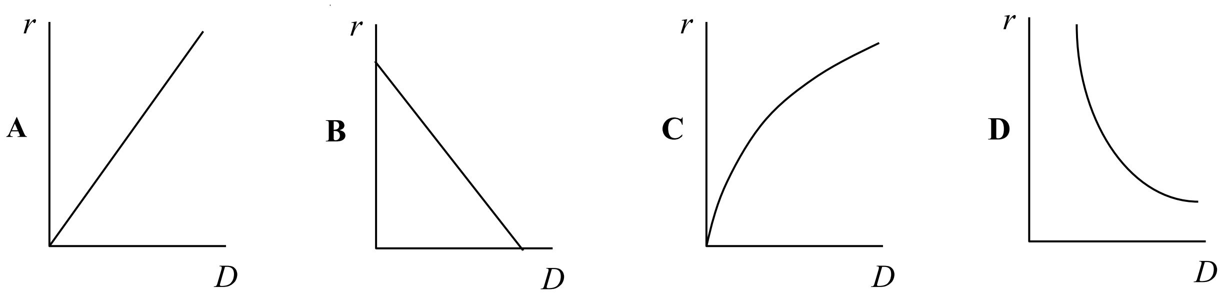
B 1700 Ω

C 2000 Ω

D 6000 Ω

3 4 Which graph shows how the resistance per unit length r of a wire varies with diameter D of the wire?

[1 mark]



A

B

C

D

END OF QUESTIONS

There are no questions printed on this page

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ANSWER IN THE SPACES PROVIDED