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OCR
Oxford Cambridge and RSA

AS Level Physics A
H156/01 Breadth in physics
Sample Question Paper

Date – Morning/Afternoon
Version 2.0

Time allowed: 1 hour 30 minutes

You must have:
• the Data, Formulae and Relationships Booklet

You may use:
• a scientific or graphical calculator

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First name	
Last name	StemUp Model Solution

Centre number						Candidate number				

INSTRUCTIONS
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Where appropriate, your answers should be supported with working. Marks may be given for a correct method even if the answer is incorrect.
- Write your answer to each question in the space provided.
- Additional paper may be used if required but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the bar codes.

INFORMATION
- The total mark for this paper is **70**.
- The marks for each question are shown in brackets **[ ]**.
- This document consists of **28** pages.

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SECTION A

You should spend a maximum of 25 minutes on this section.

Answer **all** the questions.

1 The table below shows the measurements recorded by a student for a solid metal sphere. The absolute uncertainties in the mass of the sphere and in its radius are also shown.

mass	100 ± 6 g
radius	1.60 ± 0.08 cm

What is the percentage uncertainty in the density of the sphere?

A 1%

B 11%

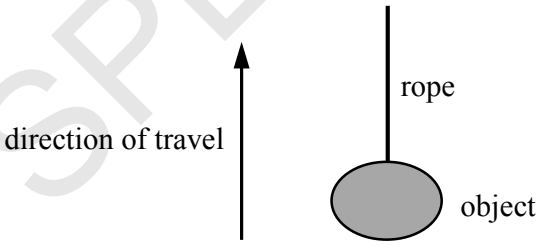
C 16%

D 21%

Your answer D

[1]

2 An object of mass 7.0 kg is pulled vertically upwards by a rope. The acceleration of the object is 2.0 m s^{-2}.



What is the tension in the rope?

A 14 N

B 55 N

C 69 N

D 83 N

Your answer D

[1]

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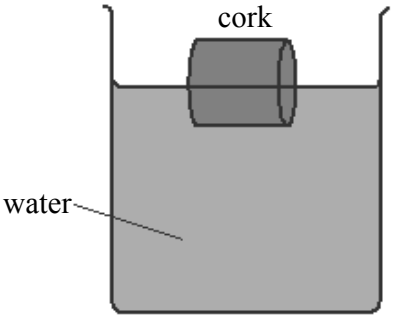
3 A bottle cork floats on water. It is partially submerged in the water.



Which of the following statements is/are true?

1 The net force acting on the cork is equal to the weight of the water displaced.

2 The weight of the cork is equal to the upthrust on the cork.

3 The upthrust on the cork is equal to the mass of the water displaced.

A 1, 2 and 3

B Only 2 and 3

C Only 3

D Only 2

Your answer D

[1]

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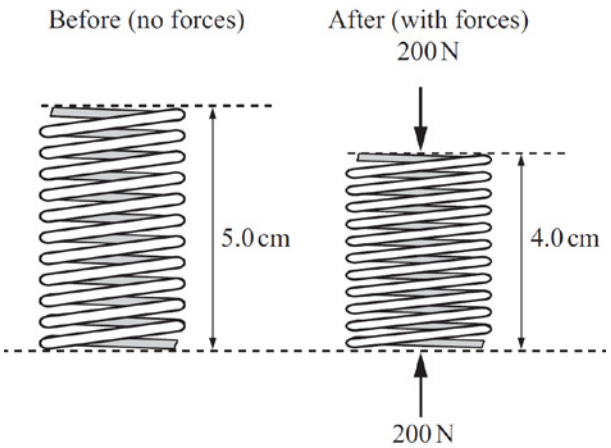
4 A compression spring is being tested in an engineering laboratory. The diagram shows the spring before and after the forces are applied to its opposite ends.



The initial length of the spring is 5.0 cm and during the application of the forces its length is 4.0 cm.

What is the force constant of this spring?

A 4.0×10^3 N m^{-1}

B 5.0×10^3 N m^{-1}

C 2.0×10^4 N m^{-1}

D 4.0×10^4 N m^{-1}

Your answer C

[1]

5 A balloon is travelling vertically downwards at a constant acceleration. The upthrust on the balloon is U, its weight is W and it experiences air resistance F.

Which statement is correct?

A $F + W > U$

B $W + U > F$

C $F > W + U$

D $W > U + F$

Your answer D

[1]

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6 A brick of mass m has sides of lengths a, b and c, where $a < b < c$. The brick is placed on a horizontal table such that the pressure it exerts on the table is a maximum.

What is the maximum pressure p acting on the table?

A $p = \frac{mg}{ab}$

B $p = \frac{mg}{ac}$

C $p = \frac{mg}{bc}$

D $p = \frac{mg}{abc}$

Your answer A

[1]

7 Two balls **X** and **Y** are dropped from a very tall building. Both balls reach terminal velocity before hitting the ground. The balls have the same diameter. The mass of **X** is greater than the mass of **Y**.

Which statement is correct?

A The balls hit the ground at the same time.

B The terminal velocity of **Y** is greater than that of **X**.

C The initial acceleration of both balls is the same.

D The balls have the same kinetic energy just before hitting the ground.

Your answer C

[1]

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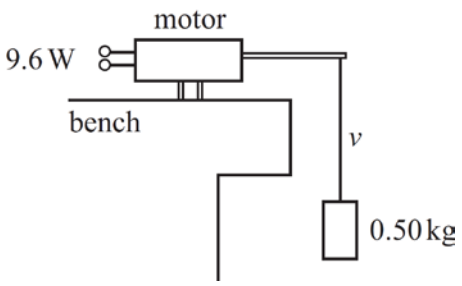
8 A small electric motor is 20% efficient. Its input power is 9.6 W when it is lifting a mass of 0.50 kg at a steady speed v.



What is the value of v?

A 0.39 m s^{-1}

B 2.0 m s^{-1}

C 2.8 m s^{-1}

D 3.8 m s^{-1}

Your answer A

[1]

9 A car accelerates uniformly from rest along a level road.
The effects of air resistance on the car are negligible.
The car travels 12 m in the second second of its journey.

How far does it travel in the fourth second?

A 28 m

B 35 m

C 48 m

D 64 m

Your answer A

[1]

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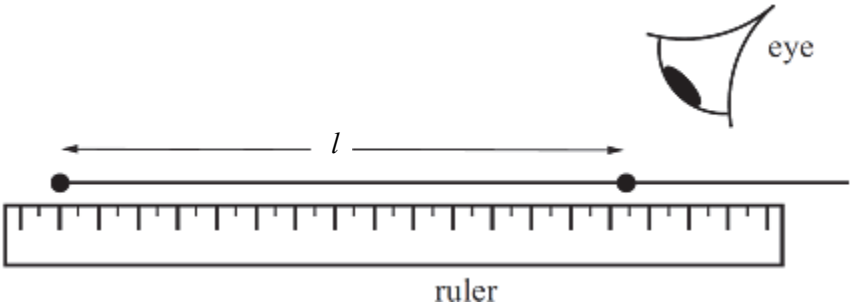
10 A metre rule is being used to measure the length l of a section of wire. The end of the ruler is displaced from the start of the wire.



What is the nature of the errors associated with the length measurement?

A There are random errors but no systematic errors.

B There are systematic errors but no random errors.

C There are both systematic and random errors.

D There is no overall error because the random and systematic errors cancel out.

Your answer C

[1]

11 Which of the following statements is/are true about photons?

1 The speed of a photon changes at the boundary between air and glass.

2 Photons are electrically neutral.

3 The energy of a photon depends only on its wavelength.

A 1, 2 and 3 are correct

B Only 1 and 2 are correct

C Only 2 and 3 are correct

D Only 1 is correct

Your answer A

[1]

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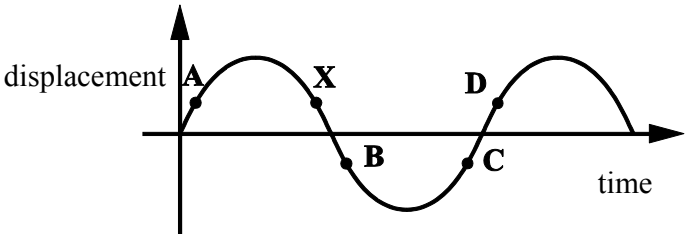
12 The diagram below shows the displacement-time graph of a particle as a progressive wave travels through a medium.

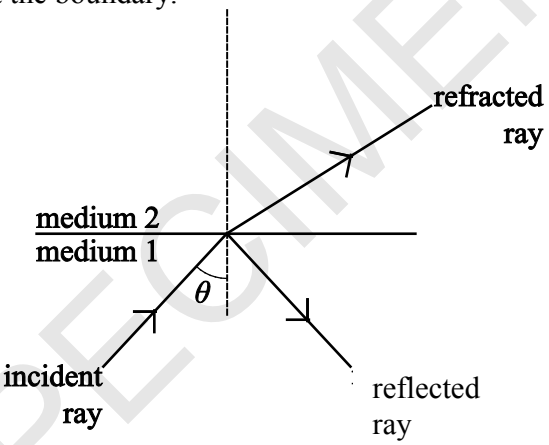


Which point **A**, **B**, **C**, or **D** has a phase difference of 180° with reference to point **X**?

Your answer C

[1]

13 A ray of monochromatic light is incident at a boundary between medium 1 and medium 2. The ray is both refracted and reflected at the boundary.



Which of the following statements is/are true?

1 The refracted light and incident light have the same wavelength.

2 The speed of light in medium 2 is greater than the speed of light in medium 1.

3 The angle θ is the critical angle.

A 1, 2 and 3

B Only 1 and 2

C Only 1

D Only 2

Your answer D

[1]

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14 A resistor is connected across a power supply.

Which statement is correct about the conduction electrons in this resistor?

A They travel at the speed of light between collisions with ions.

B They make random collisions with vibrating electrons.

C They travel at their mean drift velocity between collisions.

D They drift towards the positive end of the power supply.

Your answer D

[1]

15 A filament lamp is described as being 120 V, 60 W. The lamp is connected to a supply so that it lights normally.

Which statement is correct?

A The charge passing through the filament in one second is 2.0 coulomb.

B The lamp transfers 60 joule for each coulomb passing through the filament.

C The lamp transfers 120 joule in 2.0 second.

D The supply provides 60 joule to the lamp when the current is 2.0 ampere.

Your answer C

[1]

16 A battery of e.m.f. of 8.0 V and internal resistance 2.5 Ω is connected to an external resistor. The current in the resistor is 350 mA.

What is the power dissipated in the external resistor?

A 1.9 W

B 2.5 W

C 2.8 W

D 3.1 W

Your answer B

[1]

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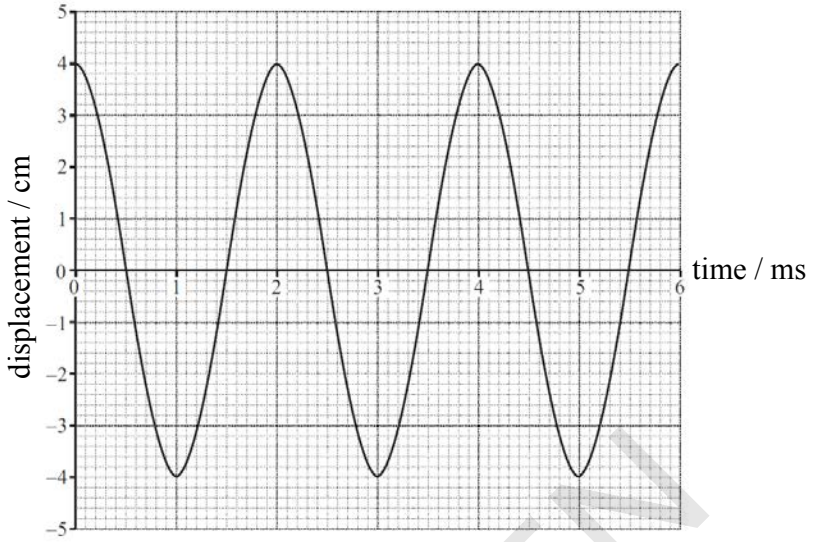
17 The diagram below shows the displacement-time graph of an air particle as a sound wave passes.



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

What is the wavelength of the sound wave?

A 0.68 m

B 1.7 m

C 170 m

D 680 m

Your answer A

[1]

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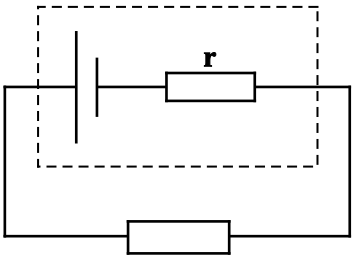
18 The diagram below shows a cell with an internal resistance connected to an external resistor.



Which of the following will increase the terminal p.d?

1 Increasing the e.m.f. of the cell.

2 Increasing the value of the external resistance.

3 Increasing the value of the internal resistance.

A 1, 2 and 3

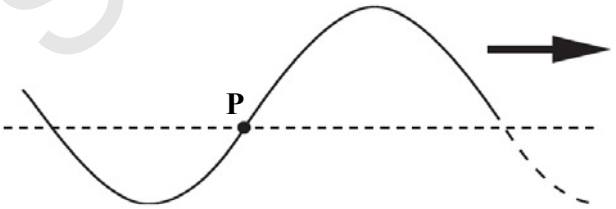
B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer B **[1]**

19 The figure shows part of a transverse progressive wave which is travelling to the right along a string. The horizontal dotted line shows the position of the string when there is no wave present. In which direction is the string at the point **P** moving at the instant shown?



A upwards

B downwards

C to the right

D it is at rest

Your answer B **[1]**

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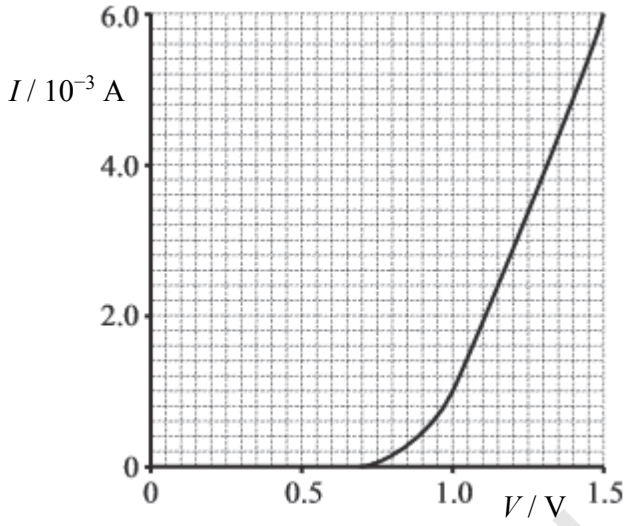
20 The graph shows the *I-V* characteristic of a semiconductor diode.



Which statement about the resistance of the diode can be deduced from the characteristic?

A It is zero between 0 V and 0.70 V.

B It is constant between 1.0 V and 1.5 V.

C It is 0.4 Ω at 1.2 V.

D It decreases between 0.70 V and 1.0 V.

Your answer D

[1]

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Section B begins on page 14

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SECTION B

Answer **all** the questions

21 **(a)** State what is meant by a *vector quantity* and give one example.

A vector quantity has both magnitude and direction, e.g. velocity.

[1]

(b) **Fig. 21.1** shows a toy locomotive on a circular track of radius 0.60 m.

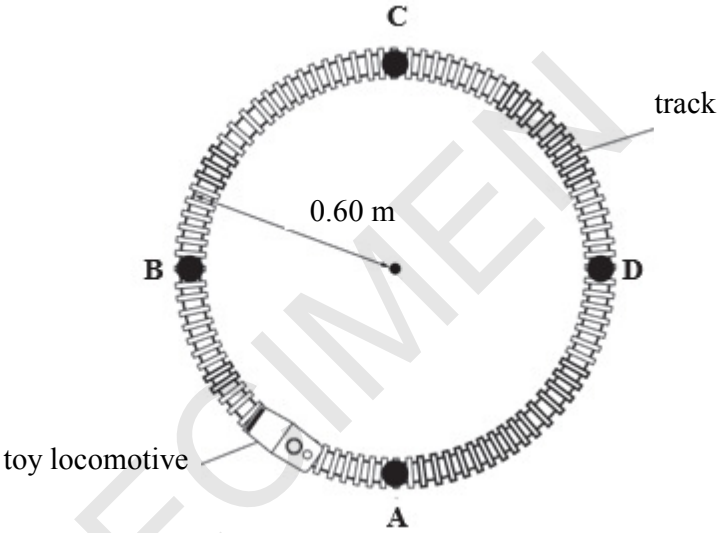

Fig. 21.1

At time $t = 0$, the locomotive is at point **A**. The locomotive travels at a constant speed round the track. It takes 20 s to travel completely round the track.

(i) Calculate the speed of the locomotive.

circumference = $2\pi r = 2\pi \times 0.60 = 3.77$ m

speed = distance / time = $2\pi \times 0.60 / 20$

speed = 0.188 m s^{-1}

speed = 0.19 m s^{-1} **[2]**

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(ii) **Fig. 21.2** shows the variation of the magnitude of the displacement *s* of the locomotive from **A** with time *t*.

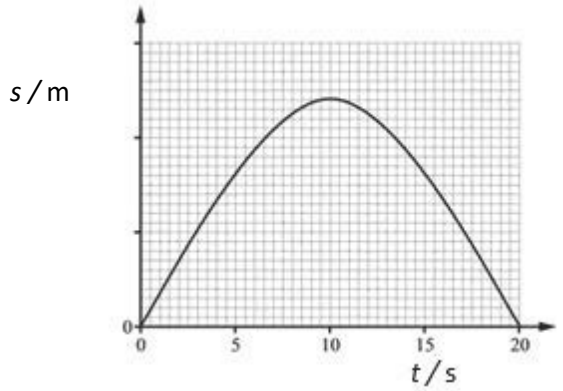

Fig. 21.2

Explain the graph shown in **Fig. 21.2**

s is the direct distance from A, so the graph is symmetrical about t = 10 s. At t = 10 s it is at C, 1.2 m from A (maximum s); at t = 20 s it is back at A (s = 0). **[2]**

(c) An object is placed on a smooth horizontal surface. Two horizontal forces act on this object. **Fig. 21.3** shows the magnitudes and the directions of these two forces.

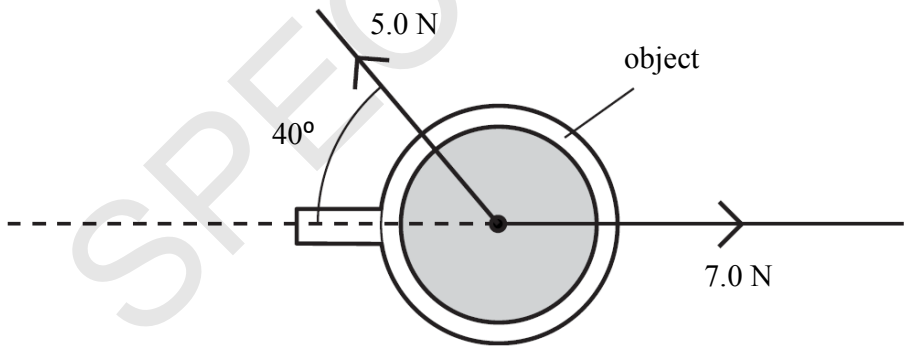

Fig. 21.3

The mass of the object is 320 g.

Calculate the magnitude of the acceleration of the object.

resultant force $F^2 = 7.0^2 + 5.0^2 - 2 \times 7.0 \times 5.0 \times \cos 40°$

$F^2 = 74 - 53.6 = 20.4$, so $F = 4.51$ N

$a = F / m = 4.51 / 0.320$

$a = 14.1$ m s^{-2}

acceleration = 14 m s^{-2} **[3]**

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22 **(a)** **Fig. 22.1** shows a graph of velocity v against time t for a skydiver falling vertically through the air.

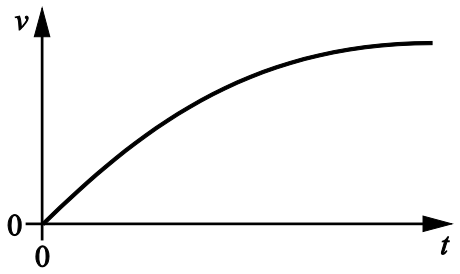

Fig. 22.1

State how you can use **Fig. 22.1** to determine the acceleration of the skydiver and describe how the acceleration varies with time.

The acceleration is equal to the gradient of the graph.

The gradient decreases, so the acceleration decreases as time increases (to zero at terminal velocity). **[2]**

(b) **Fig. 22.2** shows an arrangement used to investigate how the kinetic energy of a toy car varies with its distance d from the top of the ramp.

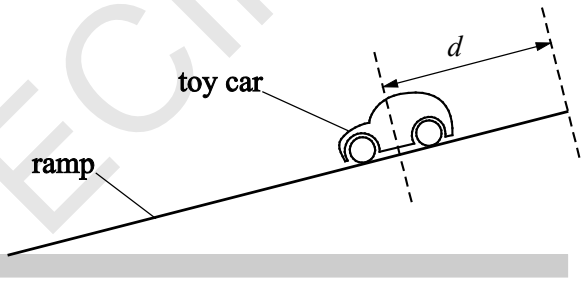

Fig. 22.2

Design a laboratory experiment to determine the kinetic energy of the car at one particular distance d from the top of the ramp.
In your description pay particular attention to

- how the apparatus is used
- what measurements are taken
- how the data is analysed.

Place a light gate at distance d from the top of the ramp, connected to a timer (or data-logger), and fix an interrupt card to the car.

Release the car from rest at the top of the ramp; the light gate records the time t taken for the card to pass through it.

Measure the length L of the card with a ruler; speed v = L / t.

Measure the mass m of the car using scales (top-pan balance).

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Kinetic energy = ½ × mass × speed^2 = ½mv^2. Repeat and average t.

[3]

(c) The toy car in **(b)** is released from rest from the top of the ramp. The two graphs in **Fig. 22.3** show the variation of the gravitational potential energy E_p of the toy car and its kinetic energy E_k with distance d from the top of the ramp.

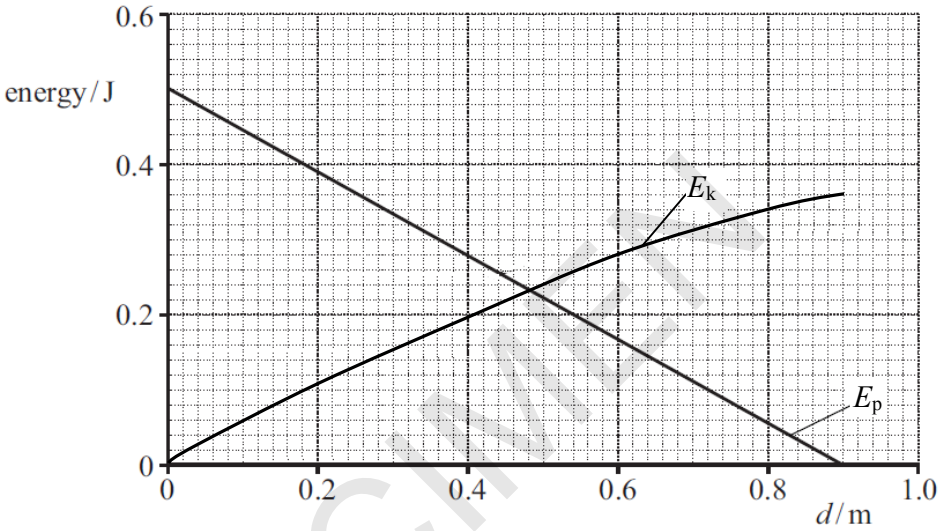

Fig. 22.3

The car travels a distance of 90 cm along the length of the ramp.

(i) The variation of E_p with d is linear.
State why the E_k against d graph is **not** linear.

There is friction, so GPE is transferred to KE and also to heat (thermal energy).

[1]

(ii) Use **Fig. 22.3** to determine the average resistive force acting on the toy car.

work done against friction = loss of GPE − gain of KE

work done = 0.50 − 0.36 = 0.14 J

F × 0.90 = 0.14, so F = 0.14 / 0.90 = 0.156 N

force = 0.16 N **[2]**

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23 The extension of a metal wire is x when the tension in the wire is F. The table in **Fig. 23.1** shows the results from an experiment, including the stress and the strain values.

F / N	x / 10^{-3} m	stress / 10^7 Pa	strain / 10^{-3}
1.9	0.4	1.73	0.20
4.0	0.8	3.50	0.40
5.9	1.2	5.21	0.60
8.0	1.6	7.00	0.80
9.0	1.8	7.95	0.90

Fig. 23.1

(a) Complete the table by determining the extension when the tension is 8.0 N. **[1]**

(b) **Fig. 23.2** shows a graph of stress against strain for the metal.

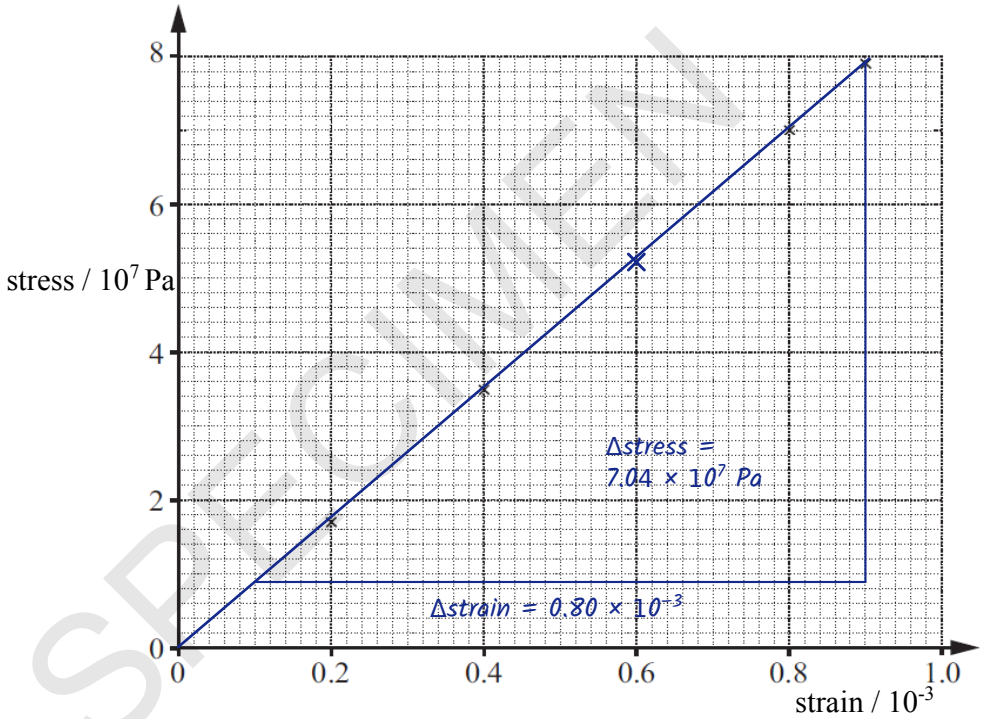

Fig. 23.2

(i) On **Fig. 23.2**, plot the data point corresponding to the tension of 5.9 N and draw the line of best fit through all the data points. **[1]**

(ii) Use **Fig. 23.2** to determine the Young modulus of the metal.

E = gradient = Δstress / Δstrain

$E = (7.92 - 0.88) \times 10^7 / (0.90 - 0.10) \times 10^{-3}$

$E = 7.04 \times 10^7 / 0.80 \times 10^{-3} = 8.8 \times 10^{10}$ Pa

Young modulus = 8.8×10^{10} Pa **[2]**

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(c) The micrometer screw gauge used to determine the diameter of the wire had a zero error. The diameter recorded by a student was larger than it should have been.

Discuss how the actual value of the Young modulus would differ from the value calculated in **(b)(ii)**.

The recorded diameter is too large, so the calculated cross-sectional area $A = \pi d^2/4$ is too large; the actual cross-sectional area is smaller.

Stress = F / A, so the actual stress values are larger than those plotted on the graph (the strain values are unaffected).

The gradient of the stress against strain graph would therefore be larger, hence the actual Young modulus of the metal is larger than the value calculated in (b)(ii).

[3]

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24 **(a)** A battery of negligible internal resistance is connected across two resistors of resistance values R and $2R$ as shown in **Fig. 24.1**.

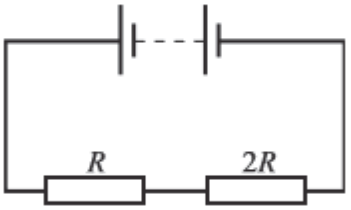

Fig. 24.1

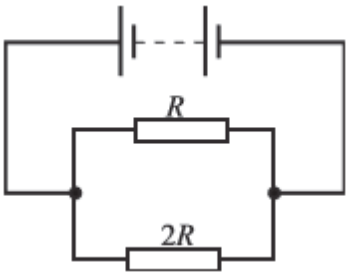

Fig. 24.2

The same battery is now connected to the same resistors as shown in **Fig. 24.2**.

Calculate the ratio

$$\frac{\text{current from battery in circuit of Fig. 24.1}}{\text{current from battery in circuit of Fig. 24.2}}.$$

Fig. 24.1: total resistance = R + 2R = 3R, so I_1 = V / 3R

Fig. 24.2: $1/R_T = 1/R + 1/2R$, so $R_T = 2R/3$, I_2 = 3V / 2R

ratio = (V / 3R) ÷ (3V / 2R) = 2/9

ratio = 0.22 **[3]**

(b) A student conducts an experiment using two identical filament lamps and a variable power supply of negligible internal resistance. The lamps are connected in series to the supply. The current in the circuit is 0.030 A and the lamps are dimly lit.

The e.m.f. of the power supply is then doubled and the experiment repeated.
The student expected the current to double, but the current only increased to 0.040 A. The lamps are brightly lit.

Use your knowledge of physics to explain these observations.

The current is not proportional to the p.d.: filament lamps are non-ohmic components.

Resistance = V/0.030 at first and 2V/0.040 after, so the total resistance of the lamps increases by a factor of 1.5.

The larger current heats the filaments (brightly lit); the resistance of each lamp increases with temperature as ions vibrate more. **[3]**

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(c) A researcher connects the circuit as shown in **Fig. 24.3** to determine the resistivity of a new metal designed from waste metals.

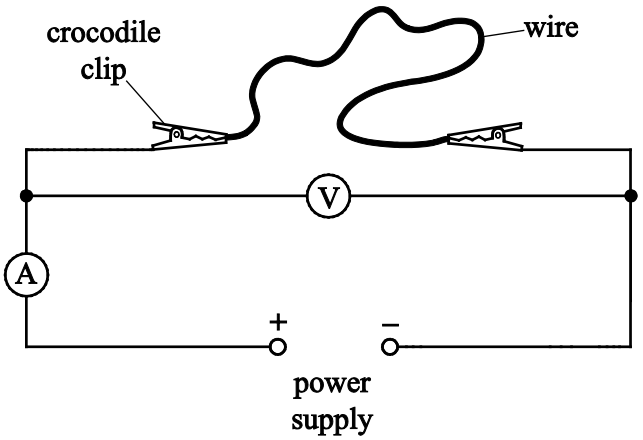

Fig. 24.3

The wire has length 0.75 m and cross-sectional area 1.3×10^{-7} m^2. The ammeter reading is 0.026 A and the voltmeter reading is 1.80 V.

(i) Calculate the resistivity of the metal.

$R = V / I = 1.80 / 0.026 = 69.2\ \Omega$

$\rho = RA / L = 69.2 \times 1.3 \times 10^{-7} / 0.75$

$\rho = 1.20 \times 10^{-5}\ \Omega\ m$

resistivity = 1.2×10^{-5} Ω m **[2]**

(ii) The resistivity of the metal in **(c)(i)** is larger than the value predicted by the researcher.

Explain **one** possible limitation of the experiment.

There is contact resistance at the crocodile clips,

hence the measured resistance in the circuit is greater than the

resistance of the wire alone, so the calculated resistivity is too large.

..... **[2]**

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25 **(a)** State what is meant by *coherent waves*.

Coherent waves have a constant phase difference (and the same frequency).

[1]

(b) Two transverse waves **P** and **Q** can pass through a point **X**. **Fig.25.1** shows the displacement-time graphs of a particle at point **X** for each wave independently.

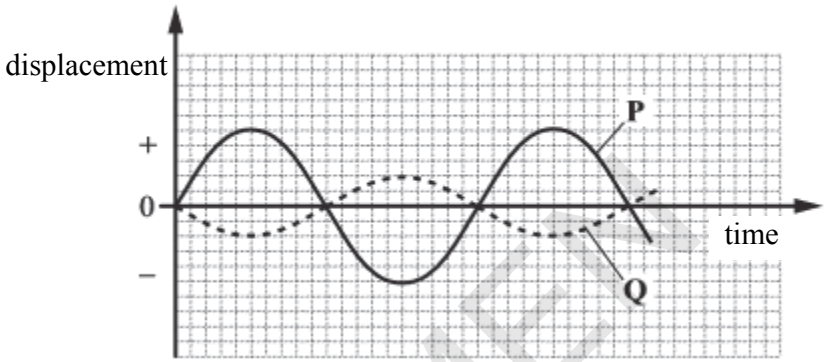

Fig. 25.1

State, with a reason, the motion of the particle at point **X** when both waves are present.

Destructive interference occurs as P and Q are in antiphase (180°). The net amplitude is non-zero as P has a larger amplitude than Q, so X oscillates with a small amplitude.

[2]

(c) A laser **A** is placed close to two slits as shown in **Fig. 25.2**.

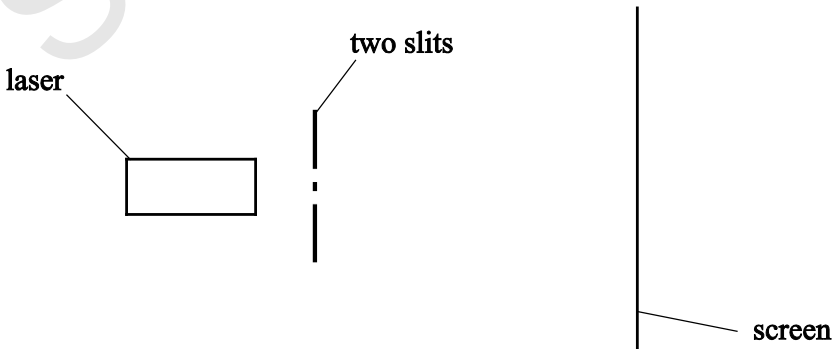

Fig. 25.2

The laser emits monochromatic light. Bright and dark fringes are observed on a screen.

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(i) Explain why bright and dark fringes are observed on the screen.

Bright fringes are due to constructive interference and dark fringes are due to destructive interference of light from the two slits.

At a bright fringe the path difference is $n\lambda$ (phase difference 0°).

At a dark fringe the path difference is $(n + ½)\lambda$ (phase difference 180°).

..... **[3]**

(ii) The laser **A** is replaced with another laser **B**. Laser **B** emits light of a different colour with a much greater intensity.

The fringe patterns observed on the screen with these two lasers are shown in **Fig. 25.3**.

Fig. 25.3 (drawn to scale)

According to a student, laser **B** produces a more spread out fringe pattern because the intensity of its light is much greater than that of laser **A**.

This suggestion is incorrect. Give the correct explanation.

Laser A emits light of shorter wavelength. Since $x = \lambda D/a$, the separation between adjacent fringes is smaller for A.

..... **[1]**

(iii) State the effect on the pattern of light seen on the screen when one of the slits is blocked.

There is no interference of light from the two slits: the fringes disappear and there is only diffraction from a single slit.

..... **[1]**

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26 **(a)** Filament lamps are being replaced by LED lamps in many large organisations. LEDs are low-powered devices.

(i) Apart from cost, state one major advantage this can have on the environment.

Less energy is used from power stations, which produce less carbon dioxide emissions, so less environmental damage. **[1]**

(ii) A light-emitting diode emits photons of a specific wavelength. The intensity of the light emitted from the LED is doubled.
Explain the effect this has on the energy of a photon.

The energy of a photon depends only on its wavelength or frequency ($E = hc/\lambda$). Energy does not depend on intensity, therefore the energy of each photon is the same. **[2]**

(b) **Fig. 26.1** shows part of the apparatus for an experiment in which electrons pass through a thin slice of graphite (carbon atoms) and emerge to produce concentric rings on a fluorescent screen.

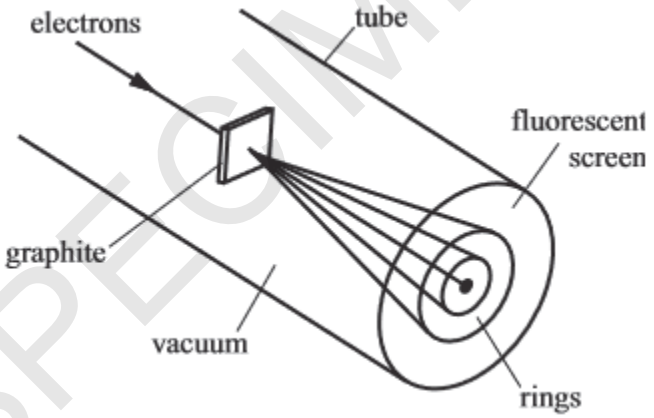

Fig. 26.1

(i) Explain how this experiment demonstrates the wave-nature of electrons.

The electrons behave (travel) as waves.

The rings show that the electrons are diffracted by the spacing between the carbon atoms in the graphite.

This happens because the de Broglie wavelength of the electrons is comparable to the spacing between carbon atoms. **[3]**

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(ii) The beam of electrons in the apparatus shown in **Fig. 26.1** is produced by accelerating electrons through a potential difference of 1200 V.

Show that the de Broglie wavelength of the electrons is 3.5×10^{-11} m.

$\frac{1}{2}mv^2 = eV$

$v^2 = 2 \times 1.60 \times 10^{-19} \times 1200 / 9.11 \times 10^{-31} = 4.22 \times 10^{14}$

$v = 2.05 \times 10^{7}\ m\ s^{-1}$

$\lambda = h / mv = 6.63 \times 10^{-34} / (9.11 \times 10^{-31} \times 2.05 \times 10^{7})$

$\lambda = 3.5 \times 10^{-11}\ m$

[2]

(iii) When de Broglie first put forward his idea it was new to the scientific community. Describe one way in which they could validate his ideas.

Publish the results to allow peer review, and share the procedure with other scientists so they can replicate the experiment.

[1]

END OF QUESTION PAPER

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