Oxford Cambridge and RSA

Tuesday 14 May 2019 – Morning

AS Level Physics B (Advancing Physics)

H157/01 Foundations of physics

Time allowed: 1 hour 30 minutes

You must have:
- the Data, Formulae and Relationships Booklet (sent with general stationery)

You may use:
- a scientific or graphical calculator
- a ruler (cm/mm)

Please write clearly in black ink. **Do not write in the barcodes.**

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

First name(s) _____

Last name _____

INSTRUCTIONS
- Use black ink. HB pencil may be used for graphs and diagrams.
- 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. If additional space is required, use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.

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 unit of electrical charge, the coulomb, C, can be expressed in base units as

A ampere per second, $A\,s^{-1}$

B ampere-second, A s

C ampere second-squared, $A\,s^{2}$

D second per ampere, $s\,A^{-1}$

Your answer ☐

[1]

2 Three identical resistors each of conductance G are connected in parallel.

The conductance of the combination is

A $3G$

B $\frac{3}{G}$

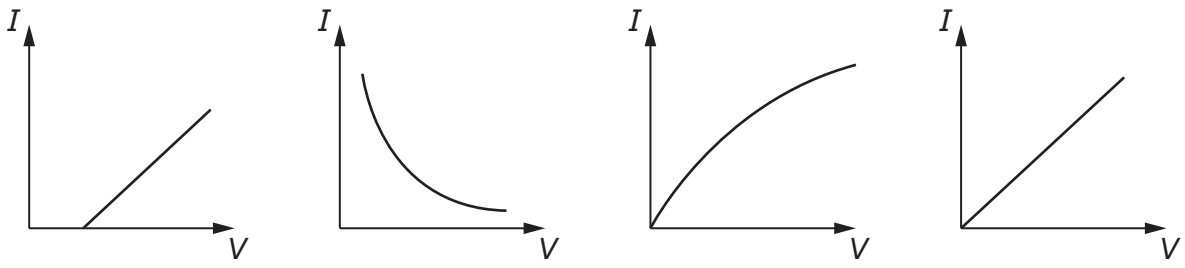
C G^3

D $\frac{G}{3}$

Your answer ☐

[1]

3 Which sketch graph shows how the current I in an ohmic resistor varies with the p.d. V across it?



A **B** **C** **D**

Your answer ☐

[1]

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4 A paintball is fired from a gun 1.8 m above the ground at a velocity of 75 m s^{-1} horizontally.

Ignore the effect of air resistance.

How long will the paintball take to hit the ground?

A 0.012 s

B 0.61 s

C 15 s

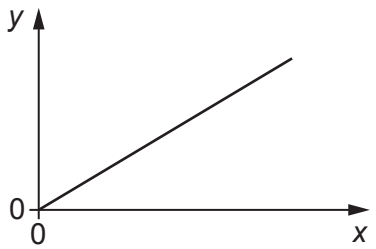
D 31 s

Your answer ☐

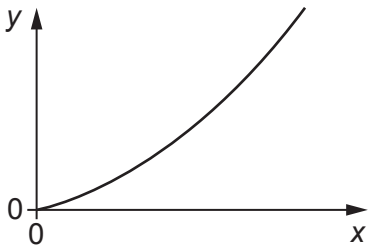
[1]

5 A large object falls vertically through the atmosphere. Write down the letter of the graph that would be obtained by plotting:

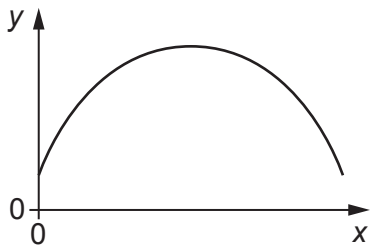
- velocity *v* of the object on the *y*-axis;
- distance *d* fallen on the *x*-axis.



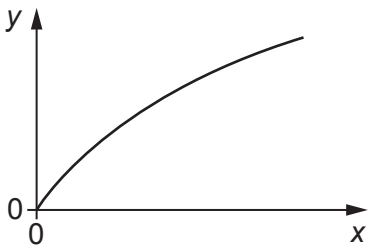
A



B



C



D

Your answer ☐

[1]

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6 A student measures the potential difference across a wire = 1.05 V (±0.01 V) and the current through the wire = 0.34 A (±0.01 A).

The percentage uncertainty in the resistance of the wire is

A 0.1%

B 2%

C 4%

D 8%

Your answer ☐

[1]

7 A ball of momentum *X* collides with an identical stationary ball.

All of the kinetic energy of the first ball is transferred to the second ball.

The change in momentum of the second ball is

A –2*X*

B –*X*

C *X*

D 2*X*

Your answer ☐

[1]

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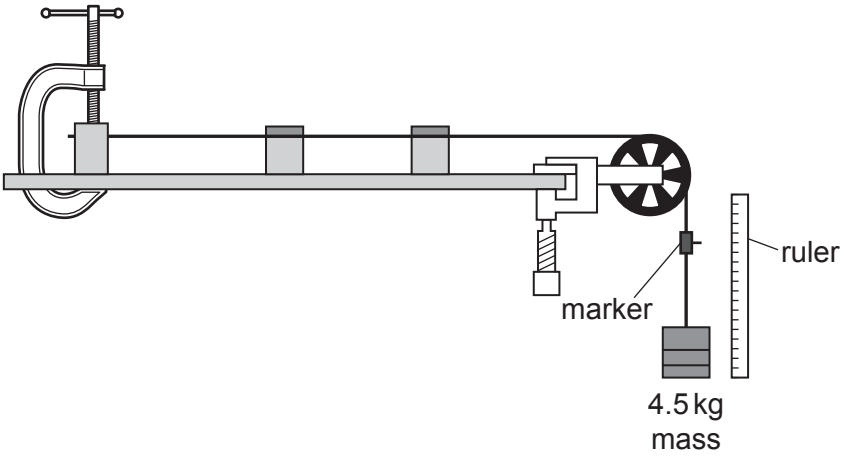
8 A wire of length 2.1 m is stretched using the apparatus shown.



A mass of 4.5 kg is attached to the end of the wire. The wire extends by 2.0 mm. The cross-sectional area of the wire is $7.5 \times 10^{-7}\,m^2$.

The Young modulus of the wire material is

A 56 kPa

B 5.6 GPa

C 6.2 GPa

D 62 GPa

Your answer ☐

[1]

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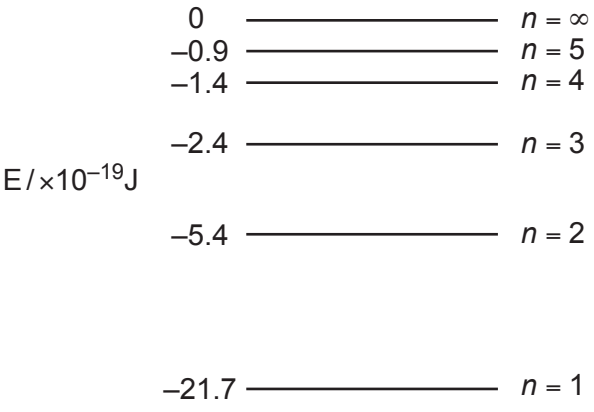
9 The diagram shows the energy levels in an atom.



An electron moves from $n = 3$ to $n = 2$. The frequency of the emitted light is

A 1.5×10^{14} Hz

B 4.1×10^{14} Hz

C 4.5×10^{14} Hz

D 2.5×10^{15} Hz

Your answer ☐

[1]

10 A sensor is made up of 32 × 32 pixels.

In one experiment:

– a source emits 4096 photons, all of which are detected by the sensor;

– the probability of arrival of a photon is the same for each pixel.

The expected number of photons detected in each pixel is

A 1

B 4

C 128

D 4096

Your answer ☐

[1]

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11 Ceramic materials are generally

A Hard and brittle

B Stiff and tough

C Strong and flexible

D Tough and hard

Your answer ☐

[1]

12 A source emits ultraviolet light of wavelength 200 nm.

The power emitted by the source is 100 mW.

The number of photons emitted by the source in 1 s is of order

A 10^{9}

B 10^{12}

C 10^{14}

D 10^{17}

Your answer ☐

[1]

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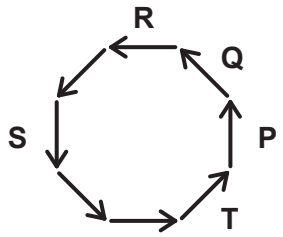
13 The diagram shows a number of phasors.



The two phasors with a phase difference of π radians are

A **P** and **R**

B **P** and **S**

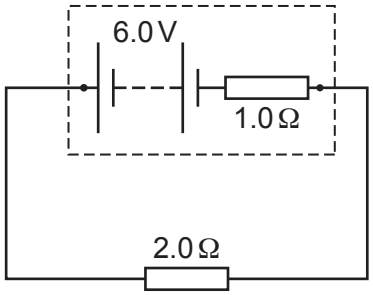
C **Q** and **T**

D **S** and **R**

Your answer ☐

[1]

14 In the circuit shown, the p.d. across the 2.0 Ω resistor is



A 2.0 V

B 3.0 V

C 4.0 V

D 6.0 V

Your answer ☐

[1]

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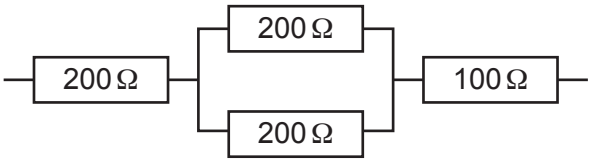
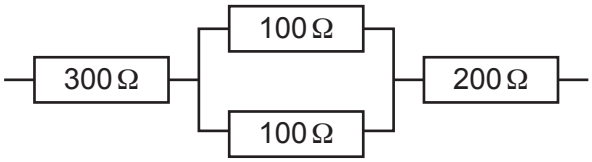
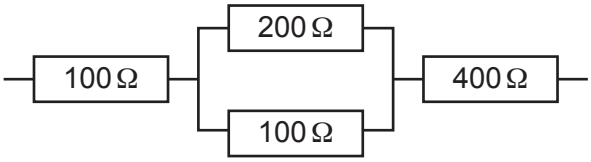
15 Which combination of resistors gives the **lowest** overall resistance?



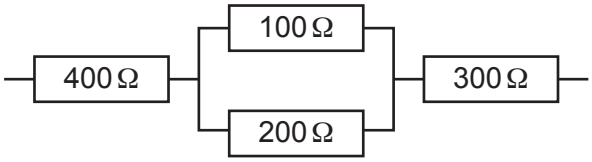
A



B



C



D

Your answer ☐

[1]

16 An unstretched spring is 20 cm long and has a spring constant of 25 N cm^{-1}.

It is stretched to 3 times its length and is still following Hooke's law.

The energy stored in the spring is

A 50 J

B 200 J

C 450 J

D 900 J

Your answer ☐

[1]

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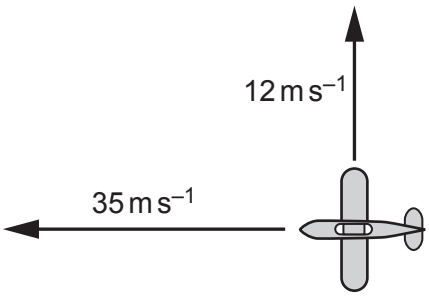
17 An aircraft is flying with a velocity of $35\,m\,s^{-1}$ westwards, relative to the air. A wind from the south pushes the aircraft northwards at a velocity of $12\,m\,s^{-1}$.



What is the magnitude of the resultant velocity of the aircraft, relative to the ground?

A $23\,m\,s^{-1}$

B $37\,m\,s^{-1}$

C $47\,m\,s^{-1}$

D $169\,m\,s^{-1}$

Your answer ☐

[1]

18 Two moving bodies, **X** and **Y**, collide and then move off together.

Mass of **X** = 3.0 kg Mass of **Y** = 4.0 kg

Speed of **X** = $3.0\,m\,s^{-1}$ Speed of **Y** = $2.0\,m\,s^{-1}$

What is the speed of the combined body after the collision?

A $0.14\,m\,s^{-1}$

B $1.5\,m\,s^{-1}$

C $2.4\,m\,s^{-1}$

D $5.0\,m\,s^{-1}$

Your answer ☐

[1]

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19 What is the de Broglie wavelength of an electron accelerated from rest through a p.d. of 0.90 kV?

A 4.1×10^{-11} m

B 5.8×10^{-11} m

C 1.4×10^{-9} m

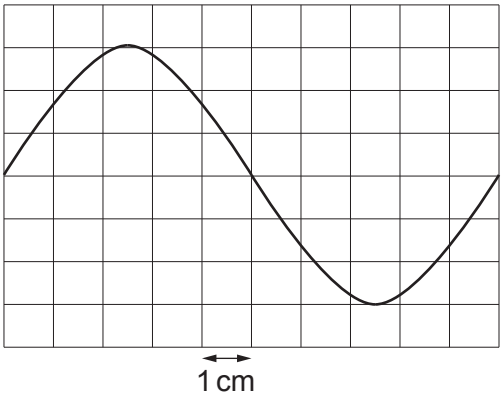
D 1.8×10^{-9} m

Your answer ☐

[1]

20 The diagram shows an oscilloscope trace of the p.d. from a signal generator.

The time base of the oscilloscope is set to 0.50 ms cm^{-1}.



What is the frequency of the signal shown?

A 0.2 Hz

B 5 Hz

C 200 Hz

D 2000 Hz

Your answer ☐

[1]

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SECTION B

Answer **all** the questions.

21 **Fig. 21** shows a model of current in a wire.

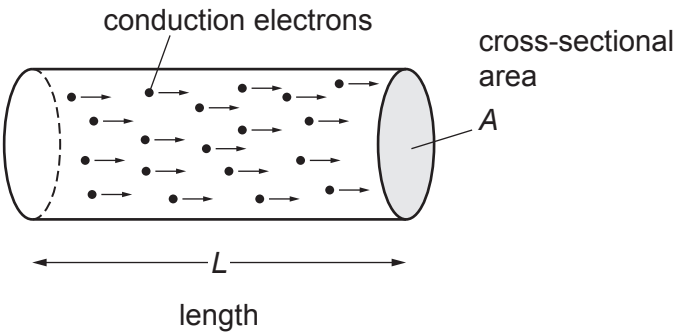

Fig. 21

n is the number density of charge carriers in the wire.

(a) What is the SI unit of charge?

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

(b) Show that the total charge, ΔQ, in the cylinder above is *nALe*, where *e* is the charge of an electron.

[2]

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(c) The current in a cylindrical wire is related to the number density of charge carriers (electrons) by the equation

$I = nAve$

where I is the current and v is the drift velocity of the electrons.

The drift velocity is the average speed of the electrons in the wire in the direction of the current.

The wire carries a current of 3.2 A.

Calculate the diameter of the wire.

Drift velocity of electrons in the wire is $0.50\,\text{mm}\,\text{s}^{-1}$.
Number density of electrons is $8.0 \times 10^{28}\,\text{m}^{-3}$.

diameter = ... m **[3]**

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22 **Fig. 22.1** shows the bottom end of some organ pipes.

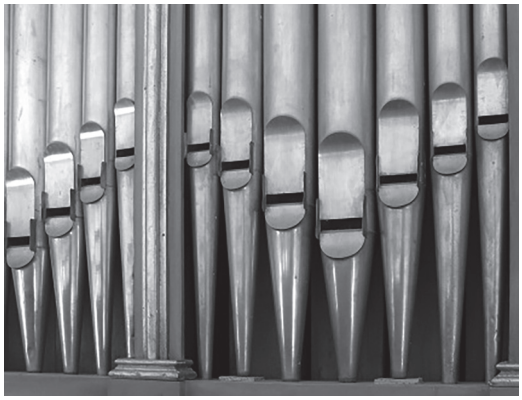

Fig. 22.1

Air is blown into the pipes from the bottom. The small opening causes the air inside to vibrate. The vibrations are reflected from the top of the pipe and form a standing wave.

Fig. 22.2 shows the pipe and the positions of the nodes (**N**) and antinodes (**A**).

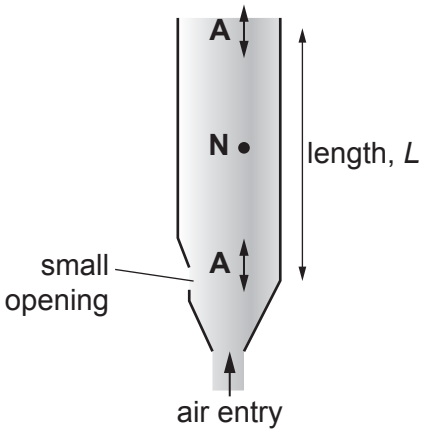

Fig. 22.2

L is the length of the vibrating air column in the pipe.

(a) What, in terms of *L*, is the wavelength of the standing wave shown in **Fig. 22.2**?

wavelength = ... **[1]**

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(b) An organ pipe like the one shown in **Fig. 22.2** has length L = 61 cm.

The speed of sound in air is 340 m s^{-1}.

Calculate the frequency of the vibration shown in **Fig. 22.2**.

Use an appropriate number of significant figures in your answer.

frequency = ... Hz **[3]**

(c) Some organ pipes are closed at the top. This causes the top end to be a node instead of an antinode.

Calculate the lowest frequency produced by a closed pipe with the same 61 cm length as in part **(b)**.

frequency = ... Hz **[2]**

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23 **Fig. 23** shows the motion of a dropped ball of mass 50 g bouncing on a hard surface.

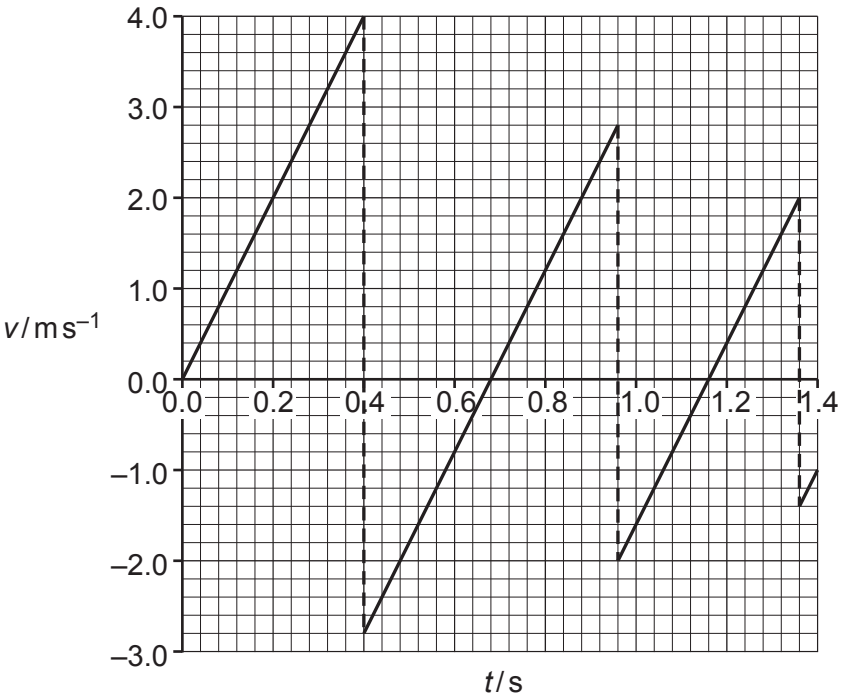

Fig. 23

The data for the graph were obtained by video capture.

(a) Explain one advantage of using video capture to collect these data.

.....

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

(b) Use the graph to show that the acceleration due to gravity is approximately $10\,m\,s^{-2}$.

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

(c) Calculate the kinetic energy of the ball just before it hits the surface for the first time.

kinetic energy = ... J **[3]**

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(d) Calculate the percentage change in kinetic energy of the ball on the bounce occurring at $t = 0.4$ s.

percentage change = ... % **[3]**

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SECTION C

Answer **all** the questions.

24 A student uses the equipment shown in **Fig. 24.1** to determine the refractive index of the glass used to make the glass block.

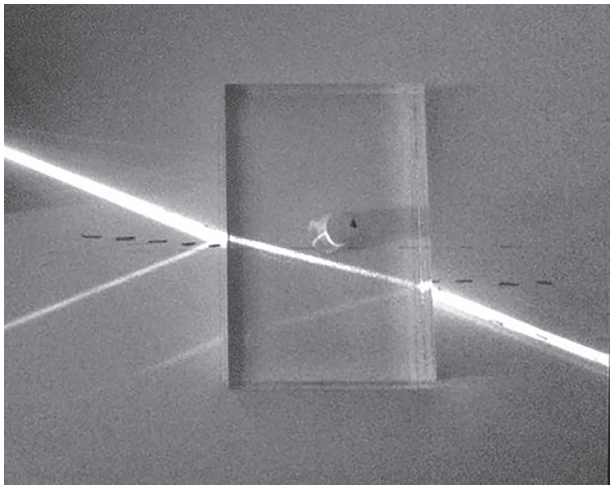

Fig. 24.1 equipment

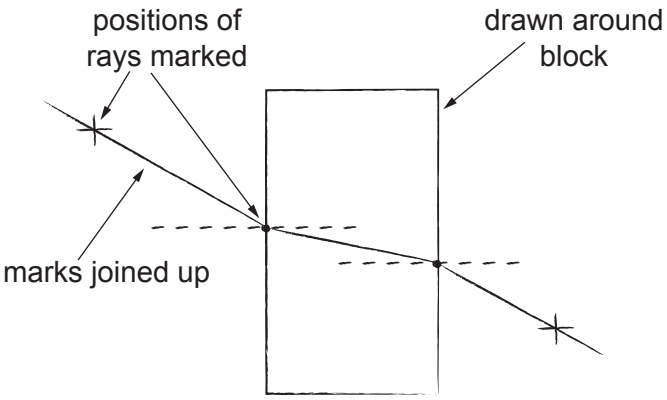

Fig. 24.2 student's marks on paper

The student measures two angles to determine the refractive index.

(a) Mark on **Fig. 24.2** two angles she can measure to determine the refractive index. **[2]**

(b) Suggest and explain one way to improve the accuracy of the angle data.

.....

.....

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

In a repeat of the experiment, the two angles are found to be 28° and 17°.

(c) Calculate the refractive index of the glass.

refractive index = ... **[2]**

(d) How does the refractive index of a material affect the properties of light passing through it?

.....

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

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25 A source of coherent light waves (a laser) is used to illuminate a single slit.

A diffraction pattern is formed on a screen a distance D = 2 m from the slit.

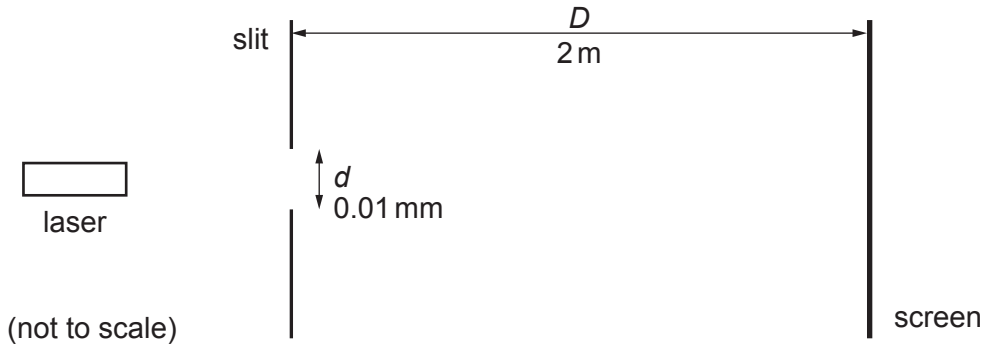

Fig. 25.1

(a) Explain the term **coherent**.

.....

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

The pattern observed on the screen is shown in **Fig. 25.2**.

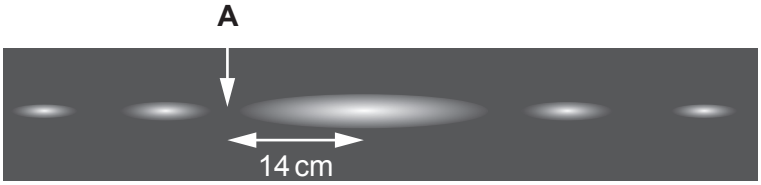

Fig. 25.2

The point labelled **A** is completely dark. **A** is at a distance of 14 cm from the centre of the pattern.

(b) Show using the small angle approximation that this is 0.07 radian from the centre line.

[2]

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A is completely dark.

(c) Explain why the path difference between two wavelets arriving at **A** from the top and bottom of the slit must be ½ λ.

.....

.....

.....

.....

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

The path difference between these two wavelets can also be calculated as ½ $d \sin \theta$, where d is the slit width and θ is the angle between **A** and the centre line.

(d) Calculate the wavelength, in nm, of the light used.

wavelength = ... nm **[2]**

The screen is moved further away from the slit and the distance from the centre of the pattern to **A** is measured again.

(e) Suggest one advantage and one disadvantage of this change when measuring the distance to **A**.

advantage .....

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

disadvantage .....

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

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26 A student is investigating the resistivity of a metal.

The student has a 1.0 m length of wire made from the metal.

Fig. 26.1 shows the circuit used by the student.

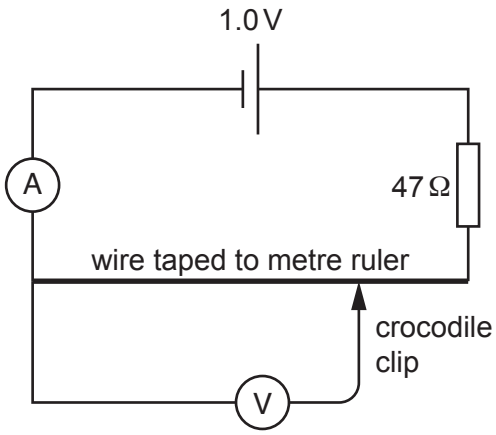

Fig. 26.1

(a) Explain why the voltmeter should have a very high resistance.

.....

.....

.....

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

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The cell has an e.m.f. of 1.0 V and negligible internal resistance.

The wire has a resistance of 3.0 Ω.

The crocodile clip is connected at the centre of the wire as shown in **Fig. 26.2**.

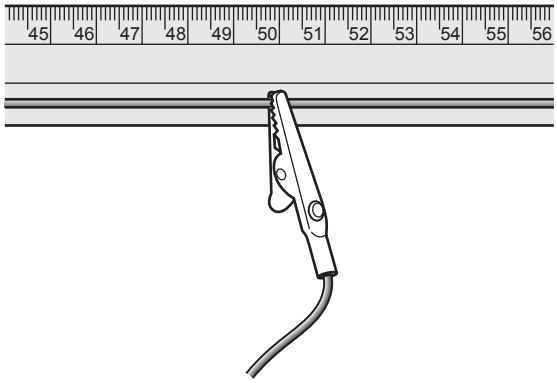

Fig. 26.2

(b) Calculate the voltmeter reading you expect the student to see.

Expected reading = ... V **[2]**

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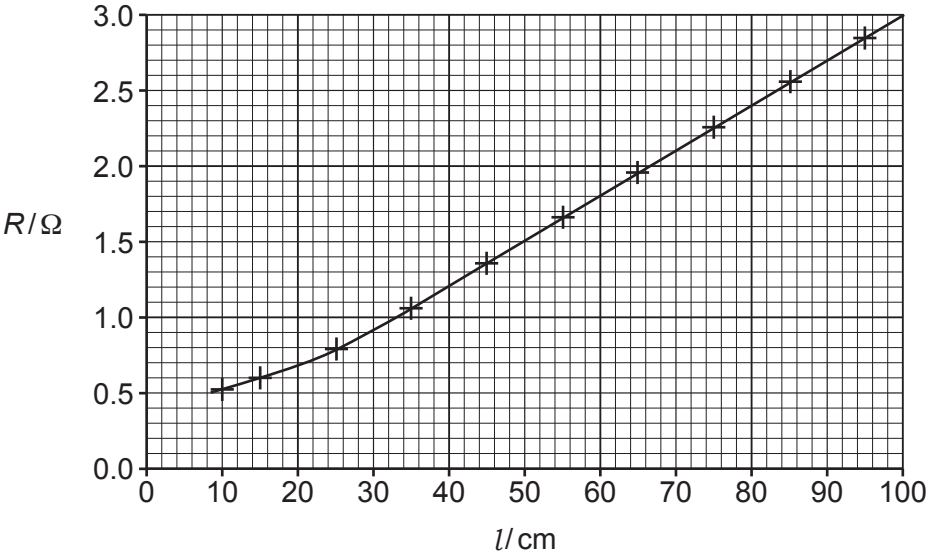
The student records the readings on the voltmeter and ammeter for a range of positions of the crocodile clip.

The student uses the results to calculate the resistance for each length l of wire under test.

The graph shows the results of the investigation.



The student expected the graph to show that R is directly proportional to l.

(c) **(i)** State the shape of graph expected if R were directly proportional to l.

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

(ii) The graph is a curve for small lengths because the higher current heats the wire and its resistivity increases.

The resistivity of the metal increases by 0.4% for each °C temperature rise.

Calculate the temperature rise of the wire when l = 20 cm.

Temperature rise = ... °C **[4]**

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(iii) State one other variable, apart from temperature, that should be controlled in this investigation.

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

Another student repeats the experiment. The crocodile clip is replaced with a sliding contact which has a sharp edge and measurements are taken as shown in **Fig. 26.3**.

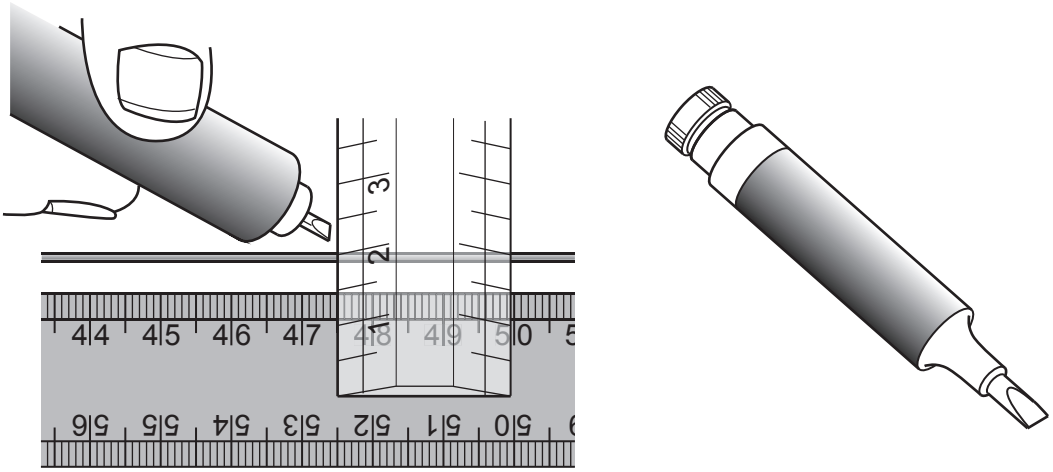

Fig. 26.3

(d) Explain how these changes will affect the quality of the measurements of length.

.....

.....

.....

.....

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

END OF QUESTION PAPER

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ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

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