OXFORD AQA

INTERNATIONAL QUALIFICATIONS

Please write clearly in block capitals.

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

Surname _____

Forename(s) _____

Candidate signature _____

I declare this is my own work.

INTERNATIONAL AS

PHYSICS

Unit 2 Electricity, waves and particles

Tuesday 20 May 2025 07:00 GMT Time allowed: 2 hours

Materials

For this paper you must have:

- a Data and Formulae Booklet as a loose insert
- a ruler with millimetre measurements
- a scientific calculator, which you are expected to use where appropriate
- a protractor.

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- All working must be shown.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12–25	
TOTAL	

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Section A

Answer **all** questions in this section.

0 1 When light of frequency 9.1×10^{14} Hz is incident on a metal surface, electrons are emitted. The stopping potential for these electrons is 1.65 V.

0 1 . 1 State what is meant by the threshold frequency for a metal.

[1 mark]

0 1 . 2 Calculate the threshold frequency for this metal.

[3 marks]

threshold frequency = _____ Hz

4

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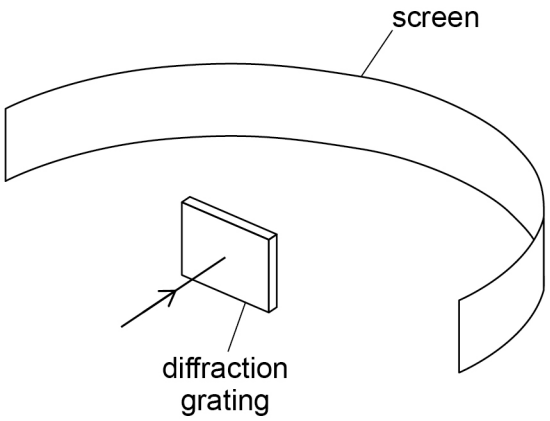
0 2 Laser light of wavelength 6.94×10^{-7} m is incident normally on a diffraction grating.

The grating has 280 lines per millimetre.

Bright spots appear on a semicircular screen, as shown in **Figure 1**.

Figure 1



Calculate the total number of bright spots that appear on the screen.

[3 marks]

number = _____

3

Turn over ►

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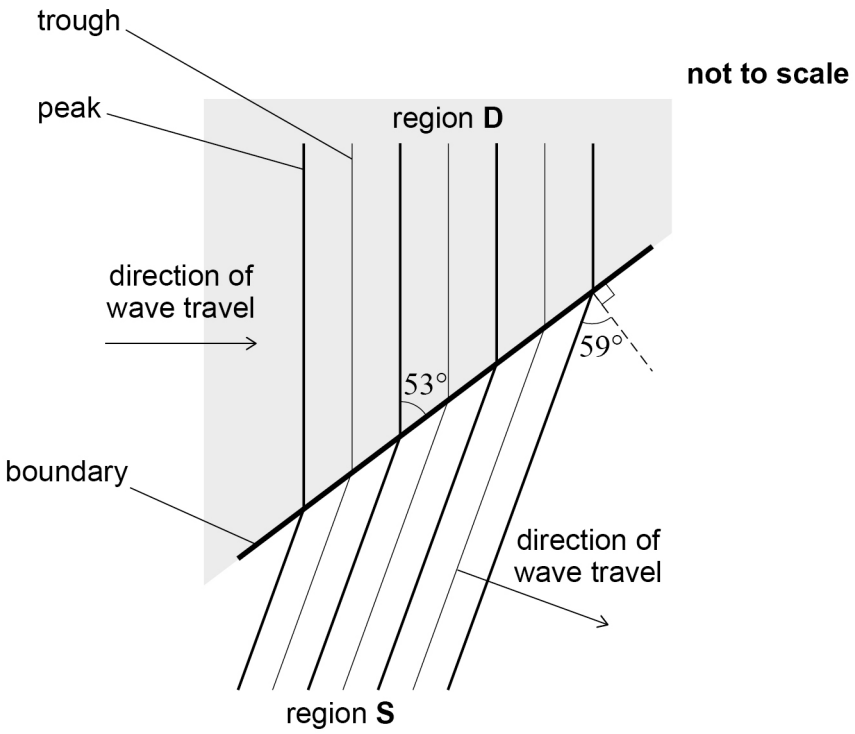
0 3 A wave on the surface of water is used to model the behaviour of light waves.

Figure 2 shows the wave travelling on the surface of water, as viewed from above. The boundary between a deep region **D** and a shallow region **S** is shown.

Figure 2



The wave travels more slowly in shallow water than in deep water.

0 3 . 1 Explain why the wavelength of the wave is greater in region **D** than in region **S**.

[1 mark]

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0 3 . 2 The speed of the wave in region **D** is v_D. The speed of the wave in region **S** is v_S.

The ratio of the speeds is given by:

$$\frac{v_D}{v_S} = \frac{\sin\theta_S}{\sin\theta_D}$$

where θ_D is the wave's angle of incidence in region **D**

θ_S is the wave's angle of refraction in region **S**.

Calculate $\frac{v_D}{v_S}$.

[1 mark]

$\frac{v_D}{v_S} =$ _____

2

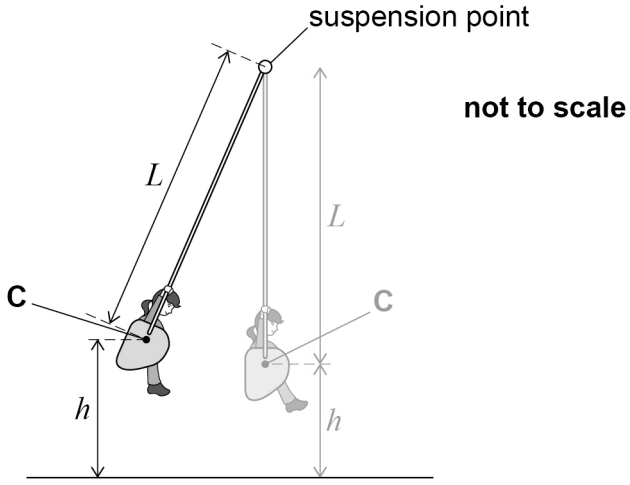
Turn over for the next question

0 4 This question is about a child moving on a swing.

C is the centre of mass of the child and seat.
h is the height of **C** above the ground.

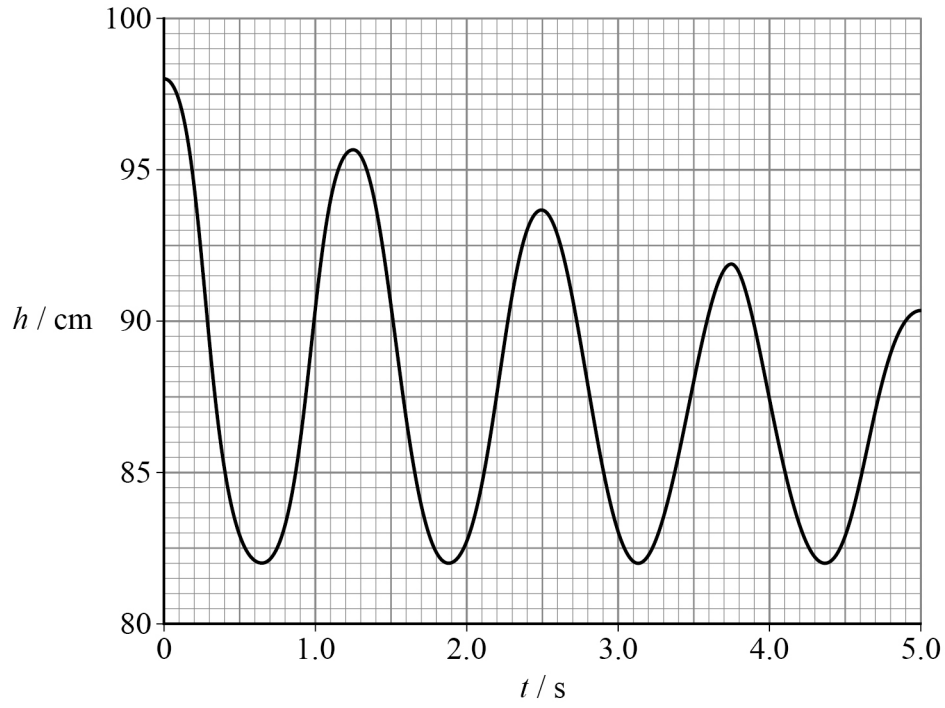
Figure 3 shows **C** at two different values of h.

Figure 3



At time $t = 0$ the child starts swinging.
Figure 4 shows the variation of h with t.

Figure 4



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0 4 . 1 Determine the time period of the oscillation.

Go on to explain how you used **Figure 4** to determine your answer.

[2 marks]

time period = _____ s

0 4 . 2 L is the distance from **C** to the suspension point of the swing.

Assume that the time period of the swing is the same as the time period for a simple pendulum of length L.

Estimate L.

[2 marks]

L = _____ m

Question 4 continues on the next page

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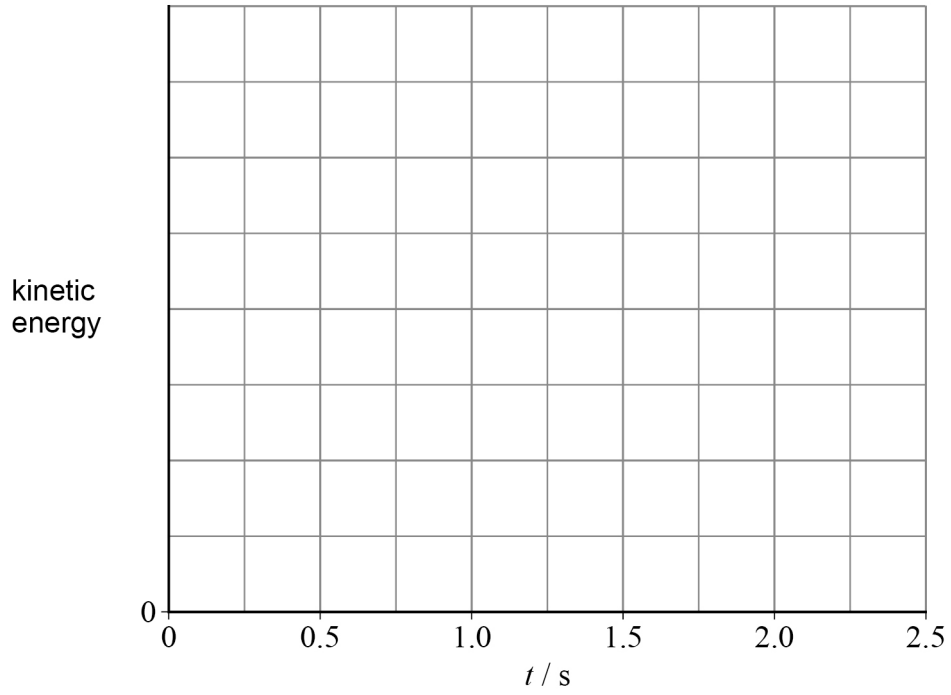
0 4 . 3 Suggest **one** reason why the swing does not behave in exactly the same way as a simple pendulum.

[1 mark]

0 4 . 4 Sketch, on **Figure 5**, the variation of the child's kinetic energy with t for the first 2.5 s of the motion.
Do not add values to the kinetic energy axis.

[3 marks]

Figure 5



8

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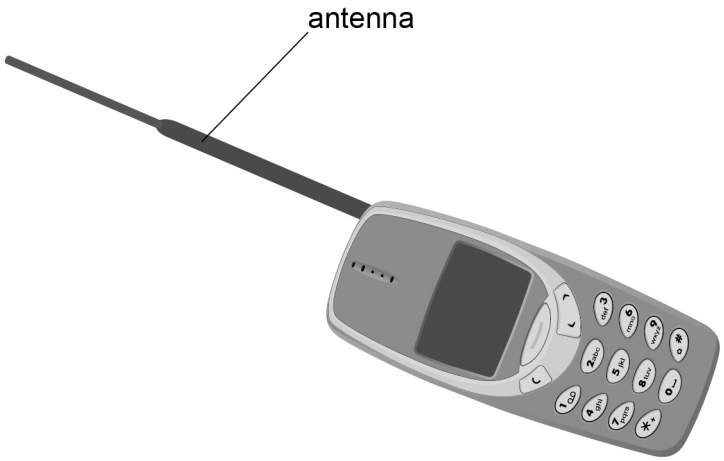
0 5 . 1 Explain why longitudinal waves cannot be polarised but transverse waves can be polarised.

[2 marks]

0 5 . 2 **Figure 6** shows an early form of mobile phone. The antenna on this mobile phone was a long thin metal rod that received microwave signals.

Figure 6



Explain why the microwaves transmitted to the mobile phone must **not** be polarised in a single plane.

[2 marks]

4

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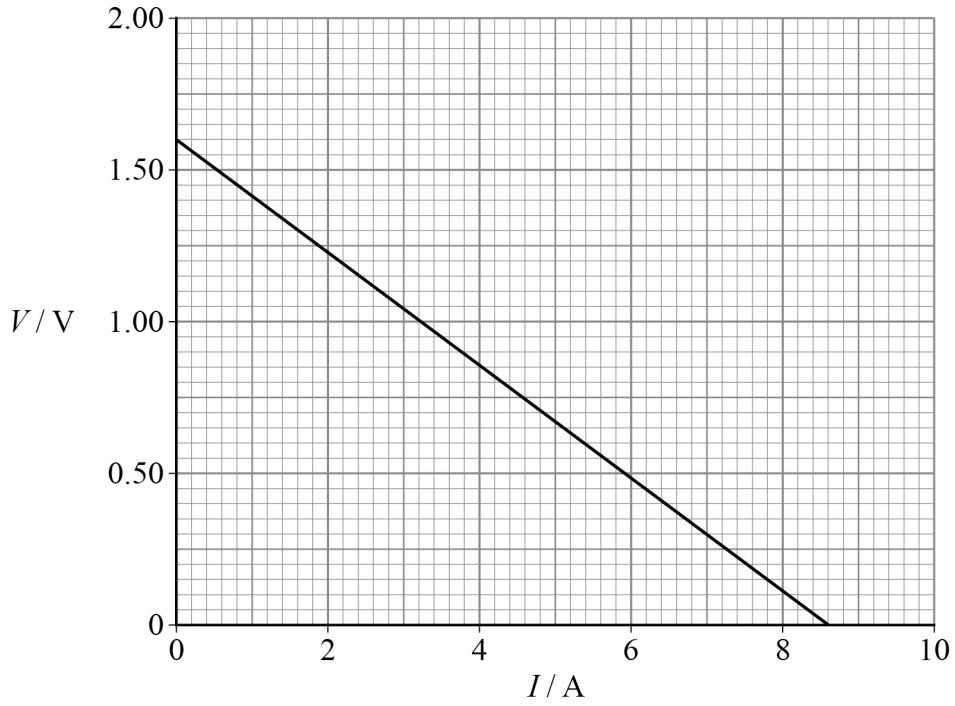
0 6 This question is about two electrical cells **A** and **B**.

Figure 7 shows the variation of terminal pd V with current I for cell **A**.

Figure 7



0 6 . 1 Determine the emf of **A**.

[1 mark]

emf = _____ V

0 6 . 2 Determine the internal resistance of **A**.

[3 marks]

internal resistance = _____ Ω

Do not write outside the box

0 6 . 3 Cell **B** has the same emf as cell **A**.
B has a much smaller internal resistance than **A**.

A is connected across a lamp.
B is connected across an identical lamp.

Explain any difference between the brightness of the lamps.
Calculations are not required.

[2 marks]

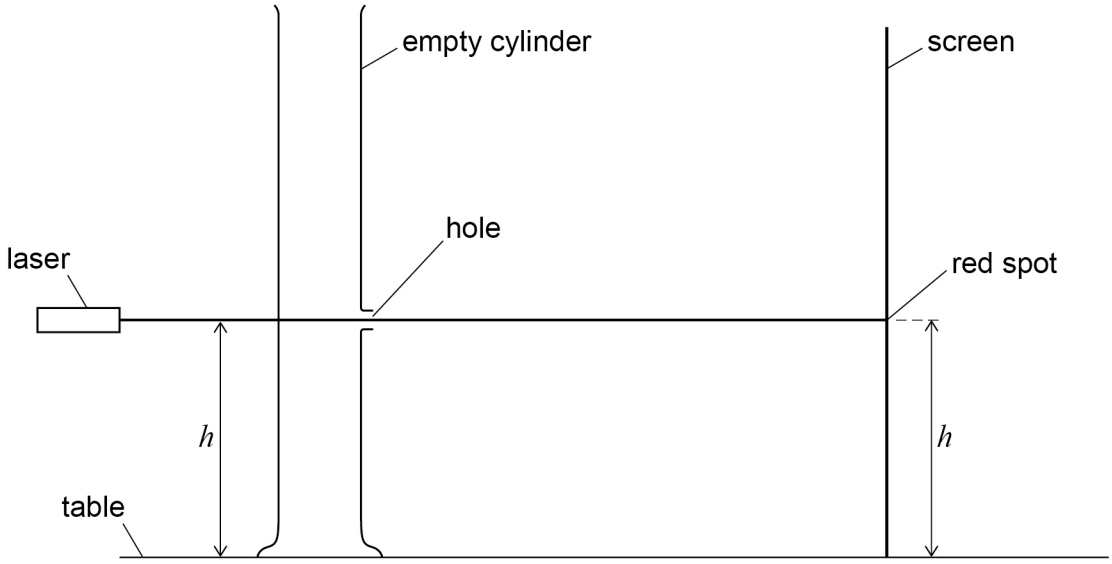
6

Turn over for the next question

0 7 **Figure 8** shows apparatus used to demonstrate refraction.

A glass measuring cylinder has a small hole on one side, at height h.
The teacher shines red laser light horizontally at height h through the wall of the empty cylinder.
The light passes through the hole and a red spot appears on a screen at height h.

Figure 8

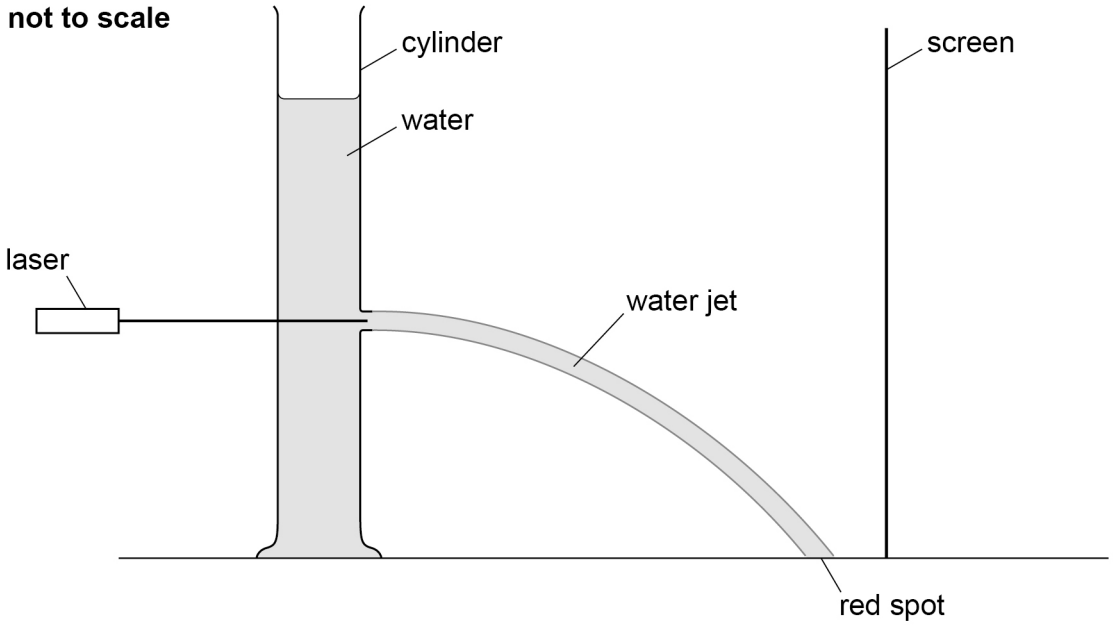


The hole is covered and the cylinder is filled with water.

The hole is then uncovered and a jet of water comes out of the hole.

The red spot disappears from the screen and appears on the table as shown in **Figure 9**.

Figure 9



0 7 . 1 Sketch, on **Figure 9**, the path of the light through the water jet.

[1 mark]

Question 7 continues on the next page

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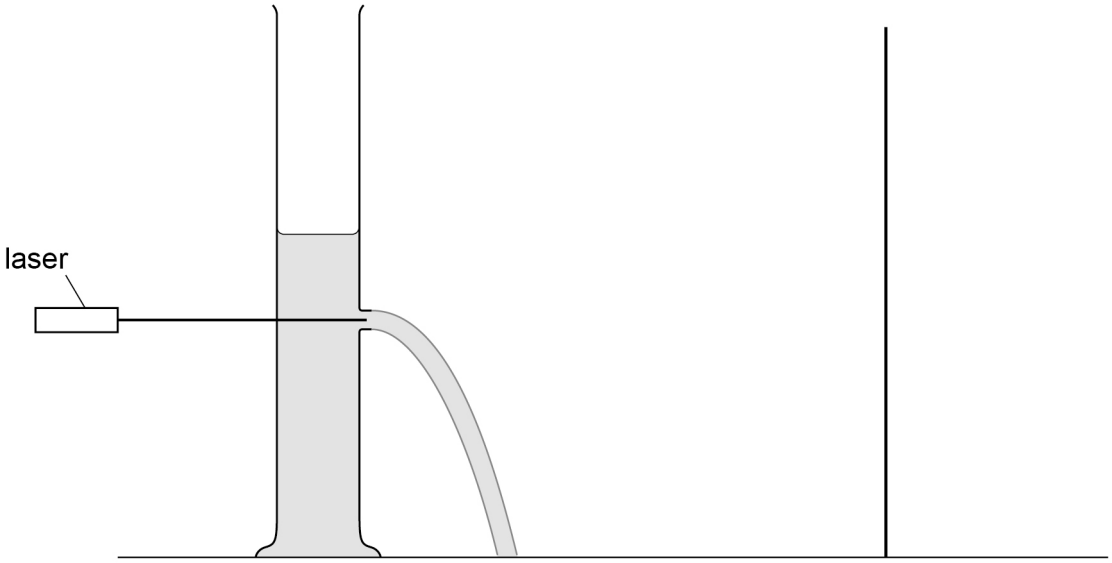
Figure 10 shows the water jet when there is less water in the cylinder.

At a particular water level, the red spot disappears from the table and reappears on the screen.

Figure 10



0 7 . 2 Draw, on **Figure 10**, the new path of the light from the hole to the screen.

[1 mark]

0 7 . 3 Explain why the spot disappears from the table and reappears in the position you drew on **Figure 10**.

[3 marks]

Do not write outside the box

0 7 . 4 State **one** safety measure when using a laser in a school laboratory.

[1 mark]

6

0 8 . 1 Describe **two** differences between the properties of a stationary wave and the properties of a progressive wave.

[2 marks]

1

2

Question 8 continues on the next page

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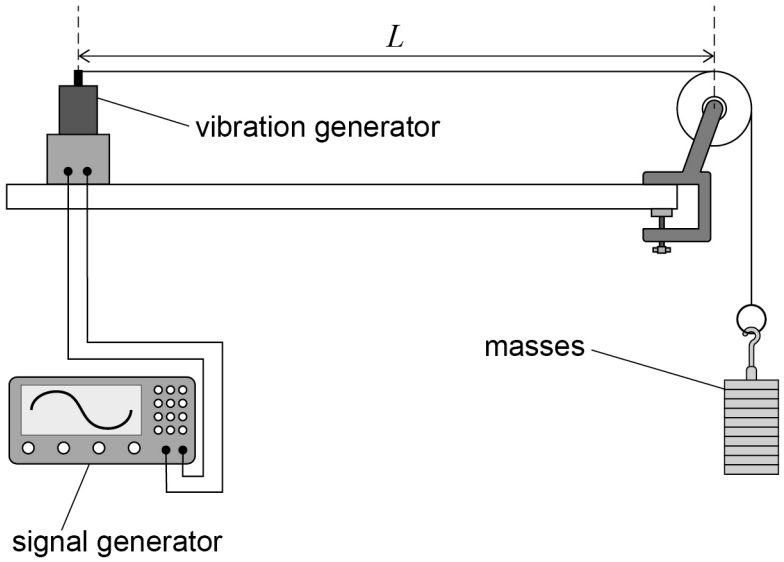
Figure 11 shows the apparatus that a student uses to investigate stationary waves on a string.

Figure 11



The string is attached to a vibration generator at one end and hangs over a pulley at the other end. A selection of different masses is available to change the tension in the string.

The vibrating length L of the string cannot be changed.

The frequency of the vibration generator is increased from zero until the first-harmonic stationary wave is observed on the string.

0 8 . 2 Describe a suitable method to determine the mass per unit length μ of the string using this apparatus.

In your answer, include:

- the measurements to be taken, including details of the measuring instruments used
- techniques to reduce the uncertainty in the experiment
- how μ is determined using a graphical method.

[6 marks]

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0 8 . 3 When the student repeats the experiment, his measurements of the first-harmonic frequency vary at each tension. This is partly due to a random error in identifying the first harmonic.

Explain why using the second harmonic would reduce the random error.

[1 mark]

9

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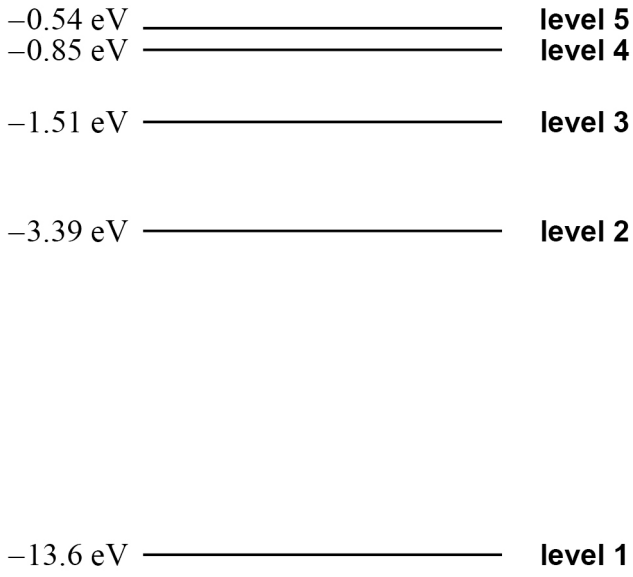
0 9 . 1 Explain how line spectra provide evidence that gas atoms have discrete energy levels.
[3 marks]

Figure 12 shows the lowest energy levels of atomic hydrogen.

Figure 12



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0 9 . 2 Determine the transition that emits light with a wavelength of $656\ \text{nm}$.

[4 marks]

transition from level _____ to level _____

0 9 . 3 A beam of photons, each of energy $12.75\ \text{eV}$, is incident on hydrogen atoms that are in level 1.

Determine the number of different photon energies that are emitted by the hydrogen atoms.

[1 mark]

number = _____

—
8

END OF SECTION A

Turn over ►

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Section B

Answer **all** questions in this section.

1 0 A student is asked to determine the volume of a wire that has a circular cross-section.

1 0 . 1 She makes six measurements of the diameter d of the wire.

Table 1 shows the measurements of d obtained by the student.

Table 1

d / mm	0.17	0.17	0.16	0.18	0.26	0.16

Suggest a suitable measuring instrument to measure d.

[1 mark]

1 0 . 2 Describe how to minimise the systematic error when making these measurements.

[1 mark]

1 0 . 3 Explain why the student makes measurements of d in more than one position along the wire.

[1 mark]

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1 0 . 4 The student uses **Table 1** to determine an accurate value for the cross-sectional area of the wire.

Calculate the percentage uncertainty in the cross-sectional area of the wire.

[3 marks]

percentage uncertainty = _____

1 0 . 5 The length of the wire is measured as $8.3\ \text{cm} \pm 0.1\ \text{cm}$.

Calculate the percentage uncertainty in the volume of the wire.

[2 marks]

percentage uncertainty = _____

8

Turn over for the next question

Do not write outside the box

1 1 A student designs a circuit to indicate the water temperature for a child's bath. A light in the circuit turns on when the bath water is above a certain temperature.

The student puts the circuit inside a floating toy as shown in **Figure 13**.

Figure 13

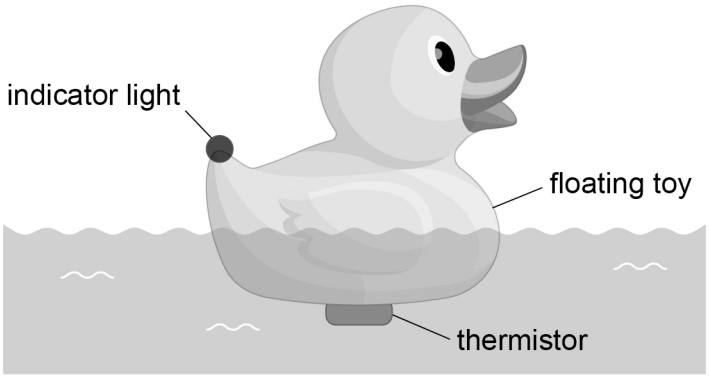
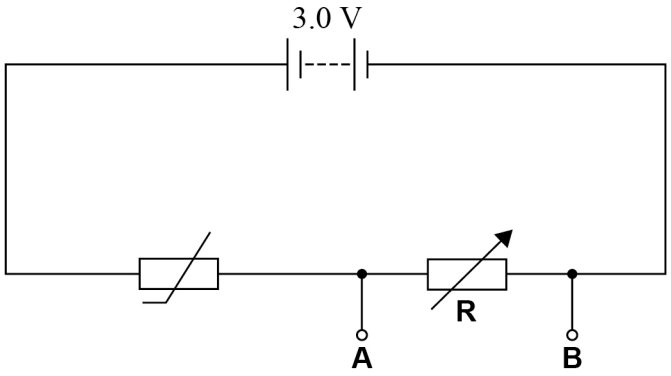


Figure 14 shows part of the circuit. This part contains a battery, a thermistor and a variable resistor **R**.

The battery has an emf of $3.0\ \text{V}$ and negligible internal resistance.

Figure 14



The part of the circuit containing the indicator light is connected between **A** and **B**. This part of the circuit is not shown and does not affect the voltage V_{AB} between **A** and **B**.

Whenever V_{AB} is greater than $0.65\ \text{V}$, the indicator light turns on.

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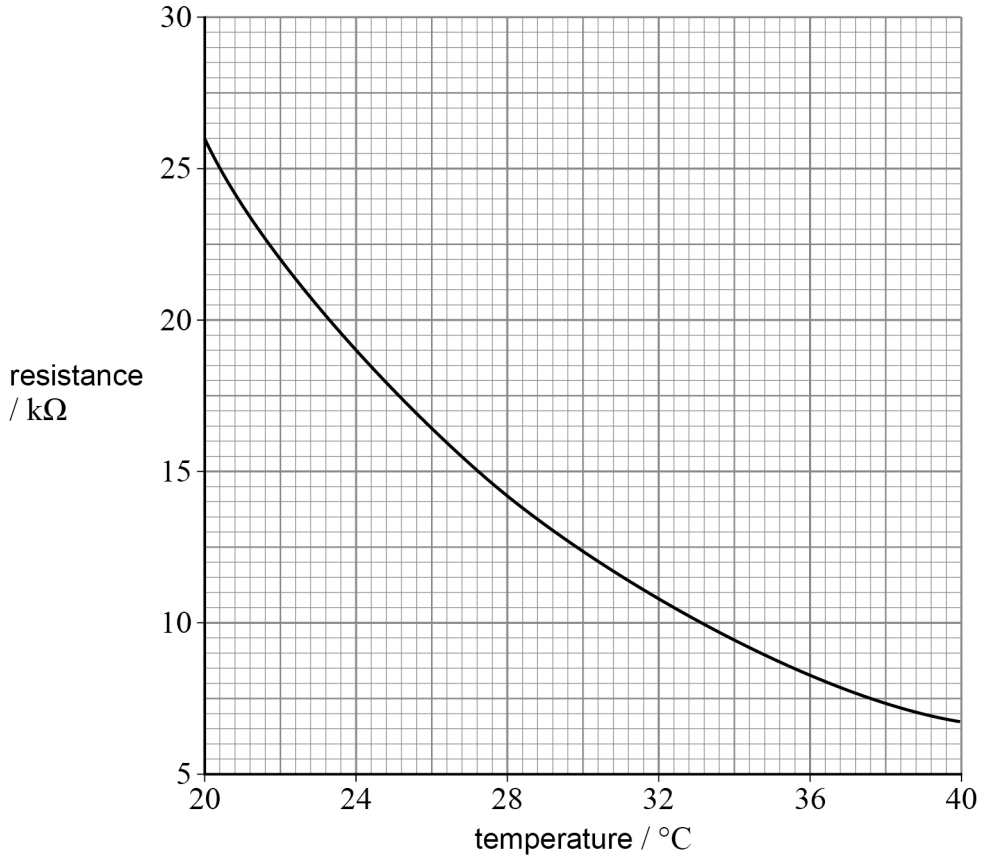
Figure 15 shows the variation of resistance with temperature for the thermistor.

Figure 15



1 1 . 1 The resistance of **R** is set so that V_{AB} is 0.65 V when the temperature is 37 °C.

Calculate the resistance of **R** at this setting.

[3 marks]

resistance = _____ Ω

Question 11 continues on the next page

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1 1 . 2 The student increases the resistance of **R**.

Explain the effect on the temperature at which the indicator light turns on.

[3 marks]

1 1 . 3 Explain the benefit of using **R** in the circuit instead of a resistor of fixed resistance.

[1 mark]

1 1 . 4 Explain whether the part of the circuit between **A** and **B** must have a very high resistance or a very low resistance.

[1 mark]

8

END OF SECTION B

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Section C

Each of the questions in this section is followed by four responses, **A**, **B**, **C** and **D**.

For each question select the best response.

Only **one** answer per question is allowed.
For each question, completely fill in the circle alongside the appropriate answer.

CORRECT METHOD 

WRONG METHODS 

If you want to change your answer you must cross out your original answer as shown. 

If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown. 

You may do your working in the blank space around each question but this will not be marked. Do **not** use additional pages for this working.

1 2 When two resistors are connected together, the total resistance of the combination is $10\ \Omega$.

One resistor has a resistance of $12\ \Omega$.

What is the resistance of the other resistor?

[1 mark]

A $2.0\ \Omega$ 

B $5.5\ \Omega$ 

C $17\ \Omega$ 

D $60\ \Omega$ 

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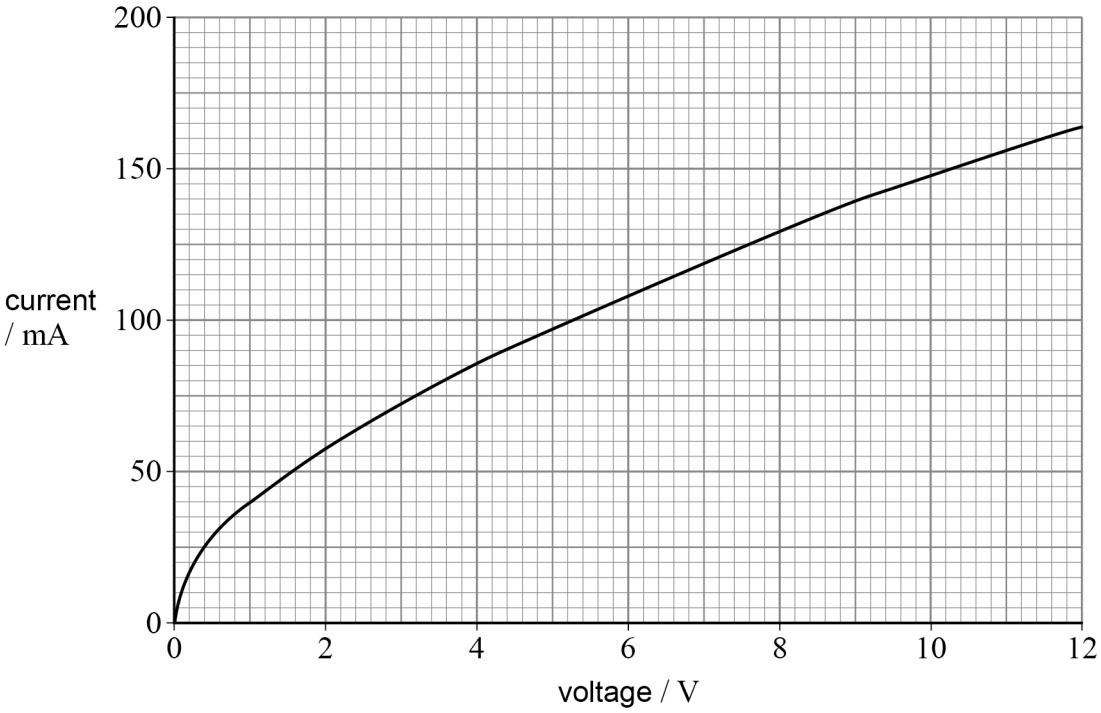
1 3 The graph shows the I–V characteristic of a filament lamp **L**.



An identical lamp is connected in parallel with **L**.
The voltage across the parallel combination is 6.0 V.

What is the total power dissipated by the two lamps?

[1 mark]

A 0.42 W ⬭

B 0.65 W ⬭

C 0.90 W ⬭

D 1.3 W ⬭

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1 4 A superconducting component **S** is placed in series with a resistor of resistance R.

The voltage across the combination is V.

Which row is correct?

[1 mark]

	Current in S	Voltage across S	Voltage across the resistor	
A	$\frac{V}{R}$	0	V	⬭
B	$\frac{V}{R}$	$\frac{V}{2}$	$\frac{V}{2}$	⬭
C	infinite	0	V	⬭
D	infinite	$\frac{V}{2}$	$\frac{V}{2}$	⬭

1 5 Two resistors $\mathbf{R_1}$ and $\mathbf{R_2}$ are connected in series.

The resistor values are:

$\mathbf{R_1} = 14\ \Omega \pm 20\%$
$\mathbf{R_2} = 30\ \Omega \pm 10\%$

What is the absolute uncertainty of the total resistance of the series combination?

[1 mark]

A $13\ \Omega$ ⬭

B $9\ \Omega$ ⬭

C $7\ \Omega$ ⬭

D $6\ \Omega$ ⬭

Do not write outside the box

1 6 A potential difference is applied across a variable resistor.

The current in the variable resistor is I. The power dissipated by the variable resistor is P.

The resistance of the variable resistor is increased by 15%. The same potential difference is applied.

Which row shows the new current and the new power?

[1 mark]

	Current	Power	
A	$0.87I$	$0.87P$	⬭
B	$0.87I$	$1.15P$	⬭
C	$0.85I$	$0.85P$	⬭
D	$0.85I$	$1.15P$	⬭

1 7 An oscillating system consists of an object of mass M suspended from a spring of stiffness k.
The object is displaced vertically and released. The system oscillates freely with a frequency f.

An object of mass $2M$ is suspended from a spring of stiffness $3k$.

What is the frequency of oscillation of this system?

[1 mark]

A $1.5f$ ⬭

B $1.2f$ ⬭

C $0.82f$ ⬭

D $0.67f$ ⬭

Do not write outside the box

1 8 A transverse wave travels along a string.

The transverse wave has a frequency of 2.0 Hz, a wavelength of 4.0 cm and an amplitude of 3.0 cm.

What is the total distance travelled by a point on the string in one second?

[1 mark]

A 6.0 cm ⬭

B 8.0 cm ⬭

C 12 cm ⬭

D 24 cm ⬭

1 9 Two aerials $\mathbf{A_1}$ and $\mathbf{A_2}$ receive radio waves from the same distant transmitter **T**.

The distance between $\mathbf{A_1}$ and **T** is d_1.
The distance between $\mathbf{A_2}$ and **T** is d_2.

The waves have a frequency of 104 MHz.
The phase difference between the waves received by $\mathbf{A_1}$ and $\mathbf{A_2}$ is 1.4 rad.

What is the minimum value for $d_1 - d_2$?

[1 mark]

A 0.32 m ⬭

B 0.64 m ⬭

C 1.3 m ⬭

D 13 m ⬭

Do not write outside the box

2 0 Light from a single monochromatic source is incident on a Young's double-slit apparatus. Fringes with spacing y are observed on a screen.

The slit separation and the distance between the slits and the screen are both doubled.

What is the new fringe spacing?

[1 mark]

A $4y$ ⬭

B $2y$ ⬭

C y ⬭

D $\frac{y}{2}$ ⬭

2 1 Ultraviolet light is incident on a metal surface.
N electrons per second are emitted from the surface.
The maximum kinetic energy of the emitted electrons is $E_{k(max)}$.

The frequency of the light is now increased while the power of the light is kept the same.

What happens to N and $E_{k(max)}$?

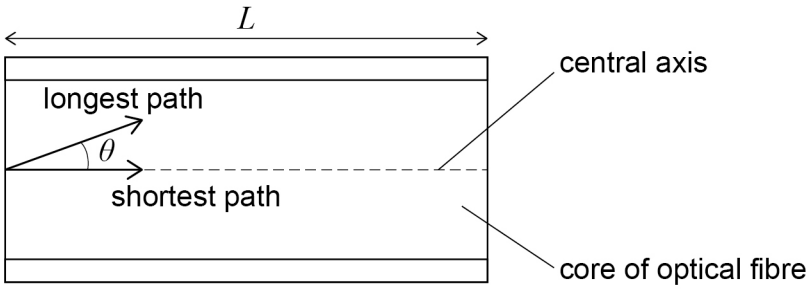
[1 mark]

	N	$E_{k(max)}$	
A	decreases	increases	⬭
B	decreases	stays the same	⬭
C	increases	increases	⬭
D	increases	stays the same	⬭

Do not write outside the box

2 2 Light travels with a speed v in the core of an optical fibre of length L.

The longest path is at an angle θ to the central axis of the fibre.
The shortest path is along the central axis of the fibre.



not to scale

What is the difference between the times taken for the light to travel along the longest path and along the shortest path?

[1 mark]

A $\frac{L}{v}\left(\frac{1}{\sin\theta} - 1\right)$ ⬭

B $\frac{L}{v}(1 - \sin\theta)$ ⬭

C $\frac{L}{v}\left(\frac{1}{\cos\theta} - 1\right)$ ⬭

D $\frac{L}{v}(1 - \cos\theta)$ ⬭

Turn over for the next question

Do not write outside the box

2 3 The refractive indices of some materials are given below.

Material	Refractive index
Teflon	1.4
acrylic	1.5
sapphire	1.7

Materials are chosen for the core and cladding of a step-index optical fibre.

Which combination results in the least modal dispersion?

[1 mark]

	Core	Cladding	
A	Teflon	sapphire	⬭
B	sapphire	Teflon	⬭
C	acrylic	Teflon	⬭
D	Teflon	acrylic	⬭

2 4 The purpose of the powder coating in a fluorescent tube is to absorb one type of particle and emit another type of particle.

Which row is correct?

[1 mark]

	Particle absorbed by the powder	Particle emitted by the powder	
A	ultraviolet photons	electrons	⬭
B	ultraviolet photons	visible photons	⬭
C	electrons	visible photons	⬭
D	electrons	ultraviolet photons	⬭

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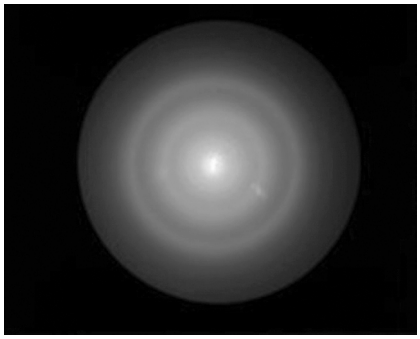
2 5 A beam of electrons is diffracted, creating a diffraction pattern consisting of bright circles.



The momentum of each electron is then decreased.
The number of electrons emitted per second in the beam stays the same.

Which row shows what happens to the de Broglie wavelength of the electrons and the diameter of the bright circles?

[1 mark]

	de Broglie wavelength	Diameter	
A	increases	decreases	⬭
B	increases	increases	⬭
C	decreases	decreases	⬭
D	decreases	increases	⬭

14

END OF QUESTIONS

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ANSWER IN THE SPACES PROVIDED

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Question number	**Additional page, if required.** **Write the question numbers in the left-hand margin.**

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Question number	**Additional page, if required.** **Write the question numbers in the left-hand margin.**