OXFORD
INTERNATIONAL
AQA EXAMINATIONS

Please write clearly in block capitals.

Centre number ☐☐☐☐☐ Candidate number ☐☐☐☐

Surname ____________________

Forename(s) ____________________

Candidate signature ____________________

INTERNATIONAL AS
PHYSICS

Unit 2 Electricity, waves and particles

Wednesday 16 January 2019 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.

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	

Do not write outside the box

Section A

Answer **all** questions in this section.

0 1 Explain why longitudinal waves cannot be polarised.

[2 marks]

2

0 2 A filament lamp operates at a power of $21\ \text{W}$ when there is a potential difference of $12\ \text{V}$ across it.

Calculate the charge that flows through the filament lamp in 10 minutes.

[3 marks]

charge = ____________________ C

3

Do not write outside the box

0 3 . 1 State **one** application of superconductors.

[1 mark]

0 3 . 2 Explain why superconductors are necessary in the application given in question **03.1**.

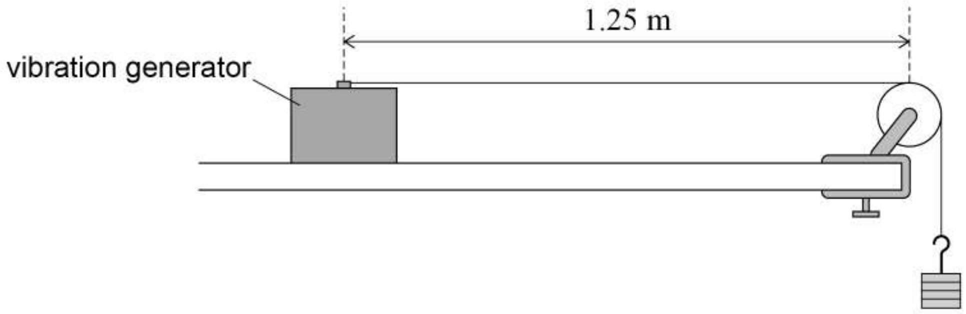
[1 mark]

2

Turn over for the next question

0 4 **Figure 1** shows an experimental arrangement used to investigate stationary waves on a stretched string.

Figure 1

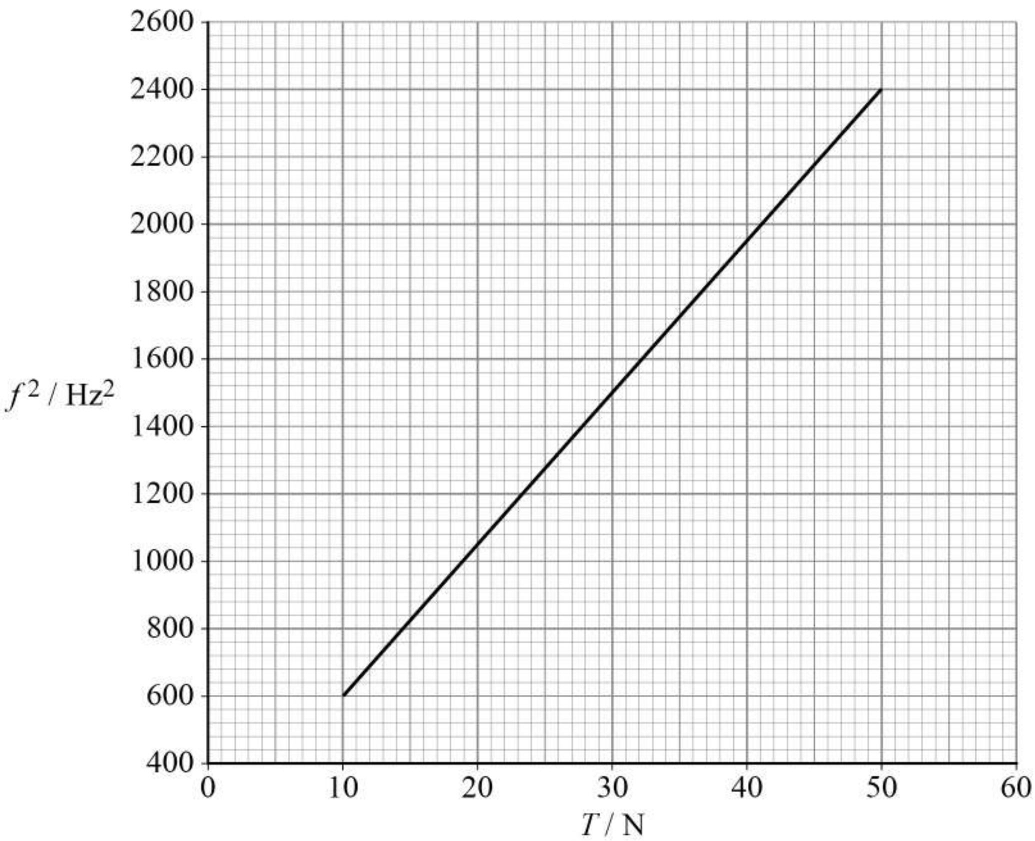


The string was made to vibrate. The vibrating length l of the string was kept constant at 1.25 m.

The frequency f of the first harmonic of the vibrating string was obtained as the tension T in the string was increased.

Figure 2 shows the variation of f^2 with T.

Figure 2



Do not write outside the box

0 4 . 1 Show that the mass per unit length, μ, of the string is equal to $\frac{1}{4l^2\text{gradient}}$

[2 marks]

0 4 . 2 Determine the mass of $1.25\ \text{m}$ of the string.

[4 marks]

mass = ____________________ kg

6

0 5 Describe how ultraviolet radiation is produced inside a fluorescent tube.

[3 marks]

____

____

____

____

____

____

____

____

3

Do not write outside the box

0 6 **Figure 3** shows the variation of resistance with temperature for a negative temperature coefficient (ntc) thermistor.

Figure 3

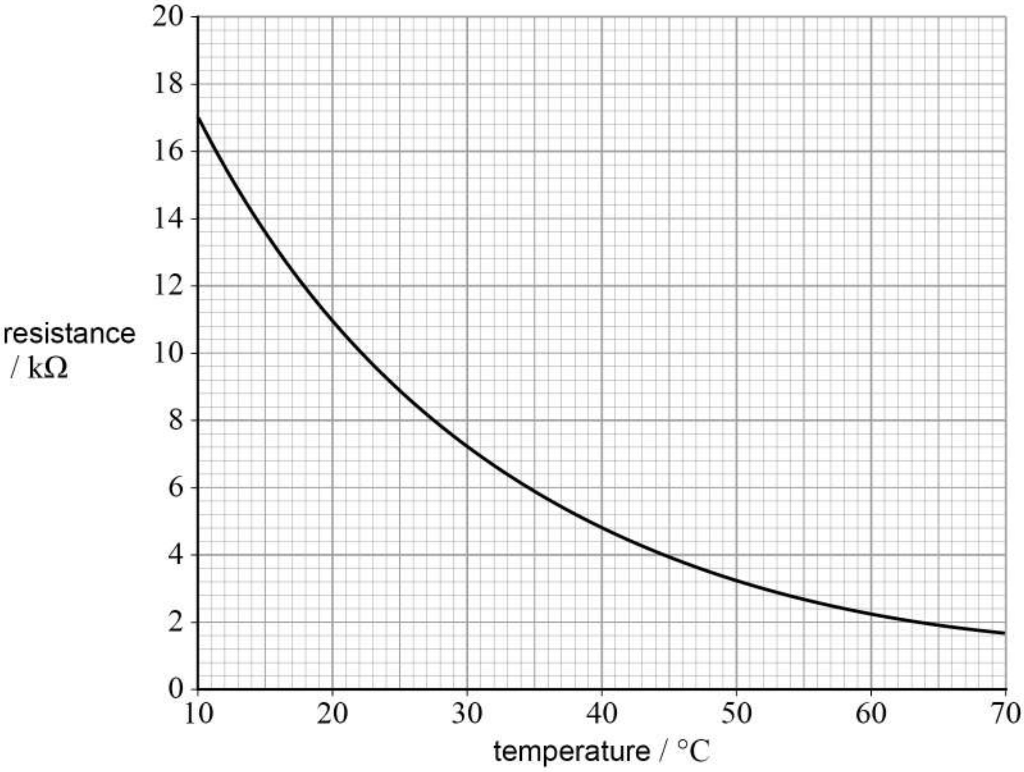
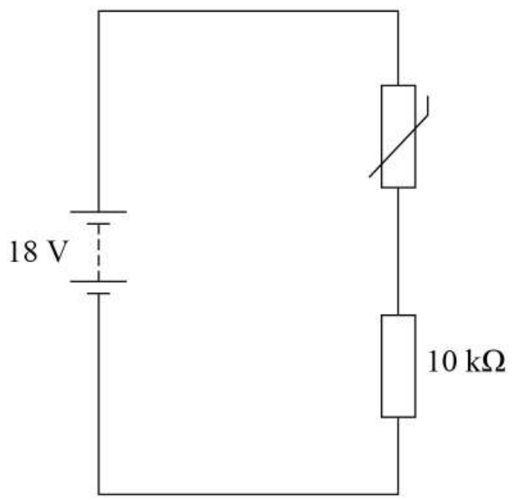


Figure 4 shows the ntc thermistor connected in series with a $10\ \text{k}\Omega$ resistor and a battery of emf $18\ \text{V}$. The temperature of the thermistor is $50\ °\text{C}$. The battery has negligible internal resistance.

Figure 4



Do not write outside the box

0 6 . 1 Determine the current in the circuit.

State an appropriate unit for your answer.

[4 marks]

current = ____________________

unit = ____________________

0 6 . 2 Calculate the rate of energy transfer by the $10\ \mathrm{k\Omega}$ resistor.

[2 marks]

rate of energy transfer = ____________________ W

6

Do not write outside the box

0 7 . 1 Define the electron volt.

[1 mark]

____

____

0 7 . 2 An electron, in a vacuum, is accelerated from rest through a potential difference V.

Show that the final speed v of the electron is given by

$$v = 5.9 \times 10^5 \sqrt{V}$$

Assume the mass of the electron is constant.

[2 marks]

0 7 . 3 An electron is accelerated from rest through a potential difference $V = 5.0\ \text{kV}$.

Calculate the minimum de Broglie wavelength for the electron.

[2 marks]

minimum wavelength = ____________________ m

Do not write outside the box

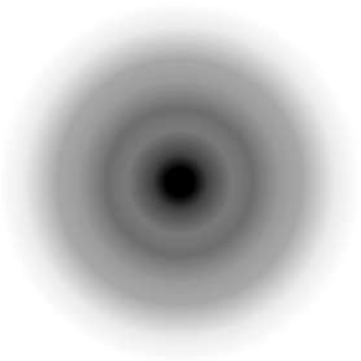
0 7 . 4 Accelerated electrons can be used to produce diffraction patterns. Electron diffraction was first observed in 1927.

Discuss why this observation led to a development in the scientific ideas about the nature of the electron.

[2 marks]

0 7 . 5 **Figure 5** shows the pattern of rings produced in an electron diffraction tube by electrons that have been accelerated by a potential difference.

Figure 5



Explain why the diameter of these rings increases when the potential difference is decreased.

[2 marks]

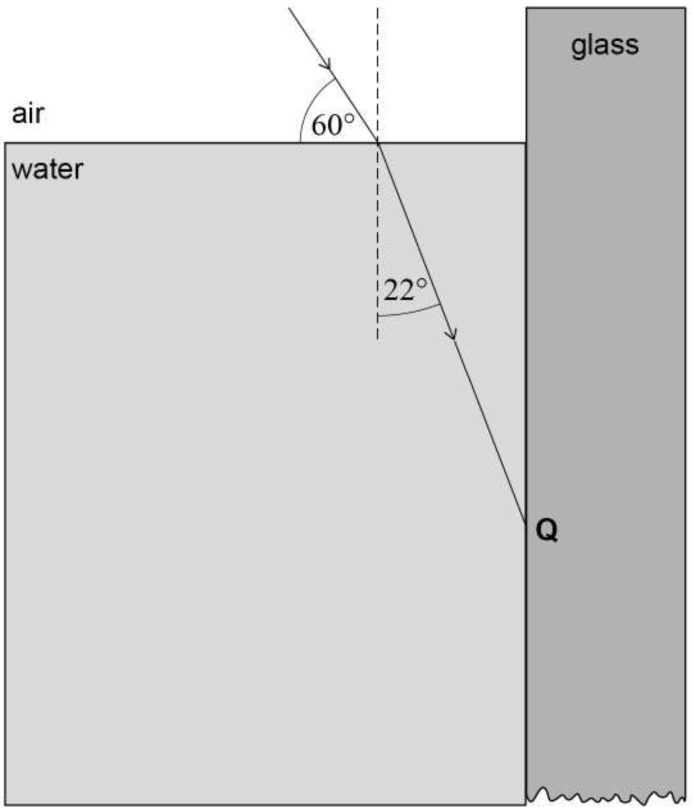
9

Do not write outside the box

0 8 A teacher shines a laser beam onto the surface of water in a glass container. **Figure 6** shows a ray entering the water. The angle between the ray and the water surface is $60°$. The refractive index of the glass is 1.55

Figure 6

not to scale



0 8 . 1 Show that the refractive index of the water is approximately 1.3

[2 marks]

0 8 . 2 The ray refracts at the vertical water–glass boundary at **Q** on **Figure 6**.

Explain why the ray cannot undergo total internal reflection at **Q**.

[1 mark]

Do not write outside the box

0 8 . 3 Determine the angle of refraction of the ray at **Q**.

[3 marks]

angle of refraction = ____________________ degrees

0 8 . 4 The ray passes from **Q** to the glass–air boundary.

Deduce what happens to the ray immediately after striking the glass–air boundary.

[3 marks]

____

____

____

0 8 . 5 A class of students observe the demonstration.

Suggest **one** safety precaution the teacher should take when using the laser.

[1 mark]

____

____

____

____

10

Do not write outside the box

0 9 **Figure 7** shows three simple pendulums suspended from a ceiling.

Table 1 shows the properties of each pendulum.

Figure 7

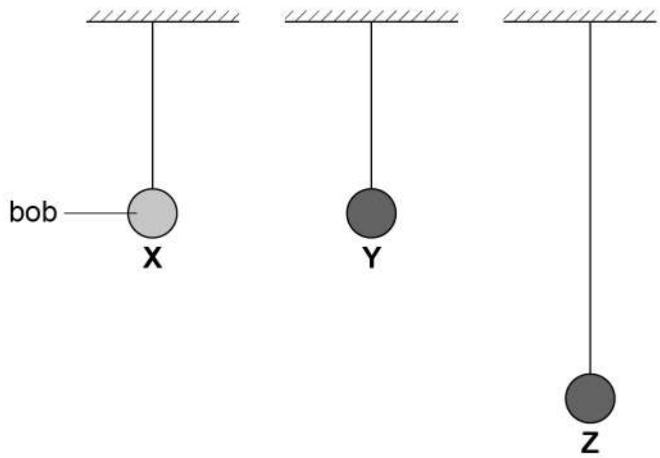


Table 1

Pendulum	Length of pendulum / cm	Mass of pendulum bob / g
X	150	100
Y	150	200
Z	300	200

Do not write outside the box

0 9 . 1 The three pendulum bobs are all pulled forward by the same small horizontal distance and then released from rest at the same time.
Ignore air resistance in this part of the question.

Compare the oscillations of the three pendulums.

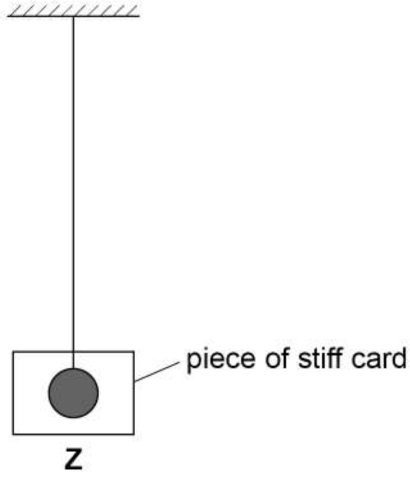
[3 marks]

Question 9 continues on the next page

Do not write outside the box

0 9 . 2 A piece of stiff card, of negligible mass, is attached to pendulum **Z** as shown in **Figure 8**. The card damps the motion of the pendulum.

Figure 8



The pendulum bob is pulled forward by the same small horizontal distance as in question **09.1** and released from rest.

Explain the effect of damping on the oscillations of pendulum **Z**.

[2 marks]

Do not write outside the box

Gravitational field strength g varies between different locations on the Earth's surface. **Table 2** shows the value of g for two locations.

Table 2

Location	**g / N kg^{-1}**
Iceland	9.85493
Kenya	9.77385

0 9 . 3 A simple pendulum of length 0.450 m is set into oscillation in Iceland.

Calculate the frequency of oscillation of the pendulum.

[2 marks]

frequency = ____________________ Hz

0 9 . 4 Explain how a simple pendulum in Kenya could be made to oscillate at the same frequency as the simple pendulum in Iceland.

You may wish to support your answer with a calculation.

[2 marks]

____

____

____

____

____

____

9

Turn over ►

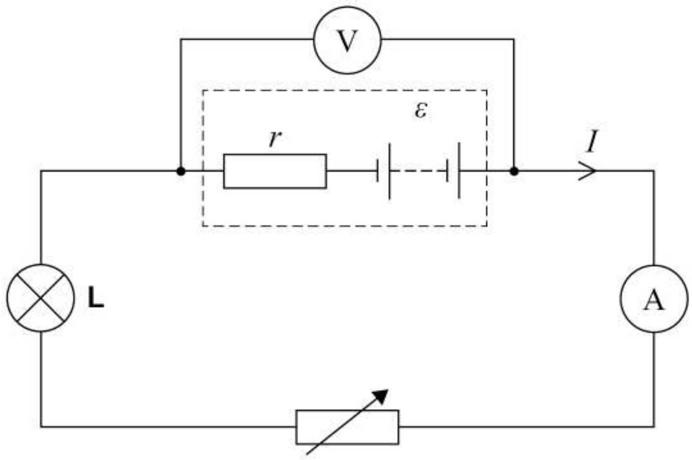
Do not write outside the box

Section B

Answer **all** questions in this section.

1 0 A battery has an emf of ε and an internal resistance of r.
Figure 9 shows a circuit used to investigate the relationship between the terminal pd V of the battery and the current I in the external circuit.

Figure 9



1 0 . 1 Suggest why the lamp **L** was included in the circuit.

[1 mark]

1 0 . 2 **Table 3** shows results from this experiment. The uncertainty in V was $\pm$ 0.02 V.
The uncertainty in I was negligible.

Table 3

I / A	1.0	1.5	2.0	2.5	3.0	3.5
V / V	7.06	6.96	6.89	6.79	6.72	6.62

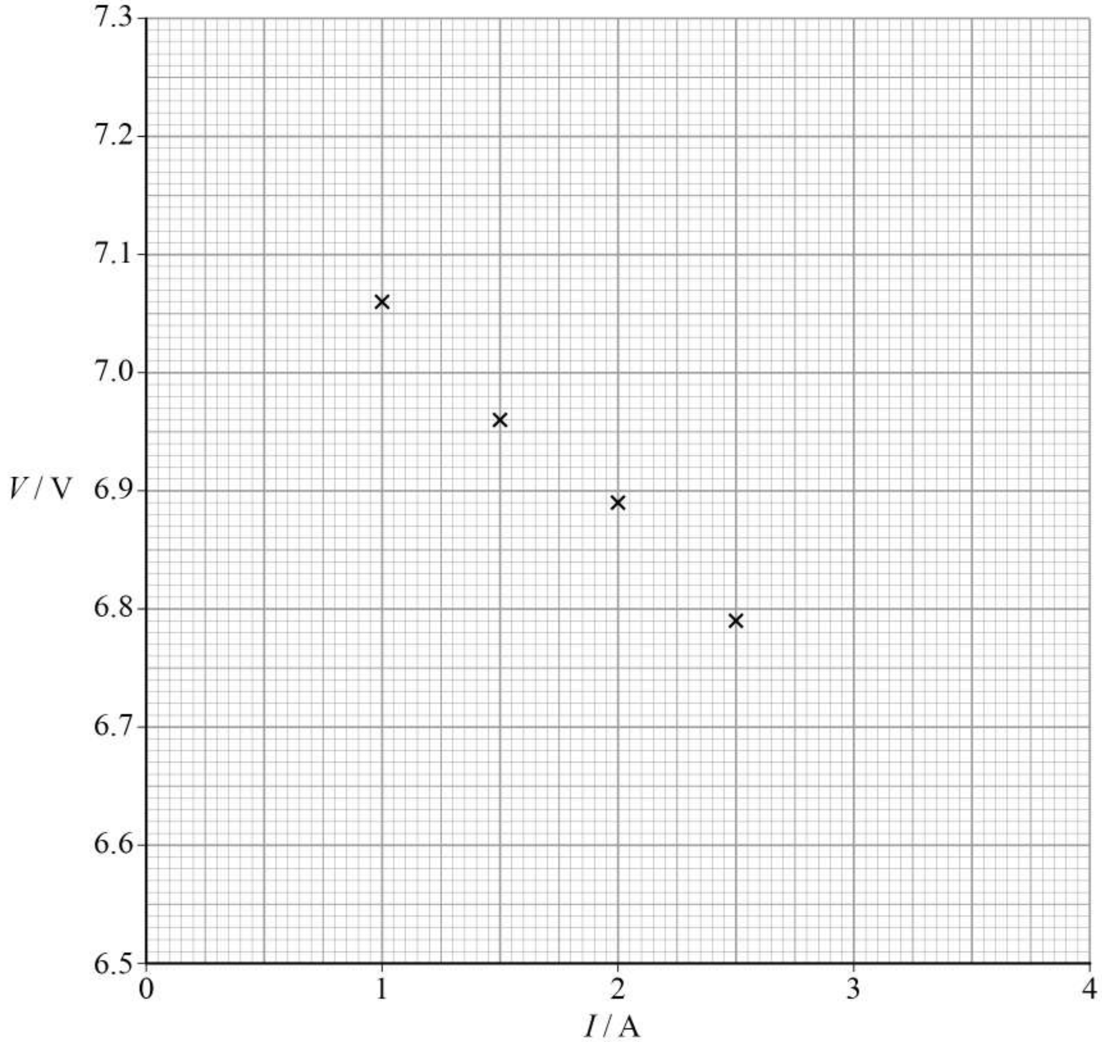
Some of these data points are plotted on **Figure 10**.

Plot the remaining **two** points and add error bars to **all** the points.

[2 marks]

Do not write outside the box

Figure 10



1 0 . 3 Draw a line of best fit on **Figure 10**.

[1 mark]

1 0 . 4 Determine the gradient of your line of best fit.

[2 marks]

gradient = ______________________ V A^{-1}

Question 10 continues on the next page

Turn over ►

Do not write outside the box

10.5 The equation that relates V and I is

$$V = \varepsilon - I r$$

Determine the values of ε and r.

[2 marks]

$\varepsilon =$ ____________________ V

$r =$ ____________________ Ω

8

Do not write outside the box

Turn over for the next question

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Do not write outside the box

1 1 **Figure 11** shows how an ultrasound scanner can be used to determine the depth of internal organs below the skin. A transducer emits an ultrasound pulse and then detects reflections of the pulse from internal organs. The reflected pulses are displayed on an oscilloscope screen.

Figure 11

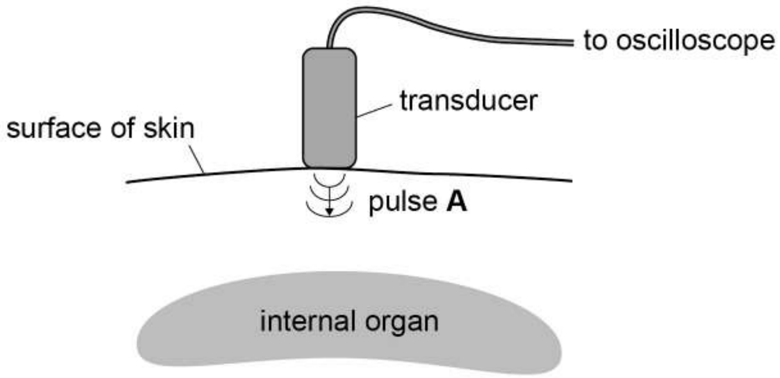
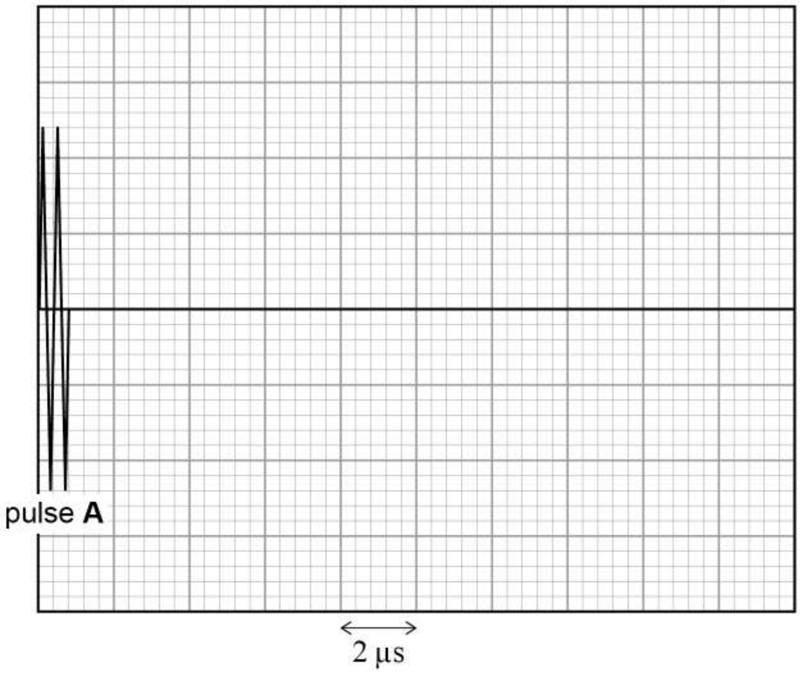


Figure 12 shows the oscilloscope display for an ultrasound pulse **A**. The time-base of the oscilloscope is set to $2\ \mu s$ per division.

Figure 12



Do not write outside the box

11.1 Determine the frequency of the ultrasound waves in pulse **A**.

[3 marks]

frequency = ________________________ Hz

11.2 One reflection of pulse **A** is detected $12.6\ \mu s$ after it was transmitted.

Sketch on **Figure 12** the appearance of the reflection of pulse **A**.

[2 marks]

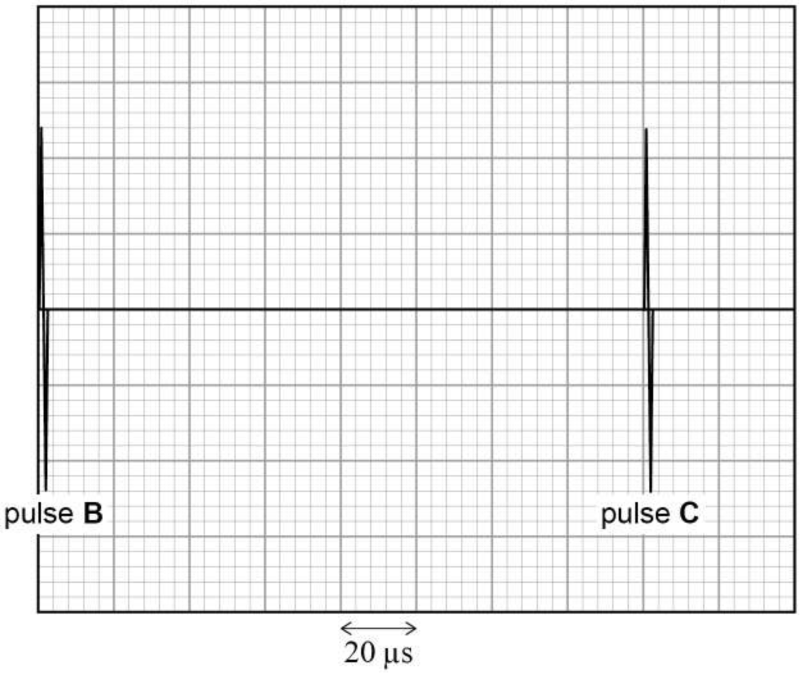
Question 11 continues on the next page

Do not write outside the box

1 1 . 3 The scanner emits ultrasound pulses at regular time intervals.

Figure 13 shows an oscilloscope display of two successive pulses, **B** and **C**, emitted from the scanner. The time-base of the oscilloscope is now set to $20\ \mu s$ per division.

Figure 13



The reflections of pulse **B** must be detected before pulse **C** is emitted, so there is a maximum depth that can be measured for an internal organ.

Calculate this maximum depth.

speed of ultrasound in body tissue $= 1540\ \text{m s}^{-1}$

[3 marks]

maximum depth = ____________________ m

8

Do not write outside the box

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 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.
Do **not** use additional sheets for this working.

1 2 The table shows the values of V and corresponding values of I for components **A**, **B**, **C** and **D**.

	A	**B**	**C**	**D**
V / V	I / A	I / A	I / A	I / A
0	0.0	0.0	0.0	0.0
2	0.4	0.9	0.2	0.0
4	0.8	1.5	0.4	0.1
6	1.2	1.9	0.6	0.7
8	1.6	2.1	0.8	1.4
10	2.0	2.2	1.0	2.1

Which component is an ohmic conductor with the lowest resistance?

[1 mark]

A ⬭

B ⬭

C ⬭

D ⬭

Do not write outside the box

1 3 A metal wire has resistance R. The wire is cut in half and the two cut pieces are joined in parallel to form one component.

What is the resistance of the component?

[1 mark]

A $4R$ ⬭

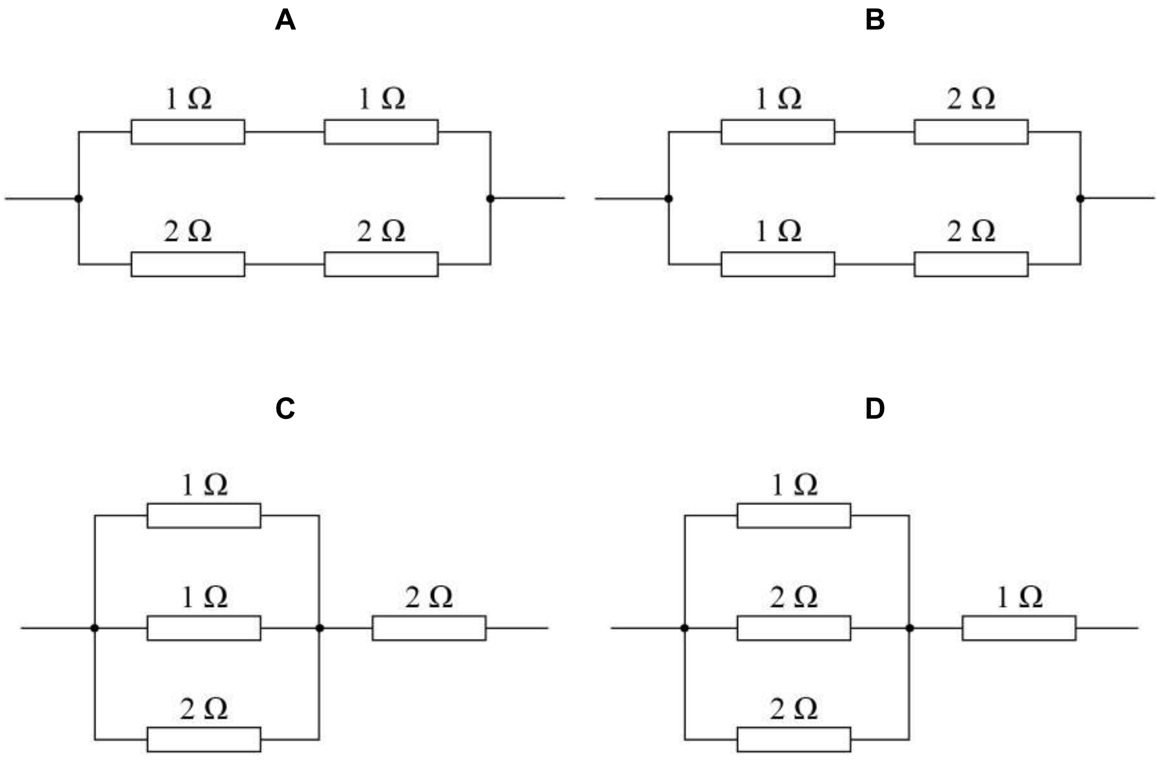
B $2R$ ⬭

C $\frac{R}{2}$ ⬭

D $\frac{R}{4}$ ⬭

1 4 Which network of resistors has the largest total resistance?

[1 mark]



A ⬭

B ⬭

C ⬭

D ⬭

Do not write outside the box

1 5 A solid copper cylinder has volume $1.3 \times 10^{-4}\ \text{m}^3$ and length $15\ \text{cm}$. Copper has a resistivity of $1.7 \times 10^{-8}\ \Omega\ \text{m}$.

What is the resistance between the two ends of the copper cylinder?

[1 mark]

A $2.9 \times 10^{-6}\ \Omega$ ⬭

B $2.0 \times 10^{-5}\ \Omega$ ⬭

C $2.0 \times 10^{-3}\ \Omega$ ⬭

D $2.9 \times 10^{-2}\ \Omega$ ⬭

1 6 What is a unit for potential difference?

[1 mark]

A $\text{A}\ \Omega^{-1}$ ⬭

B $\text{C}\ \text{J}^{-1}$ ⬭

C $\text{J}\ \text{A}^{-1}\ \text{s}^{-1}$ ⬭

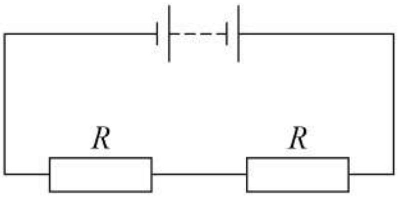
D $\text{W}\ \text{A}$ ⬭

Turn over for the next question

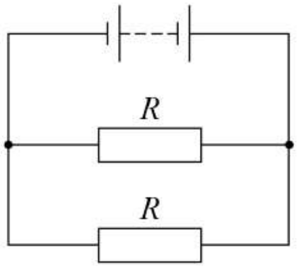
Do not write outside the box

1 7 The components in circuits **X** and **Y** are identical. The cells have negligible internal resistance.

circuit **X**



circuit **Y**



What is the ratio $\frac{\text{power dissipated in circuit } \mathbf{X}}{\text{power dissipated in circuit } \mathbf{Y}}$?

[1 mark]

A 0.25 ⬭

B 0.50 ⬭

C 2.00 ⬭

D 4.00 ⬭

1 8 A mass oscillates on a spring **P** with a time period of 2.00 s. Spring **P** has stiffness k. The same mass now oscillates on spring **Q** of stiffness $3k$.

What is the time period of the oscillation of the mass on spring **Q**?

[1 mark]

A 0.67 s ⬭

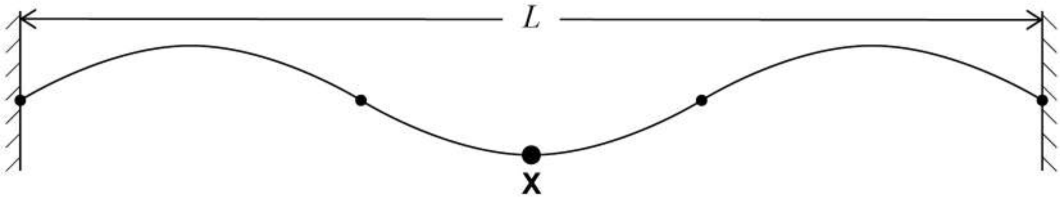
B 1.15 s ⬭

C 1.73 s ⬭

D 3.46 s ⬭

Do not write outside the box

1 9 A string oscillates at the third harmonic within a cavity of length L.
The speed of the wave is c.



Point **X** is at an antinode.

What is the shortest time before **X** returns to the same position?

[1 mark]

A $\frac{2L}{3c}$

B $\frac{3L}{2c}$

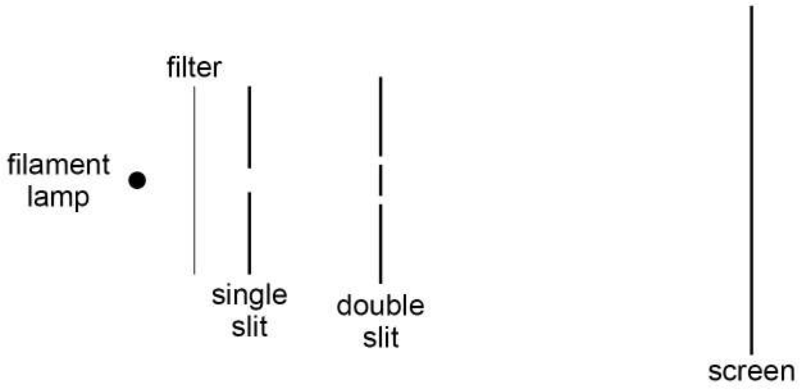
C $\frac{2c}{3L}$

D $\frac{3c}{2L}$

Turn over for the next question

Do not write outside the box

2 0 The diagram shows a demonstration of Young's double slit experiment.



Which change would increase the fringe separation observed on the screen?

[1 mark]

A Moving the lamp to the right

B Moving the single slit to the left

C Moving the double slit to the right

D Moving the screen to the right

2 1 Monochromatic light passes through a diffraction grating that has a line spacing of 2×10^{-6} m. The angle between the two $n = 2$ maxima is 64°.

What is the wavelength of this light?

[1 mark]

A 5.3×10^{-7} m

B 9.0×10^{-7} m

C 1.1×10^{-6} m

D 1.8×10^{-6} m

2 2 What change in the design of an optical fibre would reduce modal dispersion?

[1 mark]

A Decreasing the refractive index of the cladding

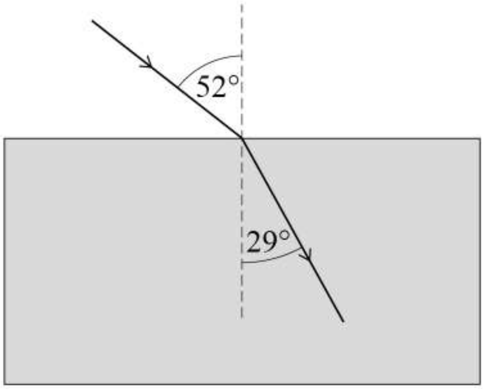
B Increasing the refractive index of the core

C Making the core narrower

D Making the core wider

Do not write outside the box

2 3 A ray of light passes from air into a transparent material.



What is the speed of light in the transparent material?

[1 mark]

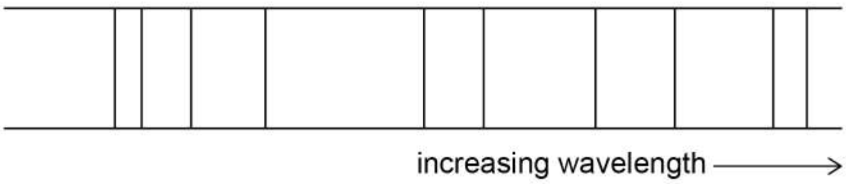
A 8.8×10^{6} m s^{-1}

B 1.7×10^{8} m s^{-1}

C 1.8×10^{8} m s^{-1}

D 3.0×10^{8} m s^{-1}

2 4 The diagram shows an atomic line spectrum.



What is the minimum number of energy levels in an atom that could produce this spectrum?

[1 mark]

A 4

B 5

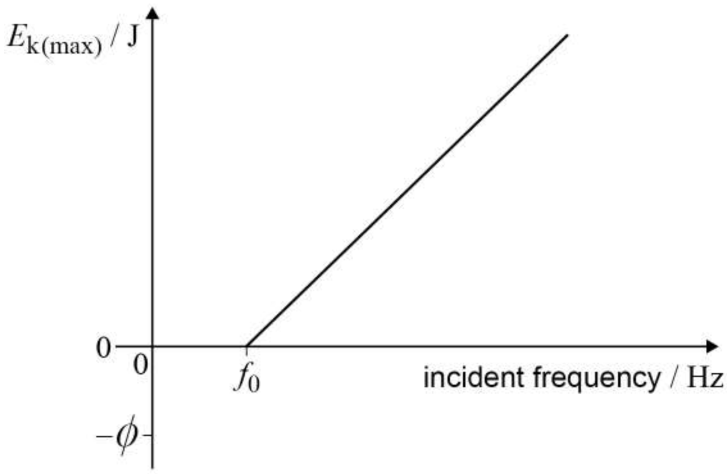
C 9

D 10

Do not write outside the box

2 5 Photoelectrons may be emitted from a metal surface when electromagnetic radiation is incident on the metal surface.

The graph shows the variation of the maximum kinetic energy $E_{k(max)}$ of the emitted photoelectrons with the frequency of the incident radiation.



Which expression is equivalent to the Planck constant?

[1 mark]

A $\dfrac{\text{gradient}}{f_0}$ ⬭

B $\dfrac{1}{\text{gradient}}$ ⬭

C $\dfrac{f_0}{\phi}$ ⬭

D $\dfrac{\phi}{f_0}$ ⬭

14

END OF QUESTIONS

Do not write outside the box

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Do not write outside the box

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

Do not write outside the box

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

Do not write outside the box

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

Do not write outside the box

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

Do not write outside the box

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Copyright information

For confidentiality purposes, acknowledgements of third-party copyright material will be published in a separate booklet rather than including them on the examination paper or support materials. This booklet is published after each examination series and is available for free download from www.oxfordaqaexams.org.uk after the live examination series.

Permission to reproduce all copyright material has been applied for. In some cases, efforts to contact copyright-holders may have been unsuccessful and Oxford International AQA Examinations will be happy to rectify any omissions of acknowledgements. If you have any queries please contact the Copyright Team, AQA, Stag Hill House, Guildford, GU2 7XJ.

Copyright © 2019 Oxford International AQA Examinations and its licensors. All rights reserved.