OCR
RECOGNISING ACHIEVEMENT

**OXFORD CAMBRIDGE AND RSA EXAMINATIONS**

**Advanced Subsidiary GCE**

# PHYSICS (B) (ADVANCING PHYSICS) 2860

Physics in Action

Friday **9 JUNE 2006** Morning 1 hour 30 minutes

Candidates answer on the question paper.
Additional materials:
Data, Formulae and Relationships Booklet
Electronic calculator
Ruler (cm/mm)

| Candidate Name | Centre Number | Candidate Number |
|---|---|---|
| | | |

**TIME** 1 hour 30 minutes

## INSTRUCTIONS TO CANDIDATES

- Write your name in the space above.
- Write your Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Write your answers in the spaces provided on the question paper.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Show clearly the working in all calculations and give answers to only a justifiable number of significant figures.

## INFORMATION FOR CANDIDATES

- You are advised to spend about 20 minutes on Section A, 40 minutes on Section B and 30 minutes on Section C.
- The number of marks is given in brackets [ ] at the end of each question or part question.
- There are four marks for the quality of written communication in Section C.
- The values of standard physical constants are given in the Data, Formulae and Relationships Booklet. Any additional data required are given in the appropriate question.

| FOR EXAMINER'S USE | | |
|---|---|---|
| **Section** | **Max.** | **Mark** |
| **A** | **20** | |
| **B** | **40** | |
| **C** | **30** | |
| **TOTAL** | **90** | |

**This question paper consists of 23 printed pages and 1 blank page.**



Registered Charity Number: 1066969
**[Turn over**

For Examiner's Use

Answer all the questions.

## Section A

1 Here is a list of units.

$kg\ m^{-3}$ $Jm^{-2}$ $Nm$ $Nm^{-2}$

Choose the correct unit for

(a) Young modulus .....

(b) density. ..... [2]

2 A teacher uses a portable radio to demonstrate some properties of waves.
He tunes in to a VHF station.

(a) He obtains the strongest signal when the aerial is vertical as shown below.

**An image has been removed due to third party copyright restrictions**

Details: An image of a portable radio with the aerial pointing upwards

aerial

However, the signal fades to a minimum when he rotates the radio through 90°, as shown below.

**An image has been removed due to third party copyright restrictions**

Details: An image of a portable radio standing on its side with the aerial pointing to the left

State the property of transverse waves that this experiment demonstrates.

[1]

(b) The teacher rotates the radio once more through another 90°, as shown below.

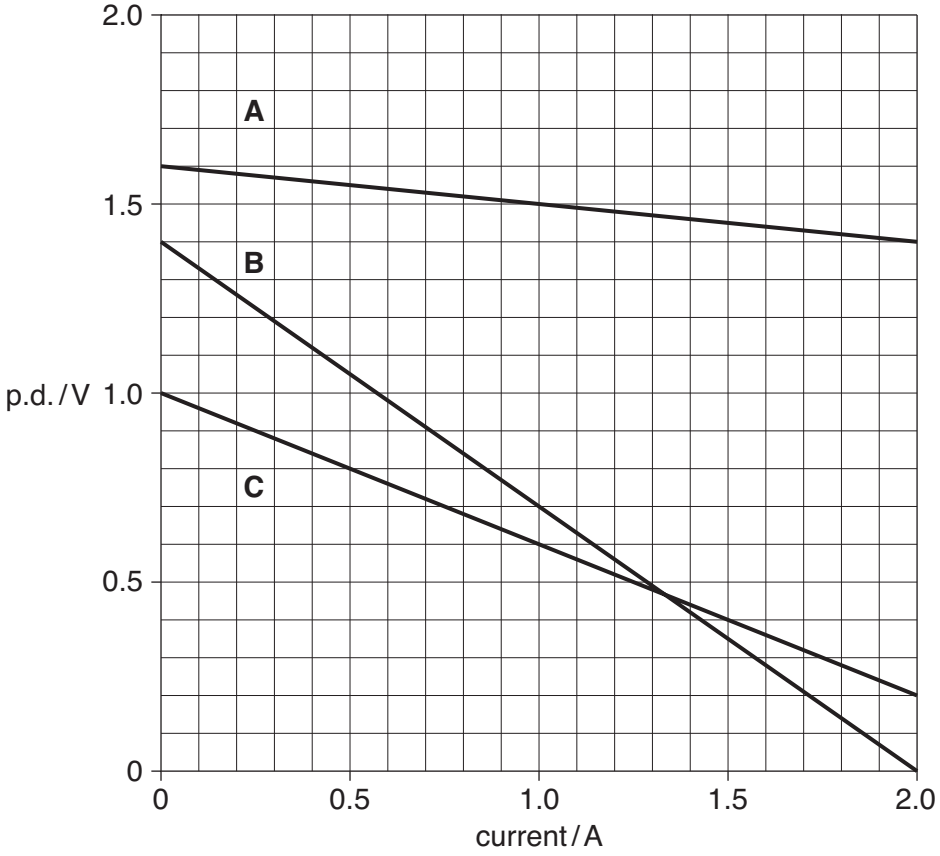
**An image has been removed due to third party copyright restrictions**

Details: An image of a portable radio which is upside down with the aerial pointing downwards

State and explain the effect this has on the strength of the received signal.

[2]

**3** The graph below shows how the p.d. across three different cells **A**, **B**, and **C** decreases as more current is drawn from each.




State which of the cells **A**, **B** or **C**

**(a)** has the smallest emf .....

**(b)** will deliver the most electrical power at a current of 1.0 A .....

**(c)** has the smallest internal resistance. .....

[3]

**4** Fig. 4.1 shows part of a scanning tunnelling microscope (STM).
Electrons flow between a fine tip and the surface.

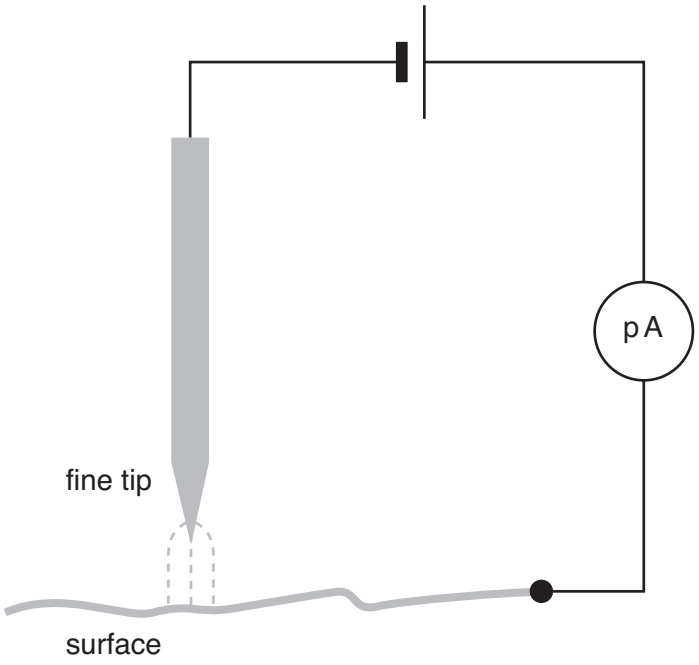



**Fig. 4.1**

20 million electrons per second flow between the tip and the surface.

Calculate the current in the circuit.

charge on electron, $e = 1.6 \times 10^{-19}$ C

current = ..... A [2]

5 Fig. 5.1 shows an STM image of 34 iron atoms arranged in a rectangle on a copper surface.

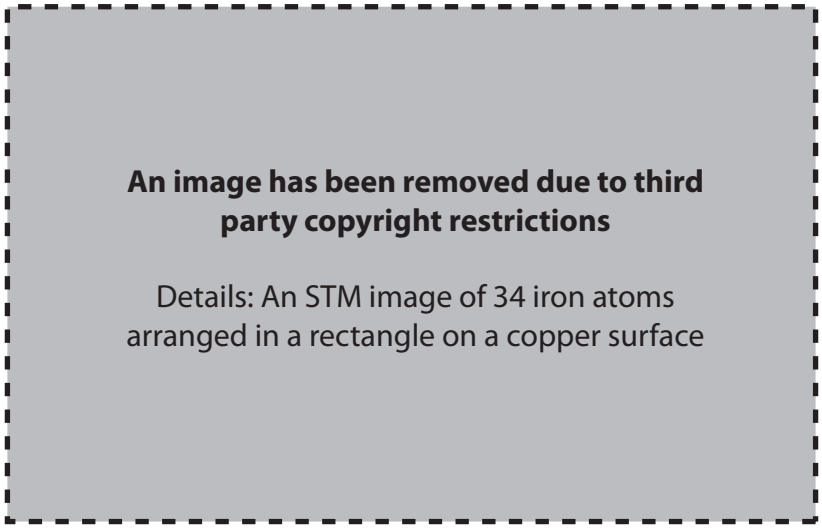



Fig. 5.1

The length of the front row of iron atoms is 2.1 nm.

Calculate the diameter of an iron atom.
Give your answer to 2 significant figures.
Show your working clearly.

diameter of iron atom = ..... m [2]

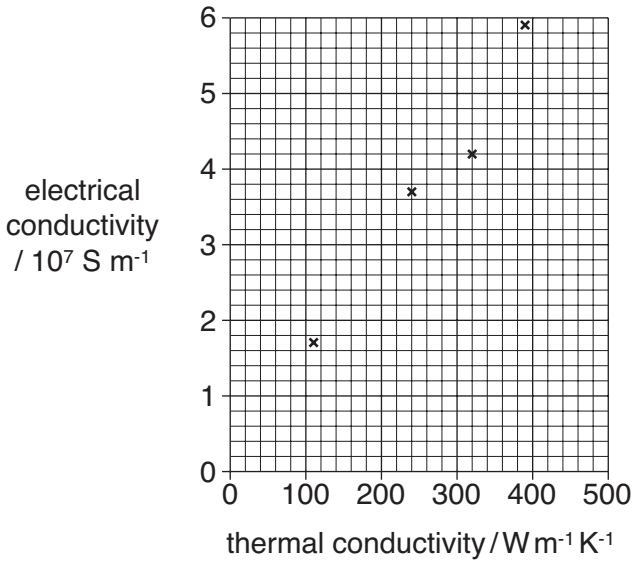
**6** The table shows the thermal and electrical conductivities of five pure metals.

| | thermal conductivity / W $m^{-1}$ $K^{-1}$ | electrical resistivity / Ω m | electrical conductivity / S $m^{-1}$ |
|---|---|---|---|
| aluminium | 240 | $2.7 \times 10^{-8}$ | $3.7 \times 10^{7}$ |
| copper | 385 | $1.7 \times 10^{-8}$ | $5.9 \times 10^{7}$ |
| gold | 310 | $2.4 \times 10^{-8}$ | $4.2 \times 10^{7}$ |
| magnesium | 150 | $4.0 \times 10^{-8}$ | |
| zinc | 110 | $5.9 \times 10^{-8}$ | $1.7 \times 10^{7}$ |

**(a)** Calculate the electrical conductivity of magnesium and record the value in the table.

[1]

**(b)** The data are plotted on the graph below.




Plot the point for magnesium on this graph. [1]

**(c)** **(i)** State the trend shown by this graph.

[1]

**(ii)** What microscopic feature of metals explains this trend?

[1]

**7** This question is about sampling an analogue signal and converting it into a binary digital code. The signal to be sampled is shown in Fig. 7.1.

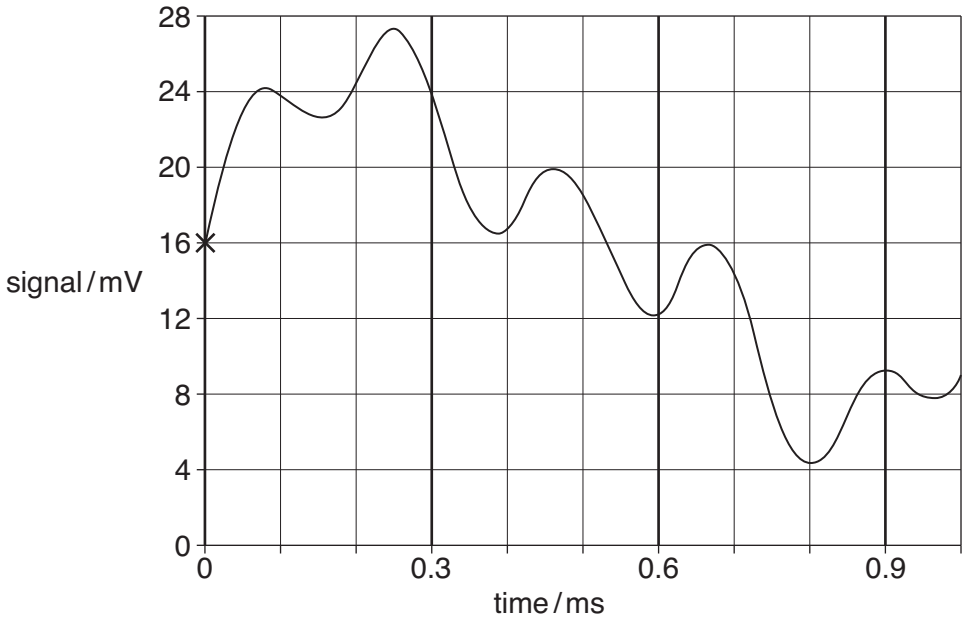



**Fig. 7.1**

The analogue signal is to be coded using 3 bit coding.
Each sample is to be taken to the **nearest** 4 mV level.

| closest voltage / mV | 0 | 4 | 8 | 12 | 16 | 20 | 24 | 28 |
|---|---|---|---|---|---|---|---|---|
| level | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| binary code | 000 | 001 | 010 | 011 | 100 | 101 | 110 | 111 |

**(a)** Sample the signal shown in Fig. 7.1 using 3 bit sampling at 0.3 ms intervals.

Plot your sampling points to the **nearest** 4 mV level on Fig. 7.1.
The first one has been done for you. [2]

**(b) (i)** Complete the first 9 bits of the digital code, for the first three samples at times 0.0, 0.3 and 0.6 ms in that order.
The first sample has been done for you.

| 1 | 0 | 0 | | | | | | |
|---|---|---|---|---|---|---|---|---|

[1]

**(ii)** Suggest **one** way that a signal reconstructed from this digital code would be different from the original signal shown in Fig. 7.1.

[1]

[Section A Total: 20]

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## Section B

**8** This question is about the heated **front windscreen** of a car.
The heater consists of resistance wires which are embedded in the glass.

**(a)** The power of the heater needs to be 180 W for satisfactory de-misting.

A car battery of negligible internal resistance supplies 12 V to operate the heated screen.

**(i)** Calculate the current required to deliver a power of 180 W.

current = ..... A [2]

**(ii)** Show that the resistance of the heater when operating is about 1 Ω.

[2]



**[Turn over**

**(b)** The heater consists of 200 wires inside the glass.
These wires are connected in parallel to the 12 V supply as shown in Fig. 8.1.

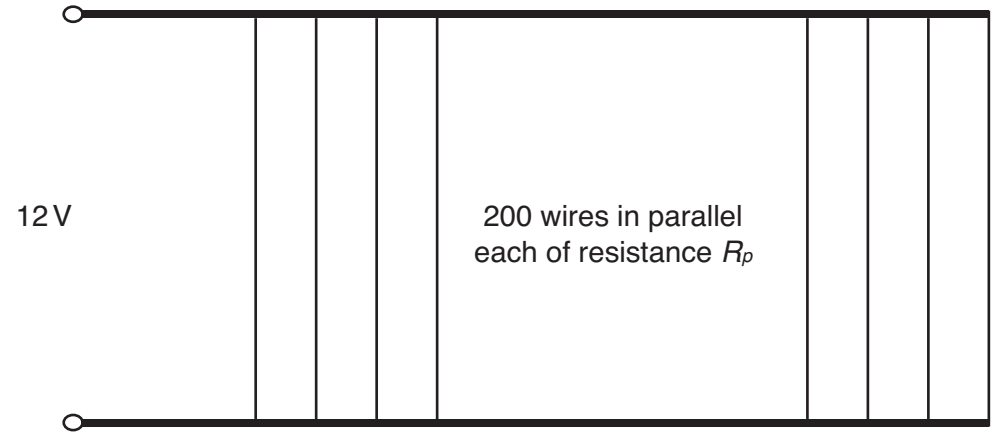



**Fig. 8.1**

Each of the 200 wires has a length of 0.70 m and resistance $R_p$ of 160 Ω.

The material of the wire has resistivity $\rho = 6.0 \times 10^{-7}\,\Omega\,\text{m}$.

Calculate the **diameter** of the wire.

diameter = ..... m [4]

**(c)** An alternative design has a heater of the **same power** rating.
The wires are connected in **series** as shown in Fig. 8.2.

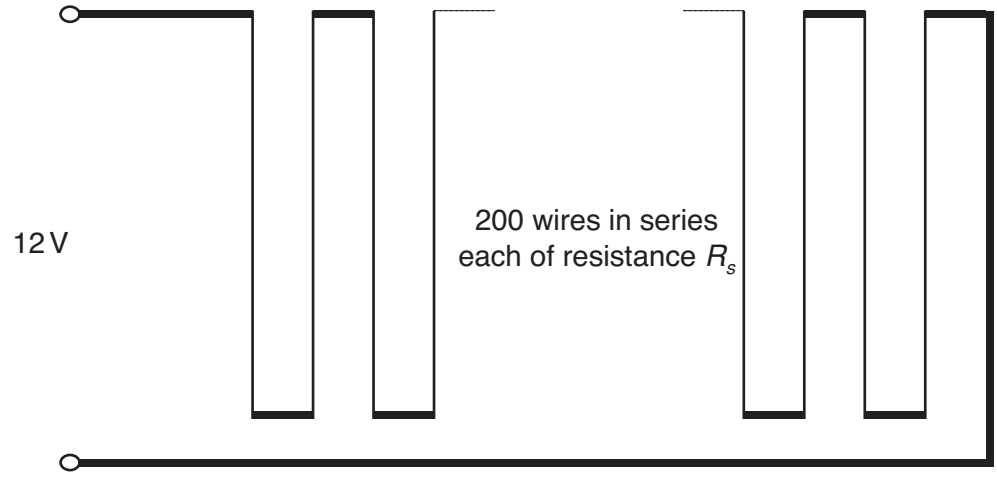



**Fig. 8.2**

The 200 wires are made of the **same material**, are each of length 0.7 m, but of resistance $R_s$.

**(i)** Calculate the resistance $R_s$ of each wire in this series arrangement, required to keep the resistance of the heater about 1 Ω.

$R_s$ = ..... Ω [1]

**(ii)** This series design would not work in this application, because the wires would have to be so thick that they would block the driver's vision.

Justify this statement.

[2]

[Total: 11]

9 Fig. 9.1 shows a diagram of part of a suspension bridge.

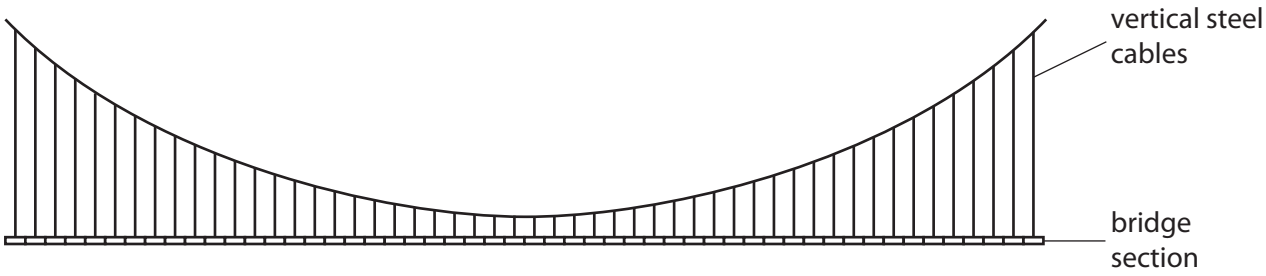



Fig. 9.1

(a) (i) Bridge sections are hung from uniform vertical steel cables.

State one mechanical property of steel that makes it a suitable material for these vertical cables.

..... [1]

(ii) Explain why this property is important.

[1]

(b) Two vertical cables support each bridge section as shown in Fig. 9.2.

**A diagram has been removed due to third party copyright restrictions**

Details: A diagram of a section of a bridge with two vertical cables coming out of it

Fig. 9.2

(i) Each bridge section weighs 1.8MN.
This weight causes a stress in each cable of 1.3 $\times 10^{8}$ Pa.

Show that the cross-sectional area of each cable is about 7 $\times 10^{-3}\,m^{2}$.

[3]

**(ii)** The longest vertical cables of the bridge are 150 m in length.

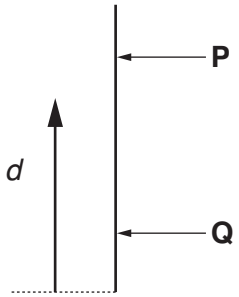
Calculate the extension of these cables when the bridge section is attached.

The Young modulus for steel = $2.1 \times 10^{11}$ Pa.

extension = ..... m [3]

**(c) (i)** Fig. 9.3 shows one freely hanging uniform vertical cable **before the bridge section is added**.

Suggest why the stress in the cable at **P** is greater than the stress at **Q**.

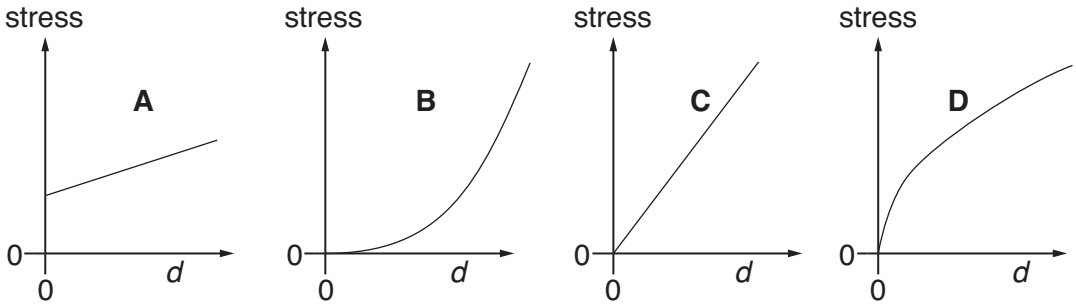



[1]

**Fig. 9.3**

**(ii)** Here are four graphs, **A**, **B**, **C**, **D**.

Select the graph which best represents how the stress in the vertical cable (y-axis) varies with distance *d* from the **bottom** of the cable (x-axis) **before the bridge section is added**.




answer ..... [1]

[Total: 10]

10 This question is about sound absorption in the home.
Fig. 10.1 shows a diagram of the construction of a sound-absorbing panel.

It consists of acoustic wool and strips of wood sandwiched between plasterboard sheets. Fig. 10.2 shows the sound reduction achieved across a range of frequencies.

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Details: A diagram of the construction of a sound-absorbing panel. The diagram shows acoustic wool and a strip of wood sanwiched between plasterboard sheets

Fig. 10.1

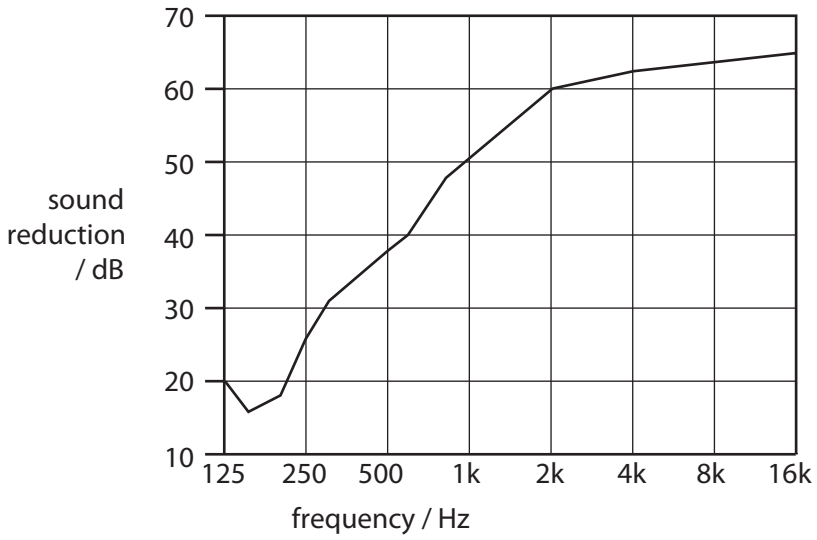


Fig. 10.2

(a) (i) Acoustic wool consists of a flexible mat of fibres in air as shown in Fig. 10.3.

**An image has been removed due to third party copyright restrictions**

Details: An image of a flexible mat of fibres

Fig. 10.3

Suggest a reason why acoustic wool is good at absorbing sound energy.

[1]

(ii) Wood transmits sound much better than acoustic wool.

Suggest a reason why wood is needed for the construction of the panel.

[1]

(b) (i) The frequency scale of Fig. 10.2 is logarithmic.

What feature of the scale shows this?

[1]

(ii) Suggest a reason why it is useful to display sound absorption data over the frequency range from 125 Hz to 16 kHz.

[1]

**(iii)** The sound absorbing panel reduces the sound intensity of music being played in an adjacent room.

State how the graph shows that the sound absorbing panel is more effective for reducing vocal sounds than sounds from a large bass drum.

[3]

**(c)** The graph Fig. 10.2 shows the sound intensity reduction at each frequency.
The sound reduction in dB is calculated using the relationship

sound reduction = $10 \log_{10}(\boldsymbol{R})$ where $\boldsymbol{R} = \frac{\text{incident intensity}}{\text{transmitted intensity}}$ .

When the incident intensity is 100 times greater than the transmitted intensity, the value of $\boldsymbol{R}$ is 100.

Calculate the sound reduction in dB for $\boldsymbol{R} = 100$.

sound reduction = ..... dB [2]

[Total: 9]

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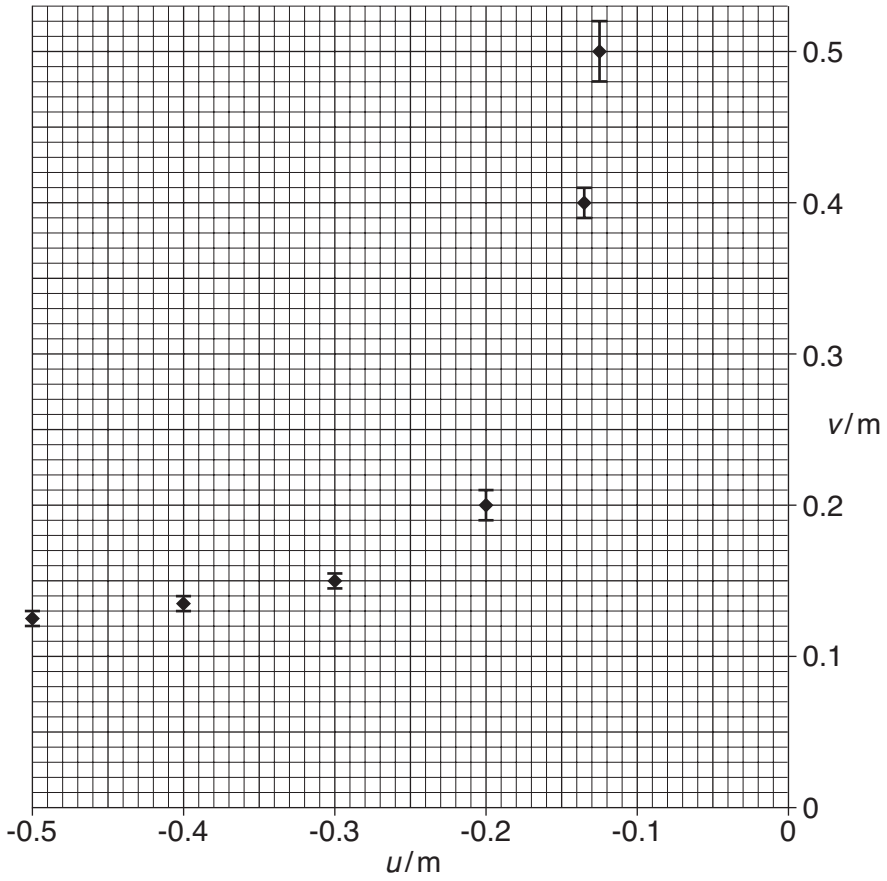
**[Turn over**

**11** A student uses a lens to form the image of a lamp filament on a screen.

**(a)** She obtains values of image distance *v* for different values of the object distance *u*. She plots a graph as shown below.




**(i)** The uncertainty (spread) in *v* values is indicated by the vertical error bars. The uncertainty in the *u* values is negligible.

Plot the point from the student's data given in the table below.
Include the error bar, to show the uncertainty.

| object distance $u$ / m | image distance $v$ / m | uncertainty in $v$ $\pm$ $v$ / m |
|---|---|---|
| –0.150 | 0.300 | 0.010 |

[2]

**(ii)** Draw the curve of best fit for the data points on the graph above. [1]

**(b) (i)** Suggest a practical difficulty that could lead to the uncertainty in the measurement of $v$.

**(ii)** Suggest how this difficulty might be overcome.

[2]

**(c) (i)** The student uses the data to calculate the focal length of the lens using the relationship

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}.$$

Complete the row in the table below for the curvatures of the wavefronts entering and leaving the lens, and for the curvature added by the lens. [1]

| object distance $u$ / m | image distance $v$ / m | curvature entering lens $\frac{1}{u}$ / D | curvature leaving lens $\frac{1}{v}$ / D | curvature added by lens $\left\{\frac{1}{v} - \frac{1}{u}\right\}$ / D |
|---|---|---|---|---|
| –0.150 | 0.300 | | | |

**(ii)** For **one** other data point on the graph, show that the curvature added to wavefronts by the lens is **approximately constant** by completing the row in the table below. [1]

| object distance $u$ / m | image distance $v$ / m | curvature entering lens $\frac{1}{u}$ / D | curvature leaving lens $\frac{1}{v}$ / D | curvature added by lens $\left\{\frac{1}{v} - \frac{1}{u}\right\}$ / D |
|---|---|---|---|---|
| | | | | |

**(iii)** Calculate the focal length of the lens used in this experiment.

focal length = ..... m [1]

**(iv)** Suggest how you could use the student's data to estimate the uncertainty in the value of the focal length.

[2]

[Total: 10]

[Section B Total: 40]

## Section C

In this section, you will choose the context in which you give your answers.

Use diagrams to help your explanations and take particular care with your written English. In this section, four marks are available for the quality of written communication.

**12** This question is about an electrical sensing system to measure a change in a physical property of the environment, for example light intensity, temperature, strain etc.

**(a) (i)** State the physical property that your choice of sensing system will measure, and a suitable transducer (sensor) for the sensing system.

physical property ..... transducer ..... [1]

**(ii)** Draw a circuit diagram of the electrical sensing system of your choice.

[3]

**(b)** Explain how your circuit converts a change in the physical environment to an appropriate electrical output signal.

[3]

**(c)** To determine the quality of your electrical sensing system you might measure its

**sensitivity** **resolution** **response time**.

Choose **one** of these quantities.

**(i)** State the quantity chosen and its meaning.

quantity .....

meaning

[2]

**(ii)** Give an estimate of the value of this quantity for your system with appropriate units.

value ..... units ..... [1]

**(iii)** Describe the experimental procedure you could perform to measure this quantity. Make clear the measurements you would take and how you would work out its value.
You are encouraged to use graphs and / or diagrams in your answer.

[3]

[Total: 13]



**[Turn over**

**13** This question is about an experiment to measure the refractive index of glass.
You may describe any suitable experiment of your choice.

**(a)** Draw a labelled diagram to show how you would set up an experiment to measure the refractive index of glass.

[3]

**(b)** Describe clearly how you would carry out the experiment and obtain the data required.

[3]

**(c)** Describe how you would use the data to obtain a value for the refractive index of glass.

[3]

**(d)** **(i)** For a sample of glass: refractive index for red light = 1.484

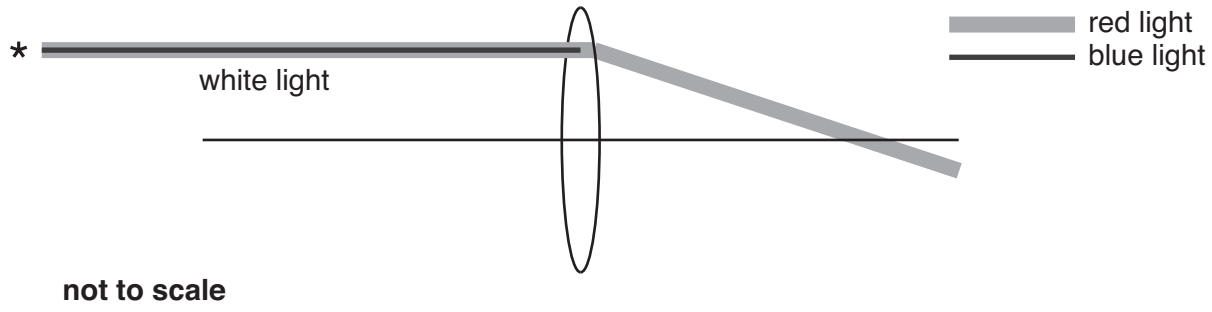
refractive index for blue light = 1.492

Explain how these data show that red light travels faster than blue light in this glass.

[2]

**(ii)** A lens made from this glass forms a real image of a distant white light source. Fig. 13.1 shows the red component of white light being refracted by the lens.

Complete the diagram showing the refraction of blue light by the lens.




[1]

**Fig. 13.1**

**Question 13 is continued over the page.**

(iii) Suggest how this dispersion of light might affect the appearance of the image of the white light source.

[1]

[Total: 13]

[Quality of Written Communication: 4]

[Section C Total: 30]

END OF QUESTION PAPER