RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary GCE

PHYSICS (B) (ADVANCING PHYSICS) 2860

Physics in Action

Wednesday **12 JANUARY 2005** Morning 1 hour 30 minutes

Candidates answer on the question paper.
Additional materials:
Data, Formulae and Relationships Booklet
Electronic calculator
Ruler

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 round 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 20 printed pages.

Answer **all** the questions.

Section A

1 Fig. 1.1 shows a plot of strength against toughness for different materials. Four areas have been shaded and labelled **A, B, C** and **D**.

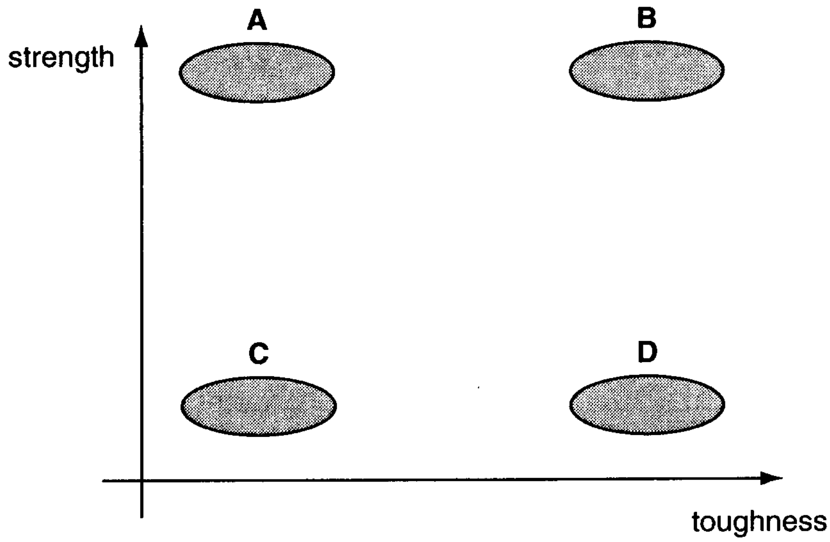


Fig. 1.1

Select the area of the graph, **A, B, C** or **D**, that best fits each of the following materials.

a material suitable for car bodies e.g. steel ....

a weak material that is easy to snap e.g. biscuit ....

a brittle metal e.g. cast iron under tension .... [3]

For Examiner's Use

2 Fig. 2.1 and Fig. 2.2 show two satellite images, taken about two weeks apart in early 2000, of the Ninnis Glacier disintegrating into the Antarctic Ocean.

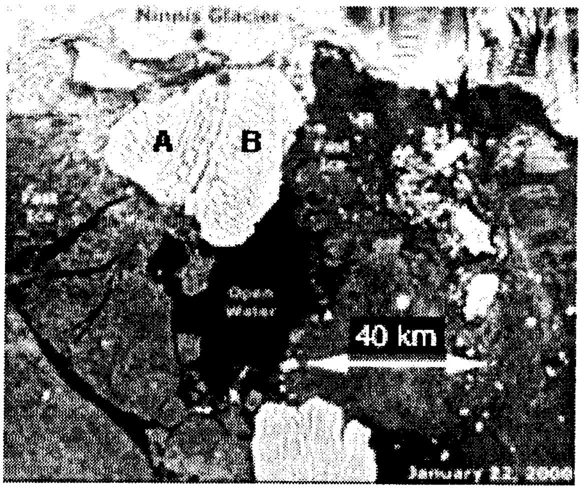


Fig. 2.1

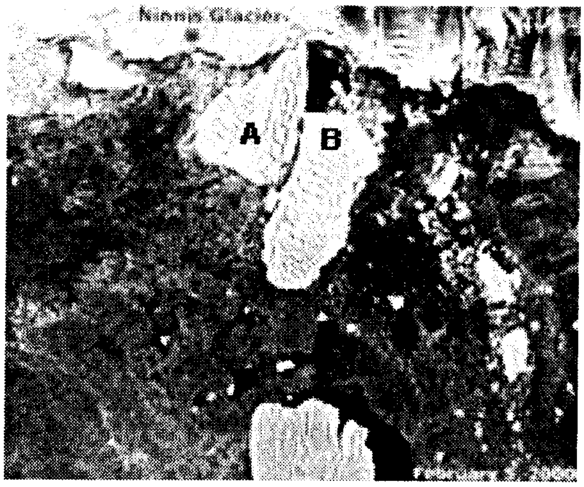


Fig. 2.2

(a) Both images are 300 pixels wide × 250 pixels high.
A 40 km scale marker has been added to Fig. 2.1.

Estimate the resolution of these images.

resolution = ... m pixel^{-1} [1]

(b) Estimate the distance ice shelf **B** has drifted during the two weeks.

distance = ... km [1]

(c) Suggest **one** aspect of human importance of the evidence presented in this pair of images.

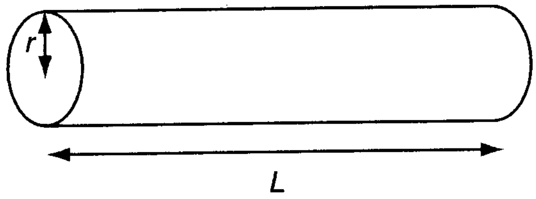
[1]

[Turn over

For Examiner's Use

3 This question is about the conductance G of a cylindrical wire given by the following equation.

$$G = \frac{\sigma A}{L} = \frac{\sigma \pi r^2}{L}$$



(a) State what the term πr^2 in the equation represents.

[1]

(b) Here is a list of multiplying factors.

$\times 4$ $\times 2$ $\times 1$ $\times \frac{1}{2}$ $\times \frac{1}{4}$

Select the factor that best describes the variations given below.

If the length L of the wire is doubled, the conductance G will be ....

If the radius r of the wire is halved, the conductance G will be ....

[2]

For Examiner's Use

4 Fig. 4.1 shows a ladder of conductivity values on a logarithmic scale, for three classes of conducting material.

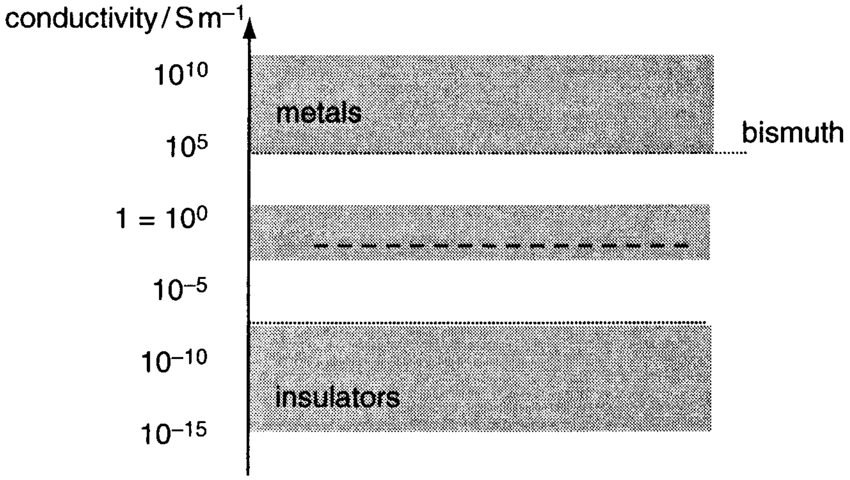


Fig. 4.1

(a) Label on Fig. 4.1 on the dashed line, the third class of conducting material. [1]

(b) The lowest conductivity of a metal indicated on the ladder is $9 \times 10^5\,\mathrm{S\,m^{-1}}$ for the metal bismuth.

Calculate the **resistivity** of bismuth. Give a suitable unit.

resistivity = ... unit .... [3]

5 Figs. 5.1 and 5.2 show the frequency components (spectra) of two sounds from a voice recognition system.

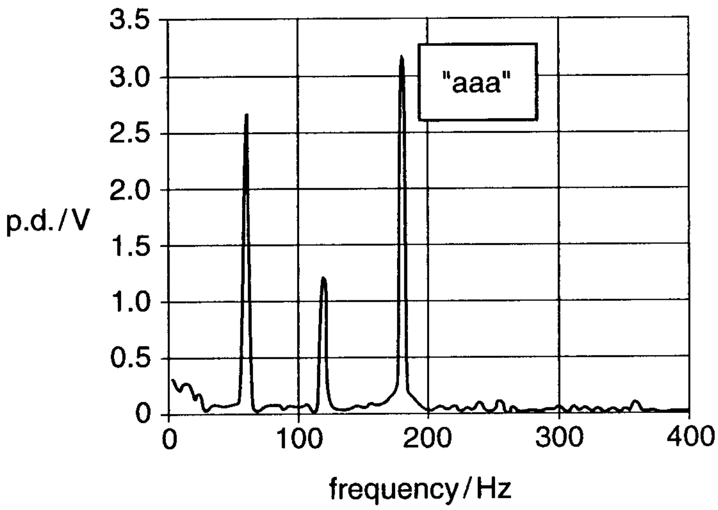


Fig. 5.1

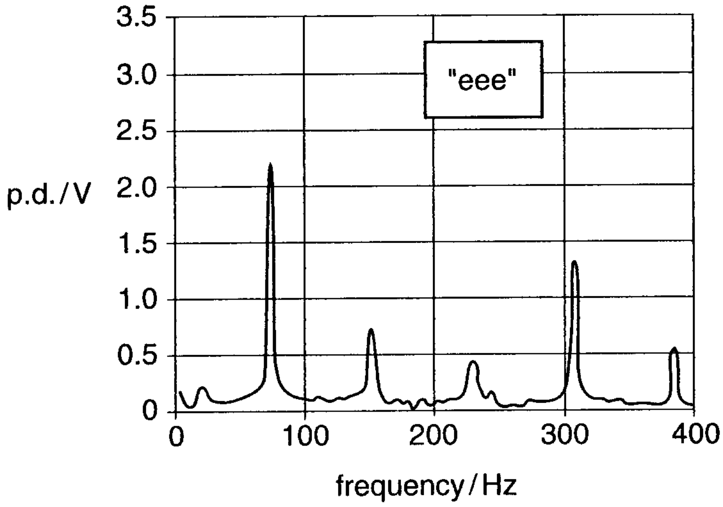


Fig. 5.2

(a) In Fig. 5.1, the voice was making an "aaa" sound, in Fig. 5.2 an "eee" sound.

Describe **two** differences between the sound spectra that would help you to distinguish between the sounds, by inspecting the spectra.

[2]

(b) The fundamental frequency component waveform of the "eee" spectrum at 77 Hz is shown in Fig. 5.3.

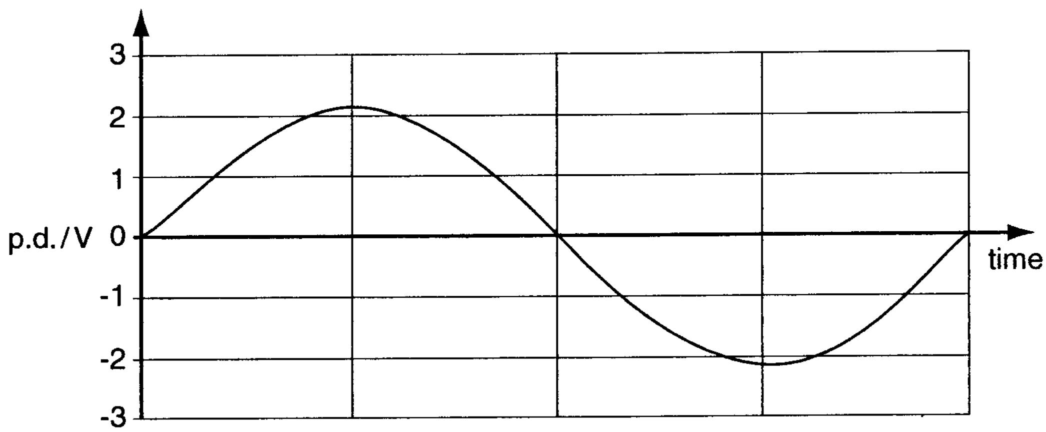


Fig. 5.3

Using information from Fig. 5.2, draw on Fig. 5.3 a waveform for the fourth harmonic component at 308 Hz at **four times** the fundamental frequency. [2]

6 Three equal resistors each of 100 Ω resistance are connected in the circuit shown in Fig. 6.1.

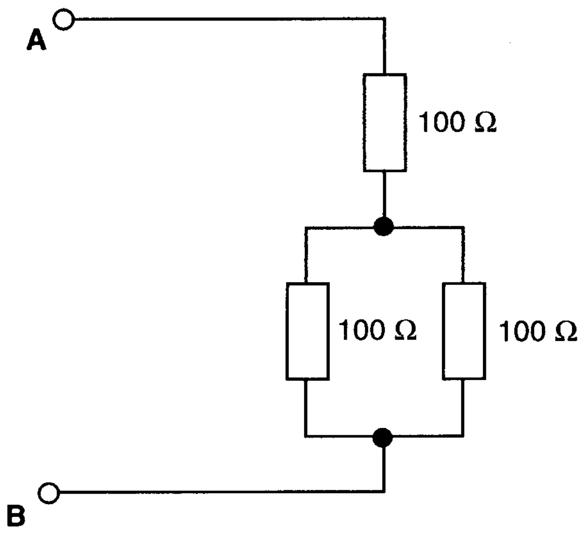


Fig. 6.1

(a) Calculate the total resistance of the circuit between points **A** and **B**.
Show your working.

resistance = ... Ω [2]

(b) The circuit is connected across a 12 V battery of negligible internal resistance.

Calculate the current drawn from the battery.

current = ... A [1]

[Section A Total: 20]

Section B

7 Read the paragraph below about the properties of spider silk.

Spider silk is a very strong material. It also requires a large energy to create new surface area or to break it. It is twice as strong as stainless steel, having a breaking stress of $2.0 \times 10^9\,N\,m^{-2}$. Yet, it can be stretched by more than one third of its original length and recover without permanent distortion.

(a) Here is a list of words describing mechanical properties of materials

elastic **hard** **plastic** **tough**

Choose **two words from this list** that best state the mechanical properties of spider silk as described in the paragraph.

.... and .... [2]

(b) A 'spiderwoman' weighs 550 N.

Calculate the **minimum** cross-sectional area of spider silk needed to support her weight.

cross-sectional area = ... m^2 [2]

(c) **(i)** Explain the meaning of *elastic limit* for a material.

[1]

(ii) At the elastic limit of spider silk, the strain is 0.35 and the stress is $1.6 \times 10^9\,N\,m^{-2}$.

Estimate the Young modulus for spider silk.

Young modulus = ... $N\,m^{-2}$ [2]

For Examiner's Use

(d) Spider silk consists of long chain polymer molecules.

Spider silk can 'be stretched by more than one third of its original length and recover without permanent distortion'.

(i) Sketch and label diagrams of a possible molecular structure for spider silk before and during stretching.

diagram of molecules before the silk is stretched

diagram of molecules while the silk is stretched

(ii) Describe how your proposed structure does enable spider silk to be stretched as described above.

[3]

[Total: 10]

For Examiner's Use

8 An active temperature sensor produces an emf $\mathcal{E}$ which depends on temperature. The points in Fig. 8.1 show how the emf varies with temperature. A straight line fitting the data up to 40 °C has been added to the graph.

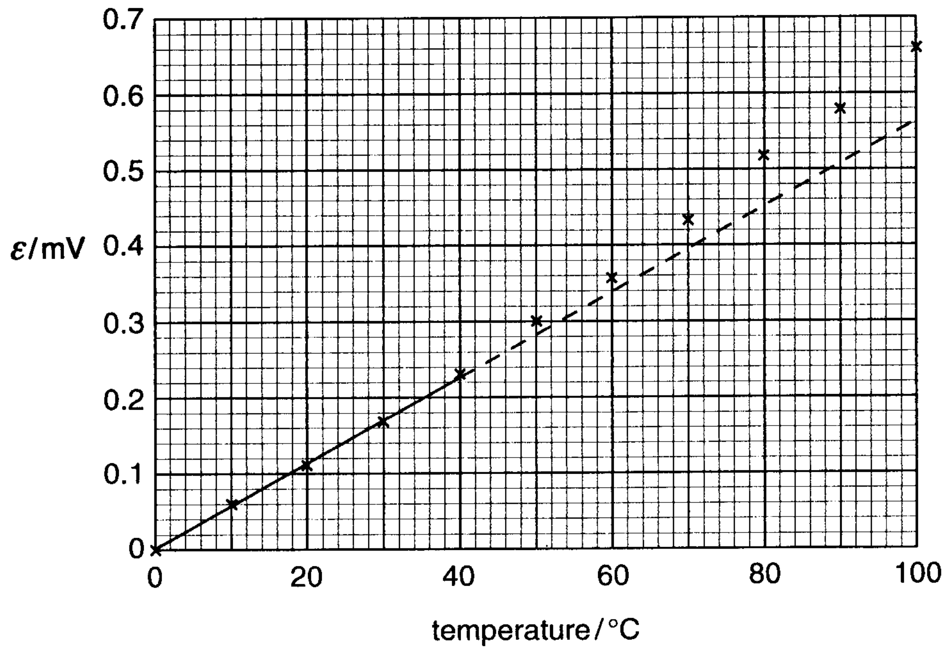


Fig. 8.1

(a) **(i)** Describe the relationship between the emf $\mathcal{E}$ and the temperature in °C shown by all the data points of Fig. 8.1.

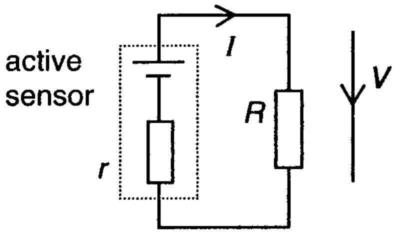
[2]

(ii) Estimate the **sensitivity** of the temperature sensor in the range 0 °C to 40 °C from the data points in Fig. 8.1.
Use units of μV °C^{-1} for the sensitivity.
Make your method of estimating the sensitivity clear.

sensitivity = ... μV °C^{-1} [2]

For Examiner's Use

(b) (i) Fig. 8.2 shows an active sensor of internal resistance r producing an emf $\mathcal{E}$ connected to an external resistance R.



The p.d. V across the sensor, and the current I in the circuit are given by the equations

$$V = \mathcal{E} - I\,r \quad \text{and} \quad I = \frac{\mathcal{E}}{(R + r)}.$$

Fig.8.2

Combine the equations to show that $V = \dfrac{\mathcal{E}\,R}{(R + r)}$.

[2]

(ii) The active temperature sensor has internal resistance $r = 0.2\,\Omega$.
Using **(b)(i)**, show that if an instrument of external resistance $R = 10\,\Omega$ is used to measure the p.d. across the sensor, it will show a reading that is about 98% of the emf $\mathcal{E}$.

[2]

(c) Instruments available to measure the output from the temperature sensor are given in the table below.

instrument	full scale deflection	sensitivity	internal resistance
moving coil meter	300 mm	$10\,\mu\text{V}\,\text{mm}^{-1}$	$10\,\Omega$
cathode ray oscilloscope	100 mm	$1.0\,\text{mV}\,\text{mm}^{-1}$	$25\,\text{M}\Omega$
digital voltmeter	$200\,\mu\text{V}$	$0.1\,\mu\text{V}$ steps	$2.0\,\text{M}\Omega$

The most suitable of these instruments to use for this sensor in the temperature range 0 to 100 °C is the **moving coil meter**.
Give **two** reasons why the **moving coil meter** is the most suitable, using the data in the table.

[2]

[Total: 10]

[Turn over

For Examiner's Use

9 This question is about a data-logger that runs on a battery supply.

(a) Sensors monitor the environment. They produce potential differences which are recorded by the data-logger. An analogue p.d. from a sensor is shown in Fig. 9.1.

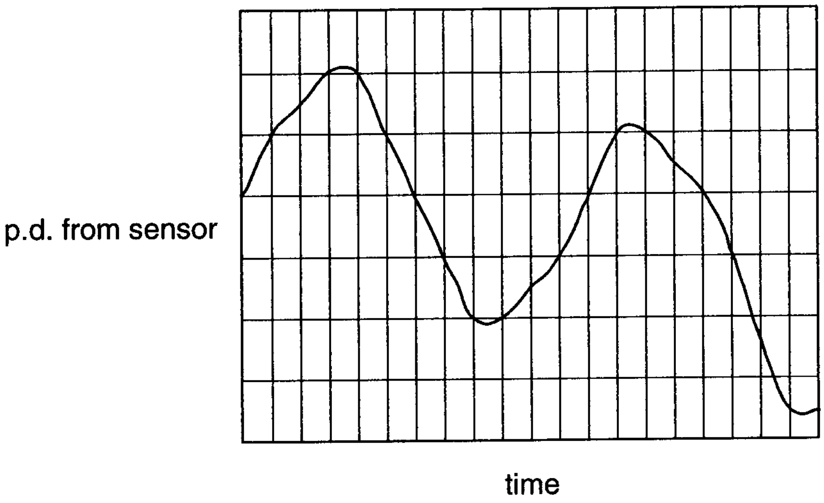


Fig. 9.1

The p.d.s are converted from analogue to digital form inside the data-logger.

(i) Describe, using Fig. 9.1, the process of converting an analogue signal to digital form. Adding annotation to Fig. 9.1 will be useful in your answer.

[3]

(ii) Each analogue sample is converted into a 10 bit number (10 bits per sample).

Calculate the number of alternative levels that the converter can resolve.

number of levels = ... [1]

(iii) The signal voltage ranges from 0 V to 9.0 V.
Show that the voltage resolution is about 9 mV.

[2]

For Examiner's Use

(b) The data-logger records 10 bits per sample from four sensors.
Samples are taken every 15 minutes ($\frac{1}{4}$ hour).
The data-logger is to collect data for 30 days unattended.

Show that the memory capacity that the data-logger needs to record all the data is greater than 10 kbytes.

[2]

(c) The battery in the data-logger can deliver a total charge of 500 C.
A current of 20 mA is needed to run the four sensors.
The memory circuit draws a negligible current from the battery.

Show that the battery **cannot** run the sensors for 30 days non-stop, so that the sensor circuits need to be switched off between readings.

[3]

[Total: 11]

10 A vertical filament lamp is placed a distance u in front of a converging lens as shown in Fig. 10.1.
A real image of height h is focused on the screen at distance v from the lens.

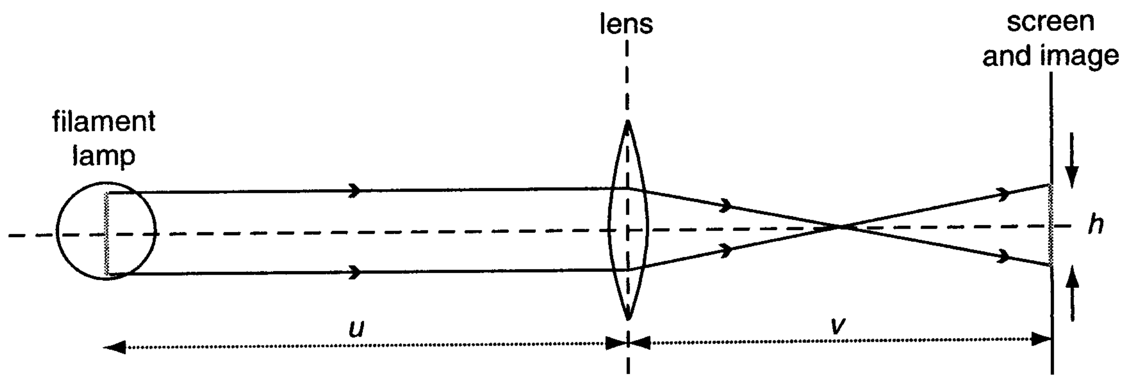


Fig. 10.1

(a) **(i)** On Fig. 10.1, mark with the letter **F** the principal focus of the converging lens. [1]

(ii) Explain using Fig. 10.1 why the real image is **inverted**.

[1]

(b) The distance of the screen from the lens is varied and the image is refocused by changing the object distance u. Values of h and v are measured and the data plotted (Fig. 10.2).

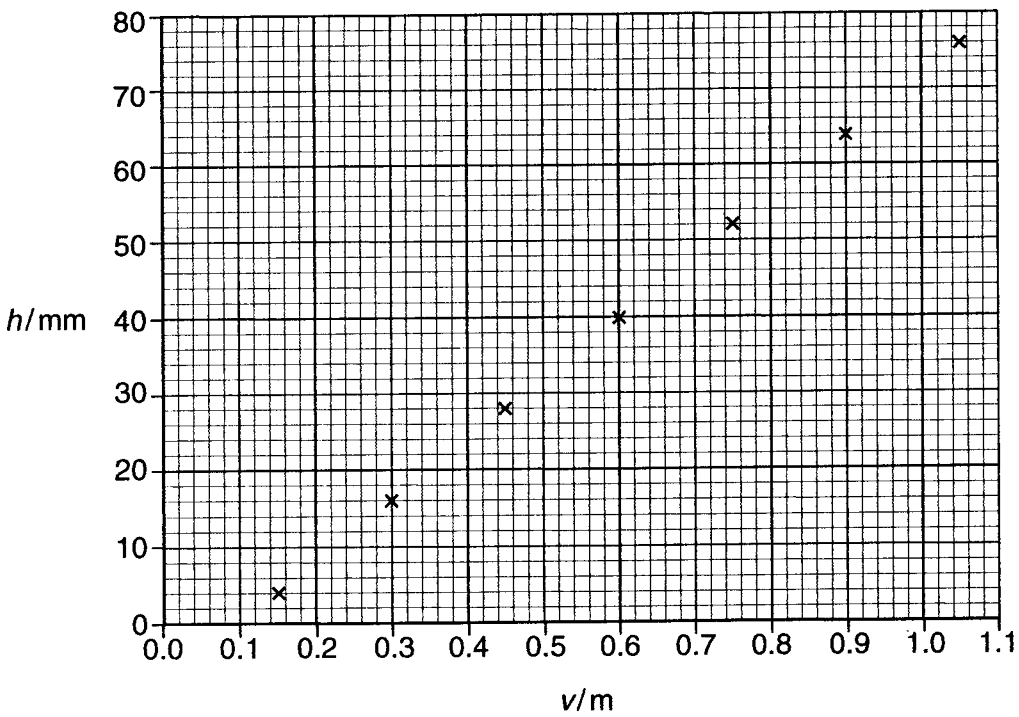


Fig. 10.2

For Examiner's Use

(i) Draw the line of best fit on Fig. 10.2. [1]

(ii) State the value of the intercept on the horizontal axis.

intercept = ... m [1]

(iii) Explain why this intercept is equal to the focal length of the lens.

[1]

(c) The filament lamp is placed 0.20 m behind the lens.

(i) Show that the **curvature** of waves entering the lens is –5.0 D.

[1]

(ii) The power of the lens is + 10 D.

Calculate the image distance *v*.

v = ... m [2]

(iii) Explain why the image is the same height as the object in this situation.

[1]

[Total: 9]

[Section B Total: 40]

For Examiner's Use

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.

11 In this question, you are asked to choose and discuss an image containing useful information, that can be processed.

(a) **(i)** Identify your chosen image ....

(ii) State **two** different kinds of information obtainable from your image. Explain why each kind of information is useful.

[4]

(b) Describe the system that forms your image. A labelled diagram will be useful in your answer.

[3]

For Examiner's Use

(c) The image can be improved by image processing.

State and describe how processing (e.g. modifying pixel values) could improve your image.

[3]

(d) Estimate the amount of information in your image, making your method clear.

[3]

[Total: 13]

[Turn over

For Examiner's Use

12 Materials are chosen, or can be designed, with properties suitable for a particular application. You are asked to illustrate these ideas with your own example.

(a) State your choice of material and give some details of an application of the material.

material ....

details of application

[3]

(b) State a physical property of your material that is important in your application.
Explain why the property is important.

[3]

For Examiner's Use

(c) Materials have internal structure, possibly on several different scales. Describe the internal structure of your material on a scale that helps you explain the property chosen in **(b)**.

Use a labelled diagram, indicating the scale of the structure, in your explanation.

[4]

(d) Materials can have a variety of applications depending on different properties. Your answers to **(d)** should be **different** to your answers to **(a)** and **(b)**.

(i) State a **second** physical property for your chosen material.

second property .... [1]

(ii) Suggest and explain a suitable application of your material that uses this property.

[2]

[Total: 13]

[Quality of Written Communication: 4]

[Section C Total: 30]

END OF QUESTION PAPER