OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
Advanced Subsidiary GCE

PHYSICS B (ADVANCING PHYSICS) PILOT & PHYSICS B (ADVANCING PHYSICS) 7730/2860

Physics in Action

Wednesday **6 JUNE 2001** Afternoon 1 hour 30 minutes

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

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 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

- The number of marks is given in brackets [ ] at the end of each question or part question.
- 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.
- You are advised to spend about 20 minutes on Section A, 40 minutes on Section B and 30 minutes on Section C.
- You will be awarded marks for the quality of written communication in Section C.

FOR EXAMINER'S USE		
Section	**Max.**	**Mark**
A	19	
B	41	
C	30	
TOTAL	90	

This question paper consists of 16 printed pages.

Registered Charity Number:1066969
[Turn over

Section A

1 In a digital image, the pixel values vary from 0 (white), to 255 (black). In the 5×5 array of pixels, shown in Fig. 1.1, there is noise.

100	100	100	100	100
100	100	100	100	100
100	100	244	100	100
100	100	100	100	100
100	100	100	100	100

Fig. 1.1 original image with noise

(a) Describe the appearance of the image.

[2]

The noise can be smoothed by **averaging** each pixel value with its surrounding 8 neighbours.

(b) The 3×3 array in figure 1.2 below represents the central 9 pixels in the averaged image. Write the averaged values for each of these 9 pixels on Fig. 1.2.

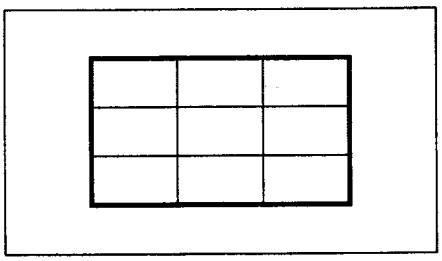

Fig. 1.2 averaged image

[2]

2 Metals have conductivities around $10^7\,S\,m^{-1}$.
Semiconductors have conductivities around $1.0\,S\,m^{-1}$.
Explain these large differences in conductivity.

[2]

3 Simon needs glasses for reading. Without glasses the nearest he can comfortably focus is 1.0 m away. He would like a normal reading distance of 0.25 m. This is illustrated in Fig. 3 below.

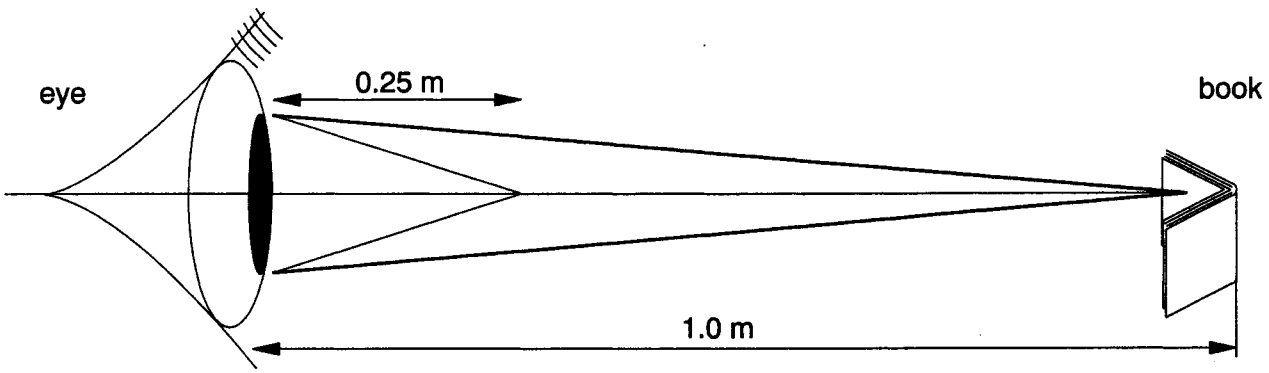

Fig. 3 (not to scale)

(a) What is the difference in curvature between the wavefronts arriving at his eye from these two distances?

difference in curvature = ... dioptre [2]

(b) What power is needed for his reading lenses?

power of lenses = ... dioptre [1]

4 A resistor is rated at 470 Ω and 0.25 W.

(a) Why is the resistor given a maximum power rating?

[1]

(b) Calculate the potential difference across the resistor, when the maximum power is 0.25 W.

potential difference = ... V [3]

5 A voice analogue waveform signal is illustrated in Fig. 5.

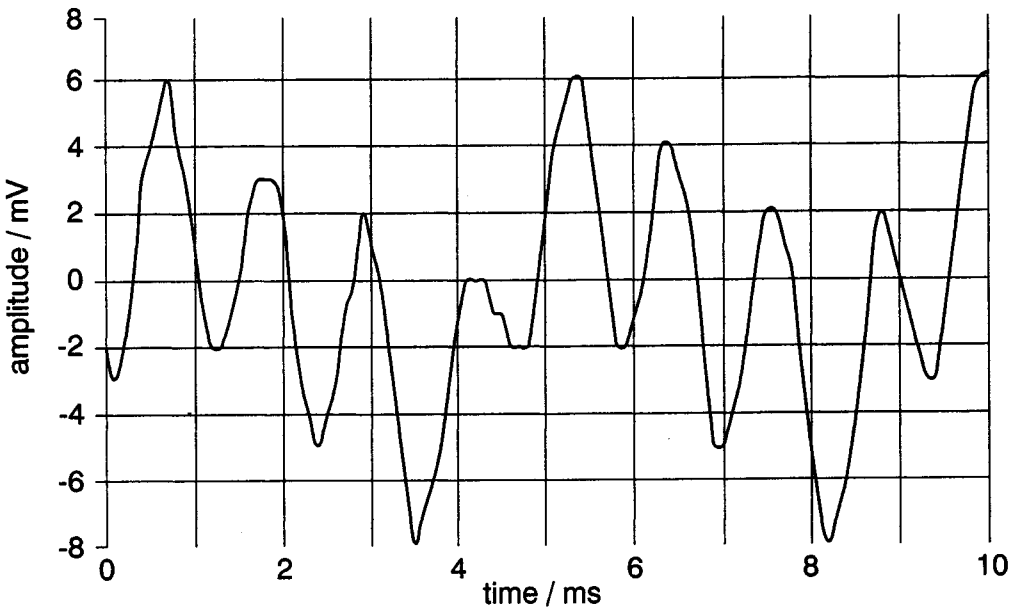

Fig. 5

(a) The waveform is to be digitised by sampling every 2 ms starting at time zero. Perform the sampling by plotting sampled points on Fig. 5. Draw a reconstructed waveform through these samples. [2]

(b) State one difference between the original and the reconstructed waveforms.

[1]

6 Fig. 6 shows the variation of potential difference with current for three electrical conductors A, B and C.

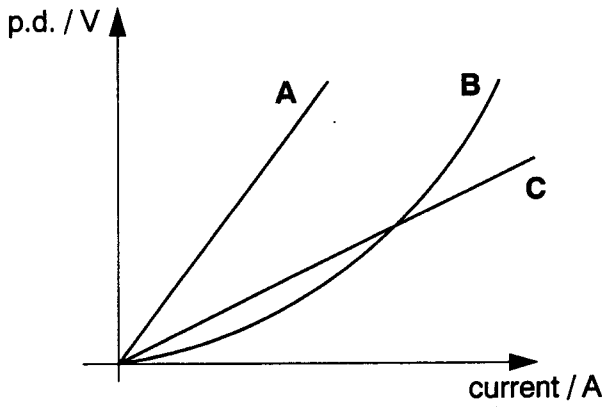

Fig. 6

(a) Which graph illustrates Ohm's Law for the largest resistance?

[1]

(b) How do the resistances of conductors B and C compare, at the point where the graphs B and C cross. Explain your answer.

[2]

Section B

7 A position sensor is needed on a greenhouse window.
The potentiometer is mounted at the window hinge as shown in Fig. 7.1. When the window opens, it rotates the wiper arm of a rotary potentiometer.

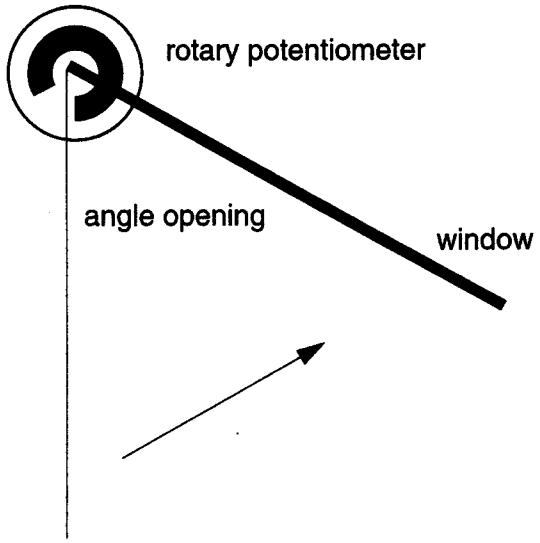

Fig. 7.1

The window may be opened between 0 and 60 degrees, but the rotary potentiometer has a 0 to 300 degree range.
The table in Fig. 7.2 shows the relationship between window position and potentiometer angle.

window position	potentiometer wiper angle / degree	output p.d. / V
shut vertical	0	0.0
fully open	60	
	300	3.0

Fig. 7.2

(a) A sensitivity of 10 mV / degree is required from the sensor.
Use this information to complete the third column in the table in Fig. 7.2. [1]

(b) The sensor circuit proposed is shown in Fig. 7.3.

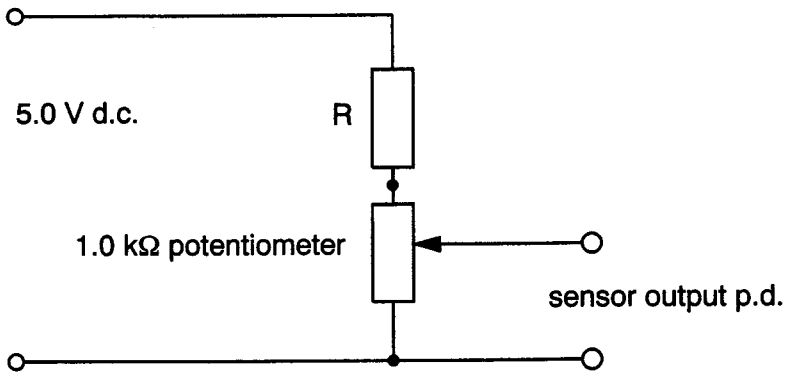

Fig. 7.3

(i) On Fig. 7.3 draw a circle around the variable wiper of the potentiometer. [1]

(ii) The sensor circuit is to run from a 5.0 V d.c. supply.
Explain the need for the fixed resistor R in the circuit.

[2]

(iii) Using data from the table in Fig. 7.2, calculate the value of R required if the potentiometer has a resistance of 1.0 kΩ.

[3]

(c) The potentiometer and the fixed resistor are made from the same composition carbon. The resistivity of carbon falls as the temperature rises. The window is fully open.
State and explain the effect on the sensor's output p.d. if the fixed resistor R is warmer than the potentiometer.

[3]

8 This question compares sending information by fax and by e-mail.

(a) A fax system converts an A4 page into an array of black (1) or white (0) pixels. There are 10 pixels per mm.
A letter **M** may occupy a square of side 2mm as shown magnified in Fig. 8.

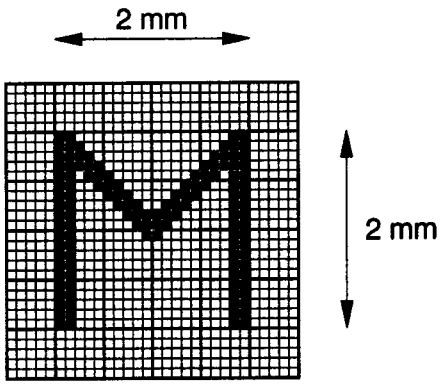

Fig. 8

(i) How many pixels are there in the 2 mm × 2 mm array?

number of pixels = ... [1]

(ii) How many bits are needed to code for each black or white pixel?

number of bits / pixel = ... [1]

(iii) How many bits are needed to code a letter (such as **M**) which occupies this area? (Assume no information compression is used).

number of bits = ... [1]

(b) **(i)** In e-mail, the letter **M** will be coded by a one byte international code. How many bits make a byte?

number of bits / byte = ... [1]

(ii) Each keyboard character (letter, number, punctuation etc.), has its own one byte code. How many different characters can be coded in a one byte code?

number of characters = ... [1]

(c) Compare and comment on the efficiency of coding information using fax and e-mail.

[2]

(d) Explain why photographic images do not transmit well on fax.

[2]

9 This question is about the passage of red light in a fibre optic lamp.

(a) Plane waves of light enter the thick glass fibre as shown in Fig. 9.1.

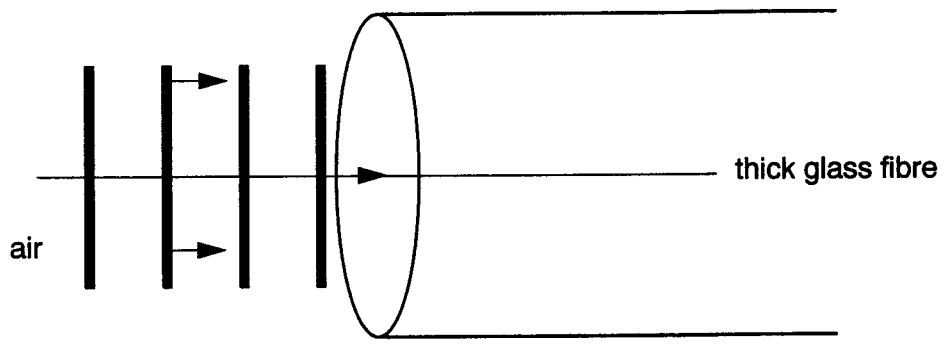

Fig. 9.1 (not to scale).

(i) Glass has a refractive index $n = 1.50$. Calculate the speed of light in the glass fibre.

speed of light in fibre = ... [3]

(ii) Complete the diagram in Fig. 9.1 to show the four wavefronts when they are in the fibre. [2]

(b) The light hits the end face of the thick glass fibre given in **(a)**.
The angle of incidence $i = 75°$ as shown in Fig. 9.2.

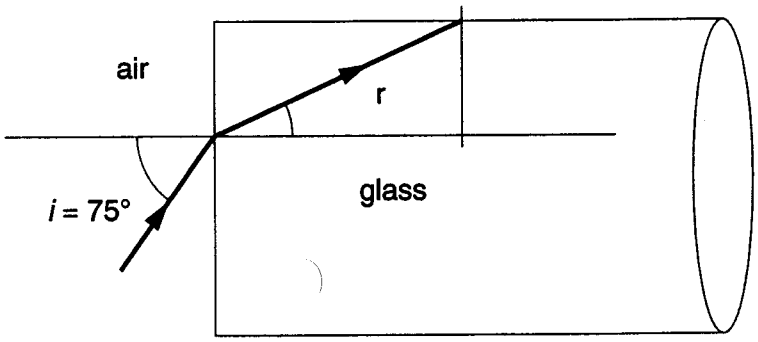

Fig. 9.2

(i) Calculate the angle of refraction r inside the glass?

angle of refraction r = ... ° [3]

(ii) The critical angle $C = 42°$ for this glass / air boundary.
Complete the diagram of Fig. 9.2 showing the ray's progress along the fibre.
Explain your reasoning.

[3]

10 A lift operates in a building 80 m tall. The cage of the lift weighs 4 000 N and is designed to carry a maximum additional load of 6 400 N. It is supported by a steel cable.

(a) (i) What is the maximum total tensile load acting on the cable?

tension in cable = ... N [1]

(ii) The steel cable that supports the lift has a tensile strength of 600 MPa. The Young modulus for steel is 200 GPa. Calculate the strain at the yield point.

breaking strain = ... [3]

(iii) Sketch the shape of the stress/strain graph for steel on Fig. 10.
Mark on your graph the point where the steel yields.

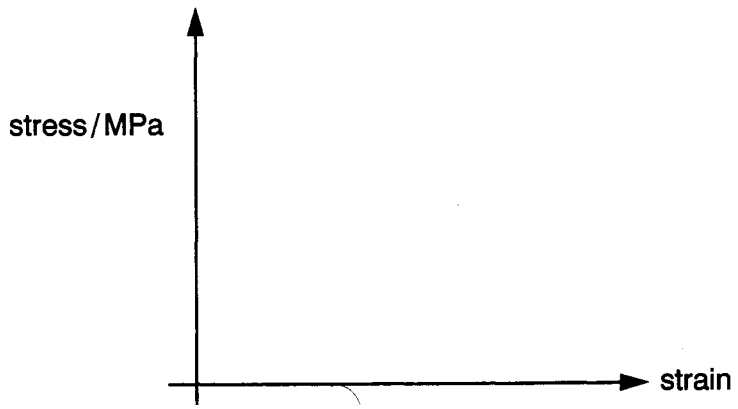

Fig. 10

[3]

(b) In choosing the thickness of the cable needed, the maximum static tensile stress should be $\frac{1}{4}$ of the tensile strength.
How much extension will this cause in the 80 m cable?

extension = ... m [4]

Section C

In this section of the paper you have the opportunity to write about some of the physics you have studied independently.

Use diagrams to help your explanations and take particular care with your written English. Up to four marks in this section will be awarded for the quality of your written communication.

11 This question is about images stored as data and displayed by computer. You are asked to give an example of such an image, to explain how it is produced, and to consider how it is of human benefit or scientific interest. You may choose any example which does **not** use visible light as the source of image data.

(a) (i) Describe the type of image you have chosen, and state the nature of the waves or radiation which carry the information needed to create the image.

[3]

(ii) Describe with the aid of a labelled diagram how the information for the image is obtained. Explain as appropriate, how emission, transmission, absorption and reflection of waves or radiation are involved.

[4]

(b) Describe one way of manipulating the image data so as to enhance the appearance of the image on the computer screen. How does this enhance the image?

[3]

(c) Describe a use of the final image, and give a reason why the information is of human benefit or scientific interest.

[3]

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 a suitable application.

[2]

(b) State one property of the material that makes it suitable for your application. Explain why the material needs this property in the application.

[4]

(c) **(i)** Materials have internal structure, possibly on several different scales. Describe the internal structure of your material on a scale of your choosing. Use a labelled diagram. You should indicate the scale of the structure.

[4]

(ii) Explain how the structure contributes to one of the required properties of the material.

[3]

Quality of Written Communication [4]