OXFORD CAMBRIDGE AND RSA EXAMINATIONS
Advanced Subsidiary GCE

PHYSICS B (Advancing Physics)   **2860**
Physics in Action

Monday   **14 January 2002**   Morning   1 hour 30 minutes

Candidates answer on the question paper.
Additional materials:
       Data, Formulae 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.

1   The graph below shows how the potential difference *V* varies with current *I* for three different conductors: **X, Y and Z**.
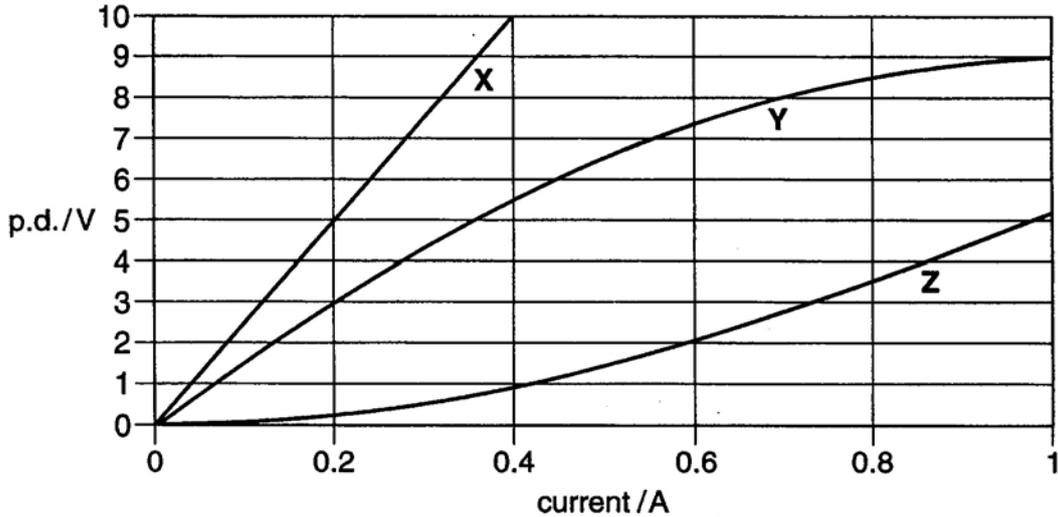
(a)   Which of the three conductors obeys Ohm's law?   ....

(b)   Which graph shows that the resistance of the conductor decreases as the current increases?

.………………………………….[2]

2   The charge coupled device (CCD) sensor in a digital camera has an array of pixels 1536 wide by 1024 high. Each pixel value is stored as an eight-bit number.

Show that the information stored in one complete image recorded by the CCD is greater than 1 Mbyte.

[3]

3   The equation describing image formation by a lens is:

$$\frac{1}{v} = \frac{1}{u} + \frac{1}{f}$$

(a)   Complete the following explanation of this equation in words.

The curvature of the wavefronts leaving the lens is equal to

………………………………………………………………………………….....................

plus the………………………………………………………………………………………

[2]

(b)   State where an object should be placed so that the image distance is approximately equal to the focal length.

[1]

4   (a)   Explain the meaning of the term brittle.

(b)   Give an example of a material that is brittle.

[2]

5 The unit for force, newton (N) is equivalent to kg m s^{-2}.
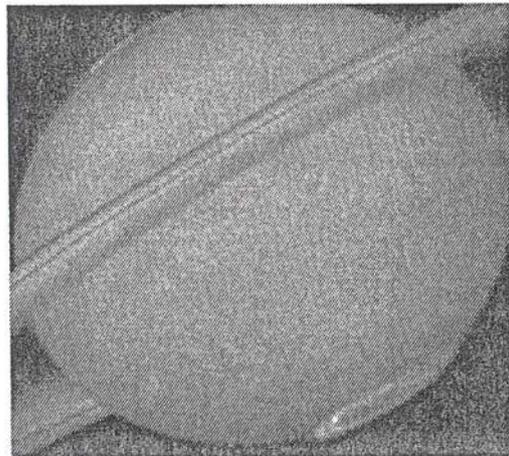The unit for stress is the pascal Pa.

(a) Express the unit Pa in terms of kg, m, s.

(b) The Young modulus is given by the ratio of stress to strain.
Explain why the value of the Young modulus can also be given in the unit Pa.

[3]

6 This is an ultraviolet image of Saturn taken from the Hubble space telescope.

512 pixels

512 pixels

(a) Suggest why ultraviolet images cannot be obtained by ground based telescopes.

[1]

Saturn has a diameter of 1.2 x 10^{8}m, and the picture contains 512 x 512 pixels.
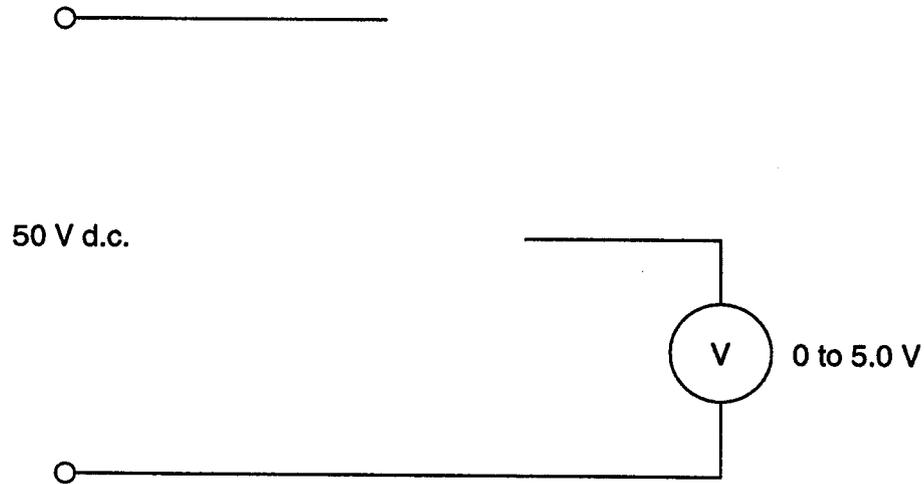
(b) Estimate the resolution of the image, making your method clear.

[2]

7   A large d.c. voltage of up to 50 V is to be measured by a voltmeter, that has a maximum scale reading of 5.0 V.

   This can be achieved with a potential divider, using two resistors of different values.

   (a)   Complete the circuit below showing how the two resistors are connected to the voltmeter.

50 V d.c.

(V) 0 to 5.0 V

[1]

   (b)   The smaller of the two resistors used is 1.0 kΩ. Calculate the value of the other resistor.

Resistance = ………………………………..kΩ [2]

8   This question is about some aspects of the operation of a computer printer.

(a)   A printer operating at medium resolution can print 10 ink dots per mm. A printed letter typically occupies an area of 2 mm by 2 mm as shown in Fig. 8.1 for the letter M.
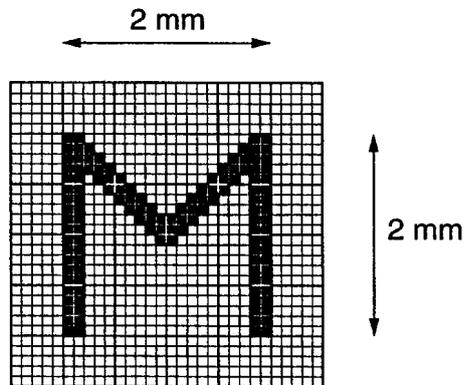

Fig. 8.1

How many ink dots would cover the area 2 mm x 2 mm?

[1]

(b)   Whether or not a dot is printed is determined by one bit of information (1 or 0). Show that 50 bytes is needed for a typical letter occupying 2 mm x 2 mm.

[1]

(c)   Different print fonts (script types) are held in printer driver software. Fig. 8.2 shows the letter M in three different fonts, to illustrate this.

Fig. 8.2

Each font can have 256 different characters. How many bytes of information are needed to code for one font?

[1]

(d)   The printer can also be used to print pictures.
       Suggest two adjustments to the text printing system that would improve the picture quality.

[2]

The printer is portable and can run on a rechargeable battery. The battery can deliver a current of 1.0 A for one hour.

(e)   The printer takes an average current of 600 mA during printing.
       Calculate the length of printing time that a battery charge will last.

time = ... s [3]

The battery has an emf of 18.0V, but the potential difference across its terminals drops to 16.0 V when the current is 600 mA.

(f)   (i)   Calculate the power delivered to the printer.

power =..................................W

       (ii)   Show that the internal resistance of the battery is 3.3 Ω.

[3]

9   This question is about the conversion of signals from analogue to digital. Figure 9.1 shows 2.0 ms of a sampled sound waveform.

(a)   State and explain one advantage and one disadvantage of a signal in digital rather than analogue form.

Advantage:

Disadvantage:

[4]

Fig. 9.1

(b)   (i)   State the number of different voltage levels used in this sampled waveform.

number of voltage levels used =................................ [1]

(ii)   State how many bits are needed to code for this number of levels, justifying your
        answer.

                                                                                            [2]

(iii)   State the sampling frequency of the digital converter.

                                    sampling frequency = ... [1]

(iv)   Calculate the information transmission rate in bits per second for this digitised
        signal.

                        information transmission rate =................................bit s^{-1} [2]

10   You are asked to plan an experiment to investigate how the intensity of light transmitted
      through an opaque liquid (like cloudy water) varies with distance travelled through the liquid.
      You are given a light sensor, which is calibrated in W m^{-2}.

      (a)   Draw a labelled diagram of the arrangement of apparatus you would need to complete
             your investigation.
             The associated electrical circuit is **not** required.

                                                                                                    [3]

   (b)   Describe your plan of the investigation, making clear what measurements you would
             take.

                                                                                                    [4]

A specimen of muddy river water transmits 50% of incident light intensity for each 2.0 cm of liquid.

The graph shows the variation of intensity transmitted with distance through the liquid.

(c)   (i)   Plot two more points and a best fit line showing the variation.

distance through liquid/cm
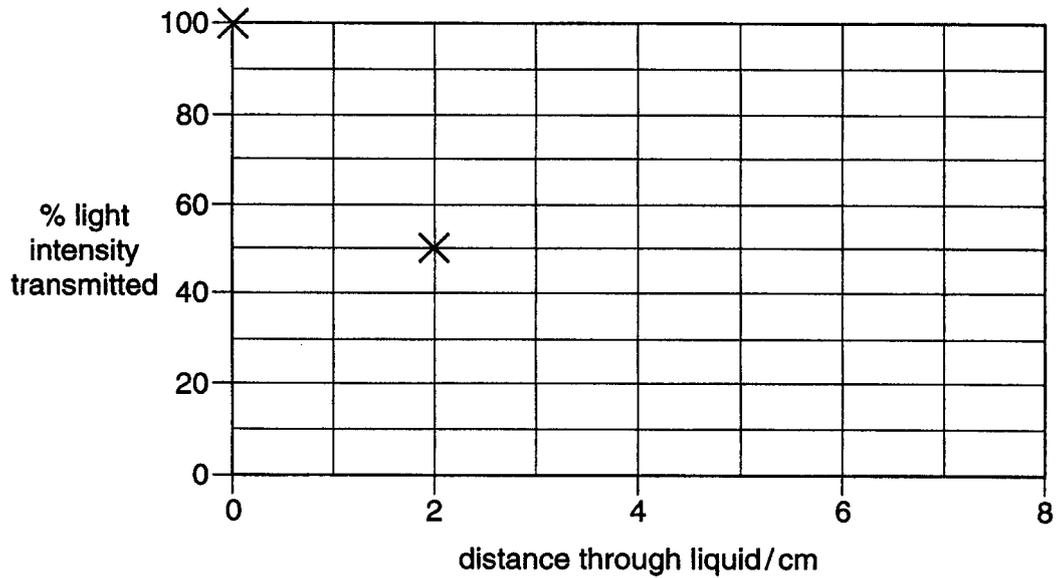
[2]

(ii)   Use your graph to estimate the depth of liquid that transmits 20% of the incident light.

[1]

11   This question is about the demister of the rear view window of a motorcar. A conducting material is fused onto the glass surface, to make an electrical heater. There are 10 conducting tracks, as illustrated below.

   (a)   On Fig. 11.1 draw a series connection of the conductors to the battery and on Fig. 11.2 draw a parallel connection to the battery.
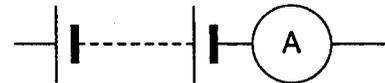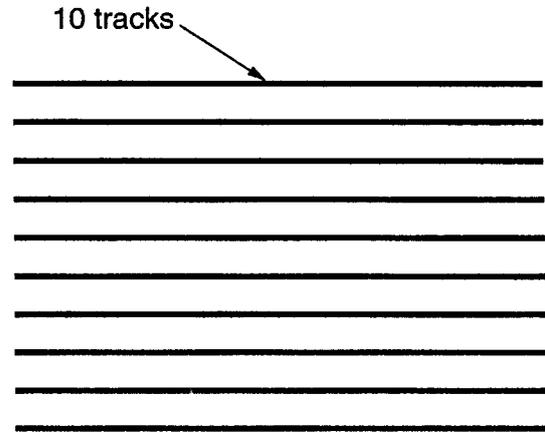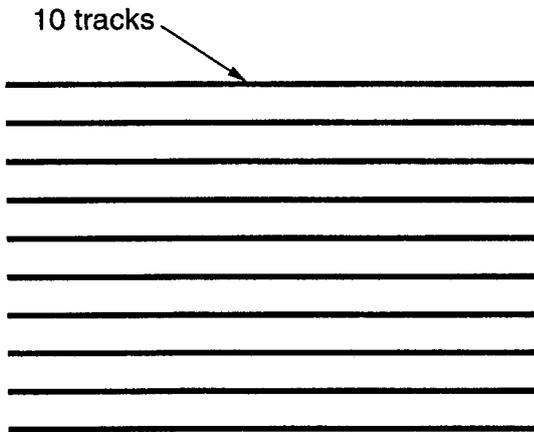

Fig. 11.1 (draw a series circuit)   Fig. 11.2 (draw a parallel circuit)

[1]

To demist effectively, each track in the heater needs to dissipate a .power of 24 W. The battery operates at 12Vd.c. (ignore the effects of internal resistance).

(b) Complete the table.

	series connection	parallel connection
p.d. across each track / V		
current in each track / A		
conductance of each track / S		

[5]

The material from which the tracks are made has a conductivity of 4.2×10^5 S m^{-1}. The tracks are 1.0 m long and 0.20 mm thick, as shown in Fig. 11.3.
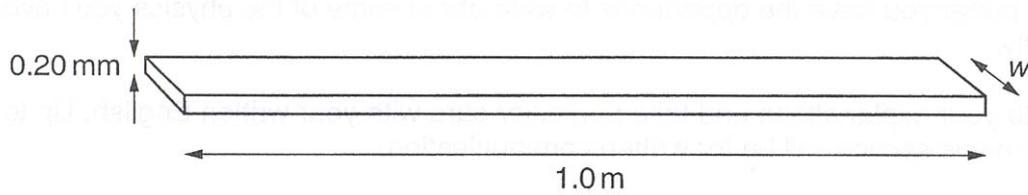

0.20 mm

w

1.0 m

Fig. 11.3 (not to scale)

(c) (i) Show that the width of each of the parallel connected tracks needs to be about 2.0 mm to achieve a conductance of 0.17 S per track.

[3]

(ii) Would you choose series or parallel connected tracks for a demister?

Give your reason.

[1]

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 awarded in this section will be for written communication.

12 In this question you are to choose an electrical/electronic sensor system for a particular purpose.

(a)   Describe the purpose for which your chosen sensor system is intended, stating a suitable choice of sensor for the purpose.

[2]

(b)   (i)   Draw a circuit diagram showing how a suitable electrical output signal can be obtained from the sensor.

(ii)   Describe how your circuit works.

[5]

(c)   Describe how you would calibrate your sensing system.

[3]

(d)   Estimate a typical sensitivity for your sensing system. Suggest how it could be increased.

[3]

13 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 an application for which it is suitable.

                                                                                    [2]

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

                                                                                    [4]

(c) 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, and indicate the scale of the structure.

[4]

(d) Comment on how one of the factors: availability, cost, aesthetics, or culture and tradition - influence the choice of material in this case.

[3]

Quality of written communication [4]