OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE

PHYSICS B (ADVANCING PHYSICS)   **2860**

Physics in Action

Candidates answer on the question paper	**Thursday 21 May 2009**
	Afternoon

OCR Supplied Materials:
*   Data, Formulae and Relationships Booklet

Other Materials Required:
*   Electronic calculator
*   Ruler (cm/mm)

Duration: 1 hour 30 minutes

Candidate Forename		Candidate Surname	

Centre Number					Candidate Number				

INSTRUCTIONS TO CANDIDATES

*   Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
*   Use black ink. Pencil may be used for graphs and diagrams only.
*   Read each question carefully and make sure that you know what you have to do before starting your answer.
*   Answer **all** the questions.
*   Do **not** write in the bar codes.
*   Write your answer to each question in the space provided, however additional paper may be used if necessary.

INFORMATION FOR CANDIDATES

*   The number of marks is given in brackets **[ ]** at the end of each question or part question.
*   The total number of marks for this paper is **90**.
*   You are advised to spend about 20 minutes on Section A, 40 minutes on Section B and 30 minutes on Section C.
*   There are four marks available 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.
*   This document consists of **20** pages. Any blank pages are indicated.

FOR EXAMINER'S USE

Section	Max.	Mark
A	20	
B	41	
C	29	
TOTAL	90	

Turn over

Answer **all** the questions.

Section A

1   Here is a list of units for mechanical quantities.

   N   Nm^{-2} kgm^{-3} Jm^{-2}

   Select the correct unit for:

   density   ....

   stress   ....

   Young modulus   ....   **[3]**

2   The refractive index of a glass block is 1.5.

   (a) Calculate the speed of light in this glass block.

       speed of light in vacuum = $3.0 \times 10^8 \, \text{m s}^{-1}$

                               speed = ... m s^{-1} **[2]**

   (b) Explain what is meant by the critical angle for a glass/air boundary. Sketch rays on the
       diagram below to help illustrate your answer.

                                                              glass
       _____
                                                              air

                                                                                         [2]

3 Fig. 3.1 shows a plot of fracture stress against Young modulus for different materials. Four areas have been shaded and labelled **A**, **B**, **C** and **D**.
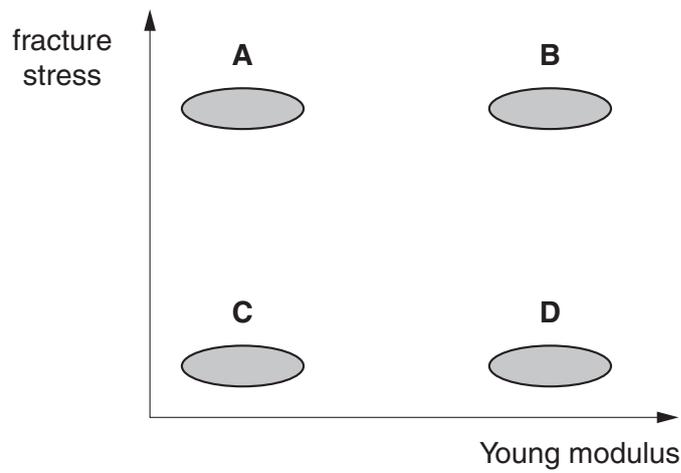

Fig. 3.1

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

a material suitable for a girder in a building e.g. steel   ....

a weak material that is hard to bend e.g. cracker biscuit   ....

a material that is **not** stiff and breaks at low stress e.g. putty ....

[3]

4 Fig. 4.1 shows an oscilloscope waveform of a pure sound wave.

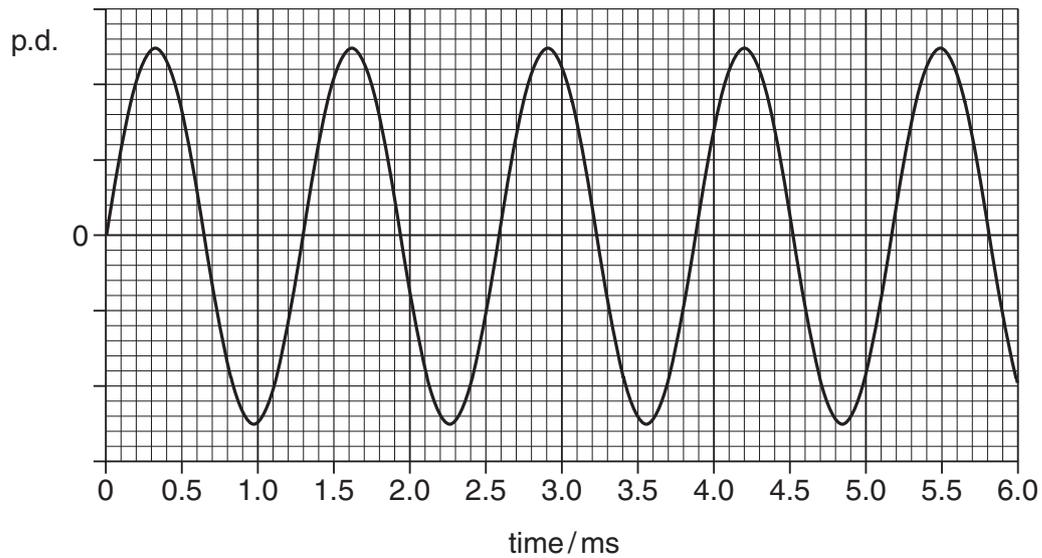**Fig. 4.1**

Use data from Fig. 4.1 to calculate the frequency of the sound wave.

Make your method clear.

frequency = ... unit .... **[3]**

5 **(a)** State the microscopic property of metals that accounts for their high electrical conductivity.

[1]

(b) Explain why semiconductors have electrical conductivities many orders of magnitude less than those of metals.

[1]

(c) Suggest why the electrical conductivity of semiconductors increases with temperature.

[1]

6 In a cinema people watching a 3-D film wear spectacles containing polarizing filters. This is so that each eye sees only one of a pair of images projected onto the same area of the screen. Two projectors are used, each projecting an image in differently polarized light to achieve this.

State and explain how the polarizing filters must be arranged in spectacles to achieve this.

[2]

7 An overhead projector uses a converging lens to produce a magnified image of a transparency, as shown in Fig. 7.1.
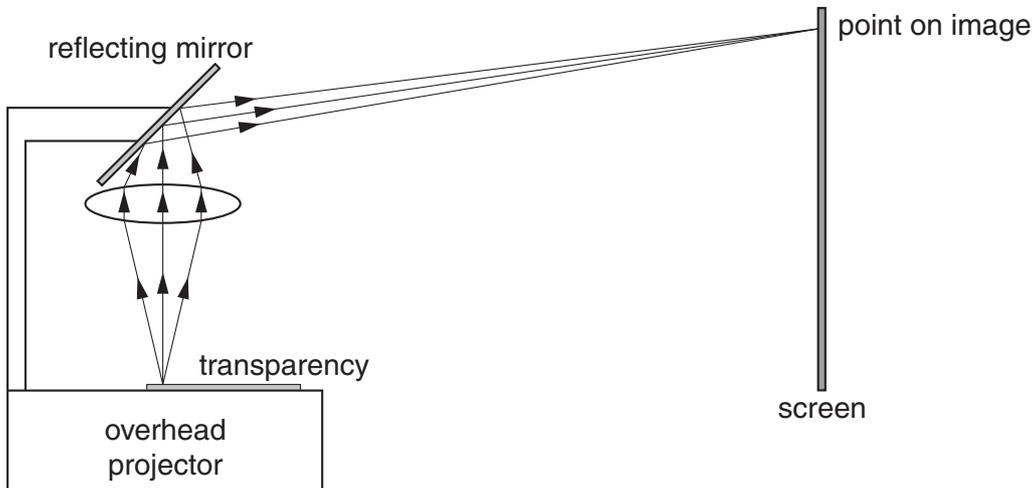

Fig. 7.1

The transparency is 0.15 m wide, and the image is 1.20 m wide.

(a) Calculate the linear magnification of the system.

linear magnification = ... **[1]**

(b) The distance of the image $v = 2.40$ m from the projector lens.

Use your answer to **(a)** to calculate the object distance u of the transparency from the lens.

object distance u = ... m **[1]**

[Section A Total: 20]

Section B

8 An electrical resistance thermometer consists of a sensor made from a platinum wire. The resistance of the wire increases with temperature.

Temperatures can be measured reliably by monitoring the resistance of the wire.

(a) A calibration temperature for the thermometer is melting ice at $0\,°C$.

The length of the platinum wire is $0.100\,m$ and its radius is $19\,\mu m$.

Show that the resistance of the platinum wire sensor is about $10\,\Omega$ at $0\,°C$.

resistivity of platinum at $0\,°C = 1.10 \times 10^{-7}\,\Omega\,m$

[3]

(b) It is found that the resistance of the sensor increases **linearly** between $0\,°C$ and $100\,°C$.

At $100\,°C$ the resistance of the sensor is $13.5\,\Omega$; at $0\,°C$ it is $9.7\,\Omega$.

Draw a (linear) calibration graph for the sensor on Fig. 8.1 by displaying its resistance against temperature in the range $0\,°C$ to $100\,°C$.

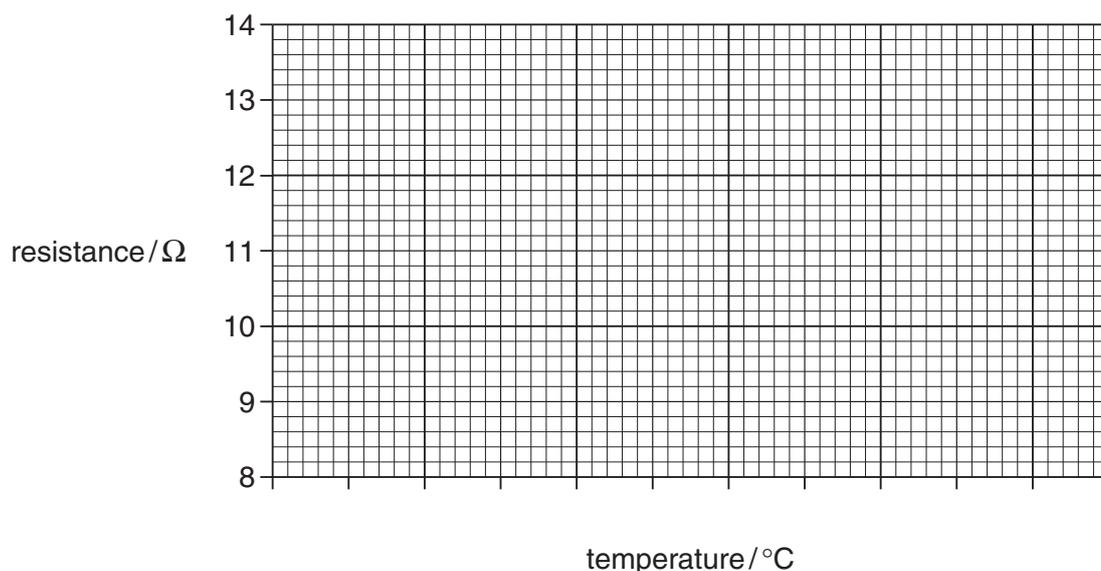Add a suitable temperature scale to the axis of the graph.

resistance$/\Omega$

temperature$/°C$

Fig. 8.1

[2]

(c) Using your calibration graph Fig. 8.1

   (i) find the resistance of the sensor at a temperature of 45.0 °C

   resistance = ... Ω **[1]**

   (ii) estimate the value of the sensitivity of this resistance thermometer.

   Make your method clear.

   sensitivity = ... unit .... **[3]**

(d) An ohmmeter is used to measure the sensor resistance.

   It measures the resistance to an uncertainty of ± 0.05 Ω.

   Calculate the uncertainty in the measurement of temperature over the range 0 °C to 100 °C.

   uncertainty in temperature = ± .... °C **[2]**

   [Total: 11]

9 In an experiment a series of weights are suspended from a rubber band and then removed again one by one. Fig. 9.1 shows the stress against strain relationship for the rubber as it is loaded and then unloaded.
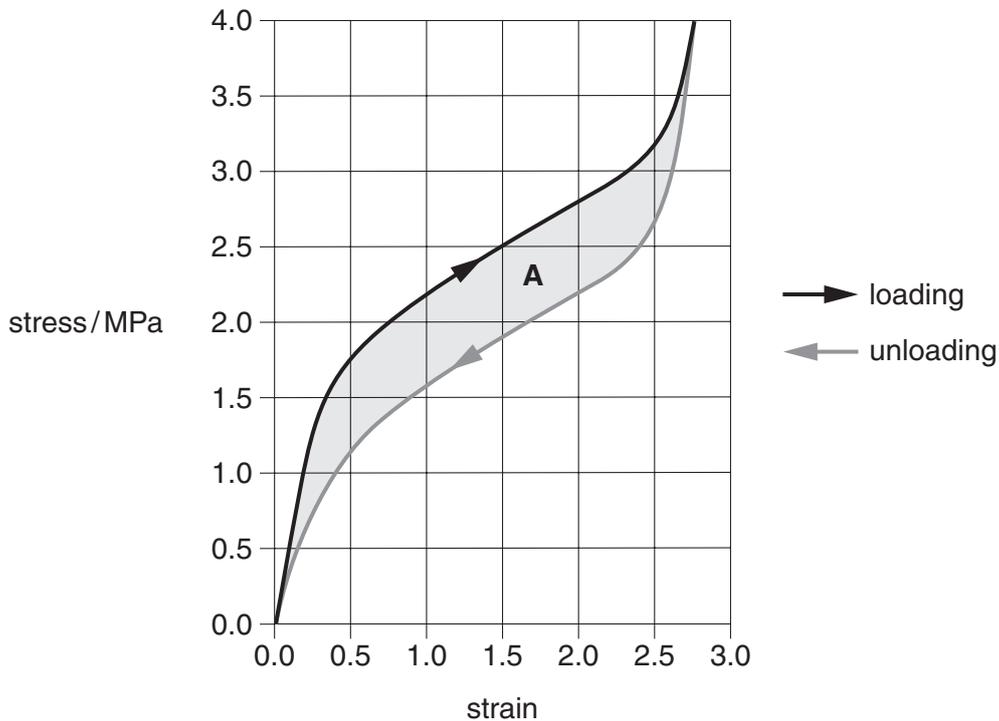

Fig. 9.1

(a) (i) State the feature of the stress against strain graph that shows that the Young modulus of rubber is not constant.

[1]

(ii) Use the graph to show that, for a small strain, the Young modulus of rubber is between 10^6 Pa and 10^7 Pa. Make your method clear.

[2]

(b) Use Fig. 9.1 to describe how the stiffness of rubber changes during loading and unloading.

[2]

 (c) The area under a stress against strain graph represents the energy per unit volume.

 (i) Use the defining equations for stress and strain to show that the quantity (stress × strain) is equivalent to energy per unit volume.

stress   =

strain   =

(stress × strain)   =

[2]

 (ii) Suggest the physical quantity that the shaded area **A** inside the loading-unloading loop in Fig. 9.1 represents.

[1]

 (iii) Estimate the value of this quantity for the rubber, making your method clear.

energy / volume = ... $J\,m^{-3}$ **[2]**

[Total: 10]

Turn over

10 Fig. 10.1 shows the principle of operation of a Scanning Tunnelling Microscope (STM). The gap between the sample and tip, both made of metal, is only a few atomic diameters in size. When a potential difference *V* is applied across the gap, there is a tunnelling current through the vacuum.
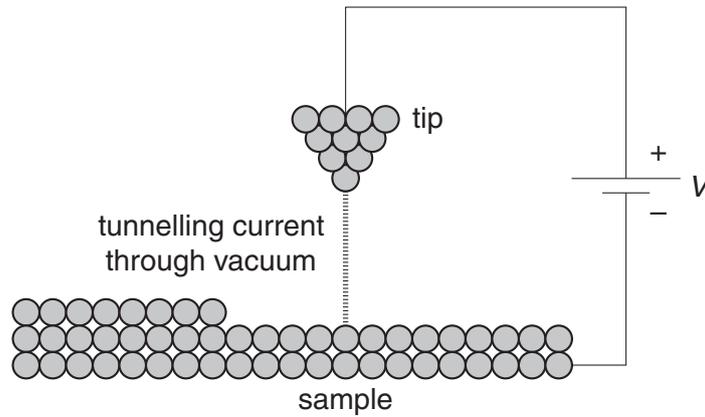

Fig. 10.1

(a) (i) A typical tunnelling current in this device is 2.0 nA.

Calculate the number of electrons crossing the gap every second at 2.0 nA.

$e = 1.6 \times 10^{-19}$ C

number = ... s^{-1} **[2]**

(ii) Suggest how the tunnelling current might vary with the p.d. *V* applied across the gap.

[1]

(b) The graph of Fig. 10.2a shows the relationship between the tunnelling current and size of gap in the STM on a log scale.
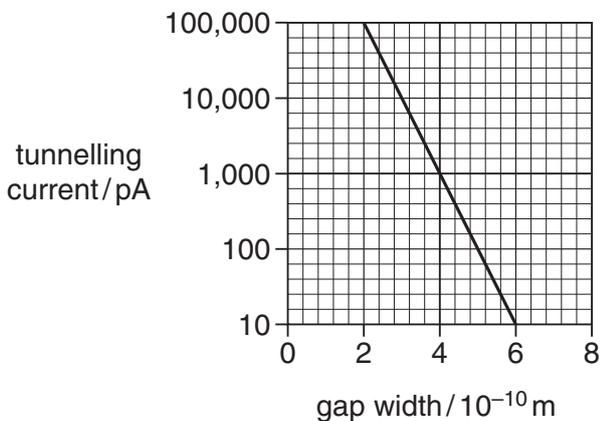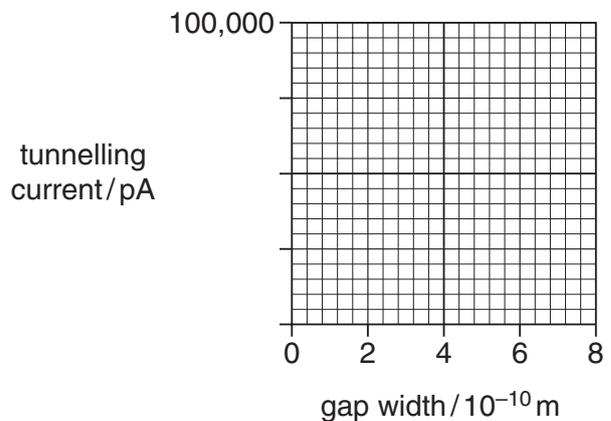

Fig. 10.2a log scale   **Fig. 10.2b** linear scale

(i) Suggest why a log scale is used for the tunnelling current in Fig. 10.2a.

[1]

(ii) On Fig. 10.2b sketch the shape of the graph if the same data were plotted on a linear scale from 0 to 10^5 pA rather than on the log scale of Fig. 10.2a. Complete the scale on the vertical axis. **[2]**

(c) Fig. 10.3 shows an STM image of the individual atoms on a silver surface.
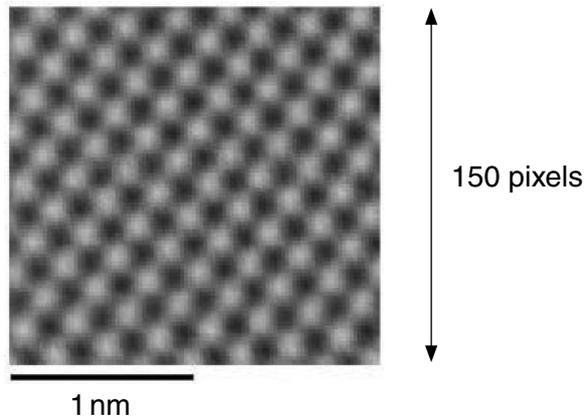
The image is 150×150 pixels.

Fig. 10.3

Estimate the resolution of the image quoting the value to 1 significant figure.

Make your method clear.

resolution = ... unit .... **[3]**

[Total: 9]

11 A set of Christmas lights has 46 lamps in a series circuit connected across the 230V mains. One of the lamps is shown in Fig. 11.1.
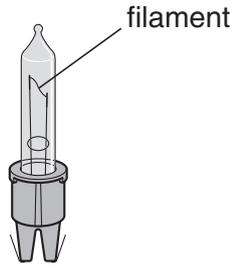

filament

Fig. 11.1

(a) Show that the potential difference across each lamp is 5V when lit normally.

[1]

(b) The p.d. against current relationship for the filament is shown in Fig. 11.2.

Fig. 11.2

   (i) Calculate the power of each lamp filament when lit normally.

power = ... W [1]

   (ii) Calculate the resistance of each lamp filament when lit normally.

resistance = ... Ω [2]

(c) In another set of 46 Christmas lights the same lamps are used, but a 60 Ω resistor in the lamp holder is connected in parallel with each lamp as shown in Fig. 11.3.
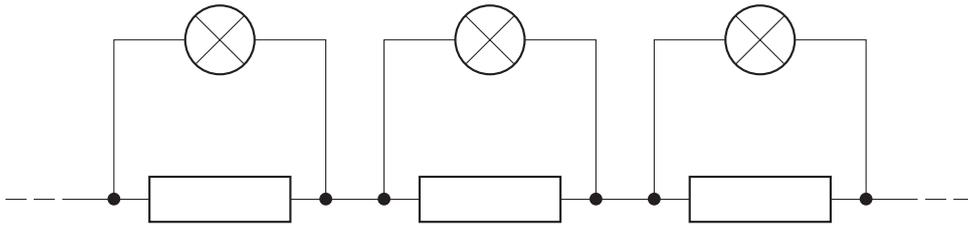

Fig. 11.3

  (i) Suggest a reason for this design with a resistor in parallel with each filament.

  ....

  ....
  [1]

  (ii) Calculate the current drawn from the mains supply by this set of lamps.

  current = ... A **[3]**

  (iii) The filament breaks in one of the lamps.

  State and explain what will happen to the brightness of the other 45 lamps.

  ....

  ....

  ....

  ....
  [2]

(d) In another set of lights which are meant to be identical to the set in part **(c)** there is a manufacturing fault. The 60 Ω resistor has been omitted from one of the lamp holders.

  Suggest and explain what will happen to the brightness of the lamp in this holder compared to the other 45 lamps.

  ....

  ....

  ....
  [1]

  [Total: 11]

  [Section B Total: 41]

Turn over

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 In this question you are asked to choose and discuss an image formed from radiation of some kind. Your example should be one where the image contains useful information and where image processing could improve or enhance the image in some way.

(a) (i) State your chosen image ....

The radiation used to form this image will have an appropriate frequency and wavelength. Name the radiation and give estimates of the frequency and wavelength used.

radiation

frequency

wavelength

[3]

(ii) Describe how the information contained in your chosen image is useful personally or to society.

[3]

(b) Describe how the radiation that was used to form your image is focused or gathered at the detector, and how the detector is used to produce pixel values for the image.

Use a labelled diagram in your answer.

[3]

(c) Images can often be improved by image processing.

Describe and explain **one** method of image processing, for example by modifying pixel values, that could improve your image.

[3]

[Total: 12]

13 In this question you are asked to choose and discuss an application of signal transmission.

(a) (i) State your example of signal transmission and the nature of the information that could be carried.

example of signal transmission ....

nature of information carried ....
[1]

(ii) Give an estimate of the rate at which your system can transfer information.

information rate = ... unit .... **[2]**

(b) (i) Communications systems often have to convert information from analogue to digital format.

A digital signal is produced by sampling and digitising an analogue signal.

Explain the terms **sampling** and **digitising**.

You may find a diagram useful in your explanation.

[3]

(ii) During the conversion of analogue into digital signals, some of the original information can be lost in the process.

State and explain clearly **two** different ways in which information loss can occur.

You may find diagrams useful in your explanations.

1.

[3]

2.

[3]

(c) State and explain **one** feature that limits the rate of transmission of information in your system.

[1]

[Total: 13]

[Quality of Written Communication: 4]

[Section C Total: 29]

END OF QUESTION PAPER

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