OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
Advanced Subsidiary GCE

PHYSICS (B) (ADVANCING PHYSICS) 2860

Physics in Action

Friday **10 JUNE 2005** 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	**39**	
C	**31**	
TOTAL	**90**	

This question paper consists of 19 printed pages and 1 blank page.

For Examiner's Use

Answer **all** the questions.

Section A

1 Here is a list of electrical units.

A s C s^{-1} J s^{-1} J C^{-1} V A^{-1}

Choose the correct unit for

(a) electric current ....

(b) resistance ....

(c) potential difference. ....

[3]

2 Fig. 2.1 shows an oscilloscope trace of a recording of a pure sound.
The signal trace is sampled at regular time intervals in order to digitise it.

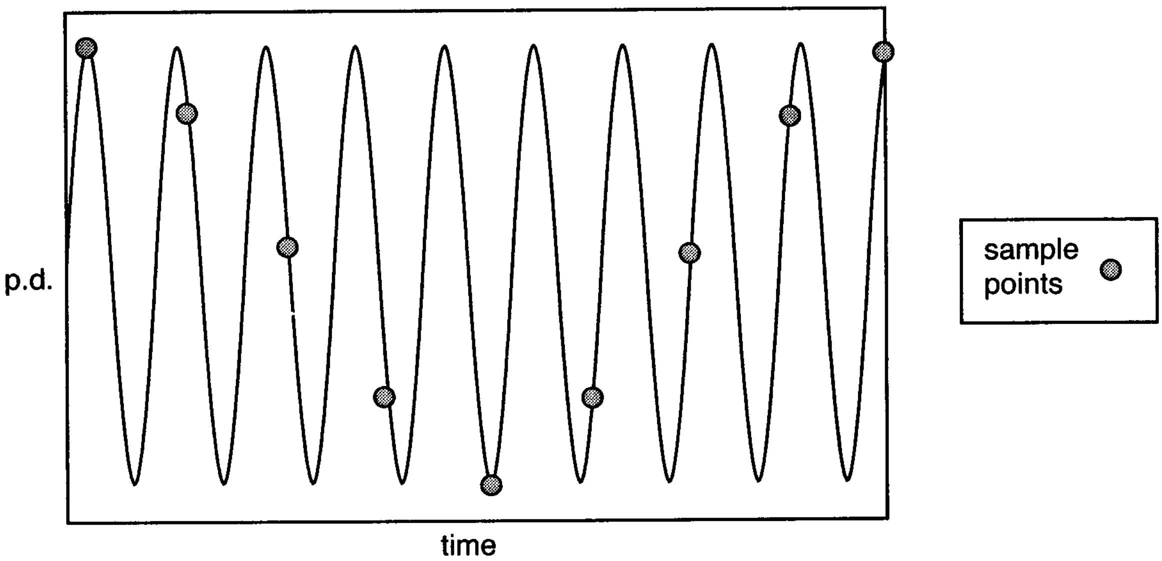

Fig. 2.1

A smooth analogue signal is reconstructed using the sample points.

(a) Sketch the reconstructed signal on Fig. 2.1. [1]

(b) Describe a difference in the sound created by the reconstructed signal, compared to the original sound.

[1]

(c) Suggest how the sampling could be altered to produce a reconstructed signal more like the original trace.

[1]

For Examiner's Use

3 This question is about selecting materials for sports equipment.

Fig. 3.1 shows, on a plot of the Young modulus against density, ranges of values for different classes of material.

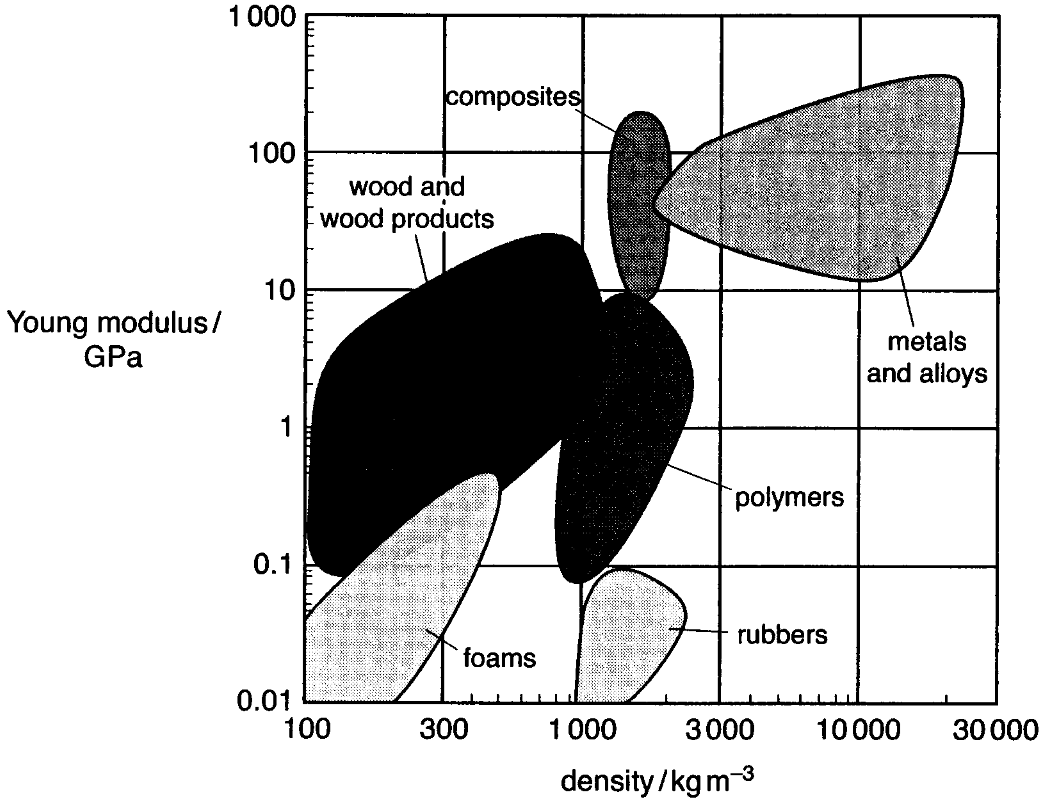

Fig. 3.1

(a) Foams are used for filling landing mats for high jumpers.

Explain this choice of material using information from Fig. 3.1.

[2]

(b) Some sports rackets are now made of a composite material rather than of metal.

Suggest and explain a reason for this change using information from Fig. 3.1.

[2]

[Turn over

4 **(a)** The grains in a photographic film are spaced about 12 μm apart.
One picture takes up an area of film that is 35 mm × 25 mm.

Show that the number of grains making up one picture is about 6×10^6.

[2]

(b) Each grain is either exposed or not and can therefore be digitised as 1 **bit** of information, either 1 or 0.

A CD can store about 650 **Mbytes** of information.

Calculate the number of these pictures that can be stored on the CD.

number of pictures = ...[2]

5 Fig. 5.1 shows an aluminium conductor on the surface of a computer chip.
It has a cross-sectional area $A = 2.0 \times 10^{-10}\,\text{m}^2$ and a length $L = 8.5 \times 10^{-4}\,\text{m}$.

conductivity σ of aluminium $= 3.8 \times 10^7\,\text{S m}^{-1}$

Calculate the conductance G of this conductor.

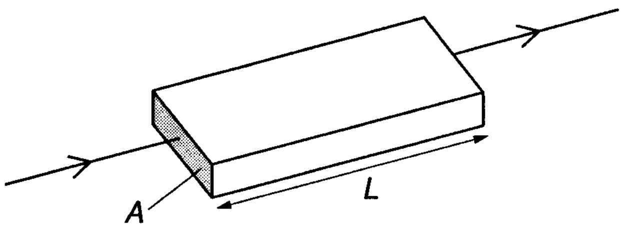

Fig. 5.1

G = ...S [1]

For Examiner's Use

6 Fig. 6.1 shows the microstructure on the surface of a brass specimen.

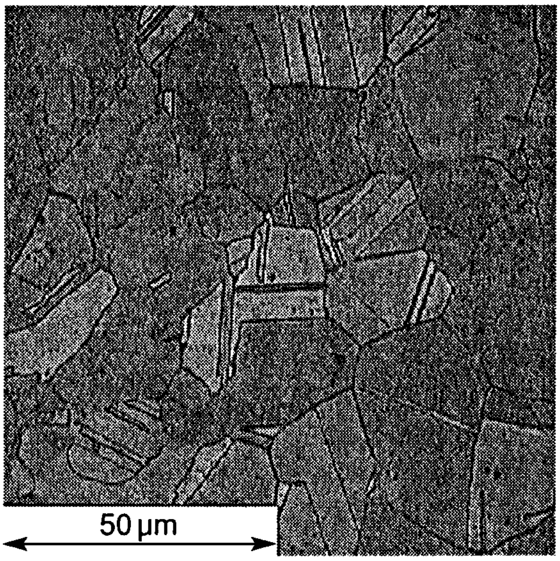

Fig. 6.1

The polycrystalline grain structure of the brass can be seen.

Explain the meaning of the term *polycrystalline*.

[2]

7 An ion beam delivers a charge of 60 nC during a time of 30 s.

(a) Calculate the current carried by the beam.

current = ...nA [1]

(b) Calculate the number of ions passing per second.

charge on each ion = 1.6×10^{-19} C

number of ions per second = ...[2]

[Section A Total: 20]

[Turn over

Section B

8 This question is about a sensing system to monitor the oil-level in a domestic oil tank. Fig. 8.1 shows a cylindrical tank of oil.

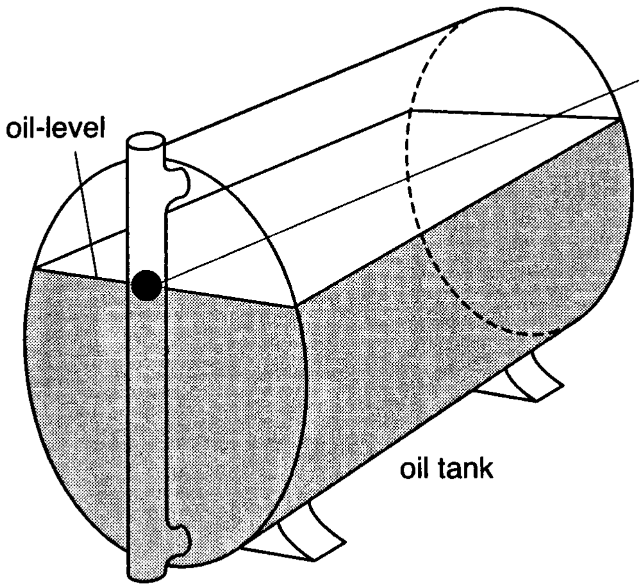

Fig. 8.1

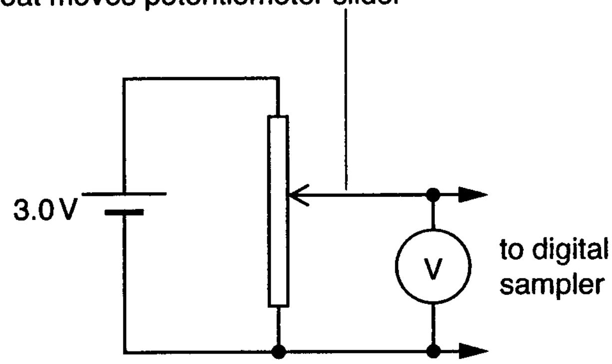

Fig. 8.2

Fig. 8.2 shows the circuit diagram of the sensor. The float rising and falling with the oil-level, moves the potentiometer slider. The potentiometer is **linear**. The voltmeter reads 0.0 V when the tank is empty and 3.0 V when it is full.

(a) **(i)** The voltage from the sensor is sampled digitally using a 3 bit sample.

Show clearly that 8 distinct levels can be represented by a 3 bit sample.

[1]

(ii) Show that the smallest change in voltage that can be represented by a 3 bit sample in this system is about 0.4 V.

[1]

(b) A radio transmitter sends a signal from the sensor to a receiver in the house. The wavelength of the signal is 0.68 m.

Calculate the frequency of this radio signal.

speed of electromagnetic waves $c = 3.0 \times 10^8\,\mathrm{m\,s^{-1}}$

frequency = ...Hz [2]

(c) The oil tank in Fig. 8.1 is a horizontal cylinder holding 1200 litres when full.

(i) State the reading on the voltmeter when the volume of oil in the tank is 600 litres.

reading on the voltmeter = ...V [1]

(ii) The sensor circuit uses a very **high** resistance voltmeter.

Explain why this is necessary to maintain linearity.

[2]

(d) The graphs **A**, **B**, **C** and **D** in Fig. 8.3 show how the voltmeter reading from the **linear** potential divider in Fig. 8.2 varies with another quantity x (x-axis).

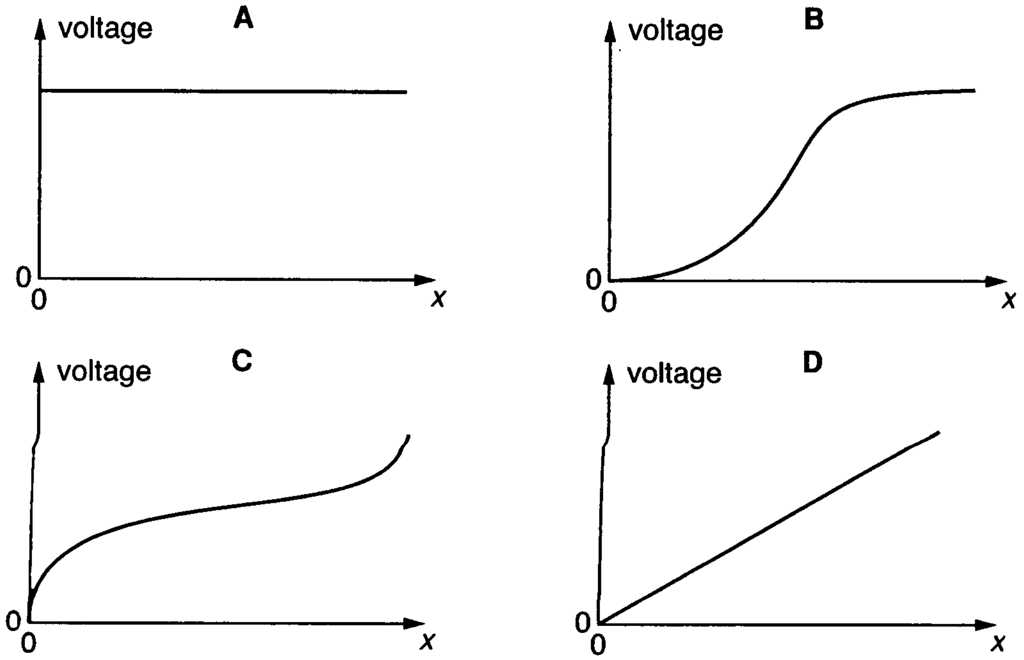

Fig. 8.3

Choose the graph that best represents how the reading on the voltmeter varies with

(i) the **depth of oil** in the tank (x-axis) ....[1]

(ii) the **volume of oil** in the tank (x-axis). ....[1]

[Total: 9]

9 A solar cell is being tested as a source of electrical power.

(a) The solar cell is connected in a circuit with a load resistor, an ammeter and a voltmeter in order to measure its power output.

Complete the circuit diagram Fig. 9.1 to show the ammeter and the voltmeter correctly connected into the circuit.

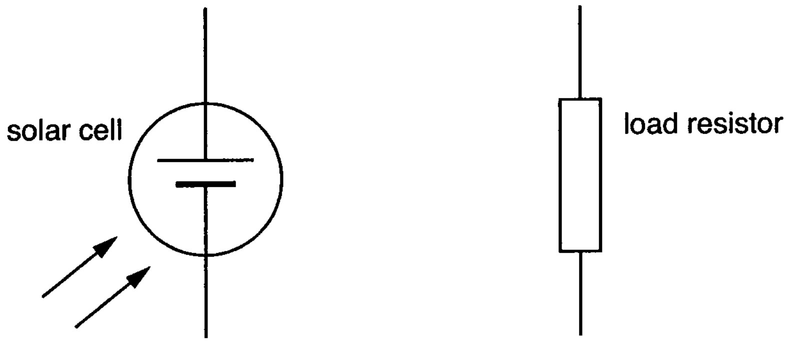

Fig. 9.1

[2]

(b) Fig. 9.2 shows the arrangement for illuminating the solar cell from an extended light source.

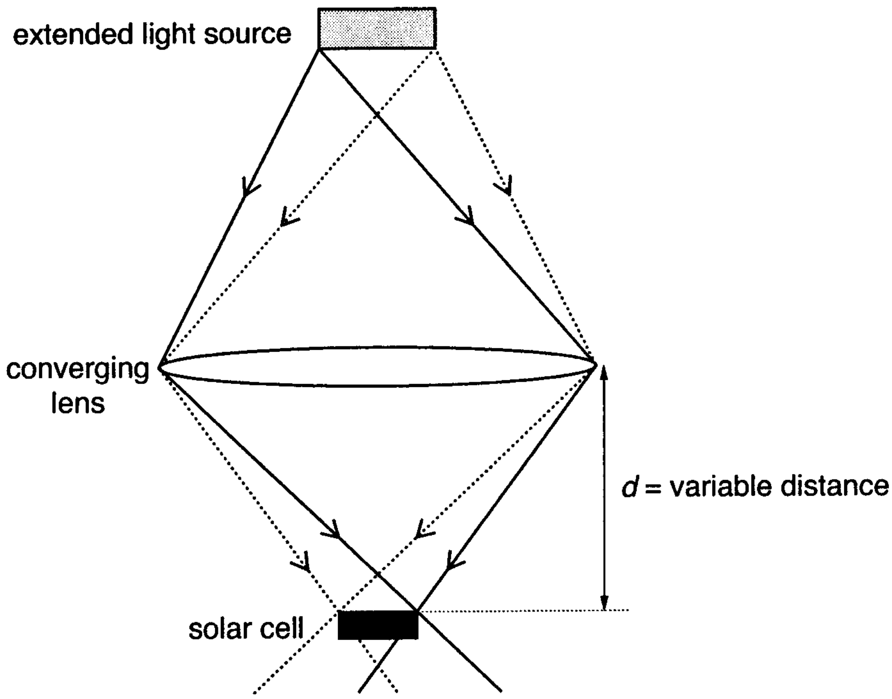

Fig. 9.2

The distance d is varied by moving the solar cell towards or away from the converging lens, to alter the intensity of illumination.

Fig. 9.3 gives a graph of the current delivered by the solar cell plotted against distance *d*.

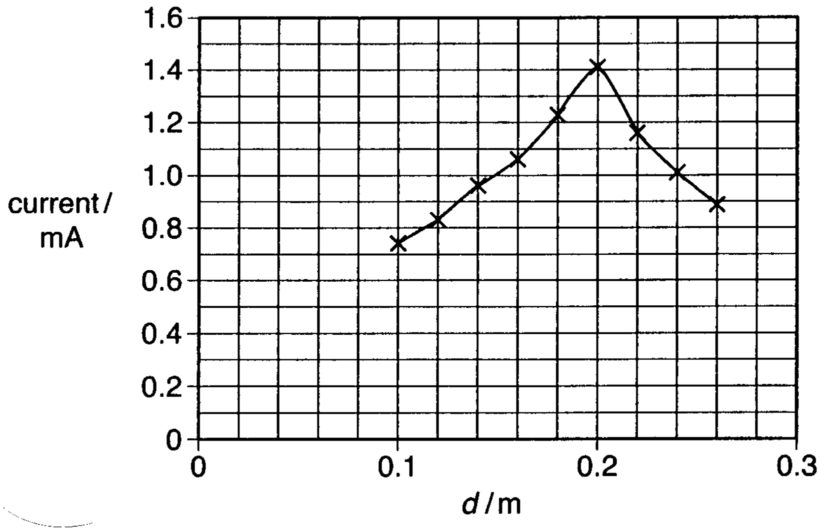

Fig. 9.3

(i) For the arrangement shown in Fig. 9.2, explain why the current varies with *d* as shown in Fig. 9.3.

[2]

(ii) Calculate the maximum power dissipated by a load resistor of 110 Ω.

maximum power = ...W [2]

Question 9 is continued over the page.

[Turn over

For Examiner's Use

(c) Fig. 9.4 shows two wavefronts from point **P** on the extended light source heading towards the lens.

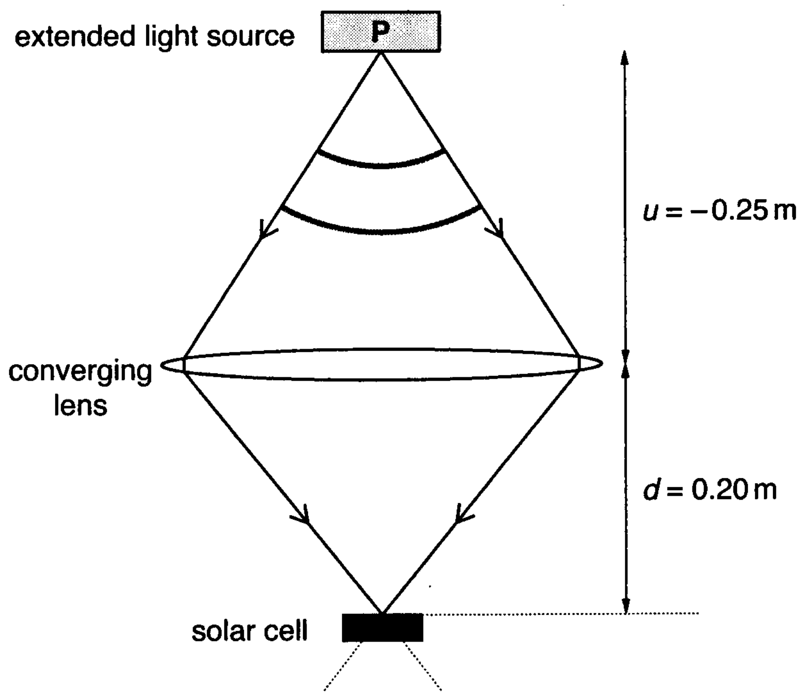

Fig. 9.4

On Fig. 9.4, draw the same **two** wavefronts to show their curvature and spacing **after** passing through the converging lens. [2]

(d) **(i)** The curvature of wavefronts entering the lens in Fig. 9.4 is –4.0 D.

Calculate the curvature of wavefronts leaving the lens, when $d = 0.20$ m.

curvature leaving = ... D

(ii) Calculate the curvature added by the lens, and the focal length of the lens.

curvature added = ... D

focal length = ... m

[3]

[Total: 11]

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[Turn over

For Examiner's Use

10 This question is about the behaviour of a metal alloy.
Fig. 10.1 shows the stress against strain graphs to breaking point for samples of a pure metal and one of its alloys.

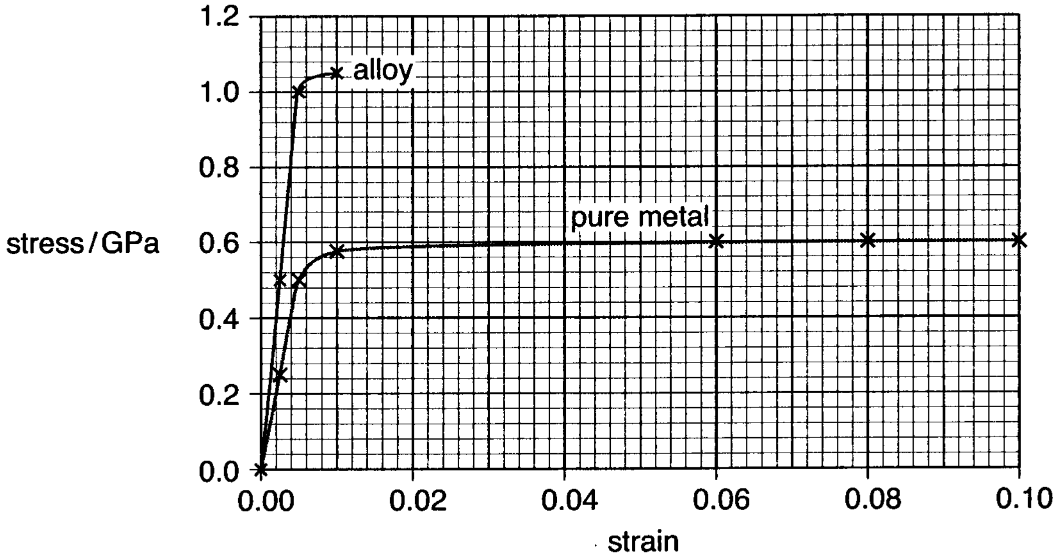


Fig. 10.1

(a) (i) Use data from Fig. 10.1 to calculate the Young modulus of the pure metal. Make your method clear.

Young modulus = ... GPa [3]

(ii) Explain how the graphs show that the alloy is stiffer and stronger but less ductile than the pure metal.

stiffer

stronger

less ductile

[3]

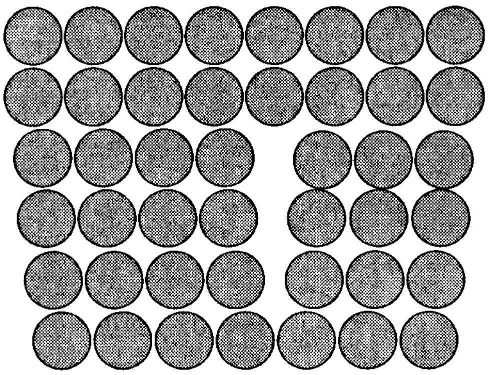
For Examiner's Use

(b) Girders to support the floors in buildings are made from this alloy rather than the pure metal.

Suggest why the properties of this alloy make it more suitable than the pure metal for girders.

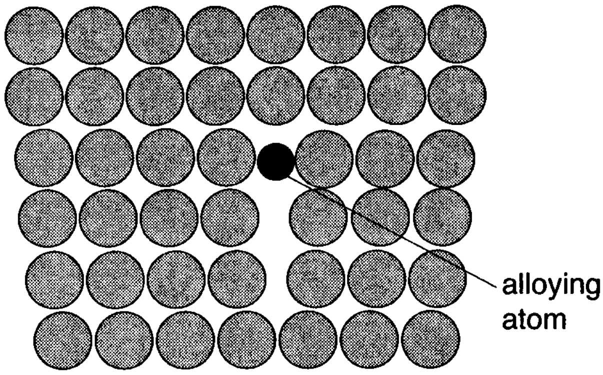
[1]

(c) The microstructure of the pure metal is shown in Fig. 10.2.



pure metal

Fig. 10.2



alloy

Fig. 10.3

The alloy microstructure is shown in Fig. 10.3.
The alloying metal atoms randomly replace a few of the host metal atoms in the structure. The alloying atoms are smaller than the host atoms.

Use the information above about the microstructures, to suggest and explain why the alloy is less ductile than the pure metal.

[3]

[Total: 10]

11 Fig. 11.1 and 11.2 show images captured by cameras aboard the Mars Global Surveyor satellite.
Fig. 11.1 shows the 140 km-wide Holden Crater.
Fig. 11.2 shows the region indicated inside Holden Crater photographed using a much higher resolution camera.

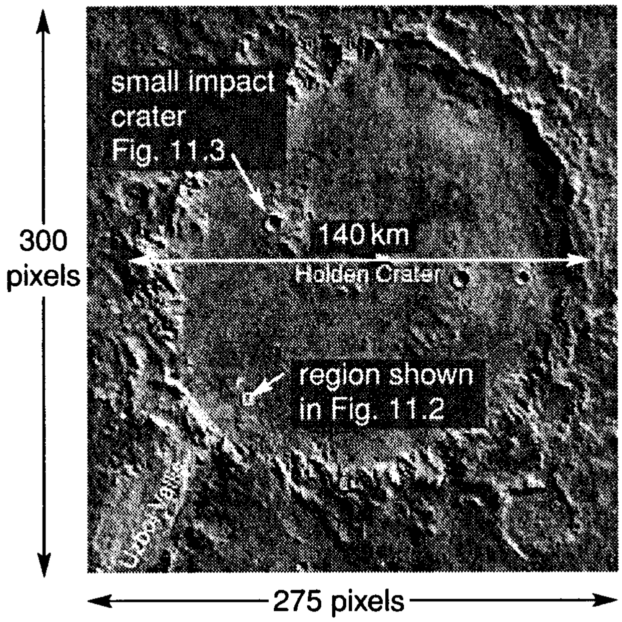


Fig. 11.1 (low resolution)

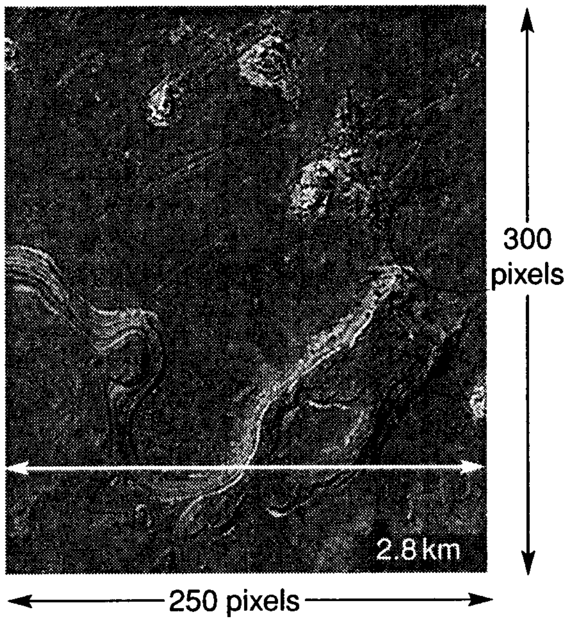


Fig. 11.2 (high resolution)

(a) **(i)** Estimate the resolution of the image shown in Fig. 11.1.

resolution = ... m pixel^{-1} [2]

(ii) Estimate the ratio

$$\frac{\text{resolution of Fig. 11.1}}{\text{resolution of Fig. 11.2}}.$$

ratio = ...[1]

(iii) Suggest and explain **one** way in which the resolution of this imaging system could be improved.

[2]

For Examiner's Use

(b) The images shown in Fig. 11.1 and 11.2 have been processed to reduce noise.

(i) State what is meant by *noise* in an image.

[1]

(ii) Explain how some of the pixel values could have been altered to reduce the noise.

[1]

(c) Physicists analysing the image are trying to find the shape of an impact crater. Fig. 11.3 shows a magnified image of the small impact crater indicated in Fig. 11.1. The crater wall casts a shadow inside the impact crater.

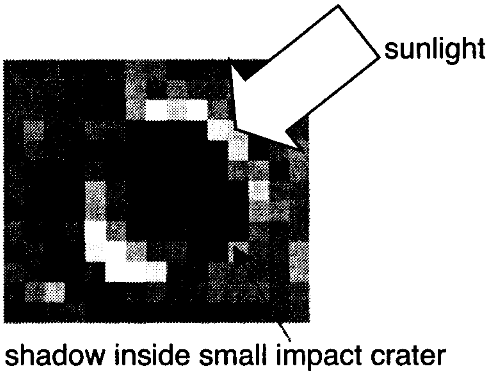


Fig. 11.3

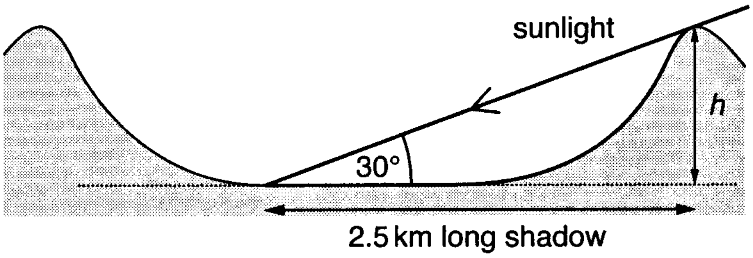


Fig. 11.4

The Sun is at an angle 30° above the horizontal causing the shadow about 2.5 km long, as shown in Fig. 11.4.

Estimate the height h of the crater rim above the crater floor, making your method clear.

h = ...m [2]

[Total: 9]

[Section B Total: 39]

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 application of signal transmission.

(a) State your example of signal transmission and give an example of the kind of information that could be carried.

example of signal transmission ....

information carried ....[1]

(b) **(i)** Explain the difference between the **speed of transmission** of a signal and the **rate of information transfer** for your chosen example.

[2]

(ii) Modern communications systems transmit information by **digital** rather than **analogue** signals.

Explain the difference between digital and analogue signals, using sketch graphs to illustrate your answer.

[3]

For Examiner's Use

(c) Discuss the advantages and/or disadvantages of your signal transmission system to society.

[3]

(d) An experimental digital fibre optic communications link has achieved a data transmission rate of 10.2×10^{12} bit s^{-1}.
The optical fibre simultaneously carries 256 channels each using a different wavelength across the infrared and visible spectrum.

(i) Calculate the data transmission rate for one channel.

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

(ii) Hence calculate the time between successive bits of information received on one channel.

time = ...s [1]

(iii) The information in a typical digitised telephone signal consists of 8 bits per sample taken at a rate of 8000 samples per second.

Show that about 160 million simultaneous telephone signals could be carried by the fibre optic link.

[2]

[Total: 13]

[Turn over

For Examiner's Use

13 You are asked to describe aspects of an experiment to measure the refractive index *n* of a material such as glass.

(a) A formula defining the refractive index is

$$n = \frac{\sin i}{\sin r}$$

where i = angle of incidence and r = angle of refraction.

Fig. 13.1 shows a ray of light being refracted by an air/glass surface.

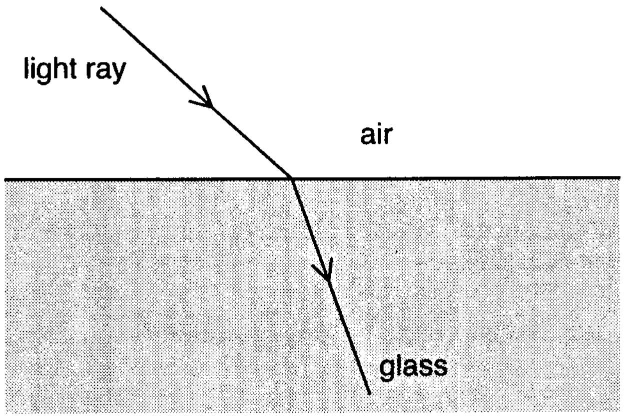


Fig.13.1

Draw the normal to the air/glass surface at the point of entry of the ray.
Indicate clearly the angles *i* and *r*. [2]

(b) **(i)** Draw a labelled diagram to show the arrangement of the apparatus you would use to measure *n* for glass.

(ii) Describe your experimental procedure making it clear what you would vary, what measurements you would take, and how you would make them.

[5]

(c) For a particular glass block, a student takes the following pair of measurements.

i	r	n
80° ± 1°	42° ± 1°	

Calculate the refractive index.
Give an estimate of the uncertainty in the value.
Show how you work out your answers.

[4]

Question 13 is continued over the page.

[Turn over

For Examiner's Use

(d) Another student takes readings that allow him to plot the following graph.

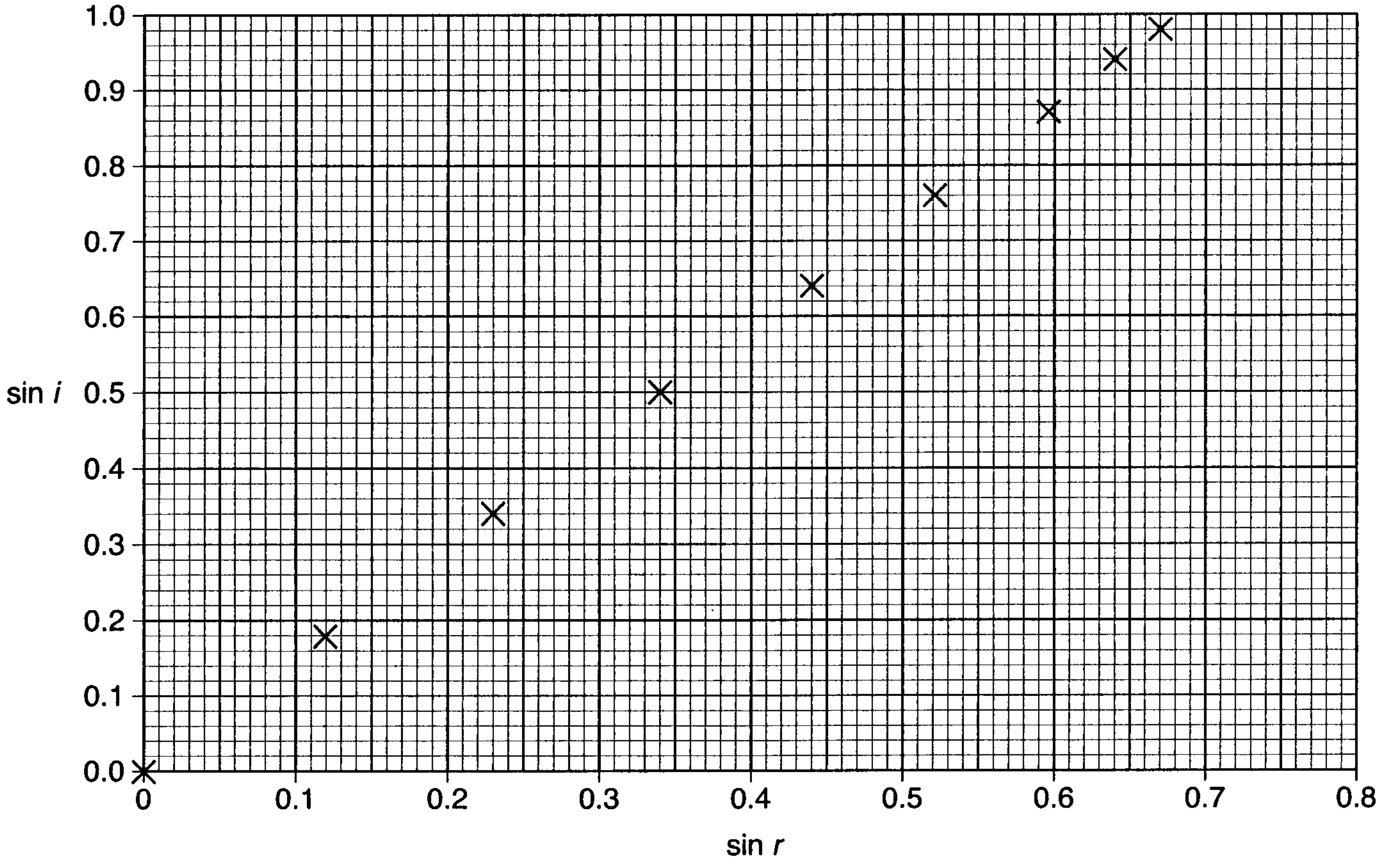


Fig. 13.2

(i) Draw the line of best fit on Fig. 13.2. [1]

(ii) Use your line to calculate the value of the refractive index *n*.

refractive index *n* = ...[2]

[Total: 14]

[Quality of Written Communication: 4]

[Section C Total: 31]

END OF QUESTION PAPER