OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary GCE

PHYSICS (B) (ADVANCING PHYSICS) — 2860

Physics in Action

Monday **14 JUNE 2004** Afternoon 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 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	**40**	
C	**30**	
TOTAL	**90**	

This question paper consists of 22 printed pages and 2 blank pages.

Answer **all** the questions.

Section A

1 A particular material breaks after plastic deformation. It requires a large energy to create new surface area, but does **not** fracture by crack propagation.

Here is a list of four different mechanical properties.

stiff strong tough hard

Write down the **one** word from the list that best describes this material.

.... [1]

2 The information in the frames of old black and white movie films deteriorates with time. It can be preserved by storing the images as arrays of pixels in a digital format. Unfortunately, defects such as scratches and dirt spots also become digitised.

The pixel values from three small regions **A**, **B** and **C** of a digitised film are shown in Fig. 2.1.

The numbers relate to a greyscale from 0 = white to 255 = black

100	100	120	120	140
100	120	250	250	140
120	120	250	250	140
120	120	140	140	180
120	140	140	180	180

A

180	180	180	100	10
180	180	100	10	10
180	100	10	10	100
100	10	10	100	180
10	10	100	180	180

B

100	120	130	140	150
130	130	140	150	150
140	140	150	150	160
150	150	160	170	170
160	160	170	170	180

C

Fig. 2.1

(a) Identify which region, **A**, **B** or **C**, has been affected by

(i) a white scratch .... **(ii)** a black dust spot .... [1]

(b) Explain how you identified the white scratch.

[1]

(c) Suggest a digital image process that could remove or reduce the effect on the pixel values of the dust spot.

[1]

For Examiner's Use

3 A spotlight beam falls on a water surface at an angle of incidence i = 80° as shown in Fig. 3.1.

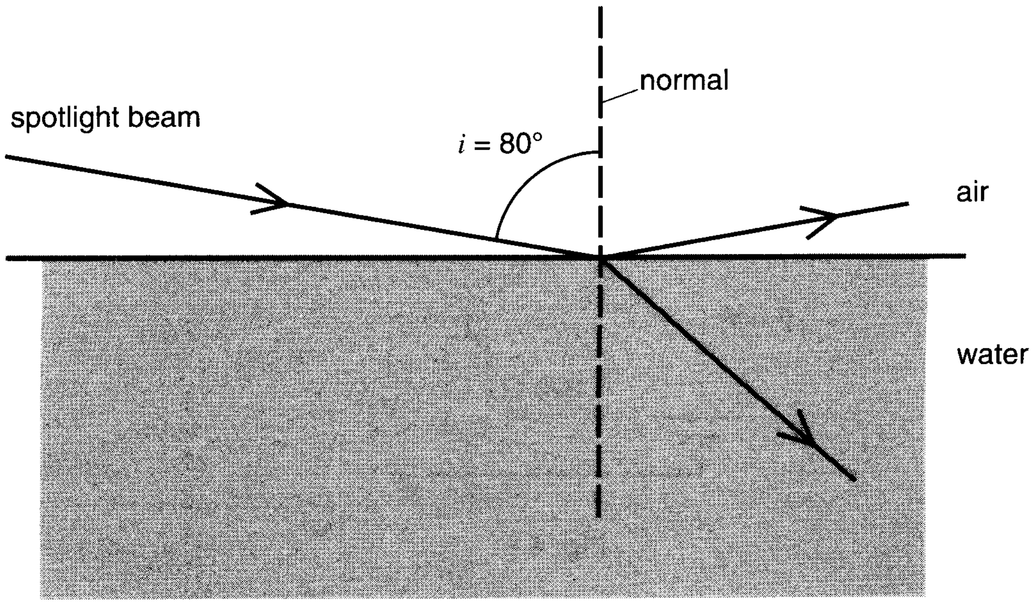


Fig. 3.1

(a) **Label** the angle of refraction r on Fig. 3.1 above. [1]

(b) Calculate the angle of refraction r in the water, quoting your final answer to an appropriate number of significant figures.

refractive index for water $n = 1.3$

[3]

4 Fig. 4.1 shows a light sensing circuit using an LDR, a fixed resistor of resistance 220 Ω and a 6.0 V battery.

The battery in the potential divider circuit is of negligible internal resistance.

The p.d. across the resistor is measured by a digital voltmeter.

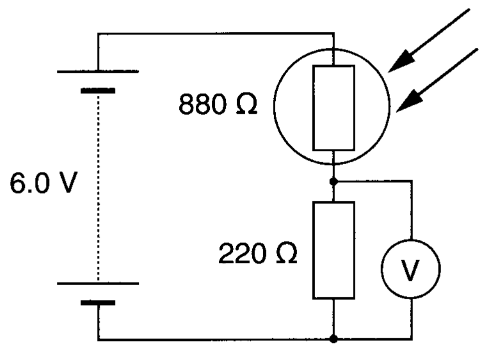


Fig. 4.1

In bright daylight, the resistance of the LDR is 880 Ω.

(a) Calculate the ratio = $\frac{\text{p.d across resistor}}{\text{p.d. across LDR}}$.

ratio = ... [1]

(b) Calculate the voltmeter reading in bright daylight.

p.d. = ... V [2]

For Examiner's Use

5 Here are two relationships for electrical components.

$$P = I\,V \qquad\qquad V = I\,R$$

(a) **Show how** to combine these two relationships to produce an equation for the electrical power P in terms of the current I and resistance R only.

[1]

(b) Complete the following statement.

When the current is doubled in a constant resistance, the power dissipated is increased

by a factor of .... [1]

6 A microwave transmitter emits vertically polarised electromagnetic waves to a receiver as shown in Fig. 6.1. Three mutually perpendicular directions **x, y** and **z** are shown.

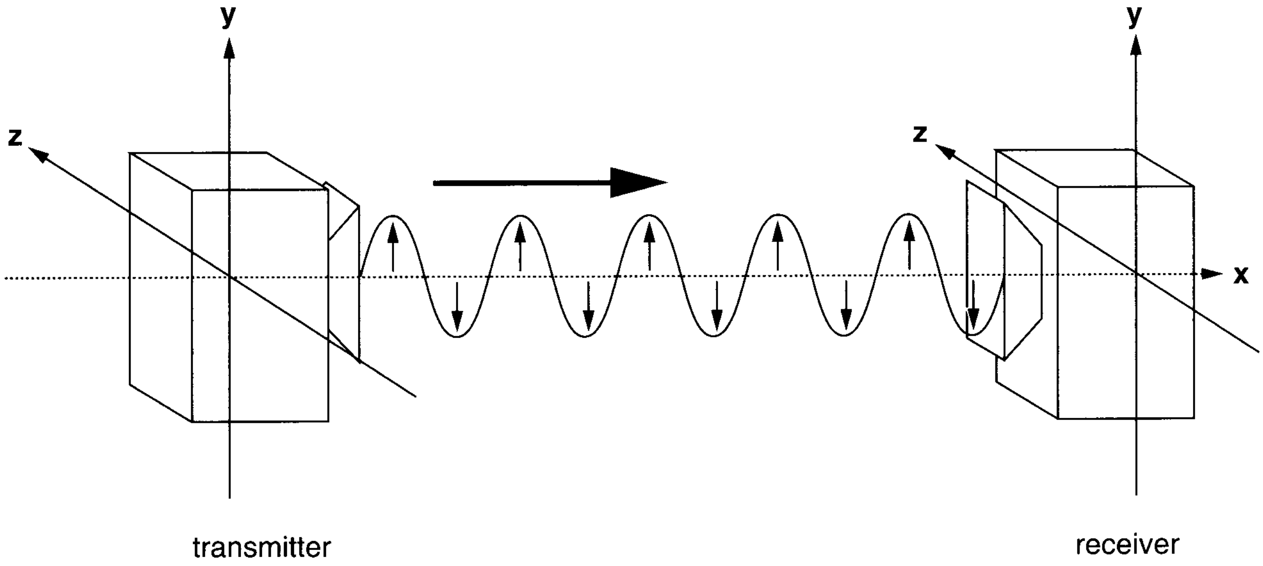


Fig. 6.1

The receiver emits an audible tone when vertically polarised microwaves enter it. The loudness of the sound depends upon the intensity of the microwaves.

Describe a simple experiment you could perform with this equipment to give evidence that the waves are vertically polarised. State the observations you would make.

You may wish to make reference to the directions **x, y** and **z** as shown in Fig. 6.1.

[3]

For Examiner's Use

7 Fig. 7.1 shows two waveforms displayed on an oscilloscope screen.
One is the original analogue signal from a recording of a dolphin whistling.
The other is the result of digitising it to the nearest of 8 binary coded levels.

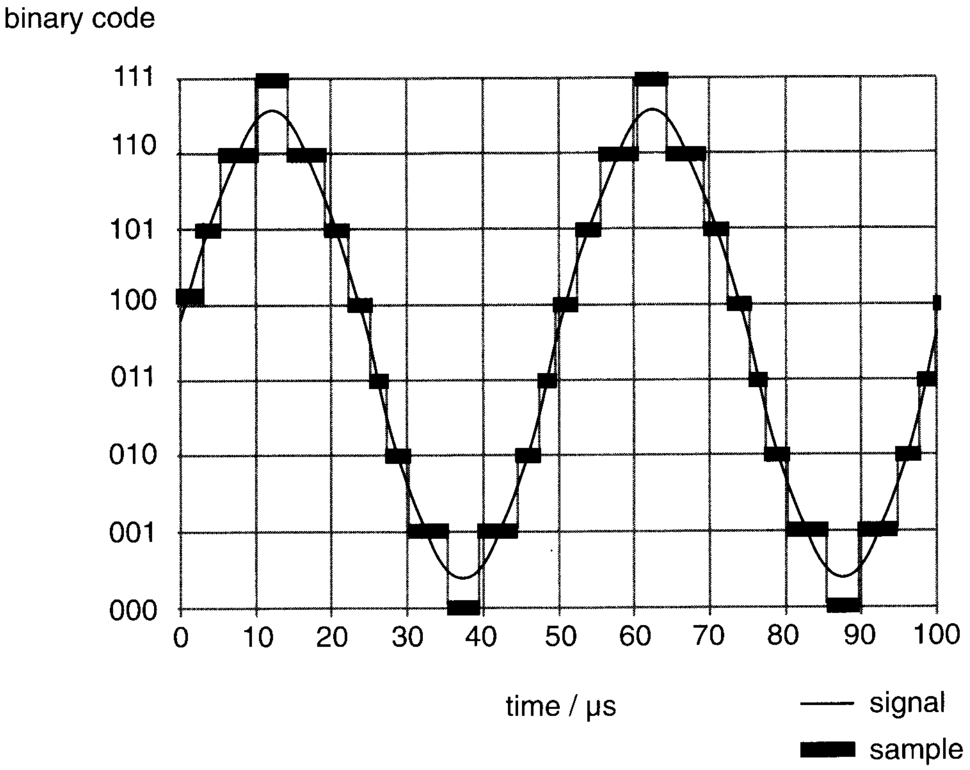


Fig. 7.1

(a) (i) Read from the graph the time period T in microseconds for one complete cycle of the dolphin whistle.

T = ... μs [1]

(ii) Calculate the frequency f corresponding to this time period T.

f = ... Hz [1]

(b) (i) State the number of bits per sample needed to code for the 8 binary levels.

number of bits = ... [1]

(ii) The waveform is sampled every 1.0 μs.

Calculate the rate at which information is digitised in this sampled waveform.

information rate = ... bits s^{-1} [1]

[Section A Total: 20]

[Turn over

Section B

8 This question is about an external rear view mirror on a motor car.
Fig. 8.1 shows the path of one of the light rays that determine the driver's field of view, entering the driver's eye, as seen from above.

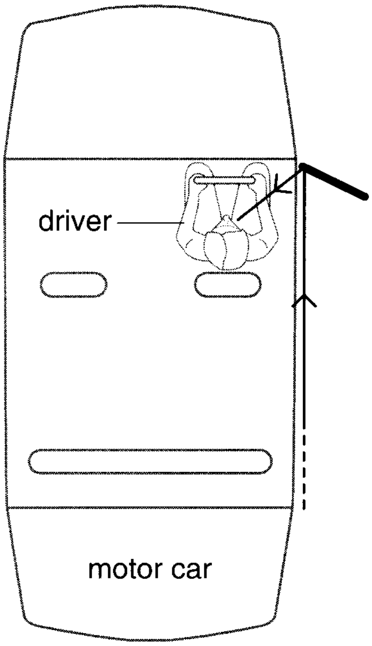


Fig. 8.1

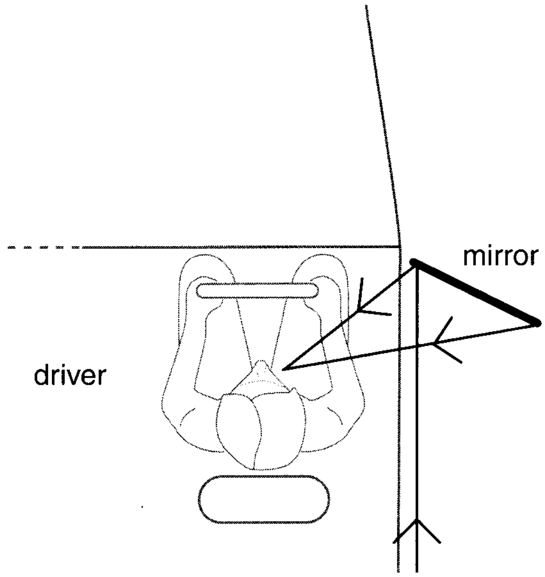


Fig. 8.2 (enlarged view)

(a) On Fig. 8.2, complete the path of the light ray incident near the outer edge of the plane mirror. [1]

(b) Another design of rear view mirror has an extra section at its outer edge at a different angle as shown in Fig. 8.3.

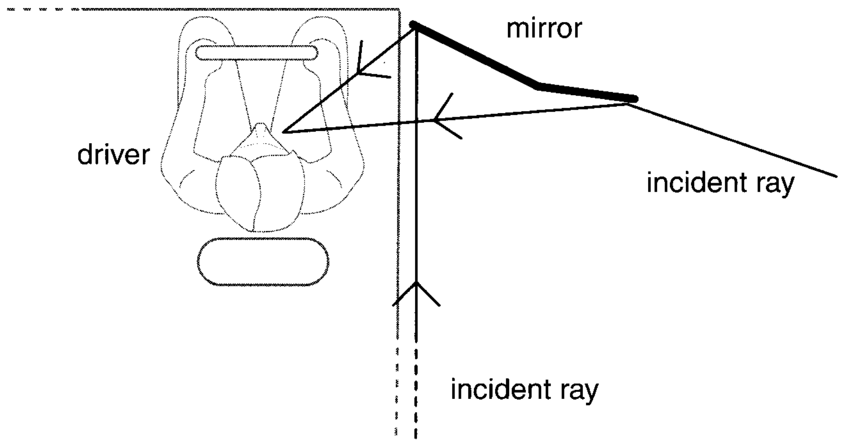


Fig. 8.3

Suggest **one** advantage and **one** disadvantage of this design of mirror compared with that shown in Fig. 8.2.

advantage ....

disadvantage ....
[2]

(c) The rear surface of the mirror can be heated electrically to clear frost and demist the mirror. A current I is passed through the reflecting alloy at the back of the mirror, as shown in Fig. 8.4.

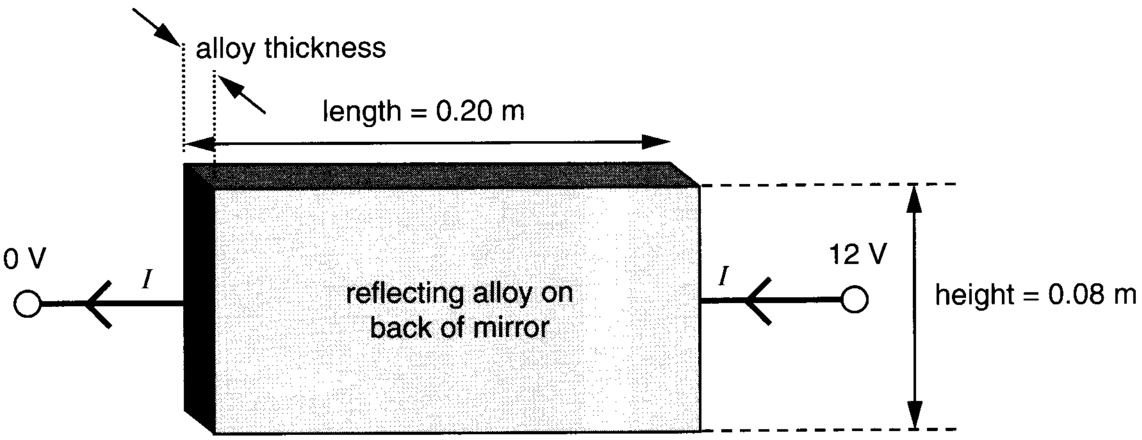


Fig. 8.4

(i) The heater dissipates 50 W from the 12 V car battery.

Show that the current I drawn by the heater is about 4 A.

[2]

(ii) Show that the conductance G of the heater is about 0.3 S.

[2]

(iii) The dimensions of the mirror are length = 0.20 m and height = 0.08 m as shown in Fig. 8.4.

Calculate the thickness of the reflecting alloy film used to heat the mirror.

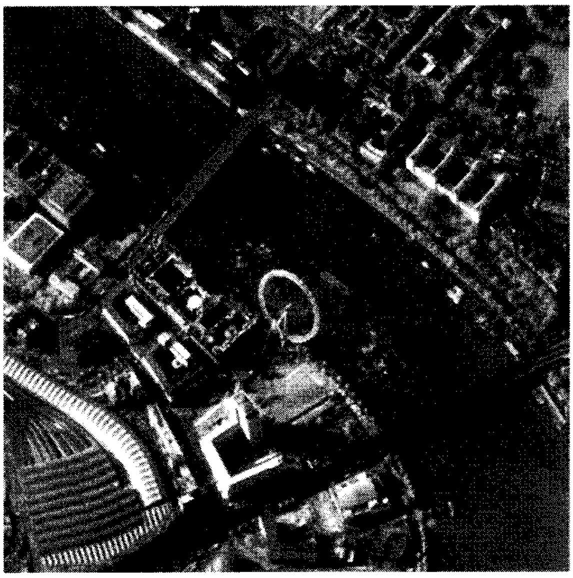
conductivity of reflecting alloy = 3.1×10^5 S m^{-1}

thickness = ... m [3]

[Total: 10]

For Examiner's Use

9 The London Eye was photographed from a satellite 200 km above the Earth. Fig. 9.1 is the original image which is 400 × 400 pixels. Fig. 9.2 is a magnified view of part of the original showing 75 × 75 individual pixels.



400 pixels

Fig. 9.1

75 pixels

Fig. 9.2

(a) Estimate the number of pixels along a diameter of the image of the London Eye.

pixels along diameter = ... [1]

(b) The London Eye is about 135 m in diameter.

Estimate the resolution of the image. Give your answer to 1 significant figure.

resolution is about .... m / pixel [1]

(c) Explain why both images in Fig. 9.1 and Fig. 9.2 have the **same** resolution.

[1]

(d) The original image Fig. 9.1 has 400 × 400 pixels and a greyscale of 8 bits per pixel.

Calculate the amount of information stored in the original image Fig. 9.1.

information = ... bits [1]

(e) The convex lens in the satellite camera forms a real image 0.16 m behind the lens. The satellite camera is focused on the ground 200 km directly below the satellite, as shown in Fig. 9.3.

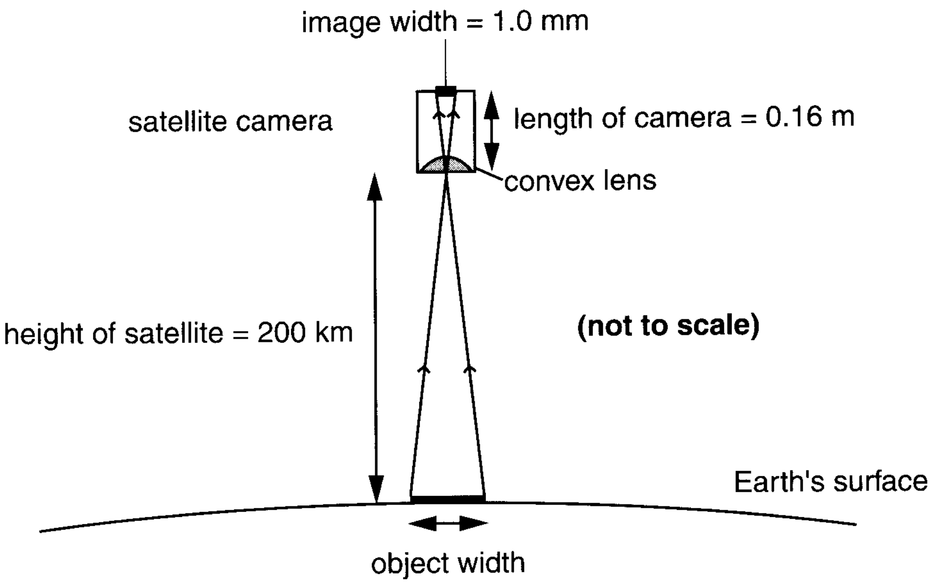


Fig. 9.3

(i) Show that the magnification is 8×10^{-7}.

[1]

(ii) Calculate the width of object on the Earth's surface that would produce an image that is 1.0 mm wide in the camera.

width of object = ... m [1]

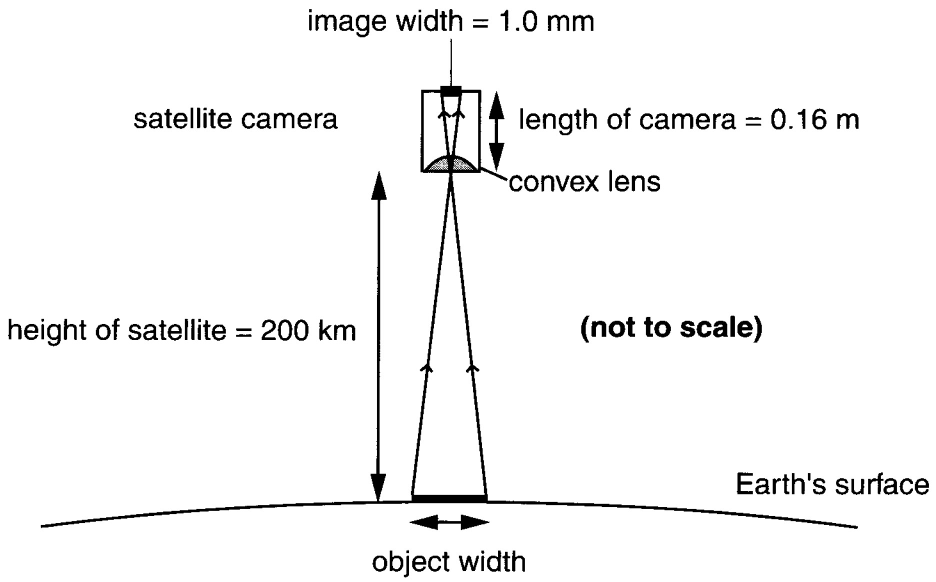


Fig. 9.3 (repeated)

(iii) Using the geometry of Fig. 9.3, explain why the ratios

$$\frac{\text{image distance}}{\text{object distance}} \text{ and } \frac{\text{image width}}{\text{object width}} \text{ are equal.}$$

[1]

(f) Using the lens equation

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

explain why, for this camera, the image distance v is very nearly equal to the focal length f of the lens.

[2]

[Total: 9]

Turn over for Question 10.

10 A battery is being tested. Fig. 10.1 shows the battery connected to a variable load resistor **R** and two meters.

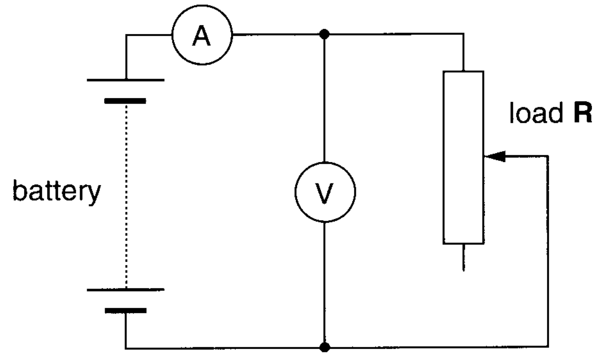


Fig. 10.1

Fig. 10.2 is a plot of the p.d. V across the battery against the current I, as **R** is varied.

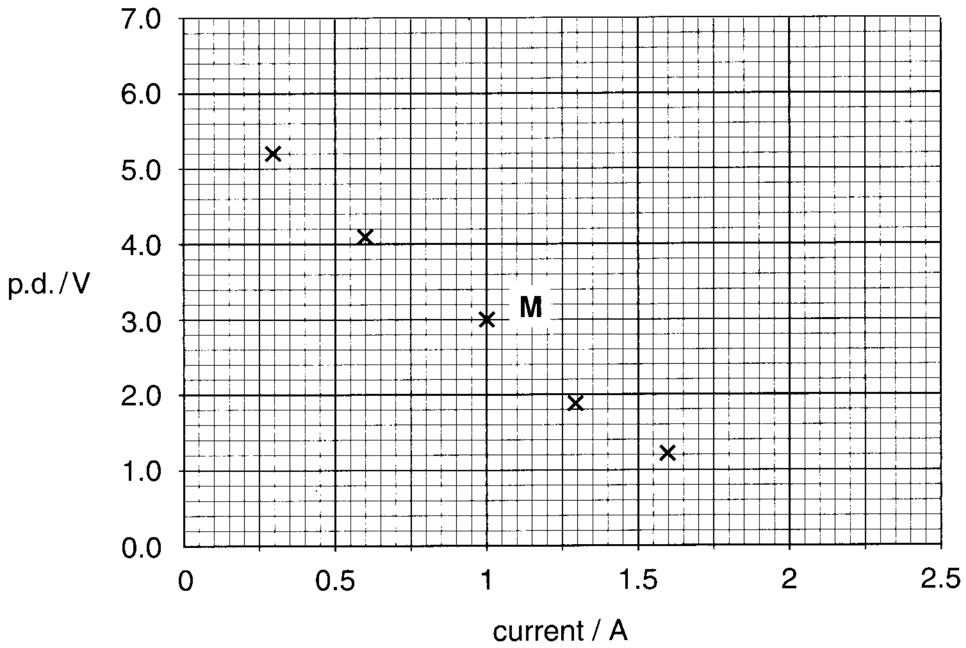


Fig. 10.2

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

(ii) Use your line of best fit to

1. estimate the e.m.f. $\mathcal{E}$ of the battery $\mathcal{E}$ = ... V [1]

2. calculate the internal resistance r of the battery. Show your working clearly.

r = ... Ω [3]

For Examiner's Use

(b) When the equation $V = \mathcal{E} - I\,r$

is multiplied throughout by the current I, an equation for the power, $I\,V$, delivered to the load resistance is

$$I\,V = I\,\mathcal{E} - I^2\,r.$$

Complete the gaps in the following sentence to explain the physical meaning of the second equation.

The electrical power delivered to the external load resistance is equal to

the power .... minus

the power ....[2]

(c) **(i)** Using point **M** on Fig. 10.2, where $I = 1.0$ A and p.d. $V = 3.0$ V, calculate

1. the resistance of the variable load resistor **R**

$R =$ .... Ω [1]

2. the power dissipated in **R**.

power = ... W [1]

(ii) The efficiency of a battery under load can be defined as follows

$$\text{efficiency} = \frac{\text{useful power}}{\text{total power}}.$$

Calculate the efficiency of the battery operating at point **M** on the graph.

efficiency = ... [1]

(iii) Choose **one** other data point from the graph Fig. 10.2.

Show that the power dissipated in **R** at this point is smaller than the power at point **M**, calculated in **(c)(i)**.

[1]

[Total: 11]

For Examiner's Use

11 This question is about the mechanical properties of human hair.

A single hair recovers almost completely elastically when strains of up to 25% are removed.

The table gives typical data for human hair.

diameter	50 μm
Young modulus	5.0×10^9 Pa
breaking stress	3.0×10^8 Pa
breaking strain	25%

(a) Up to 5% strain, the stress is directly proportional to the strain. At greater than 5% strain the relationship becomes non-linear.

Show that the stress at 5% strain is 2.5×10^8 Pa.

[1]

(b) Sketch the stress against strain graph for hair, up to its breaking point, on the axes of Fig. 11.1.

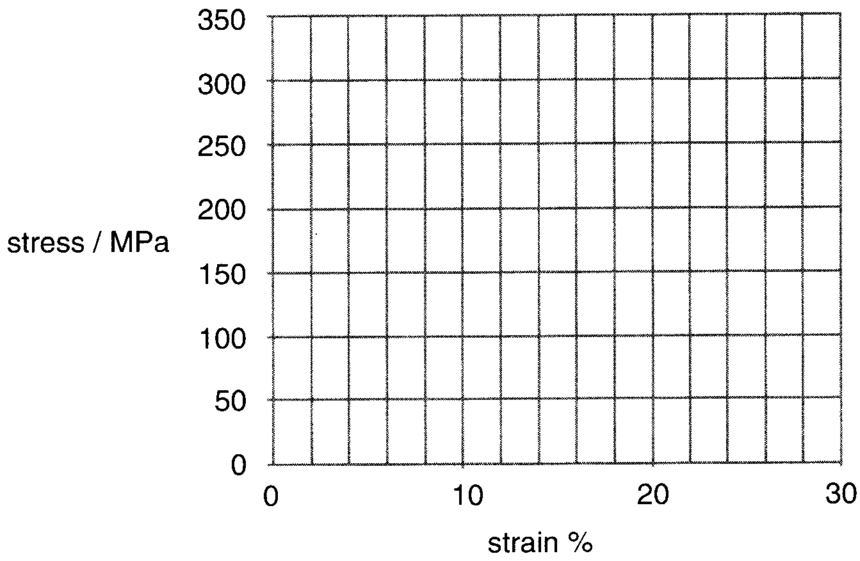


Fig. 11.1 [2]

(c) **(i)** Show that the cross-sectional area of a typical hair is about 2×10^{-9} m^2.

[1]

(ii) Calculate the force that breaks such a hair.

force = ... N [2]

For Examiner's Use

(d) Hair is a composite material. Its microscopic structure influences its mechanical behaviour.

(i) Hairs are made of bundles of strong protein fibres, embedded in an amorphous protein matrix (Fig. 11.2). Strong sulphur bonds glue the bundles of fibres to the amorphous matrix.

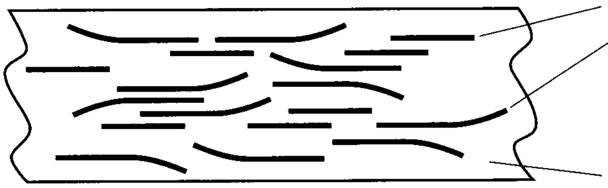


Fig. 11.2

Suggest and explain one mechanical property that hair is likely to have as a result of this composite microstructure.

[2]

(ii) The protein fibres are made of long coiled protein molecules (Fig. 11.3).

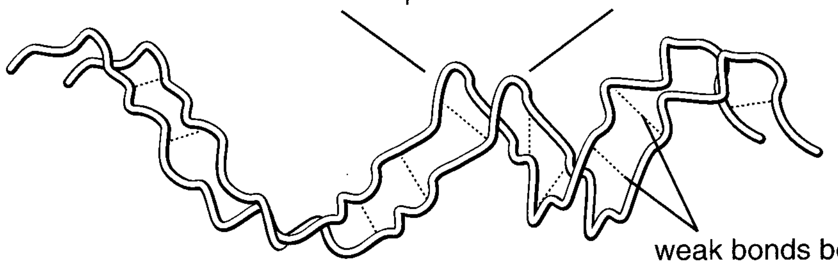


Fig. 11.3

Bundles of protein fibres consist of several protein molecules coiling around each other. Weak bonds hold the protein molecules to their neighbours, giving the fibres large flexibility.

Suggest how hair can recover almost completely elastically up to strains of 25% as a result of this microstructure.

[2]

[Total: 10]

[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.

12 In this question, you are asked to choose and discuss a practical example of a transmission system in which signals carry information.

(a) **(i)** Name the kind of information to be transmitted by the system that you have chosen, and state your example of signal transmission.

kind of information transmitted ....

example of signal transmission system ....
[2]

(ii) The frequency of the signal is related to the rate at which information is transferred.

Give an estimate of a transmission frequency in your system. State what physical quantity the frequency represents.

[3]

(iii) Explain the advantage of using a **high** transmission frequency.

[1]

For Examiner's Use

Signalling systems can be based on **analogue** or **digital** information transfer.

(b) Distinguish carefully between these two types of information system.

[3]

(c) Modern communications systems have possible **advantages** and **disadvantages** to humankind.

State and **explain** one advantage and one disadvantage of such systems.

advantage

disadvantage

[4]

[Total: 13]

For Examiner's Use

13 In this question, you are to discuss an electrical sensor system of your own choice.

(a) State the physical variable that your chosen sensor system is intended to monitor, and a suitable choice of component to make the sensor.

physical variable ....

component ....

[2]

(b) Draw a circuit diagram for the sensor system.
Show how a suitable electrical output signal can be obtained from the circuit.

[3]

(c) **(i)** State how you could calibrate your sensor system and determine its sensitivity.

[3]

For Examiner's Use

(ii) Give an estimate of the sensitivity, including appropriate units.

sensitivity .... units .... [2]

(iii) Suppose that your electrical sensing system is **not** sufficiently sensitive.

State and explain how you would modify your circuit to improve the sensitivity, **other than** by using a more sensitive sensor.

[3]

[Total: 13]

Quality of Written Communication [4]

[Section C Total: 30]

END OF QUESTION PAPER