OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE **2860**

PHYSICS B (ADVANCING PHYSICS)

Physics in Action

FRIDAY 11 JANUARY 2008 Afternoon

Time: 1 hour 30 minutes

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

CUP/T27852

Candidate Forename | Candidate Surname

Centre Number | Candidate Number

INSTRUCTIONS TO CANDIDATES

- Write your name in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use blue or 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.
- Do **not** write outside the box bordering each page.
- Write your answer to each question in the space provided.

INFORMATION FOR CANDIDATES

- The number of marks for each question 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 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	**18**	
B	**42**	
C	**30**	
TOTAL	**90**	

This document consists of **21** printed pages and **3** blank pages.

Answer **all** the questions.

Section A

1 Here is a list of units.

$J\,m^{-2}$ **$kg\,m\,s^{-2}$** **$kg\,m^{-3}$** **$N\,m^{-2}$**

State the correct units for:

density .... toughness .... stress .... [3]

2 Fig. 2.1 shows a ray of light being refracted at an air-glass boundary.

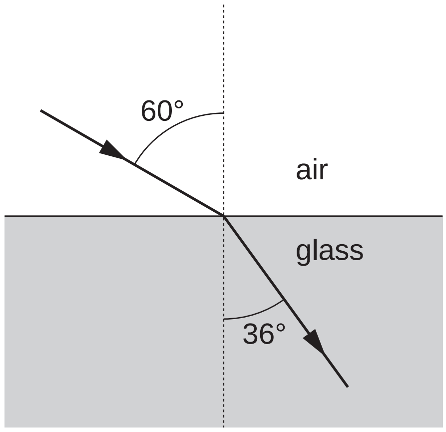


Fig. 2.1

(a) Calculate the refractive index *n* of the glass using the angles shown on Fig. 2.1.

n = ... [1]

(b) Calculate the speed of light in the glass.

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

speed of light in glass = ... $m\,s^{-1}$ [2]

3 The output voltage of a pressure sensor varies with the pressure applied to it.
Fig. 3.1 shows the calibration graphs for four different pressure sensors **A**, **B**, **C** and **D**.

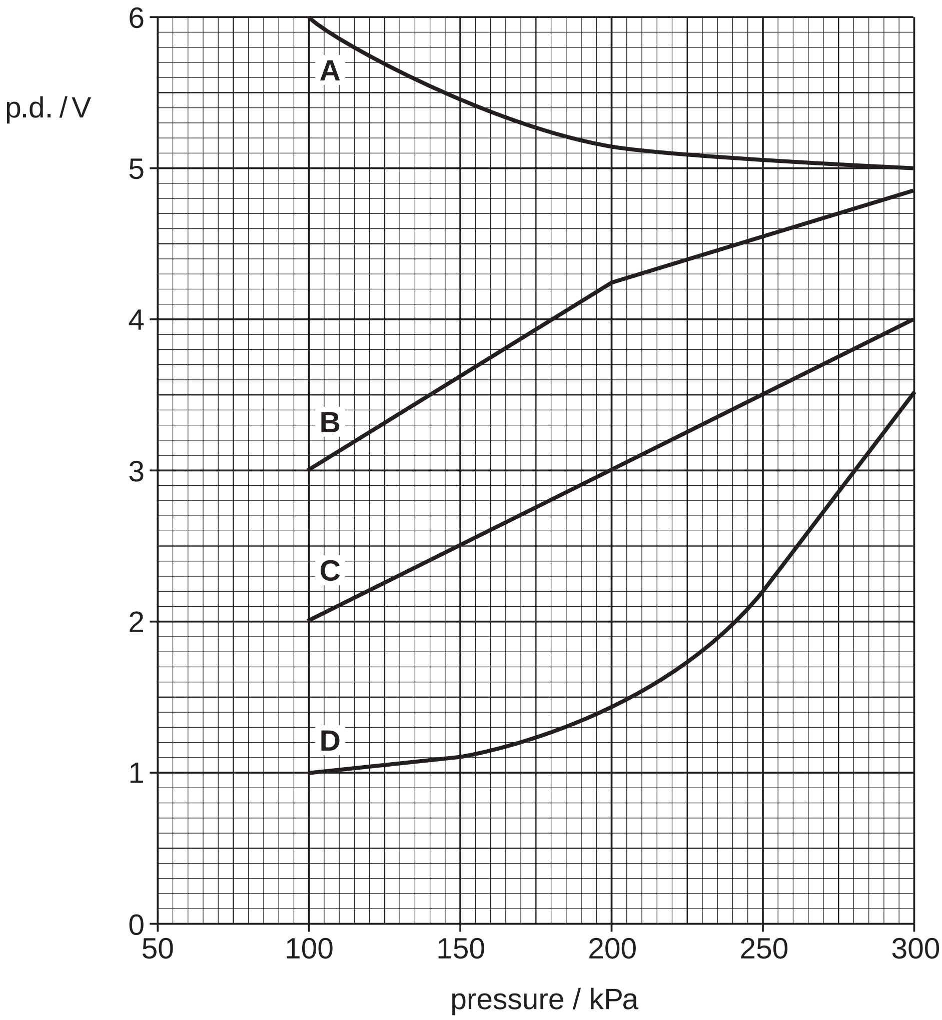


Fig. 3.1

(a) State which graph **A**, **B**, **C** or **D** shows:

an output p.d. that decreases with increasing pressure ....

greatest sensitivity at high pressure ....

a constant sensitivity .... [3]

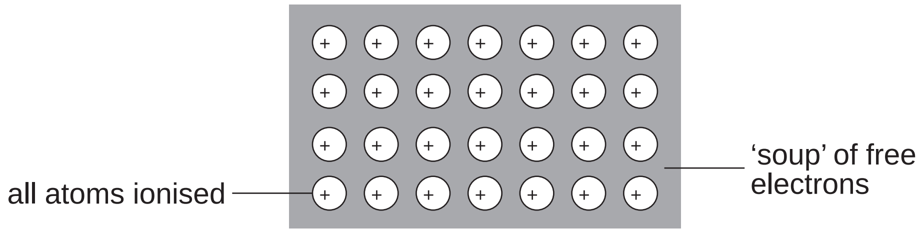
(b) Calculate the sensitivity of sensor **B** in the range 100 to 200 kPa.

sensitivity = ... V kPa^{-1} [2]

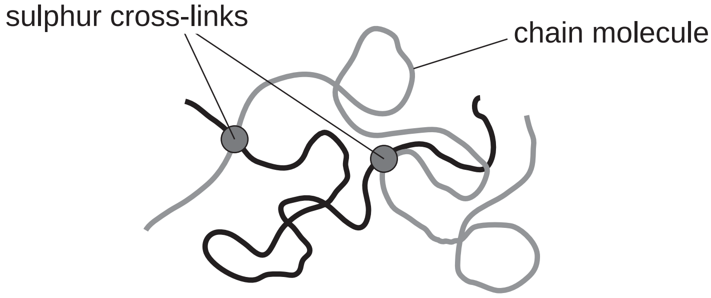
4 Electromagnetic waves can be **polarised**.
Explain what is meant by the term **polarised waves**.
Use a diagram to illustrate your answer.

[2]

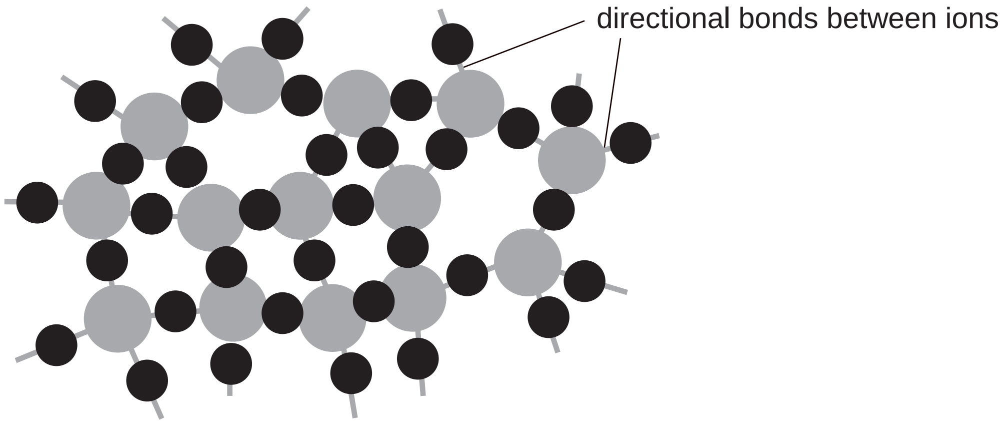
5 Here are four diagrams **A**, **B**, **C**, **D** of the microstructures of different classes of materials.



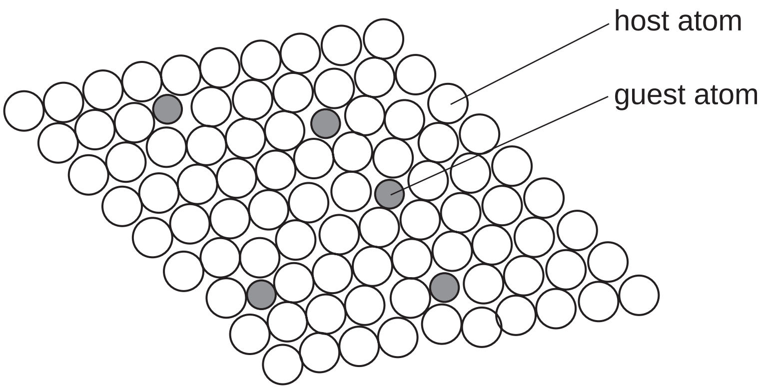
A



B



C



D

State which diagram **A**, **B**, **C** or **D** best represents the internal structure of:

a pure metal .... an alloy................. a glass .... [3]

6 A speech recognition system 'learns' to interpret different sounds by analysing their sound spectra.
Fig. 6.1 and Fig. 6.2 show the sound spectra for the sounds "mm" and "oh".

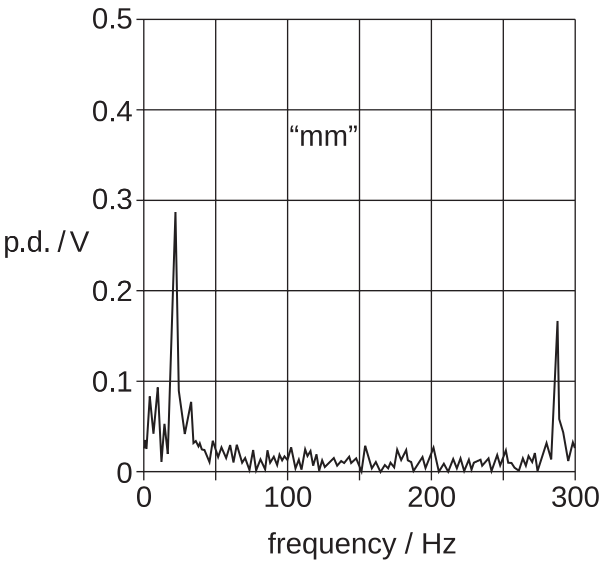


Fig. 6.1

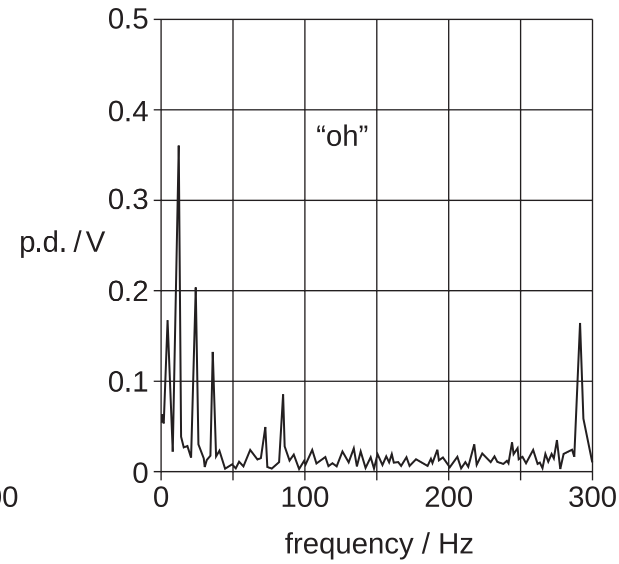


Fig. 6.2

(a) State one way in which the sound spectra are similar.

[1]

(b) State one way in which the sound spectra are different.

[1]

[Section A Total: 18]

Section B

7 A student investigates the relationship between object distance *u* and image distance *v* for a converging lens.
Fig. 7.1 shows a graph of her results.

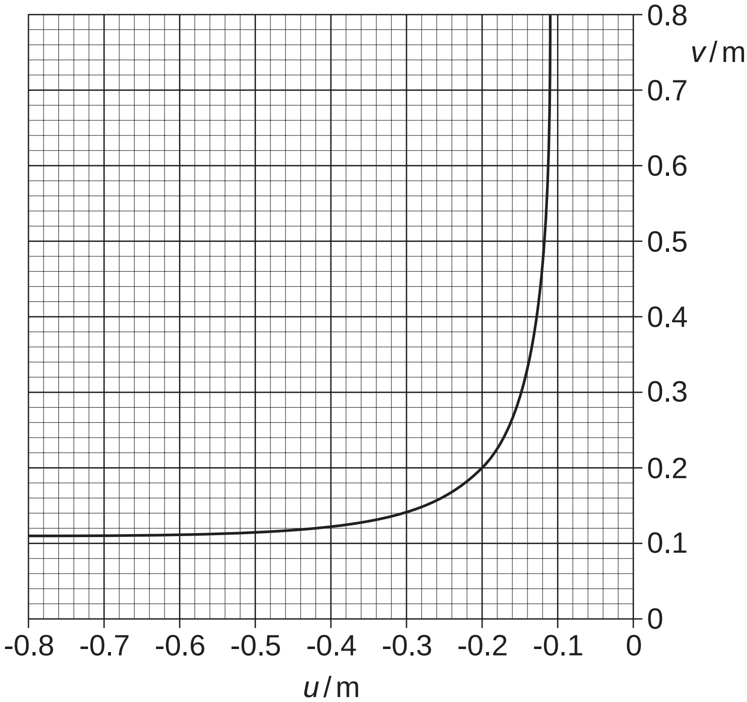


Fig. 7.1

(a) Complete the following sentences, which describe the trend shown by the graph.

As the object is moved towards the converging lens from a large distance, the image moves

....

When the object gets close to the focal point of the lens, the image ....

.... [2]

(b) Use data from Fig. 7.1 to find the focal length *f* of the lens.
Make your method clear.

f = ... m [2]

(c) On Fig. 7.1 draw the graph that you would expect for a lens of **twice** the optical power. [2]

(d) Fig. 7.2. shows another way of displaying the **same data** by plotting a graph of $1/u$ against $1/v$.

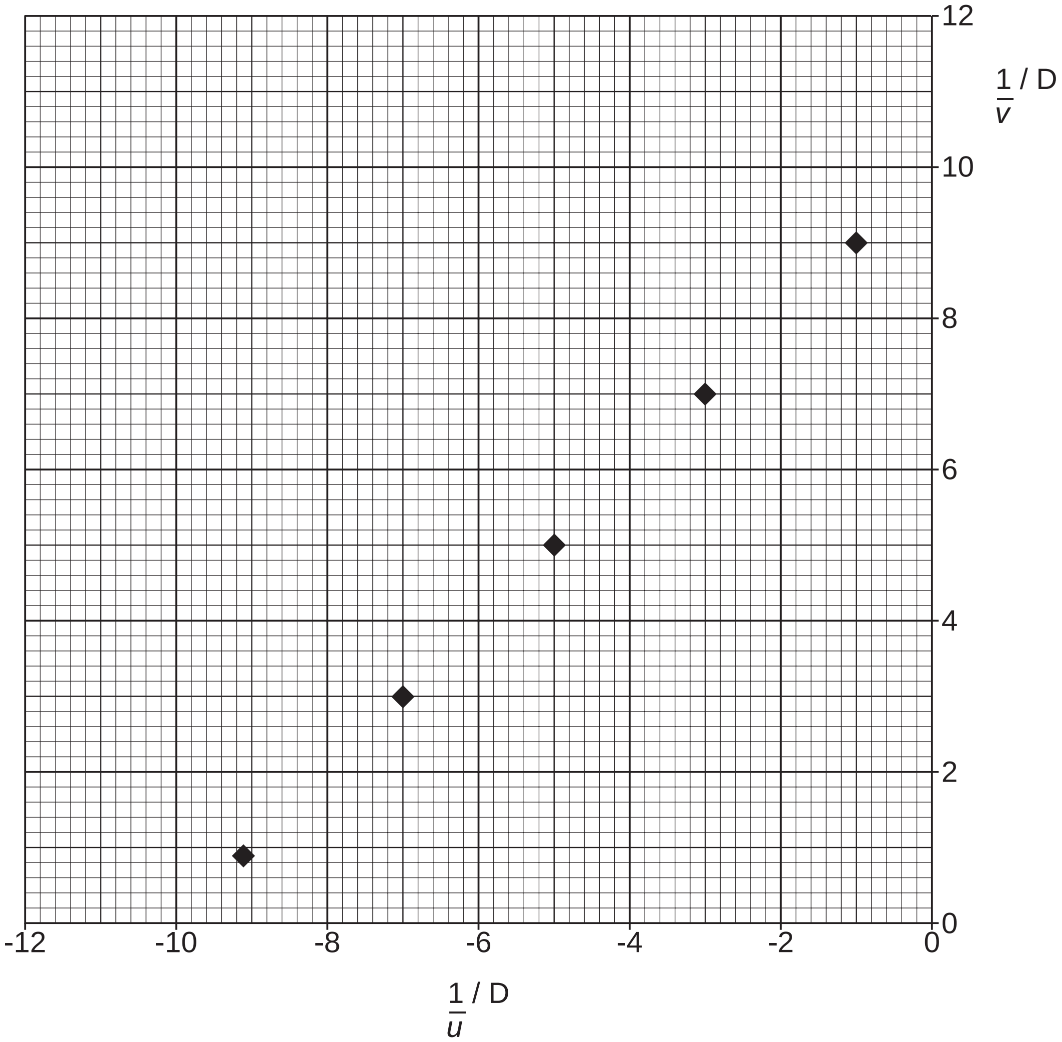


Fig. 7.2

(i) Use the equation $\frac{1}{v} = \frac{1}{u} + \frac{1}{f}$ to explain why the points lie on a straight line.

[2]

(ii) Use the graph Fig. 7.2 to confirm the value of *f* that you found in **(b)**.

[2]

[Total: 10]

8 This question is about the choice of materials to construct the overhead power cables for the National Grid.
Fig. 8.1 shows cables suspended from pylons.

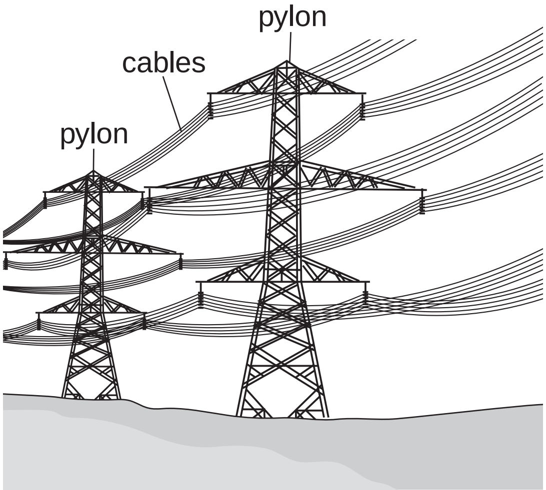


Fig. 8.1

(a) **(i)** Each cable operates at a p.d. of 400 kV above Earth voltage.

Calculate the power transmitted by each cable if the current in it is 100 A.

power = ... W [1]

(ii) Power cables inevitably lose some energy during transmission.

State where this energy goes.

[1]

(iii) An acceptable power loss is 1.4 kW per km length of cable at a current of 100 A.

Show that the conductance *G* of a 1.0 km length of the cable must be greater than about 7 S, so that it does not lose more power than 1.4 kW per km.

[2]

(b) **(i)** The mass m of the cable is given by $$m = A L \rho$$

where A is the cross-sectional area, L is the length and ρ the density of the cable material.

The conductance G of the cable is given by $$G = \frac{\sigma A}{L}$$

where σ is the conductivity of the cable material.

Combine these two relationships to show that $$m = \frac{G L^2 \rho}{\sigma}.$$

[1]

(ii) Aluminium and steel are used for making the cables.
Fig. 8.2 shows the ratios (steel / aluminium) of conductivity, density, yield stress, and Young Modulus for these two materials.

conductivity of steel / conductivity of aluminium	0.18
density of steel / density of aluminium	2.9
yield stress of steel / yield stress of aluminium	6.0
Young modulus of steel / Young modulus of aluminium	3.0

Fig. 8.2

Using these data and the formula in **(i)**

calculate the ratio $\dfrac{\text{mass of steel cable}}{\text{mass of aluminium cable}}$

for cables of length 1.0 km and conductance of 7 S.

ratio = ... [2]

(c) The cables are made from a combination of steel and aluminium strands.

Fig. 8.3 shows a composite cable made of 7 central steel strands surrounded by 30 aluminium strands.

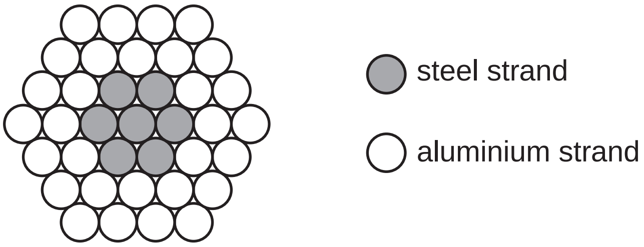


Fig. 8.3

(i) The conductance G_{steel} of 1.0 km of the 7 steel strands is 0.29 S.
Use data from table Fig. 8.2 to show that the conductance of 1.0 km of the 30 aluminium strands is close to 7 S.
All the strands have the same cross-sectional area.

[3]

(ii) Calculate the conductance of 1.0 km of the composite cable.

conductance = ... S [1]

(iii) Suggest **one** reason why a composite conductor composed of steel and aluminium strands is chosen for the National Grid.

[1]

[Total: 12]

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9 This question is about a light sensor circuit.

(a) A light dependent resistor (LDR) and a fixed resistor are to be set up in a potential divider circuit to act as a light sensor. The resistance of the LDR **decreases** when the light intensity falling on it increases.

Draw a circuit diagram for this sensor, indicating where the output p.d. is to be measured so that its value **increases** as the light intensity increases.

[3]

(b) A light emitting diode (LED) illuminates the LDR.
The p.d. across the LED switches it ON and OFF as shown in Fig. 9.1.
The other curve on Fig. 9.1 is the corresponding output p.d. from the light sensor circuit.

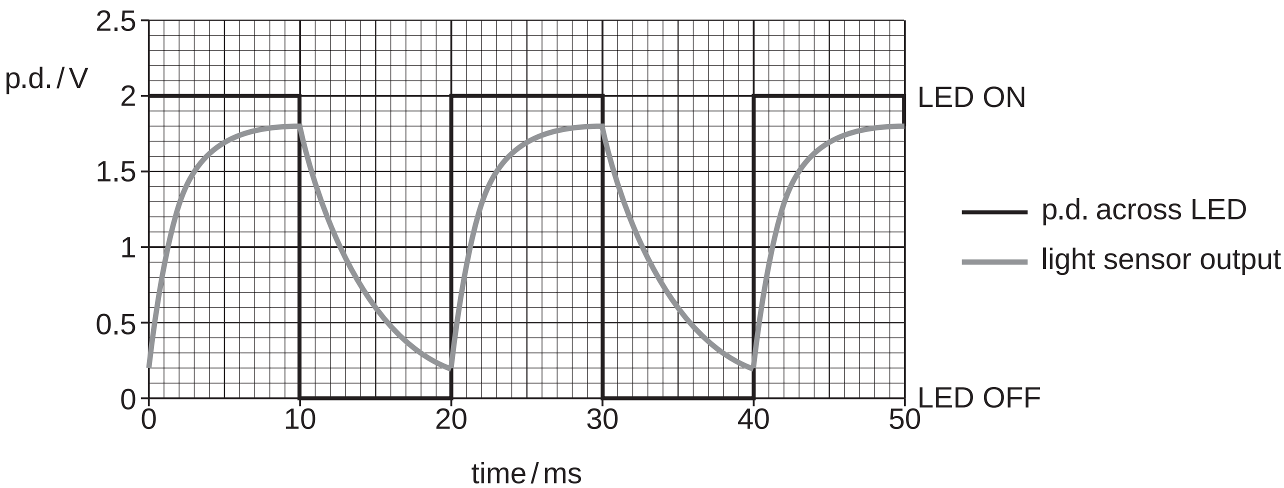


Fig. 9.1

(i) Use Fig. 9.1 to calculate the frequency of the flashes of light from the LED.
Make your method clear.

frequency = ... Hz [2]

(ii) Explain how the two graphs of Fig. 9.1 show that the sensor takes time to respond when the LED flashes ON.

[2]

(iii) Use Fig. 9.1 to estimate the response time of the sensor when the LED flashes ON.

response time = ... s [1]

(iv) A person looking at the flashing LED sees a continuous red light.

Suggest a property of the human eye which might explain this observation.

[1]

(c) The LED now flashes at **ten** times the original frequency.

Fig. 9.2 shows the new output from the sensor circuit.

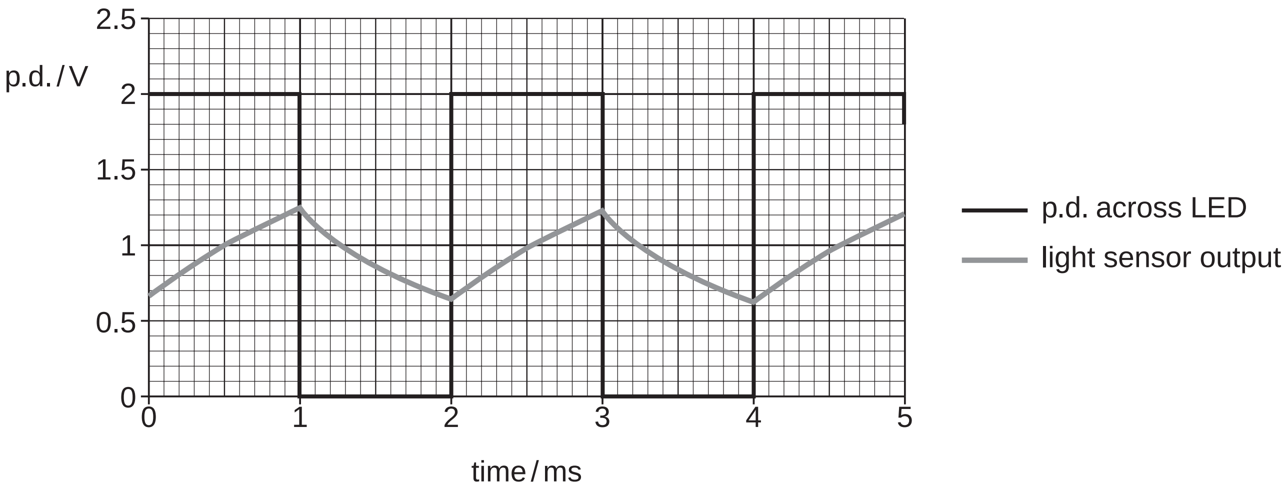


Fig. 9.2

State and explain **one** change in the output p.d. of the sensor circuit when the frequency is increased.

[2]

[Total: 11]

10 This question is about how an imaging system can be used to recognise the size of an apple. Traditionally, in an apple-packing factory a worker manually removed apples of the wrong size. The process has now been automated using a digital camera which takes an image of each apple as it passes the camera.

(a) Fig. 10.1 shows the image of an apple.

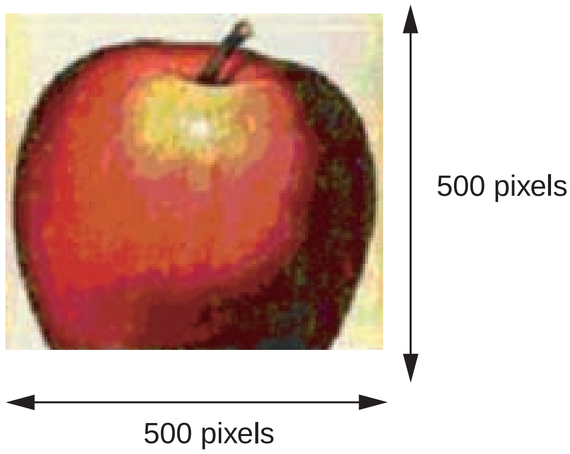


Fig. 10.1

The image is made up of 500 × 500 pixels.
The resolution is 2.1×10^{-4} m per pixel.

Estimate the horizontal diameter of this apple. Make your method clear.

diameter = ... m [2]

(b) **(i)** The greyscale used for the pixel values in the image uses 6 bit resolution.

State the number of alternative greyscale values using 6 bits.

number = ... [1]

(ii) The camera takes 4 images per second.

Estimate the data transfer rate from the camera.

data transfer rate = ... bits s^{-1} [3]

(c) To help to measure the size of an apple, a computer processes the image data by edge detection. A processed image is shown in Fig. 10.2.

Fig. 10.2

To find edges, the value of each pixel P has been replaced as follows.
New value of **P** = 4 × P – (N+E+S+W),

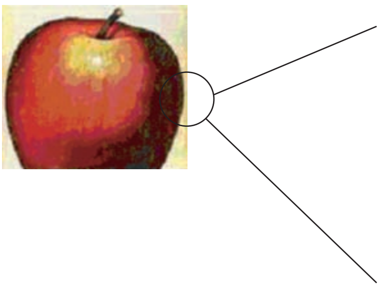
where N, S, E and W are the pixel values for the positions shown below.

	N	
W	P	E
	S	

Any new value of **P** which is **negative** is replaced with the value **zero**.

Fig. 10.3(a) shows the pixel values for a region near the edge of the apple before the rule has been applied.

Calculate the new values for each of the central 9 pixels of Fig. 10.3(a) using the rule described above.
Enter these new values on the grid in the white area in Fig. 10.3(b).



50	50	50	10	10
50	50	50	10	10
50	50	50	10	10
50	50	50	10	10
50	50	50	10	10

Fig. 10.3(a) (before)

Fig. 10.3(b) (after) [2]

(d) Apples less than 8.0 cm in horizontal diameter are rejected.

Calculate the number of horizontal pixels between the vertical edges of the processed image for an apple of this diameter.

number of pixels = ... [1]

[Total: 9]

[Section B Total: 42]

[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.

11 This question is about an experiment to measure the Young modulus of a metal.
You may describe any suitable experiment of your choice.

(a) Draw a labelled diagram to show how you would set up an experiment to measure the Young modulus of a metal.

[3]

(b) Describe clearly how you would carry out the experiment and obtain the data required.

[3]

(c) Describe how you would use the data to obtain a value for the Young modulus of the metal.

[4]

(d) Describe any procedures that you could adopt to minimise experimental errors in determining the value of the Young modulus of the metal.

[3]

[Total: 13]

12 In this question you are asked to choose and write about a signal transmission system.

(a) **(i)** State your example of signal transmission.

example of signal transmission .... [1]

(ii) State what is meant by the **speed of transmission**.

[1]

(iii) State what is meant by the **rate of information transfer** of the signal.

Give an estimate of the rate of information transfer with appropriate units.

[1]

rate = ... unit .... [2]

(iv) 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]

(b) Digital signal transmission systems are designed to reduce the effects of **noise** in the received **signal**.

(i) State clearly the difference between **noise** and **signal** in a signalling system.
A diagram may help your answer.

[2]

(ii) Explain how digital systems can reduce the effects of noise in signals compared with analogue systems.

You may wish to use sketch graphs to illustrate your answer.

[3]

[Total: 13]

[Quality of Written Communication 4]

[Section C Total: 30]

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