Answer **all** the questions.

Section A

1 The two columns below list the usual units of four electrical quantities and a set of equivalent alternative units.

units	equivalents
A	$J\ s^{-1}$
V	$V\ A^{-1}$
W	$C\ s^{-1}$
Ω	$J\ C^{-1}$

Draw a straight line from each **unit** box to the corresponding **equivalent** box. **[3]**

2 The two columns below list four mechanical properties of materials and a set of definitions.

properties	definitions
stiff	the force per unit cross-sectional area
stress	difficult to indent or scratch
hard	a small strain for a large stress on a material
tough	needs a large energy to break and create a new fracture surface

Draw a straight line from each **property** box to the corresponding **definition** box. **[3]**

3 Two resistors are connected in series to a 6.0 V supply of negligible internal resistance as shown in Fig. 3.1.

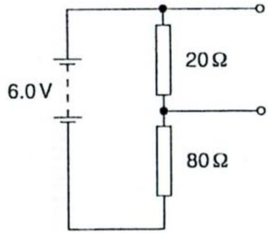


Fig. 3.1

(a) Show that the p.d. across the 20 Ω resistor is greater than 1 V.

$V_{OUT} = \frac{R_2}{R_1 + R_2} V_{IN} = \frac{20}{100} \times 6.0 = 1.2\ V$

(From data sheet.)

[2]

(b) Calculate the power dissipated in the 20 Ω resistor.

$P = IV \qquad I = V/R$

$\therefore P = V^2/R = 1.2^2/20 =$

power = 0.072 W **[2]**

4 A resistance thermometer uses changes in resistance with temperature to measure temperature. Fig. 4.1 is the calibration graph of its resistance against temperature.

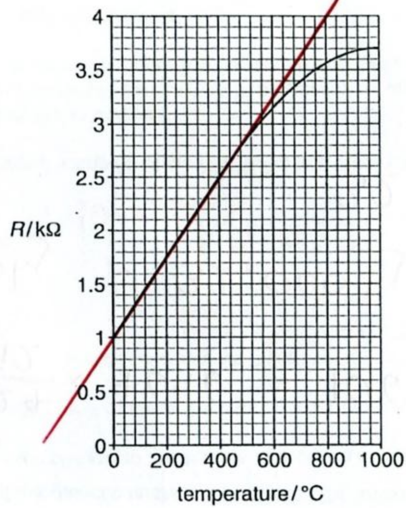


Fig. 4.1

(a) Calculate the sensitivity of the thermometer at 200 °C.

$$\text{sensitivity} = \frac{\Delta\ \text{OUPUT}}{\Delta\ \text{INPUT}} = \frac{4-1\ \text{k}\Omega}{800\ °\text{C}}$$

$$\frac{3\times10^3\ \Omega}{800\ °\text{C}} =$$

sensitivity = 3.75 Ω °C^{-1} **[2]**

(b) Describe what happens to the sensitivity of the thermometer as the temperature increases from 0 °C to 1000 °C.

Sensitivity is constant (3.75) up to 500°C it then falls and reaches ~ 0 by 1000 °C

[2]

5 Fig. 5.1 shows a lens system being used to make a micro-circuit by producing a tiny image.

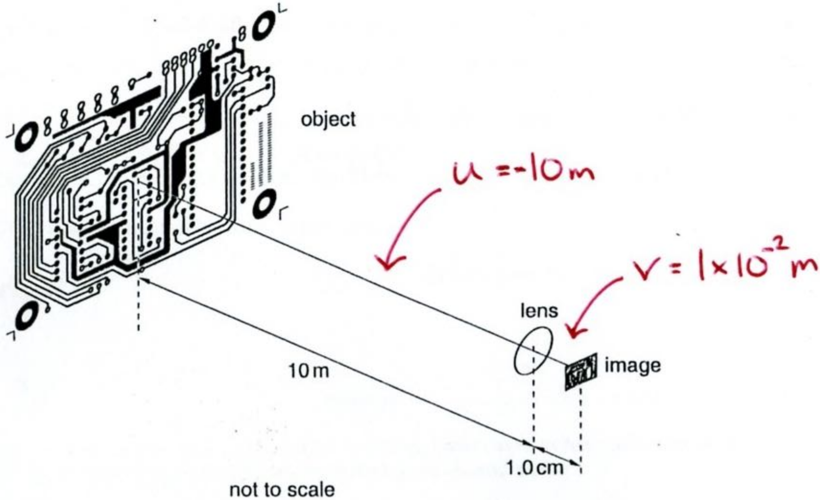


Fig. 5.1

(a) Calculate the magnification of the lens system using the data in Fig. 5.1.

$m = \frac{v}{u} = \;= 1\times10^{-2}/10$

magnification = 1×10^{-3} **[2]**

(b) Calculate the power of the lens needed to achieve this magnification.

Make your method clear.

$\frac{1}{v} = \frac{1}{u} + \frac{1}{f}$ $\quad P = \frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

power = 100 D **[3]**

$P = \frac{1}{1\times10^{-2}} - \frac{1}{-10} = 100 - 1$

6 Fig. 6.1 shows an image of the Andromeda galaxy taken by the Hubble Space Telescope. The image contains 4096 × 3072 pixels as shown.

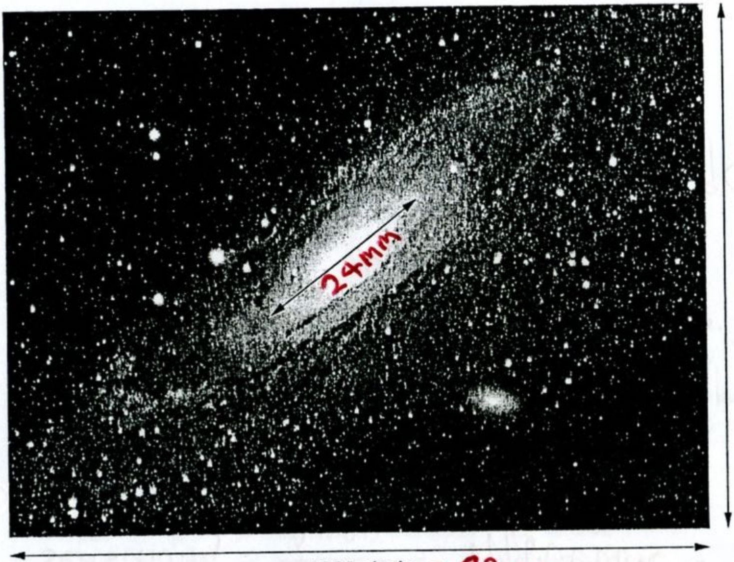


Fig. 6.1

The resolution of the image is 30 light years per pixel.

Calculate the diameter of the galactic nucleus indicated by the arrow in Fig. 6.1.

Make your method clear.

Nucleus = $\frac{24}{92} \times 4096$ = 1068 pixels

1068 × 30ly =

diameter = ...32,000.... light years [3]

7 Here is a list of numbers.

0.005 0.05 0.5 5.0 50

Write down the number from the list which is the closest estimate for:

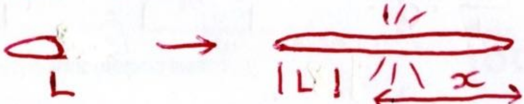
(a) the breaking strain of a rubber band .... 5 ....

(b) the power in kW for a 'one cup' kettle .... 0·5 .... kW

[2]

[Section A Total: 24]

Rubber band



$\frac{x}{L} \approx 4 \rightarrow$ 5

Kettle Max Power = 13A × 230V = 3 kW

so must be lower, → 0-5
prob quite a lot
as its just 1 cup

8 This question is about stretching polythene.

(a) A long narrow sample strip of polythene is cut from a shopping bag. It stretches elastically up to a strain of 0.082 at a stress of 14 MPa. This is the elastic limit of the material.

(i) Calculate the Young modulus of the polythene and state the unit.

$E = \frac{\text{stress}}{\text{strain}} = 14 \times 10^6 / 0.082 =$

$170 \rightarrow$ MPa

OR $0.17 \rightarrow$ GPa

Young modulus = 0.17 unit GPa [3]

(ii) The cross-sectional area of the sample is $1.9 \times 10^{-7}\,m^2$.

Calculate the force applied to the sample to produce a stress of 14 MPa.

$P = F/A$

$F = PA = 14 \times 10^6 \times 1.9 \times 10^{-7} =$

force = 2.7 N [2]

(b) Fig. 8.1 shows the stress against strain graph for the sample to its breaking point.

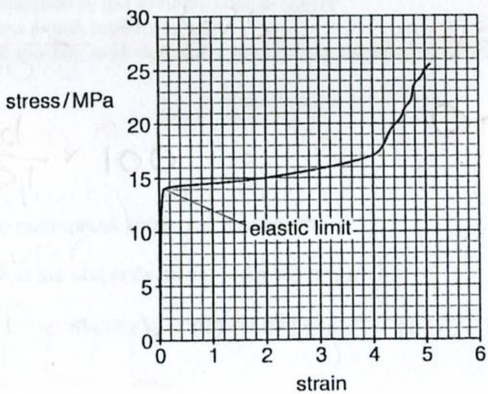


Fig. 8.1

(i) Describe the behaviour of the sample as it is stretched from the elastic limit to its breaking point.

Small increase in stress gives large increase in strain. At around strain of 4 sample becomes stiffer untill it breaks at ~ 6x origonal length.

[2]

(ii) Use Fig. 8.1 to calculate the extension of the sample at the breaking point.

The original length of the sample is 15 cm.

$strain = x/L \qquad x = strain \times L$

$= 5.1 \times 15\,cm$

extension = 76.5 cm [3]

(c) Suggest and explain what is happening to the **long chain molecules** in the sample between the elastic limit and the breaking point as stress is increased slowly.

You may wish to use labelled diagrams.

In your answer you should use appropriate technical terms spelled correctly.

The chains start out random and folded but as bonds rotate they line up and the material becomes more crystalline so has greater intermolecular forces making it stiffer. Eventually some bonds break as it fails

[4]

[Total: 14]

9 One method of calibrating a voltmeter is to measure the known p.d. across a standard cell. A standard cell is one whose emf is stable and accurately known.

One such standard cell has an emf ε of 1.019V at room temperature.

(a) State the number of significant figures in this emf value.

number of significant figures = 4 [1]

(b) The uncertainty in the emf is given as 1.019 ± 0.001 V.

Calculate the % uncertainty implied by this data.

$$\frac{0.001}{1.019} \times 100 =$$

% uncertainty = 0.1 % [1]

(c) The p.d. across the cell may change if the current exceeds 2.8 μA or if more than 10 μC of charge are drawn in any measurement.
The internal resistance of the standard cell is 350 Ω.

(i) In a particular voltmeter calibration by a student the current drawn is 1.1 μA.

Show that the maximum time the student has to complete the measurement is less than 10 s.

$$Q = It$$

$$t = Q/I = 10 \times 10^{-6}\,C / 1.1 \times 10^{-6}\,A$$

$$= 9.1\ s$$

[2]

(ii) Calculate the resistance of the voltmeter being calibrated.

Make your method clear.

$$R = V/I = \frac{1.019V}{1.1 \times 10^{-6}A} = 9.26 \times 10^{5}\ \Omega$$

(TOTAL IN CIRCUIT)

$$9.26 \times 10^{5} - 350\Omega =$$

resistance of voltmeter = 9.26×10^{5} Ω [3]

(iii) Calculate the voltage drop across the internal resistance of the standard cell during the calibration.

$V = IR = 1.1 \times 10^{-6} \times 350 =$

voltage drop = 3.85×10^{-4} V **[2]**

(d) Suggest and explain a problem that would arise in an attempt to calibrate a voltmeter of much lower internal resistance using this standard cell.

If internal resistance is lower the current drawn will be higher. It may exceed 2.8 μA. Also it would not take very long before the 10 μC charge limit was exceeded.

[2]

[Total: 11]

10 This question is about a 3-D television system. The TV screen contains 1920 × 1080 colour-pixels. Each colour-pixel consists of three sub-pixels, one red, one green and one blue.

(a) (i) The intensity of light emitted by each sub-pixel in the screen is coded by a 12 bit number.

Calculate the number of alternative intensities for each sub-pixel.

$2^{12} =$

number of intensities = 4096 [1]

(ii) Show that about 75 Mbits of uncompressed information are needed to produce one image on the screen.

$1920 \times 1080 \times 12 \times 3 = 74.6 \times 10^6$ bit

[1]

(iii) 120 images are displayed on the screen each second.

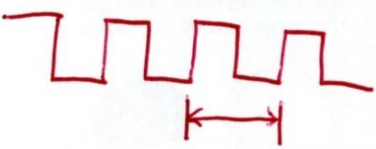
Estimate the bandwidth required for transmission of uncompressed image data for this TV system. Make your method clear.

bit rate $= 74.6 \times 10^6 \times 120 = 9.0 \times 10^9$

bit rate ≈ bandwidth $= 9.0 \times 10^9$ Hz

OR bandwidth ≈ bit rate/2 $= 4.5 \times 10^9$ Hz

bandwidth = ... Hz [2]



1 cycle ↔ 2 bits

(in best case scenario)

(b) Light emitted from the 3-D TV screen is unpolarised. To produce a 3-D effect viewers wear glasses containing polarising filters.

(i) Explain the difference between unpolarised and polarised light.

You should use labelled diagrams in your explanation.

unpolarised light oscillates in all possible directions

Looking down direction of motion of transverse wave. →

etc.

polarized light oscillates in one plane / direction only

e.g.

or

[3]

(ii) The images on the TV screen alternate between the views which should be seen by the left and right eyes. An electronic signal to the glasses, synchronised with the TV images, causes the light to be blocked alternately to the left and right eyes. See Fig. 10.1. Each eye sees 60 frames per second, and then the brain integrates these into a single 3-D image with no flicker.

active 3-D glasses blank out left vision when the right eye frame is displayed on the TV

then blanks out right vision when the left eye frame is displayed

Fig. 10.1

Each lens contains two polarising filters. One filter has a fixed plane of polarisation; the other is made from a liquid-crystal material. This material acts as a polarising filter when a voltage is applied across it.

Using your knowledge of polarisation suggest and explain how the glasses alternately block the light to the left and right eye.

Organise your explanation clearly and coherently.

Plane of polarisation of the liquid crystal is at 90° to the fixed filter. When the liquid-crystal is on the crossed filters will not transmit any light. When it is off the fixed filter will transmit. The voltage is applied alternatly to each liquid-crystal filter in time with the left and right eye images.

[4]

[Total: 11]

[Section B Total: 36]

END OF QUESTION PAPER