P510/2
PHYSICS
Paper 2
Nov./Dec. 2011
2½ hours

UGANDA NATIONAL EXAMINATIONS BOARD

Uganda Advanced Certificate of Education

PHYSICS

Paper 2

2 hours 30 minutes

INSTRUCTIONS TO CANDIDATES:

Answer **five** *questions, including at least* **one**, *but not more than* **two** *questions from each of the sections* **A, B** *and* **C.**

Mathematical tables and squared paper will be provided.

Non-programmable scientific calculators may be used.

Assume where necessary:

Acceleration due to gravity, g	=	$9.81\ ms^{-2}$
Speed of light in a vacuum, c	=	$3.0 \times 10^{8}\ ms^{-1}$
Electron charge, e	=	1.6×10^{-19} C
Electron mass	=	9.11×10^{-31} kg
Plank's constant, h	=	6.6×10^{-34} Js
Permeability of free space, μ_0	=	$4.0\pi \times 10^{-7}\ Hm^{-1}$
Permittivity of free space, ε_0	=	$8.85 \times 10^{-12}\ Fm^{-1}$
The constant $\frac{1}{4\pi\varepsilon_0}$	=	$9.0 \times 10^{9}\ F^{-1}m$
One electron volt (eV)	=	1.6×10^{-19} J
Avogadro's number N_A	=	$6.02 \times 10^{23}\ mol^{-1}$
Resistivity of Nichrome wire at 25°C	=	$1.2 \times 10^{-6}\ \Omega m$
Specific heat capacity of water	=	$4.2 \times 10^{3}\ J\ kg^{-1}\ K^{-1}$

Turn Over

SECTION A

1. (a) Define the following terms a applied to a concave lens:

   (i) Principal focus, *(01 mark)*
   (ii) Radii of curvature. *(01 mark)*

   (b) A point object is placed at a distance U in front of a diverging lens of focal length, f, to form an image at a distance V from the lens. Derive an expression that relates U,V and f. *(04 marks)*

   (c) Describe an experiment to determine the focal length of a concave lens using a plane mirror, a converging lens and an illuminated object. *(04 marks)*

   (d) What is meant by a:

   (i) visual angle? *(01 mark)*
   (ii) near point? *(01 mark)*

   (e) A person with a normal near point distance of 25cm wears spectacles with a diverging lens of focal length 200cm in order to correct the far point distance to infinity. Calculate the near point distance when viewing using the spectacles. *(03 marks)*

   (f) (i) Draw a ray diagram to show the formation of an image of a distant object in a terrestrial telescope in normal adjustment. *(03 marks)*

   (ii) State two disadvantages of the terrestrial telescope. *(02 marks)*

2. (a) What is meant by the term:

   (i) refraction? *(01 mark)*
   (ii) absolute refractive index? *(01 mark)*

   (b) Describe an experiment to determine the refractive index of a liquid using a travelling microscope. *(04 marks)*

(c) Figure 1 shows monochromatic light X incident towards A on a vertical screen.

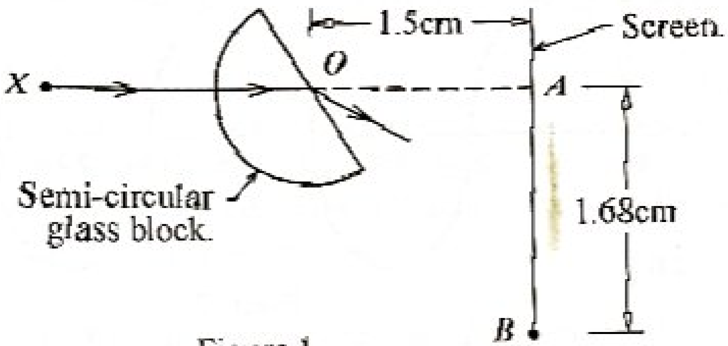

Figure 1

When the semicircular glass block is placed across the path of light with its *flat face* parallel to the screen, a bright spot is formed at A. When the glass block is rotated about a horizontal axis through O, the bright spot moves down from A towards B and then just disappears at B, a distance 1.68cm from A.

(i) Find the refractive index of the material of the glass block. *(04 marks)*

(ii) Explain whether AB would be longer or shorter if a block of glass of higher refractive index was used. *(02 marks)*

(d) (i) A ray of monochromatic light is incident at a small angle of incidence on a small-angle prism in air. Obtain the expression $d = (n - 1)A$, for the deviation, d of the light by the prism, where A is the refracting angle of the prism and n the refractive index. *(04 marks)*

(ii) Calculate the minimum deviation produced by a 60° glass prism if the refractive index of the glass is 1.50. *(03 marks)*

(iii) State any two applications of total internal reflection. *(01 mark)*

3. (a) (i) Define the terms **wave front** and **a ray** in reference to a progressive wave. *(02 marks)*

(ii) Draw a sketch diagram showing reflection of a circular wave by a plane reflector. *(02 marks)*

Turn Over

(b) Figure **2** below shows a wave travelling in the positive x-direction away from the origin with a velocity of $9\ ms^{-1}$.

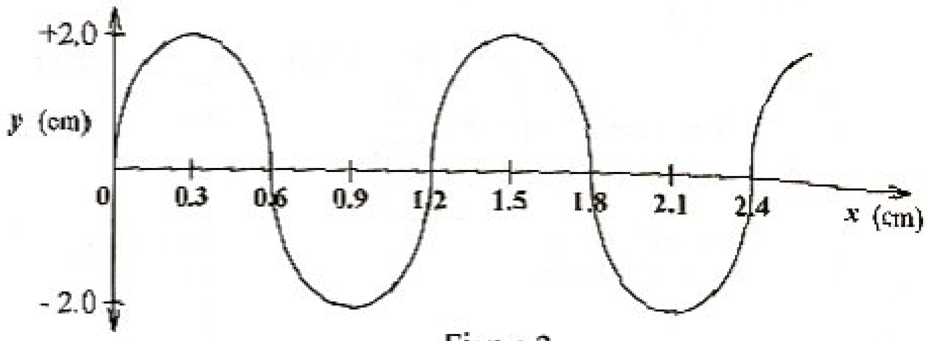

Figure 2

(i) What is the period of the wave? *(03 marks)*

(ii) Show that the displacement equation for the wave is

$$y = 2\sin\frac{5}{3}\pi(9t - x).$$ *(03 marks)*

(c) What is meant by **Doppler effect**? *(01 mark)*

(d) One species of bats locates obstacles by emitting high frequency sound waves and detecting the reflected waves. A bat flying at a steady speed of $5\ ms^{-1}$ emits sound of frequency 78.0 kHz and is reflected back to it.

(i) Derive the equation for the frequency of the sound waves reaching the bat after reflection. *(05 marks)*

(ii) Calculate the frequency of the sound received by the bat given that the speed of sound in air is $340\ ms^{-1}$. *(02 marks)*

(e) (i) What is meant by intensity of a sound note? *(01 mark)*

(ii) Distinguish between **loudness** and **pitch** of a sound note. *(01 mark)*

4. (a) What is meant by the following terms:

(i) Unpolarised light, *(01 mark)*

(ii) Plane polarised light? *(01 mark)*

(b) (i) Describe briefly how plane polarized light is produced by double refraction. *(03 marks)*

(ii) Explain briefly **one** application of polarized light. *(02 marks)*

(c) Explain:

(i) how two coherent sources are obtained using a biprism. *(03 marks)*

(ii) why interference effects are not observed in thick films. *(03 marks)*

(d) In Young's double slit experiment, the slits are separated by 0.28mm and the screen is 4m away. The distance between the fourth bright fringe and the central fringe is 1.2cm. Determine the wavelength of the light used in the experiment. *(04 marks)*

(e) Explain the effect of increasing the number of narrow slits in diffraction grating on the intensity of diffraction fringes. *(03 marks)*

SECTION B

5. (a) Define the following terms as applied to alternating voltage.

(i) Root-mean-square value, *(01 mark)*

(ii) Peak value. *(01 mark)*

(b) (i) An alternating voltage is applied across a capacitor of capacitance, *C*. Show that the current in the circuit leads the voltage by $\pi/2$. *(03 marks)*

(ii) Find the expression for the capacitive reactance in terms of frequency, f and capacitance, *C*. *(02 marks)*

(iii) A capacitor of 0.1μF is in series with an a.c. source of frequency 500Hz. If the r. m. s value of the current flowing is 6mA, calculate the voltage across the capacitor. *(03 marks)*

(c) A bulb is connected in series with an inductive coil and a d.c. source as shown in Figure 3.

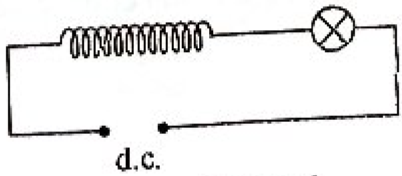

Figure 3

Turn Over

(i) What happens to the brightness of the bulb when an iron core is inserted in the coil? *(01 mark)*

(ii) Explain what happens to the brightness of the bulb when the d.c. source is replaced with a.c. and an iron core inserted in the coil. *(03 marks)*

(d) (i) What is **hysteresis loss**? *(01 mark)*

(ii) How can hysteresis loss be minimised in the a.c. transformer? *(01 mark)*

(iii) Explain why the primary current in the a.c transformer increases when the secondary coil is connected to the load. *(04 marks)*

6. (a) (i) Draw a well labelled diagram to show the structure of the repulsion type moving iron ammeter. *(02 marks)*

(ii) Explain how the ammeter in (a) (i) above is able to measure alternating current. *(05 marks)*

(b) (i) Write down an expression for the magnetic flux density at the centre of a flat circular coil of, N, turns each of radius, a, carrying current, I. *(01 mark)*

(ii) Describe how you would determine the value of the earth's magnetic flux density at a place, using a search coil. *(06 marks)*

(c) A coil of 50 turns and radius 4cm is placed with its plane in the earth's magnetic meridian. A compass needle is placed at the centre of the coil. When a current of 0.1A passes through the coil, the compass needle deflects through 40°. When the current is reversed, the needle deflects through 43° in the opposite direction.

(i) Calculate the horizontal component of the earth's flux density. *(04 marks)*

(ii) Calculate the magnetic flux density of the earth at that place given that the angle of dip at the place is 15°. *(02 marks)*

7. (a) State the laws of electromagnetic induction. *(02 marks)*

(b) (i) A circular metal disc of radius, R, rotates in an anticlockwise direction at an angular velocity, ω, in a uniform magnetic field of flux density, B directed into paper as shown in Figure 4.

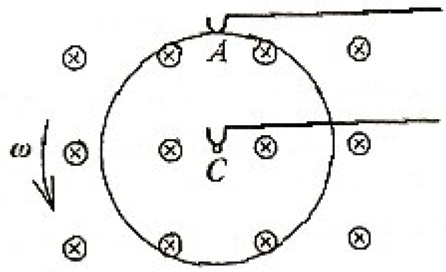

Figure 4

A and C are contact points .
Derive an expression for the e.m.f. induced between A and C. *(03 marks)*

(ii) A copper disc of radius 10 cm is placed in a uniform magnetic field of flux density, $0.02T$, with its plane perpendicular to the field. If the disc is rotated parallel to the field about an axis through its centre at 3000 rev min^{-1}, calculate the e.m.f. that is generated between its rim and the centre. *(03 marks)*

(c) Describe an experiment to demonstrate mutual induction. *(04 marks)*

(d) The diagram in Figure 5 shows the arrangement by which a laboratory balance is critically damped. The aluminium beam supporting the pan moves in the magnetic field of two powerful magnets.

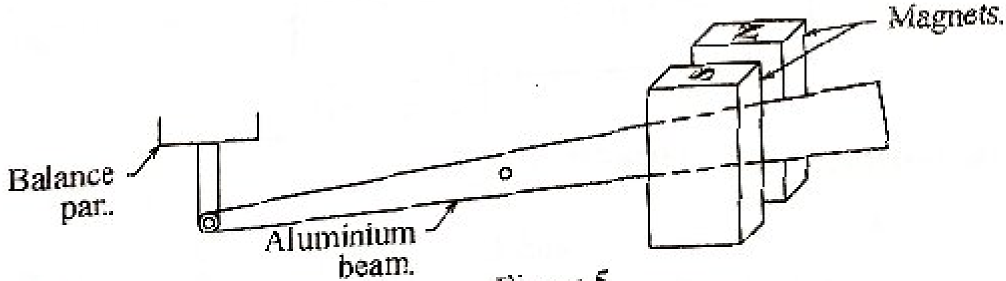

Figure 5

(i) Explain how damping is caused. *(03 marks)*

(ii) What change would occur in the performance of the balance if the magnets were replaced by weaker ones? *(01 mark)*

Turn Over

(e) (i) Define the ampere. *(01 mark)*

(ii) Two parallel wires, P and Q of equal length 0.1m, each carrying a current of 10A are a distance 0.05m apart, with P directly above Q. If P remains stationary, find the weight of P. *(03 marks)*

SECTION C

8. (a) (i) Define electromotive force of a battery. *(01 mark)*

(ii) A cell of e.m.f, E and internal resistance, r, drives current through a resistor of resistance, R connected in series with it. Derive an expression for the efficiency of the circuit. *(04 marks)*

(b) Describe with the aid of a diagram how you would standardise a slide wire potentiometer. *(03 marks)*

(c) In Figure 6, AB is a uniform resistance wire of length 1m and resistance 4Ω. X is a driver cell of e.m.f 3V and internal resistance 1Ω and E_s is a standard cell. R_s is a standard resistor of resistance 10Ω which is connected in series with cell Y of e.m.f 1.2V and internal resistance 0.5Ω.

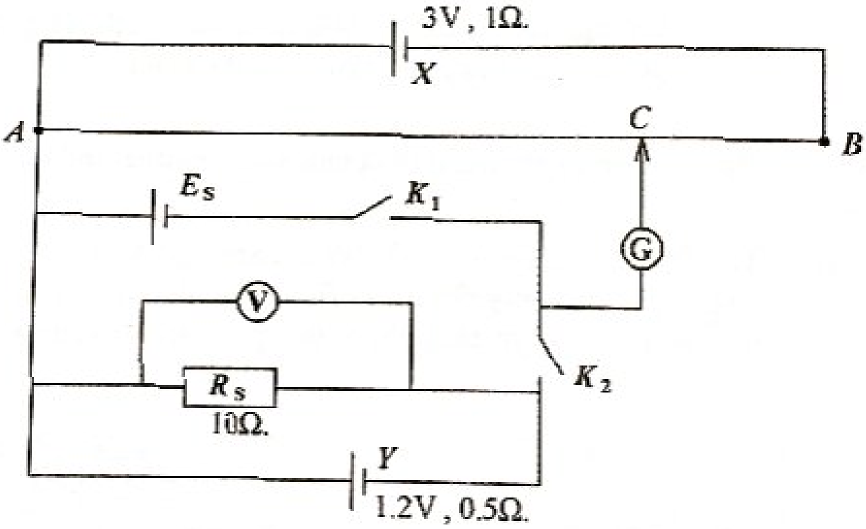

Figure 6

With switch K_1 closed and K_2 open, the balance length, AC is 60cm while the voltmeter reading is 1.14V. With switch K_1 open and K_2 closed, the balance length is 80cm. Calculate the:

(i) e.m.f, E_s of the standard cell, *(03 marks)*

(ii) percentage error in the voltmeter reading. *(03 marks)*

(d) Describe with the aid of a circuit diagram how you would measure the temperature coefficient of resistance of a material in form of a wire. *(06 marks)*

9. (a) State **Coulomb's law** of electrostatics. *(01 mark)*

(b) Derive the relation between electric field intensity, E, and electric potential, V, due to a charge at a point. *(04 marks)*

(c) Two pith balls P and Q each of mass 0.1g are separately suspended from the same point by threads 30 cm long. When the balls are given equal charges, they repel each other and come to rest 18 cm apart. Calculate the magnitude of charge on each ball. *(06 marks)*

(d) Describe how you would investigate the distribution of charge on a pear-shaped conductor. *(04 marks)*

(e) Explain how a charged body attracts uncharged conductor. *(03 marks)*

(f) Describe how an electroscope can be used to distinguish a conductor from an insulator. *(02 marks)*

10. (a) Define **dielectric strength**. *(01 mark)*

(b) (i) Explain briefly how a capacitor in which the potential difference V_o across the plates, can be fully discharged. *(02 marks)*

(ii) Sketch a graph showing a variation of potential difference with time for the process in (b) (i) above. *(01 mark)*

(c) (i) Two capacitors of capacitances C_1 and C_2 are connected in series. Show that the effective capacitance, C is given by

$$C = \frac{C_1 C_2}{C_1 + C_2}.$$ *(04 marks)*

(ii) A 10.0μF capacitor charged to 200V is connected across an uncharged 50μF capacitor.
Calculate the total energy stored in both capacitors before and after connection. *(04 marks)*

(iii) Account for the difference in the energies calculated in (c) (ii) above. *(01 mark)*

Turn Over

(d) In Figure 7, Q_1 and Q_2 are point charges of magnitudes +5.0 μC and -5.0 μC respectively.

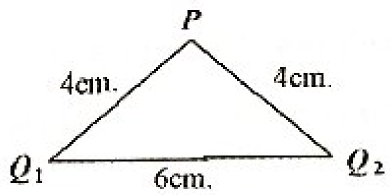

Figure 7

Calculate the:

(i) electric field intensity at P, *(03 marks)*

(ii) potential energy of a point charge Q_3 of 0.8 μC placed at P. *(04 marks)*

END

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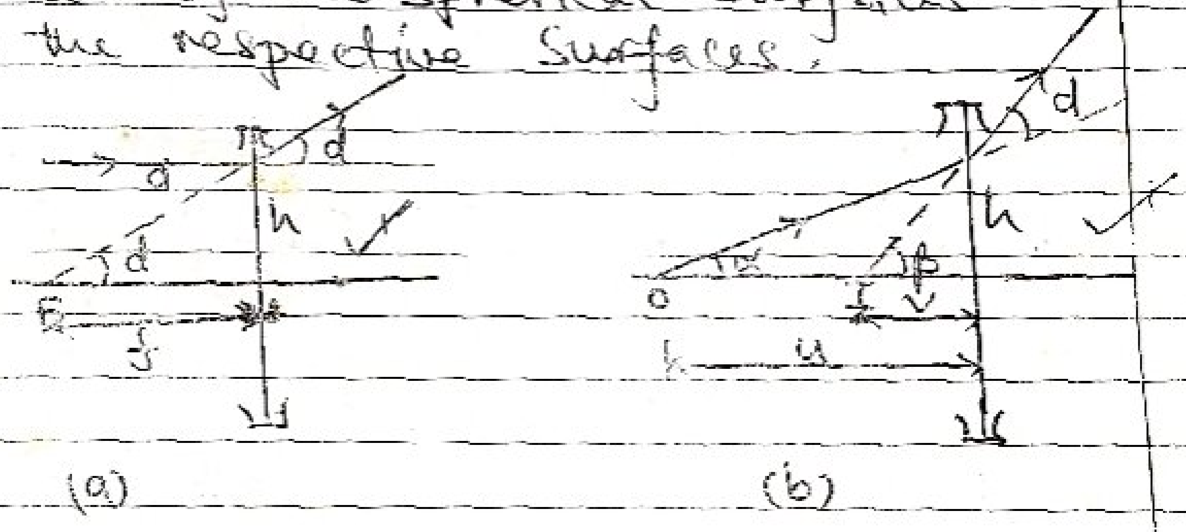
1(a)(i) It is the point on the principal axis where rays of light originally parallel and close to the principal axis appear to diverge from after refraction by the lens. ✓ (1)

(ii) Are the radii of curvature of the spheres of which the lens surfaces forms parts or the distances of the centres of curvature of each of the spherical surfaces from the respective surfaces. ✓ (1)

(b)



From figure (a) above deviation d is small, and if it is measured in radians then $d \simeq \tan d = \frac{h}{f}$ ✓

From fig. (b), [illegible] β ✓

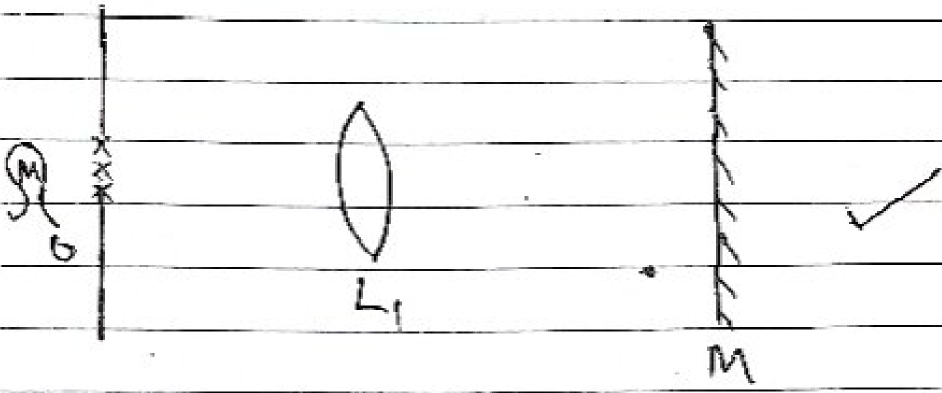
Now for small angles α, β measured in radians $\alpha \simeq \tan\alpha = \frac{h}{u}$; $\beta \simeq \tan\beta = \frac{h}{v}$ ✓

(2)

$\therefore d = \frac{h}{u} - \frac{h}{v} \Leftrightarrow -\frac{h}{f} = \frac{h}{u} - \frac{h}{v}$ ✓

$\Rightarrow -\frac{1}{f} = \frac{1}{u} - \frac{1}{v}$ ✓ (4)

(C)



The apparatus is arranged as above. The wire gauze is illuminated with a bulb, and the position of the Lens L_1 is adjusted until the sharp image of the wire gauze is formed on the object screen O. The distance OL_1 is measured and recorded as f_1. The test Lens L_2 is now cemented on L_1 and again placed between O and M. The position of the combined Lens is adjusted until a sharp image of the wire gauze is formed on O. The distance OL is measured and recorded as f. Focal length of the test Lens is then calculated (4)

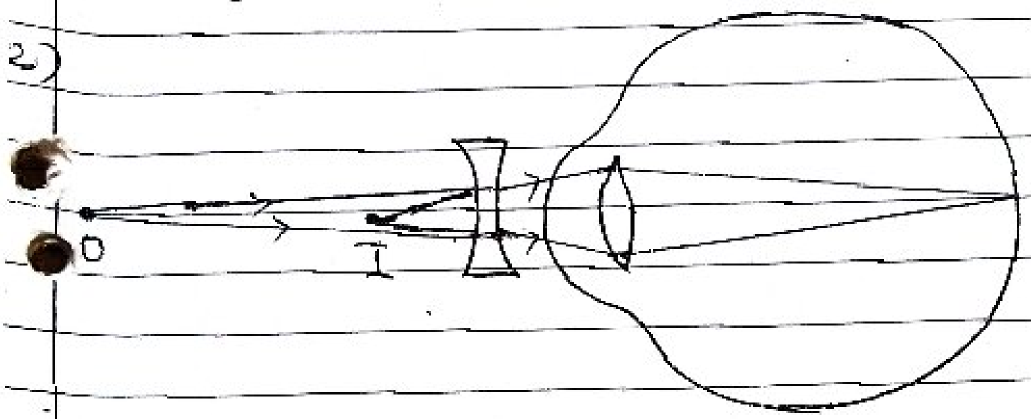
$\frac{1}{f_2} = \frac{1}{f} - \frac{1}{f_1}$ ✓

(3)

(i) Visual angle is the angle subtended by an object or image at the eye. (1)

(ii) The near point is the point at which the eye is able to view the object in greatest detail (1)

2)



The object at O appears to be at I. The near point for the eye. Now $V = -25cm$ and $f = -200cm$.

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

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

$$= \frac{1}{-200} + \frac{1}{25}$$

(3)

$$\frac{1}{u} = \frac{-1+8}{200}$$

$$\therefore u = \frac{200}{7}$$

$$= 28.6CM$$

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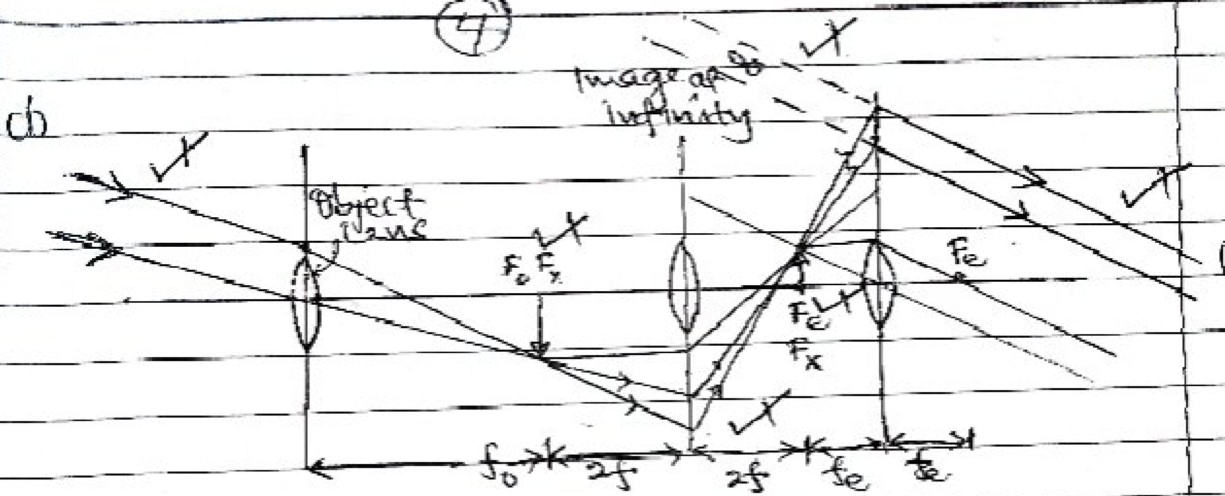
f) (i)



(3)

(ii) It's relatively longer, making it cumbersome to carry out.
Its ~~intensity~~ brightness of the final image is decreased due to extra reflections which occur at the lens surface (2)

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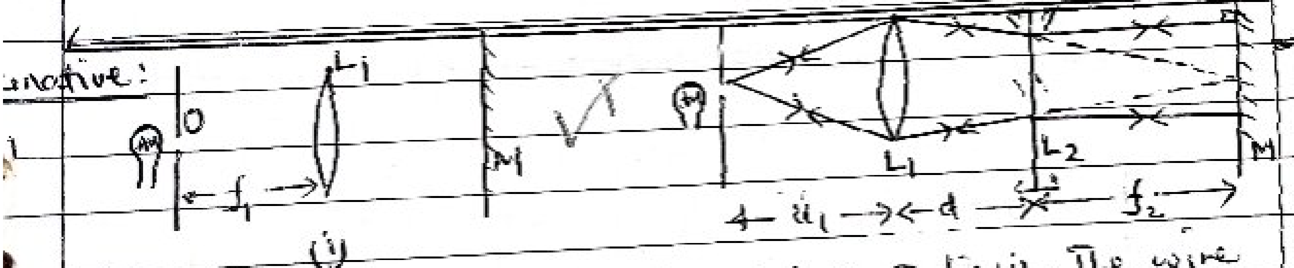
Alternative:

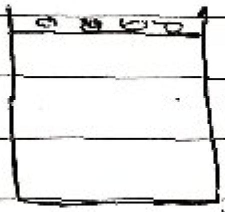


- The apparatus are set up as shown above in fig (i). The wire gauze is illuminated with a bulb and the position of lens L_1 is adjusted until a sharp image of the wire gauze is focussed on the object screen O. Distance OL_1 is measured and recorded as f_1. ~~The distance OL_1 is then rec~~ position of L_1 is adjusted by moving it towards M and the test lens L_2 is introduced between L_1 and M. The relative positions of L_1 and L_2 are ~~adjusted until a sharp image of the wire gauze~~ adjusted until a sharp image of the wire gauze is formed just besides O. The distances u_1 and d are measured and recorded from which the focal length f_2 of lens L_2 is determined from $f_2 = -(v_1 - d)$ where v_1 is calculated from the lens formula $\frac{1}{u_1} + \frac{1}{v_1} = \frac{1}{f_1}$.

2 (a)(i) Refraction is the change in direction of propagation of light as it travels from one medium to another (1)

(ii) Absolute refractive index of a medium is the ratio of speed of light in vacuum to speed of light in a medium. OR
The ratio of the sine of angle of incidence to the sine of angle of refraction for light moving from vacuum to a medium. (1)

(b)



A scratch is made at the bottom of a beaker and the beaker is placed under a travelling microscope. The microscope is adjusted until the scratch is focused clearly. The scale reading on the microscope is taken, a cm. The test liquid is poured in the beaker and the microscope adjusted again until the scratch is clearly seen. The scale reading is recorded b cm. Some particles that can float on the surface of the liquid are sprinkled on the surface of the liquid. The microscope is again adjusted until the particles are seen clearly and the scale reading c cm is recorded. Refractive index, η, is now calculated from $\eta = \frac{c-a}{c-b}$ (4)

C (i) When spot just disappears at B then total internal reflection has occured at O.

$$\therefore \eta = \frac{1}{\sin C} \quad \text{where } C = 90° - \theta$$

But $\tan\theta = \frac{1.68}{1.5} = 1.12 \Rightarrow \theta = 48.2°$

$$c = 90 - 48.2° = 41.8°$$

$n = \frac{\sqrt{AB^2 + OA^2}}{OA}$

$$\therefore \eta = \frac{1}{\sin 41.8°}$$

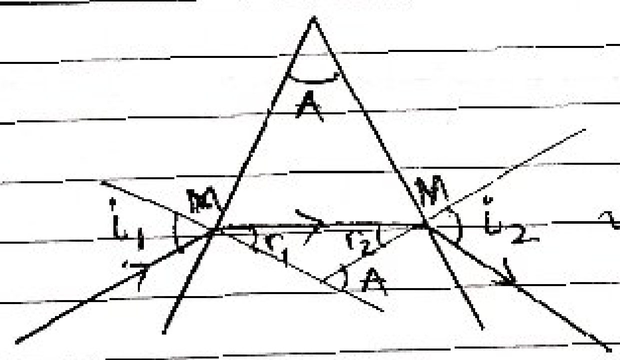
$$= 1.5$$

(4)

since OA is fixed $n \propto AB$ when n increases AB increases

(ii) If the refractive index is higher, the ray is deviated (or refracted) more. Hence AB would be longer. (2)

(d)



Consider a ray of light passing through a small angled prism as above. At M $\sin i_1 = \eta \sin r_1$. For small angles i and r measured in radians $\sin i \approx i$ and $\sin r \approx r \Rightarrow i_1 = \eta r_1$. Now $r_2 = A - r_1$ since A and r_1 are both small r_2 is small, $\sin r_2 = \eta \sin r_2$ since r_2 is small and i_2 is also small

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Q 3 $\therefore \sin i_2 \approx i_2$ and $\sin r_2 \approx r_2$

$\therefore i_2 = \eta r_2$ —— (2)

Now deviation produced by refraction by the prism

$$d = i_1 - r_1 + i_2 - r_2$$
$$= \eta r_1 - r_1 + \eta r_2 - r_2$$
$$= (\eta - 1)(r_1 + r_2)$$
$$= (\eta - 1)A.$$ (4)

(ii) using $\eta = \dfrac{\sin\left(\frac{A+D}{2}\right)}{\sin A/2}$ $\sin \frac{D+A}{2} = 1.5 \sin \frac{60}{2}$

$= 0.75$

$\therefore \left(\frac{D+A}{2}\right) = \sin^{-1} 0.75$

$\therefore D = 48.6 \times 2 - \cancel{60}\ 60$

$= 37.2^\circ$ (3)

(iii) - Used in ~~for sending messages through~~ optical fibres

- Used in determining refractive index of transparent materials (1)
- used in radio broadcast
- Total reflecting prisms in binoculars, periscopes

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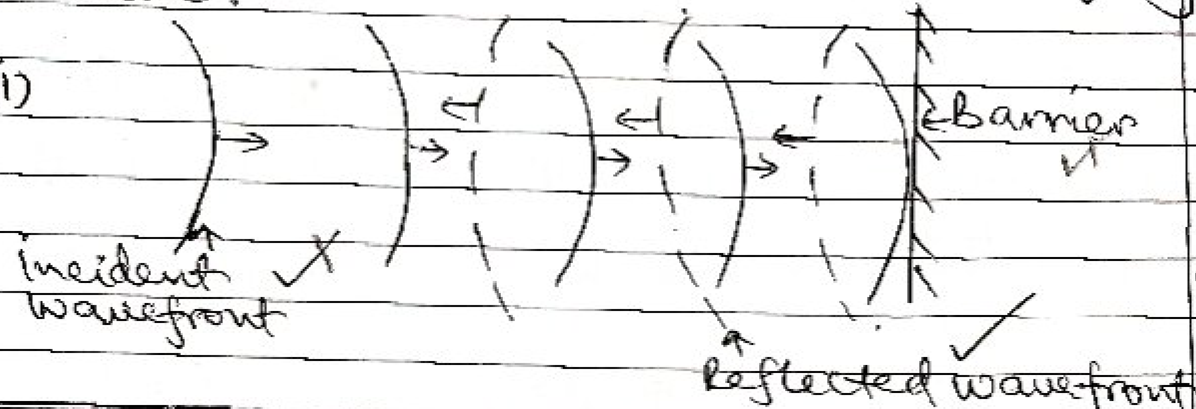
(8)

3(a) (i) <u>Wavefront</u> is a section through an advancing wave along which all particles are in phase

<u>A ray</u> is the direction of an advancing wave. (2)

(ii)



(2)

(b) (i) Wavelength = 1.2 cm = $\frac{1.2}{100}$ m

velocity = $9\,ms^{-1}$

Period $T = \frac{\lambda}{V} = \frac{1.2}{900} = 1.33 \times 10^{-3}$ s (3)

(ii) the wave is moving from left to right

c.f $y = a\sin 2\pi\left(ft - \frac{x}{\lambda}\right)$

now $a = 2$ cm, $f = 750$ Hz and $\lambda = 1.2$ cm

$\therefore$ $y = 2\sin 2\pi\left(750t - \frac{x}{1.2}\right)$

or c.f $y = a\sin\frac{2\pi}{\lambda}(vt - x)$

$a = 2$ cm, $\lambda = 1.2$ cm, $V = 900$ cm/s

$y = 2\sin\frac{2\pi}{\lambda}(900t - x)$

$= 2\sin\frac{2\pi}{1.2}(900t - x)$

$= 2\sin\frac{5\pi}{3}(900t - x)$ (3)

c.f $y = a\sin\frac{2\pi}{\lambda}(vt - x)$

$= 2\sin\frac{2\pi}{1.2}(900t - x)$

$= 2\sin\frac{5\pi}{3}(900t - x)$

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(9)

c) Doppler effect is the apparent change in frequency of a wave due relative motion between the Observer and the source. (1)

(d)(i) Velocity of sound wave from bats $= C - V_b$

Apparent wavelength $\lambda_a = \frac{C - V_b}{f}$

Velocity of sound wave detected by bat $= C + V_b$

Frequency detected, $f_a = \frac{C + V_b}{\lambda_a}$

$= \frac{(C + V_b)}{(C - V_b)} f$ (5)

(ii) $f_a = \left(\frac{C + V_b}{C - V_b}\right) f$

$= \left(\frac{340 + 5}{340 - 5}\right) 78$ (2)

$= 80.3 \text{ KHz}$

e(i) Intensity is the rate of flow of energy through an area of 1 m^2 perpendicular to the path of travel of sound. (1)

(ii) Loudness refers to amount of sound energy entering the ear per second whereas pitch ~~varies with the frequency of the note~~ (1)

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Loudness - depends on intensity or amplitude of the sound whereas pitch varies with frequency.

(10)

4(a)(i) Unpolarised light is one whose vibrations in electric and magnetic vectors take place in more than one plane. (1)

(ii) Plane polarised light is one whose electric vector varies in only one plane. (1)

(b)(i) A narrow beam of ordinary light is made incident on a nicol prism ~~at above~~ and viewed through the analyser. The angle of incidence is increased gradually. For each angle of incidence the emergent light is viewed through the analyser while rotating it about an axis ~~through~~ perpendicular to the plane of the analyser. At a certain angle of incidence light gets extinguished completely. At this point the emergent light is completely plane polarised. (3)

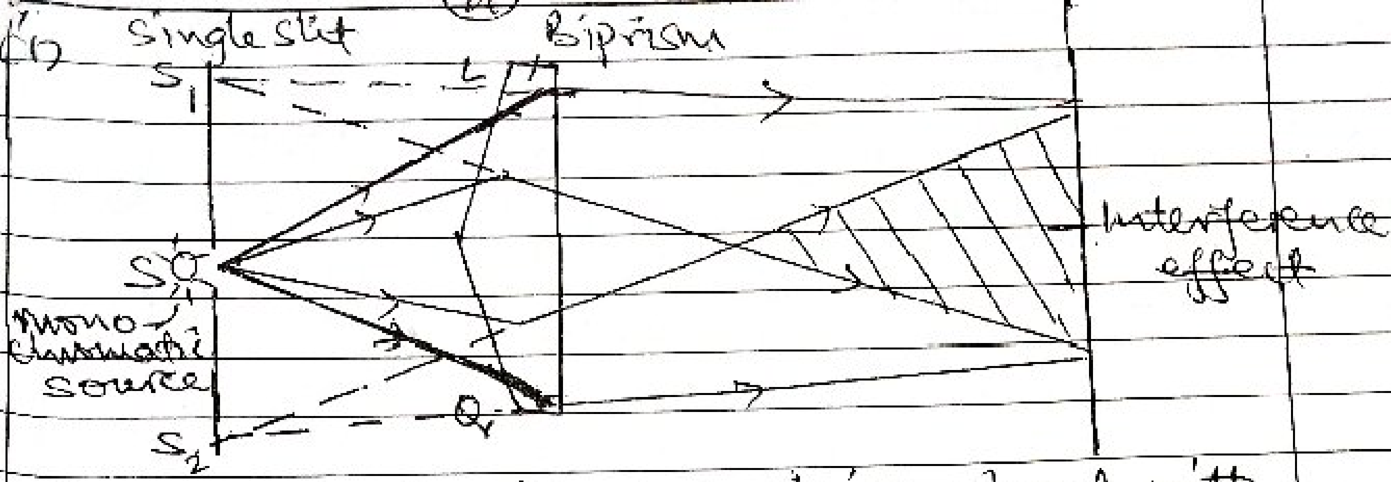
(ii) When polarised light is passed through stressed material, bright and dark fringes are seen on the screen which vary according to the concentration of the stress. It is therefore used in stress analysis. (2)

R

- Used to determine concentration of sugar solution. Polarised light is passed through the solution viewing through the analyser: the analyser is turned till the light is extinguished, the angle of rotation is proportional to the concentration, therefore concentration can be determined. (2)

(11)

(i)



A prism of very large angle is placed with its refracting edge facing a narrow source of light S. Light incident on face P is refracted and appear to come from a point S_1 and that incident on Q appears to come from S_2 due to refraction. The two sources are thus coherent since they both originate from (3)

(ii) Bright fringes occur when the path difference for the wavelength is equal to $(n-\frac{1}{2})\lambda$ where $n = 1, 2, 3, \ldots$

When the film is thick, each colour attains this path difference forming bright band. The different colours thus overlap leading to uniform white illumination (3)

(d) Slit separation $a = 0.28\text{ mm}$, $D = 4\text{ m}$

$$\lambda = \frac{ay}{D} = \frac{0.28 \times 10^{-3} \times 1.2 \times 10^{-2}}{4} \quad (4)$$

$$= 0.28 \times 10^{-6}\text{ m}$$

$$= 2.8 \times 10^{-7}\text{ m}$$

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4(e) Increasing the number of slits, the intensity of the principal maxima increases and the subsidiary decreases. The interference at the principal maxima are always constructive hence intensity increases; interference at the subsidiary maxima are destructive hence intensity decreases. (3)

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4(e)(ii) Alternative:

Monochromatic light from most sources are not truely monochromatic. They consist of more than one wave length.

When the film is thick and the path differences are large, the position of the dark bands for some wave lengths coincide with positions of bright bands for others. This leads to blurring of the fringes or uniform illumination

(3)

(12)

(a)(i) Root mean square value of an alternating voltage is the value of the steady voltage that dissipate electrical energy (heat) in a given resistor at the same rate as the alternating voltage (1)

(ii) Peak value of the alternating voltage is the maximum value of the alternating voltage. (1)

(i) Let $V = V_0 \sin \omega t$ and from $Q = CV$

$$I = \frac{dQ}{dt} = \frac{d}{dt}(CV)$$

$$I = \frac{d}{dt}(CV \sin \omega t)$$

$$= CV_0 \omega \cos \omega t$$ (3)

$$= CV_0 \omega \sin(\omega t + \pi/2)$$

current leads voltage by $\pi/2$

$V = V_0 \cos \omega t$, $Q = CV$, $I = \frac{dQ}{dt} = \frac{d}{dt}(CV_0 \cos \omega t) = -\omega C V_0 \sin \omega t$, I leads V by $\pi/2$.

(ii) $I = C\omega V_0 \sin(\omega t + \frac{\pi}{2})$

$I_0 = C\omega V_0$ (2)

$$X_c = \frac{V_0}{I_0} = \frac{1}{\omega C} = \frac{1}{2\pi f C}$$

(iii) $X_c = \frac{1}{2\pi f C}$

$$= \frac{10^6}{2 \times 3.14 \times 500 \times 0.1} = 3185\,\Omega$$ (3)

Voltage $= I X_c = \frac{6}{1000} \times 3185 = 19.1\,V$

$I_0 = I_{rms}\sqrt{2} = 6 \times 10^{-3}\sqrt{2} = 8.49 \times 10^{-3}\,A$

$V_0 = \frac{I_0}{2\pi f C} = \frac{8.49 \times 10^{-3}}{2\pi(500) \times 0.1 \times 10^{-6}} = 27$ (3)

$V = \ldots = 19.1$

(12)

c (i) Brightness doesn't change
OR
The bulb dims and then becomes bright again (1)

(ii) The brightness decreases (or bulb dims) when the iron core is inserted magnetic flux Linkage is enhanced and the rate of change of magnetic flux Linkage or reactance increase leading to larger back emf current flowing is thus reduced leading to dimming of the bulb (3)

(d) (i) Hysteresis loss is the loss in energy ~~lost on~~ due to turning the magnetic domains from one direction to the other as the current changes. (1)

(ii) It is minimised by using soft magnetic materials like soft iron, mumetal, perm alloy (1)

(iii) When a load is connected to the secondary current flows in secondary which induces magnetic flux in the core in opposition to magnetic flux due to primary current. Magnetic flux in the core thus reduces. This lead to reduction in back emf in the primary and hence the primary current increase. (4)

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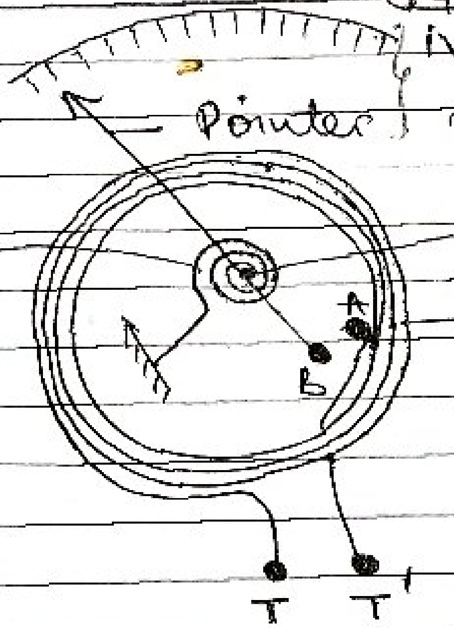
6 a(i)



(2)

A is fixed soft iron rod
B is movable soft iron rod
T & T' are terminals of source

(ii) When a.c is passed through the coil the iron rods magnetise in the same sense whatever the direction of the current. Hence they repel and the pointer moves in the same (or one) direction until it is stopped by the restoring spring. Now the magnetic force is proportional to the square of the average current hence the deflection is proportional to the square of the average current (5)

(b)(i) $B = \frac{\mu_0 N I}{2a}$ (1)

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b(ii) A coil of known number of turn N and area A is connected to a calibrated ballistic galvanometer so that the total resistance in the circuit is R. The coil is placed in a vertical plane perpendicular to magnetic meridian of the Earth. The coil is then rotated through 180° about the vertical axis. The maximum throw θ_1 of the BG is noted.
The coil is then placed with its plane in horizontal plane perpendicular to the magnetic meridian of the Earth. The coil is again rotated through 180° about horizontal axis and the maximum throw θ_2 is noted

$$\Rightarrow B_H = \frac{K\theta_1 R}{2NA}$$

$$\Rightarrow B_V = \frac{K\theta_2 R}{2NA}$$

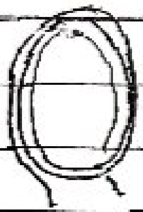
K is determined by charging a standard capacitor C to a known p.d V and then discharging it through the B.G and the deflection α noted

$$\Rightarrow K = \frac{CV}{\alpha}$$

(6)

Then B is calculated from $B = \sqrt{B_H^2 + B_V^2}$

(1b)



$$\tan\theta = \frac{B_c}{B_H} \Rightarrow B_H = \frac{B_c}{\tan\theta}$$

But $\theta = \frac{40+43}{2} = 41.5^\circ$ and $B_c = \frac{\mu_0 N I}{2a}$

$$\therefore B_H = \frac{\mu_0 N I}{2a\tan\theta}$$

$$= \frac{4\pi\times10^{-7}\times50\times0.1}{2\times4\times10^{-2}\times\tan 41.5^\circ}$$ (4)

$$= 8.88\times10^{-5}\ T$$

(ii) $B_H = B\cos\theta$

$$\therefore B = \frac{B_H}{\cos\theta} = \frac{8.88\times10^{-5}}{\cos 15}$$ (2)

$$= 9.19\times10^{-5}\ T$$

7 (a) Faraday's law - states that the magnitude of the induced emf in a conductor is directly proportional to the rate of change of magnetic flux linking the conductor (1)

Lenz's law - states that the direction of the induced e.m.f is such that the current which it causes to flow oppose the change which is producing it (1)

b (i) Let r = radius of disc

Thus AC cuts magnetic flux continuously

The average velocity V of $AC = \frac{0 + R\omega}{2}$

$= \frac{R\omega}{2}$

$\therefore$ Induced emf in AC, $E = BLV$ (3)

$= \frac{B R R\omega}{2}$

$= \frac{1}{2} B R^2 \omega$

(ii) Since $E = \frac{1}{2} B r^2 \omega$, $\omega = 2\pi f$

$= \frac{1}{2} \cdot B \cdot r^2 \times 2\pi f$

$= \pi B r^2 f$. If $f = 3000 \text{rev min}^{-1}$

$= \frac{3000}{60}$

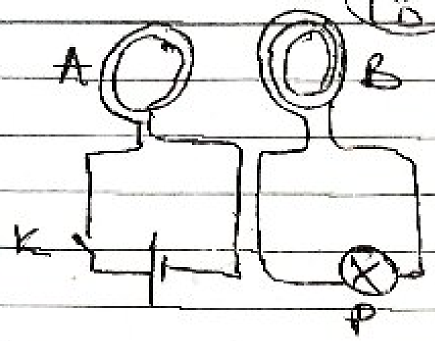
$= 50 Hz$

$\therefore E = 3.14 \times 0.01 \times (0.1)^2 \times 50$ (3)

$= 3.14 \times 10^{-2} V$

(13)

(c)



Coil A and B are placed close to each other. When K is closed, bulb P lights. ~~Hence the~~ e.m.f is induced in B. Since ~~the~~ circuit is closed current flows and the bulb lights (4)

(d) (i) When the beam moves between the magnetic poles, it cuts the magnetic field. Eddy currents are induced in the beam whose magnetic field opposes its movement. Hence damping the motion (3)

(ii) The beam takes longer to settle (1)

(e) (i) The ampere is the current which when flowing in each of the two infinitely long parallel wires of negligible cross sectional area separated by a distance of 1m in [illegible] produces a force of $2\times10^{-7}\,Nm^{-1}$ on each other (1)

(ii) Force due to magnetic field on P = weight of P, W

$$\therefore W = \frac{\mu_0 I_1 I_2 L}{2\pi a} = \frac{4\pi\times10^{-7}\times10\times10\times0.1}{2\pi\times0.05} = 4\times10^{-5}\,N$$ (3)

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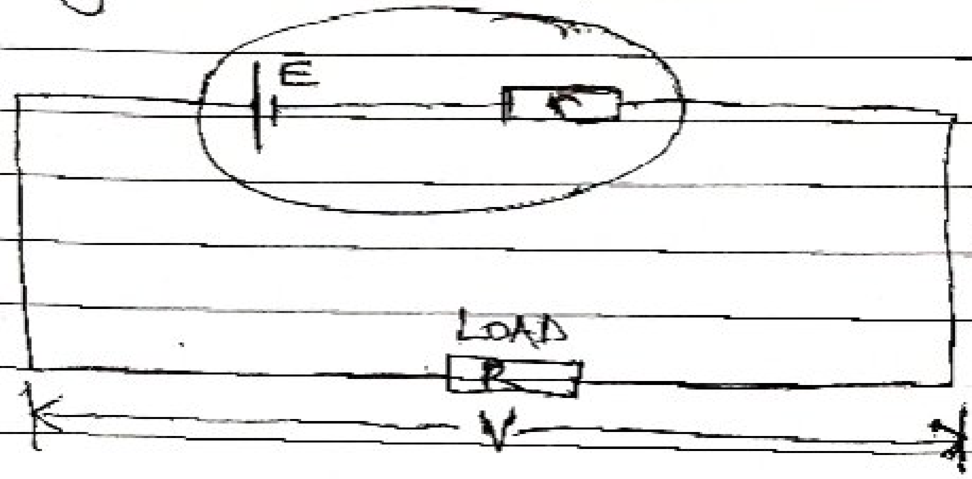
8 (a) Electromotive force of a battery is the energy supplied by the battery to transfer 1C of ~~positive~~ charge around a complete circuit in which the battery is connected.

(ii)



Power delivered to the load, $P_{out} = IV$

Power supplied by battery $P_{gain} = IE$

Efficiency, $\eta = \frac{P_{out}}{P_{gain}} \times 100$

$= \frac{IV}{IE} \times 100$

$= \frac{V}{E} \times 100$

But $V = IR$ and $E = I(R+r)$

$\therefore \eta = \frac{R}{R+r} \times 100$

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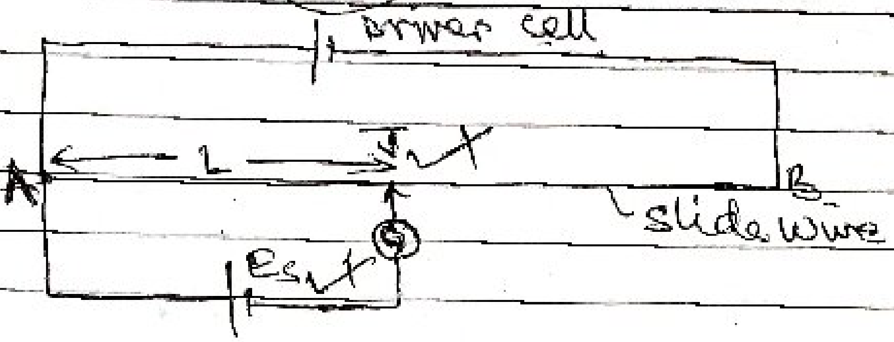
(b)



The sliding contact is moved along the uniform wire AB until a point is ~~reached~~ found when the galvanometer G shows no deflection, the balance length L is measured. (3)

At balance P.d across AJ = Emf E_s

$\Rightarrow E_s = kL$

$\therefore k = \frac{E_s}{L}$

where k = calibration constant

(c)(i) $E_s = k \times 60$ ...

Driver current $I_d = \frac{E_D}{R} = \frac{3}{1+4} = \frac{3}{5} = 0.6A$

Resistance 1cm of the wire $= \frac{4}{100} = 0.04\Omega$

$\therefore E_s = k \times 60$

$= 0.6 \times \frac{4}{100} \times 60$

$= 1.44V$

$k = 0.6 \times \frac{4}{100} = 0.024 V$ (3)

(ii) When K_1 is open and K_2 closed

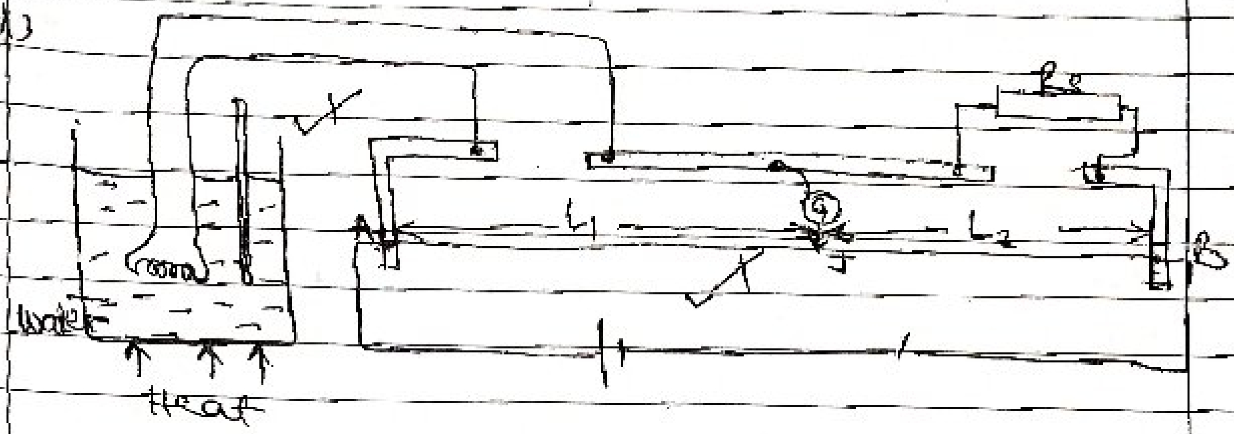
$\therefore (I_d \times R_s) = k \times 80$

$= 0.6 \times \frac{4}{100} \times 80 = 1.92V$

$V_r = 1.14 \therefore$ Error $= 1.92 - 1.14 = 0.78V$ (3)

% error $= \frac{0.78}{1.92} \times 100 = 40.6\%$

8 (d)



The apparatus are set up as above. The specimen wire is made into a coil and immersed in water bath, The ends of the coil are connected to the left gap of the metre bridge and a standard resistor R_S in the right hand gap. The water bath is heated to a suitable temperature θ and after through stirring ~~heating is stopped~~ and switch K is closed. The jockey is tapped at different points on uniform wire AB until a point is found where the galvanometer shows no deflection. The balance length L_1 and L_2 are measured and recorded. The procedure is repeated for different values of temperature, θ and the results are tabulated including values of

$R_\theta = R_S \times L_1/L_2$; A graph of R_θ against θ is plotted. Its slope s found. The intercept R_0 on the R_θ axis is also noted. The mean temperature coefficient $\alpha = S/R_0$

(6)

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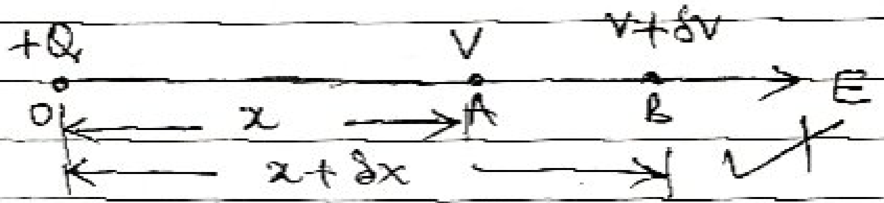
1(a) The force between two point charges is directly proportional to the product of the magnitude of the charges and inversely proportional to the square of the distance of separation of the charges (1)

(b)(i) Consider two points A and B in the field of a point charge +Q



If the potential at A is V and that at B is V + δV, the potential difference between A and B is

$$V_{AB} = V_A - V_B$$
$$= V - (V + \delta V)$$
$$= -\delta V \quad \text{--- (i)}$$

Work done to move 1 C of charge from A to B = P.d and is given by

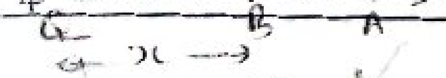
$$V_{AB} = E\delta x \quad \text{--- (ii)} \qquad (4)$$

From (i) = (ii)

$$-\delta V = E\delta x$$
$$\Rightarrow E = -\frac{\delta V}{\delta x}$$

In the Limit as $\delta x \to 0$ then

$$E = -\frac{dV}{dx}$$



$\delta V = \frac{\delta W}{Q} = -E\delta x$

$\delta W = -F\delta x$

$E = F/Q \Rightarrow F = EQ$

$\lim_{\delta x \to 0} \frac{\delta V}{\delta x} = \frac{dV}{dx}$

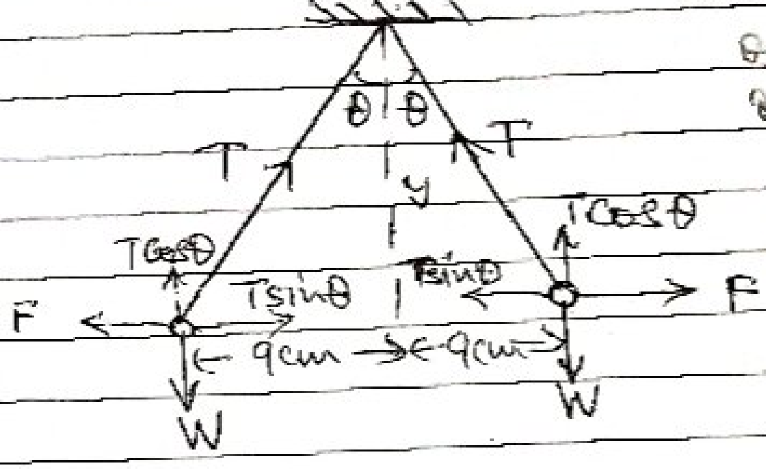
$= -\frac{dV}{dx}$

9 (c)

$\sin\theta = 9/30$

$\theta = \sin^{-1}(9/30)$

$\theta = 17.5^\circ$



$y^2 = 30^2 - 9^2 \therefore y = 28.6$

Horizontally $F = T\sin\theta$ --- (i)

vertically $mg = W = T\cos\theta$ --- (ii)

From (i) and (ii)

$\Rightarrow \frac{F}{mg} = \tan\theta$

(6)

$F = mg\tan\theta$

$= 0.1 \times 10^{-3} \times 9.81 \times \frac{9}{28.6}$

$= 0.309 \times 10^{-3}$

But $F = \frac{kQ^2}{r^2} = \frac{9 \times 10^9 \times Q^2}{(18 \times 10^{-2})^2} = 2.78 \times 10^{11} Q^2$ N

$\therefore 0.309 \times 10^{-3} = 2.78 \times 10^{11} Q^2$

$Q = \cancel{1.054 \times 10^{-6}}$ 3.33×10^{-8} C

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(d) A proof plane is placed on the surface of the conductor. A sample of charge acquired by the proof plane is then transferd to a hollow metal can placed on the cap of the neutral electroscope. The deflection of the electroscope is noted. The proof plane ~~and the~~ is then used to pick sample charges ~~electroscope~~ ~~are discharged wet~~. ~~Sample of charge are then picked~~ from different parts of the conductor and each time the deflection of the electroscope is noted. The greatest deflection is obtained when samples of charge are picked from the pointed end of the conductor. Therefore the surface density of charge is greatest where the curvature is greatest. (4)

e) Consider the uncharged conductor being brought near a negatively charged ebonite rod. The negative charges on the rod repel the free electrons in the conductor to the remote end. Positive charge is thus left near the end of the metal adjacent to the ebonite rod so the conductor is now attracted by the ebonite rod. (3)

9(f) An electroscope is given charge and the divergence noted. The material is brought near the cap of the electroscope. If there is no change in divergence the material is an insulator. If the divergence reduces, then the material is a conductor. (2)

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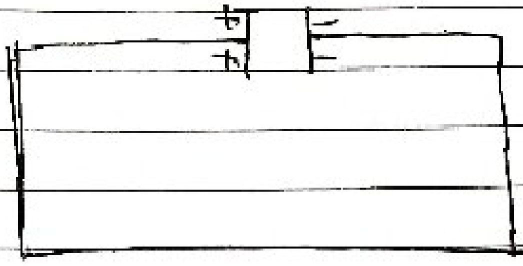
10 (a)(i) Dielectric strength is the maximum electric field intensity an insulator can withstand without becoming conducting (1)

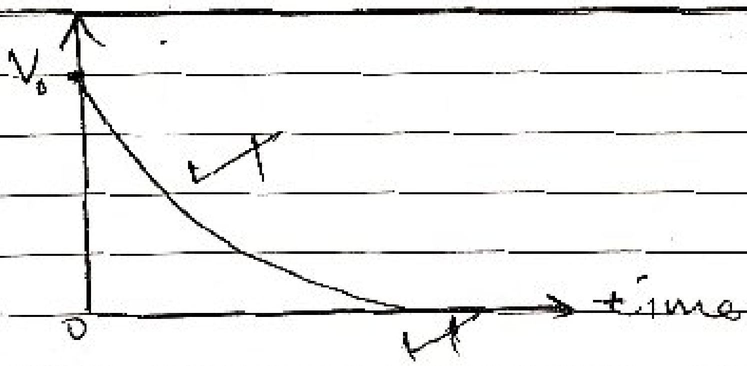
or the maximum potential gradient an insulator can withstand without conducting.

(b)(i)



Connect a wire from the positive place to the negative plate. Electrons flow from the negative plate to the positive plate through the wire until ~~there is no charge~~ the pd is zero either the capacitor is then fully discharged. (2)

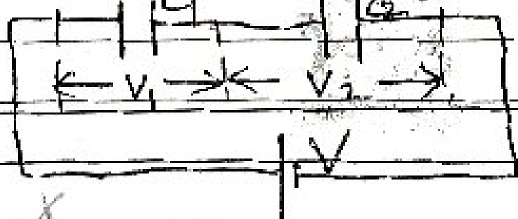
(ii)



(1)

P.d across eventually become zero

c (i)



magnitude of charge on each plate is the same; call it Q

$V = V_1 + V_2$

but $V_1 = \frac{Q}{C_1}$, $V_2 = \frac{Q}{C_2}$

$\therefore V = \frac{Q}{C_1} + \frac{Q}{C_2}$

$\frac{V}{Q} = \frac{1}{C_1} + \frac{1}{C_2}$

$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$

where C is the effective capacitance of the capacitor.

Series charge Q is the same

$Q_c = CV$

$\Rightarrow \cancel{Q_1 = C_1V_1}, \cancel{Q_2 = C_2V_2}, \cancel{Q_1 = Q_2}$

$\Rightarrow \cancel{V_1 = \frac{Q_1}{C_1}}, \cancel{\frac{Q_2}{C_2} = V_2}$

$\Leftrightarrow \cancel{\frac{Q_1}{C_1}} = \cancel{\frac{Q_2}{C_2}}$

Also $V = V_1 + V_2$

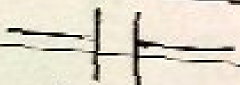
$\therefore \frac{Q_c}{C} = \frac{Q_c}{C_1} + \frac{Q_c}{C_2}$

$\frac{1}{C} = \frac{C_2 + C_1}{C_1C_2}$

$\therefore C = \frac{C_1C_2}{C_1 + C_2}$

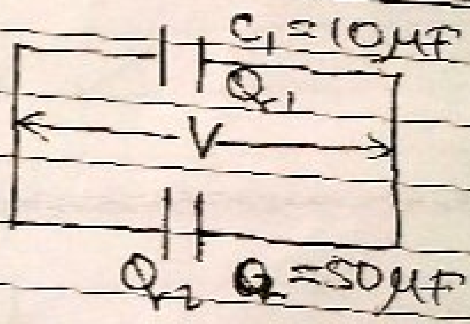
(4)

c (ii)



$C_1 = 10\mu F$

$V_0 = 200V$



Total charge before connection

$Q_{T0} = CV_0 = 10 \times 10^{-6} \times 200 = 2.0 \times 10^{-3} C$

The total remains constant

Energy stored ~~connection~~

$E_1 = \frac{1}{2}\frac{Q_0^2}{C_1} = \frac{1}{2}(2.0 \times 10^{-3})^2 \times \frac{1}{10 \times 10^{-6}}$

$= 0.2 J$

After connection, effective capacitance

$C = C_1 + C_2 = 10 + 50 = 60 \mu F$

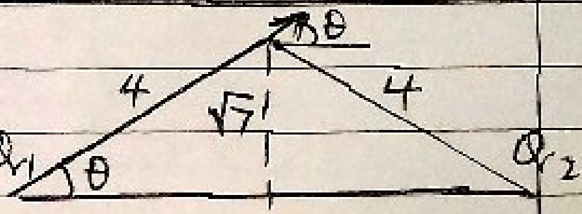
c(ii) Thus final total energy stored $= \frac{1}{2}\frac{Q^2}{C}$

$$E_2 = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}\times(2.0\times10^{-3})^2\times\frac{1}{60\times10^{-6}}$$ (4)

$$= 0.033\,J$$

(iii) The difference in energy $(0.2 - 0.03) = 0.17J$ is converted into heat in the connecting wires as the capacitors are connected together. (1)

(d)(i) $E_1 = \frac{kQ}{r^2}$



$$= \frac{9\times10^{9}\times5\times10^{-6}}{(0.04)^2}$$

$$= 2.81\times10^{7}\,NC^{-1}$$

$E_2 = \frac{kQ}{r^2}$

$$= \frac{9\times10^{9}\times5\times10^{-6}}{(0.04)^2}$$

$$= 2.81\times10^{7}\,NC^{-1}$$ (3)

But $\cos\theta = 3/4$

$\therefore E_R = 2E_1\cos\theta = 2\times2.81\times10^{7}\times3/4$

$= 4.2\times10^{7}\,NC^{-1}$

Horizontally to the right

(Direction not there deduct $\frac{1}{2}$ mark)

(29)

(d)(ii) Potential energy, W of charge Q_3 at P

$W = QV$

where V = total potential at P

But $V_1 = \frac{Q}{4\pi\varepsilon_0 r} = \frac{9\times10^9\times5\times10^{-6}}{(0.04)}$

$= +1.13\times10^6\ V$

$V_2 = -\frac{Q}{4\pi\varepsilon_0 r} = \frac{-9\times10^9\times5\times10^{-6}}{(0.04)}$

$= -1.13\times10^6\ V$

(4)

Total potential at P $= V_1 + V_2$

$= 0\ V$

$\therefore\ W = Q_3 \times 0$

$= 0\ J$

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