P510/2 - P510/2
1996 - 2016

P510/2
PHYSICS
Paper 2
Nov. / Dec. 2016
2½ hours

YEARS WITH COMPLETE GUIDES
- 2016
- 2015
- 2014
- 2013
- 2010
- 2009
- 2005

UGANDA NATIONAL EXAMINATIONS BOARD

Uganda Advanced Certificate of Education

PHYSICS

Paper 2

2 hours 30 minutes

INSTRUCTIONS TO CANDIDATES:

Answer **five** *questions, taking at least* **one** *from each of the sections,* **A**, **B**, **C** and **D**, *but* **not** *more than* **one** *question should be chosen from either* **A** *or* **B**.

Any additional question(s) answered will **not** *be marked.*

Mathematical tables and squared paper are 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	=	$1.6 \times 10^{-19}\ C$
Electron mass	=	$9.11 \times 10^{-31}\ kg$
Planck's constant, h	=	$6.6 \times 10^{-34}\ Js$
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)	=	$1.6 \times 10^{-19}\ J$
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	=	$4.2 \times 10^{3}\ Jkg^{-1}K^{-1}$

YEARS WITH INCOMPLETE GUIDES
- 2012 - LACKING NO.4 (c) $ (d) NO.5 $ NO.9
- 2011 - LACKING NO.4 (a) $ (b) NO 9 (c) $ (f)
- 2008 - COMPLETELY MISSING
- 2007 - BEGINS FROM NO 2(b) (iii)
- 2006 - LACKING NO.5(a) $ (b) NO.9(a), (b) & (c)(iii) NO.10

SECTION A

1. (a) (i) Describe how the focal length of a convex mirror can be measured using a convex lens of a known focal length. *(04 marks)*

(ii) The plane mirror, P, in figure 1 is adjusted to a position 20 cm from the optical pin, the image of the pin in P coincides with its image in M.

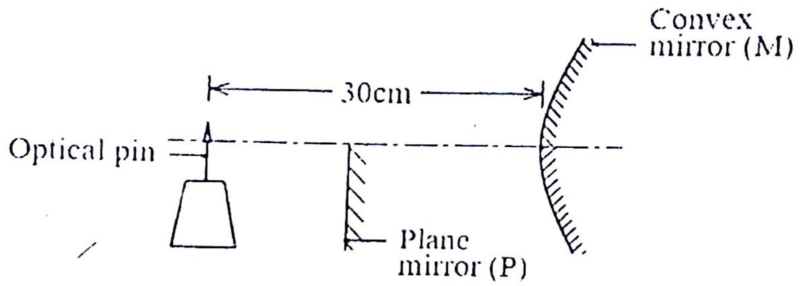


Fig. 1

Calculate the focal length of the convex mirror. *(04 marks)*

(b) A pin is clamped horizontally above a concave mirror with its tip along the principal axis. When the pin is adjusted, it coincides with its image at a distance R from the mirror. When a small amount of liquid of refractive index, n, is put in the mirror, the pin again coincides with its image at a distance R' from the mirror. Show that the refractive index , n, is given by

$$n = \frac{R}{R'}$$

(04 marks)

(c) (i) Explain the term **eye-ring** as applied to a telescope? *(02 marks)*

(ii) Draw a ray diagram to show the formation of a final image in a Galilean telescope in normal adjustment. *(03 marks)*

(iii) Explain **two** advantages and **one** disadvantage of the telescope in (c)(ii). *(03 marks)*

2. (a) (i) When does light pass through a prism symmetrically? *(01 mark)*

(ii) Find the angle of incidence, i, on an equilateral prism of refractive index 1.5 placed in air, when light passes through it symmetrically. *(03 marks)*

(iii) Describe what happens to the deviation of light passing through the prism in (a) (ii) when the angle of incidence is increased from a value less than i to a value greater than i. *(02 marks)*

(b) Describe how the refracting angle of a prism can be determined using optical pins. *(05 marks)*

(c) (i) Draw a sketch ray diagram showing formation of the image of a finite size real object by a concave lens. *(02 marks)*

(ii) A concave lens of focal length 15.0 cm is arranged coaxially with a concave mirror of focal length 10.0 cm, a distance of 4.0 cm apart. An object is placed 20.0 cm in front of the lens, on the side remote from the mirror.
Find the distance of the final image from the lens. *(04 marks)*

(d) With the aid of a sketch ray diagram explain **spherical aberration** in concave lenses, and state how it is minimised. *(03 marks)*

SECTION B

3. (a) What is meant by the following as applied to waves?

(i) Resonance. *(01 mark)*
(ii) Frequency. *(01 mark)*

(b) Explain with the aid of suitable diagrams, the terms **fundamental note** and **overtone** as applied to vibrating air in a closed pipe. *(05 marks)*

(c) Describe how you would determine the speed of sound in air using a resonance tube and several tuning forks. *(05 marks)*

(d) (i) Explain the formation of beats. *(02 marks)*

(ii) Derive the expression for the beat frequency. *(03 marks)*

(e) Two observers A and B are provided with sources of sound of frequency 750 Hz. If A remains stationary while B moves away at a velocity of 2.0 ms^{-1} find the number of beats heard per second by A. (*Velocity of sound in air* = $330 ms^{-1}$).
(03 marks)

4. (a) What is meant by **diffraction**? *(01 mark)*

(b) Explain using Huygen's principle, the diffraction pattern produced by a single slit. *(06 marks)*

(c) Light of wavelength 5.0×10^{-7} m falls on a grating with 600 lines per mm. Determine the highest order of diffraction that can be observed. *(04 marks)*

(d) (i) Explain what is meant by the **plane of polarization of light**. *(02 marks)*

(ii) A liquid of refractive index 1.3 is used to produce polarised light by reflection. Calculate the angle of incidence of light on the liquid surface. *(02 marks)*

(e) (i) Describe how the polarised light can be produced by reflection. *(03 marks)*

(ii) State **two** uses of polarised light. *(02 marks)*

SECTION C

5. (a) (i) What is the difference between a **motor** and a **dynamo**? *(01 mark)*

(ii) Describe with the aid of a labelled diagram the structure and mode of operation of a d.c generator. *(06 marks)*

(iii) Describe briefly the factors that determine the peak value of the induced e.m.f. *(03 marks)*

(iv) How can a d.c generator be converted into an a.c generator? *(01 mark)*

(b) Figure **2** shows two wires *AB* and *CD* of length 5.0 cm each carrying a current of 10.0 A in the direction shown. A long conductor carrying a current of 15 A is placed parallel to the wire *CD*, 2.0 cm below it.

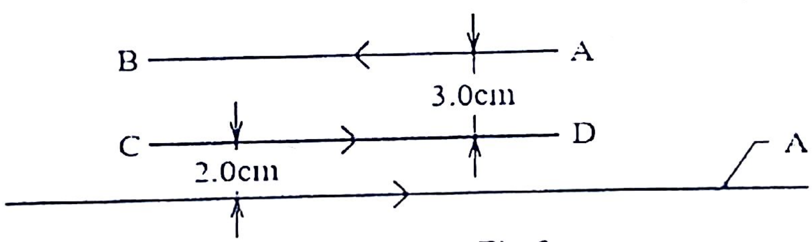


Fig. 2

(i) Calculate the net force on the long wire. *(06 marks)*

(ii) Sketch the magnetic field pattern between the long wire and the wire *CD* after removing wire *AB*. Use the field pattern to define a neutral point. *(03 marks)*

6. (a) What is meant by the following as applied to the earth's magnetic field?

(i) Magnetic meridian. *(01 mark)*

(ii) Magnetic variation. *(01 mark)*

(b) Describe the structure and mode of action of the deflection magnetometer. *(06 marks)*

(c) A circular coil of four turns and diameter 11 cm has its plane vertical and parallel to the magnetic meridian of the earth. Determine the resultant magnetic flux density at the centre of the coil when a current of 0.35 A flows in it.
(Take the horizontal component of the earth's magnetic flux density to be 1.6×10^{-5} T). *(04 marks)*

(d) (i) Define **self-induction** and **mutual induction** . *(02 marks)*

(ii) Give the causes of power loss in an **a.c.** transformer and state how each can be minimised. *(04 marks)*

(iii) Explain why the current in the primary coil of a transformer increases when the seconday is connected to a load. *(02 marks)*

7. (a) Define **root mean square (rms)** value of an alternating voltage. *(01 mark)*

(b) A resistor of resistance 100 Ω is connected across an alternating voltage $V = 20 \sin 120\pi t$

(i) Find the frequency of the alternating voltage. *(01 mark)*

(ii) Calculate the mean power dissipated in the resistor. *(03 marks)*

(c) (i) Show that when an inductor is connected to an **a.c.** supply voltage of $V = V_0 \sin 2\pi ft$, the resulting current lags the voltage by 90^0. *(04 marks)*

(ii) Sketch on the same axes the variation with time of the voltage and current if a capacitor is connected to the voltage supply in (c)(i). *(02 marks)*

(d) (i) Describe how a thermocouple meter works. *(04 marks)*

(ii) Explain any precautionary measure taken in the design of the thermocouple meter. *(02 marks)*

(e) A capacitor of capacitance $60\,\mu F$ is connected to an a.c voltage supply of frequency 40 Hz. An a.c ammeter connected in series with the capacitor reads 2.2 A. Find the p.d across the capacitor. *(03 marks)*

SECTION D

8. (a) (i) Define **electrical resistivity**. *(01 mark)*

(ii) Explain how length and temperature of a conductor affect its resistance. *(04 marks)*

(iii) Figure **3** shows the current-voltage graphs for a metallic wire at two different temperatures T_1 and T_2

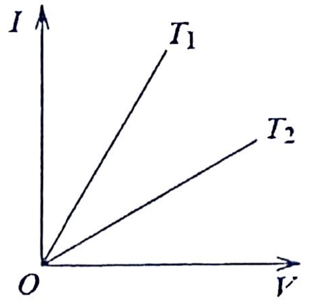


Fig. 3

State which of the two temperatures is greater and explain your answer. *(03 marks)*

(b) (i) Derive the balance condition when using a metre bridge to measure resistance. *(04 marks)*

(ii) State **two** precautions taken to achieve an accurate measurement. *(02 marks)*

(c) Figure **4** shows two resistors P and Q of resistance 5 Ω and 2 Ω respectively connected in the two gaps of the metre bridge.

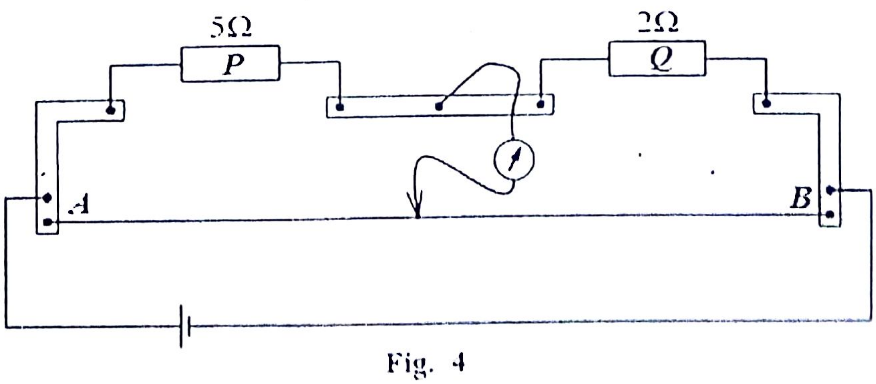


Fig. 4

A resistance X of cross-sectional area 1 mm^2 is connected across P so that the balance point is 66.7 cm from A. If the resistivity of wire X is 1.0×10^{-5} Ωm and the resistance wire AB of the metre bridge is 100 cm long, calculate the length of X. *(04 marks)*

(d) Explain how electrons attain a steady drift velocity when current flows through a conductor. *(02 marks)*

9. (a) (i) Explain an **equipotential surface**. *(04 marks)*

(ii) Give an example of an equipotential surface. *(01 mark)*

(b) (i) State **Coulomb's law**. *(01 mark)*

(ii) With the aid of a sketch diagram, explain the variation of electric potential with distance from the centre of a charged metal sphere. *(03 marks)*

(iii) Two metal plates A and B, 30 cm apart are connected to a 5 kV d.c supply as shown in figure 5.

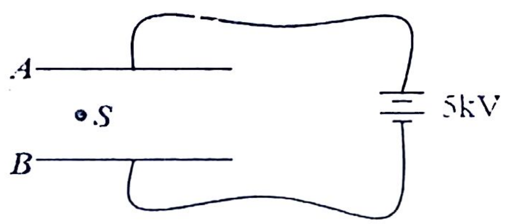


Fig. 5

When a small charged sphere, S, of mass 9.0×10^{-3} kg is placed between the plates, it remains stationary. Indicate the forces acting on the sphere and determine the magnitude of the charge on the sphere. *(04 marks)*

(c) (i) Define **electric field intensity**. *(01 mark)*

(ii) With the aid of a diagram, explain electrostatic shielding. *(04 marks)*

(d) Explain briefly why a neutral metal body is attracted to a charged body when brought near it. *(02 marks)*

10. (a) (i) What is meant by **capacitance** of a capacitor? *(01 mark)*

(ii) A parallel plate capacitor is connected across a battery and charged fully. When a dielectric material is now inserted between its plates, the amount of charge stored in the capacitor changes. Explain the change. *(04 marks)*

(iii) Describe an experiment to determine the relative permittivity of a dielectric. *(04 marks)*

(b) A network of capacitors of capacitances 40 μF, 50 μF, and 70 μF is connected to a battery of 9 V as shown in figure 6.

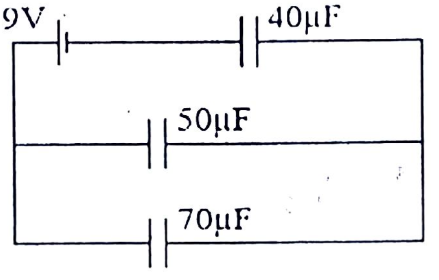


Fig. 6

Calculate

(i) charge stored in the 50 μF capacitor. *(05 marks)*

(ii) energy stored in the 40 μF capacitor. *(03 marks)*

(c) Explain **corona discharge**. *(03 marks)*

END

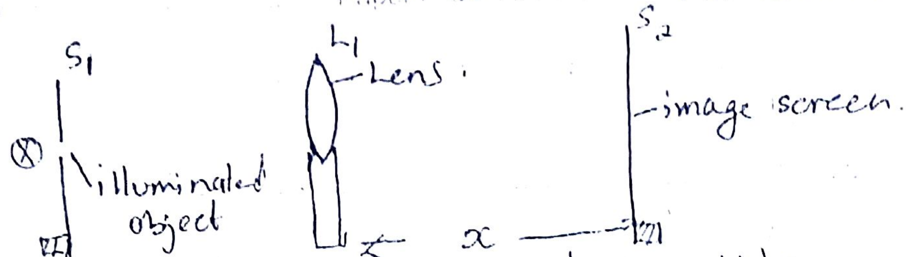
PHYSIC P510/2 GUIDE 2016

(1)

Candidate's Name .... Random No ....

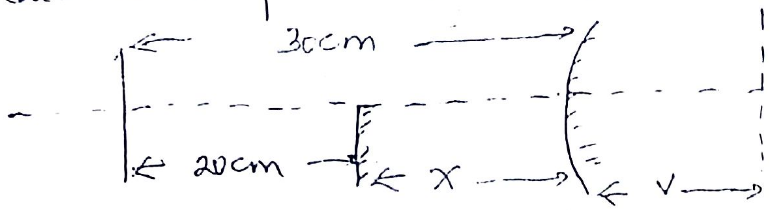
Paper code .... Personal Number ....

1(a)(i)



The illuminated object is placed at a distance greater than the focal length of the lens and the apparatus are set as shown above. The screen S_2 is adjusted until a sharp image is formed on it. The distance x btn L_1 and S_2 is measured. The convex mirror whose focal length is required is placed coaxially between L_1 and S_2.
The mirror is adjusted until a sharp image is formed on S_1 adjacent to the object. The distance y between L_1 and the mirror is measured. The focal length f is calculated from $f = \frac{x-y}{2}$ (04)

(ii)



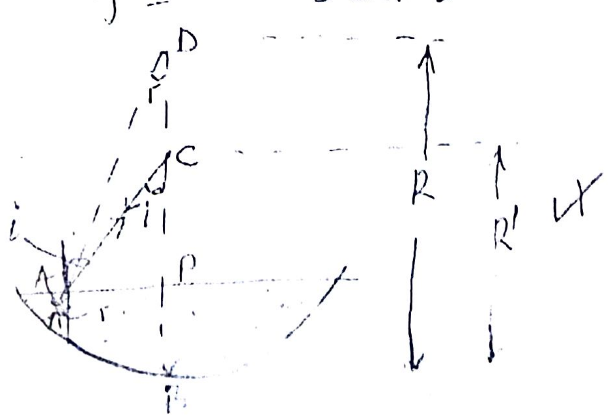
$V = 20 - x$
$= 20 - (30 - 20)$
$= 10\text{cm}$

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

$\frac{1}{f} = \frac{1}{30} + \frac{1}{-10}$

$f = -15\text{cm}$ (04)

(b)



At A, $n_L = \frac{\sin i}{\sin r}$

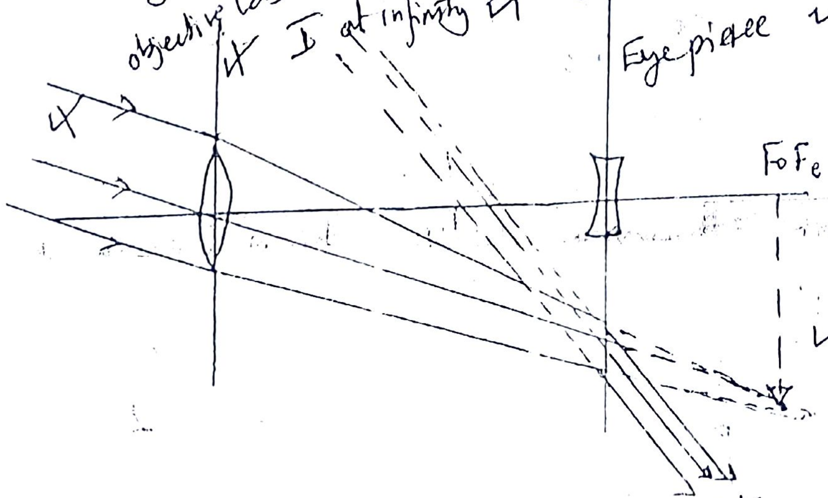
from diagram $\sin i = \frac{AP}{AC}$

$\sin r = \frac{AP}{AD}$

For small angles, $\sin\theta, \simeq \theta$ rad, AD $\simeq$ PD and (04)
AC $\simeq$ PC
Also for small thin layer of Liquid PD $\simeq$ BD and PC $\simeq$ BC

$\Rightarrow n_L = \frac{BD}{BC} = \frac{R}{R'}$

(c)(i) Eye ring is the (circular) image of the objective formed by the eye piece. It is the best position for the eye to observe image (in details) (02)

(ii) 

(03)

(iii) Advantages.
- It forms erect image with only two lenses
- The distance between the lenses is $f_o - f_e$ so it is short and therefore portable.

Disadvantage (inaccessible)
- It has a virtual eyering hence limited field of view. (03)

T = 20

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3

2(a)(i) Light is said to be passing through a prism symmetrically when the angle of incidence is equal to the angle of emergence. OR Minimum deviation occurs. (01)

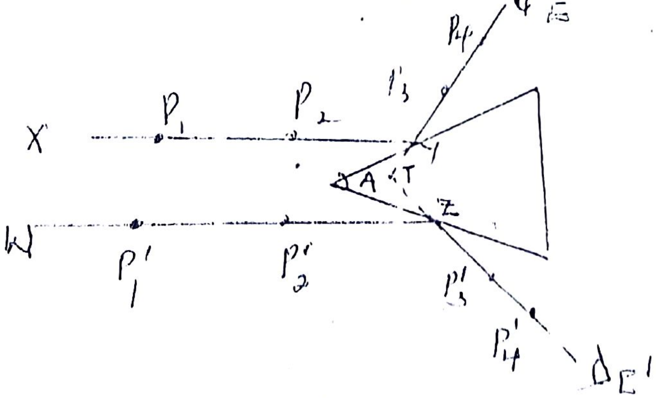
(ii) for snell's law $\frac{\sin i}{\sin r} = 1.5$

But $r = \frac{A}{2}$, $\sin i = 1.5 \sin \frac{A}{2} = 1.5 \sin 30$ (03)

$i = 48.6°$

(iii) As the angle of incidence is being increased to 48.6°, the deviation decreases to a minimum and then increases as the angle of incidence is increased beyond 48.6° (02)

(b). The prism is placed on a white sheet of paper on a soft board and its outline is drawn. The prism is removed and two parallel lines XY and WZ are drawn to touch the outline as shown below



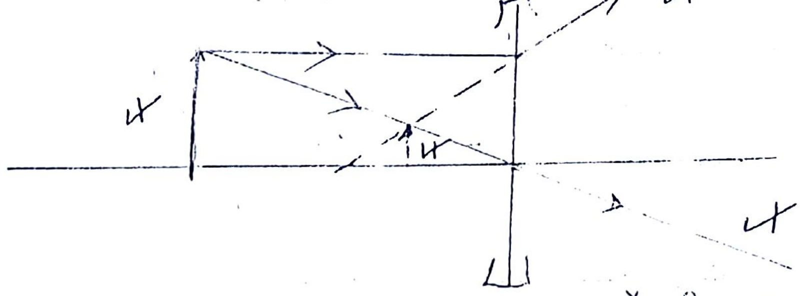
The prism is placed back on the outlines. Two pins P_1 and P_2 are stuck on line XY. Looking through the prism, two pins P_3 and P_4 are placed such that they appear to be in straight line with the images of P_1 & P_2

(4)

The procedure is repeated for the other line ✓ (05)
The prism is removed and line EY through P_3 and P_4 is drawn to meet the line E'Z through P_3' and P_4' at T. ✓ The angle YTZ is measured
The refracting angle A is obtained from $A = \frac{YTZ}{2}$ ✓

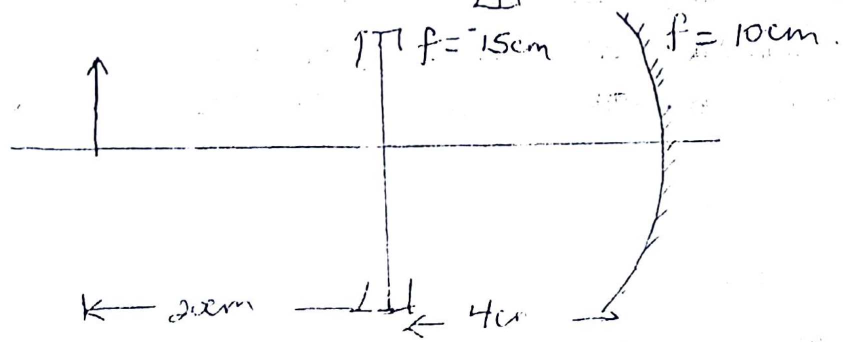
SEE ALTERNATIVE AFTER SOLUTION FOR QN 10:

c (i)



(02)

(ii)



Action of Concave lens

$\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = -\frac{1}{15} - \frac{1}{20}$ ✓

$v = -\frac{60}{7} = 8.6\text{cm}$

Action of Concave mirror

$u = \frac{60}{7} + 4 = \frac{88}{7} = 12.6$

$f = 10\text{cm}$

$\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{10} - \frac{1}{12.6}$ ✓

$v = 48.5\text{cm}$ ✓

Action of the lens

$u = -(48.5 - 4)$

$= -44.5$

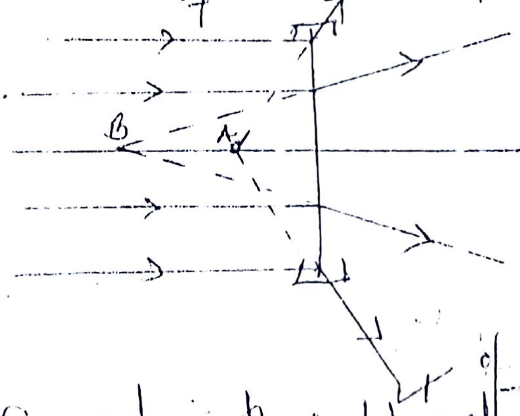
$f = -15$

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

$= -\frac{1}{15} - \frac{1}{44.5}$

$v = -22.6\text{cm}$

(d)



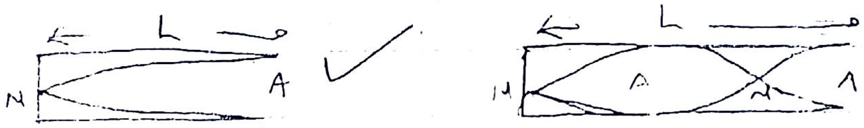
✓ When a wide beam of light falls on the lens, marginal rays are refracted and appear to come from a point different from that of the central rays. The image formed is thus blurred (distorted). This is called spherical aberration. It is minimised by use of an opaque disc with a central hole covering the lens.

Question 3:

(a)(i) Resonance is said to occur when a body is set to vibrate at its natural frequency due to impulses received from a nearby source of the same frequency (01)

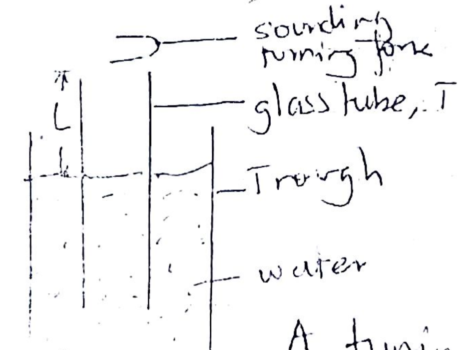
(ii) Frequency is the number of cycles made by a wave per second, or the no of waves produced per second (01)

(b) When air is blown into a pipe, it vibrates in many different modes, producing notes of different frequencies. The note of lowest frequency is the dominant one and is called the fundamental note. The other notes have frequencies higher than that of the fundamental note and are usually less intense. They are called overtones (05)



and others

(c)



A large glass trough is filled with water and a resonance tube is lowered into it until a short length of air column appears above it (05)

A tuning fork is sounded and held above T. T is raised slowly until a loud sound is heard. The length l of the air column is measured and recorded together with the frequency f of the tuning fork. The expt is repeated with other tuning forks and the results recorded in a table including values of $\frac{1}{f}$. A graph of $\frac{1}{f}$ against l is plotted [illegible] the slope s is obtained. The velocity v of sound is then obtained from $v = \frac{4}{s}$ [illegible] d (i) When two notes of slightly different frequencies but similar amplitudes are sounded together they superpose (interfere), producing a note whose intensity increases and reduces periodically. This phenomenon is called beats.

(ii) Consider two notes of frequencies f_1 and f_2 sounded together. Suppose the wave of frequency f_1 makes one cycle more than that of f_2 in time T.
In time, T, the number of waves of f_1 is $f_1 T$
number of waves of f_2 is $f_2 T$
Therefore $f_1 T - f_2 T = 1$

$\Rightarrow \quad f_1 - f_2 = \frac{1}{T}$ but $\frac{1}{T} = f$ (03)

$f_1 - f_2 = f$ beat frequency

(e) A hears a note of freq 750 Hz due to its own source.
He also hears a note of freq f' due to B.
But $f' = \frac{V}{\lambda'} = \left(\frac{V}{V+U}\right) f$ where $\lambda' = \frac{V+U}{f}$

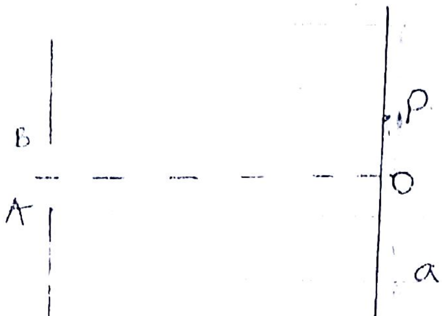
$\Rightarrow \quad f' = \left(\frac{330}{330+2}\right) \times 750$

$= 745.5\text{ Hz}$ (03)

Beat frequency $f = f_A - f' = 750 - 745.5$
4.5 Hz

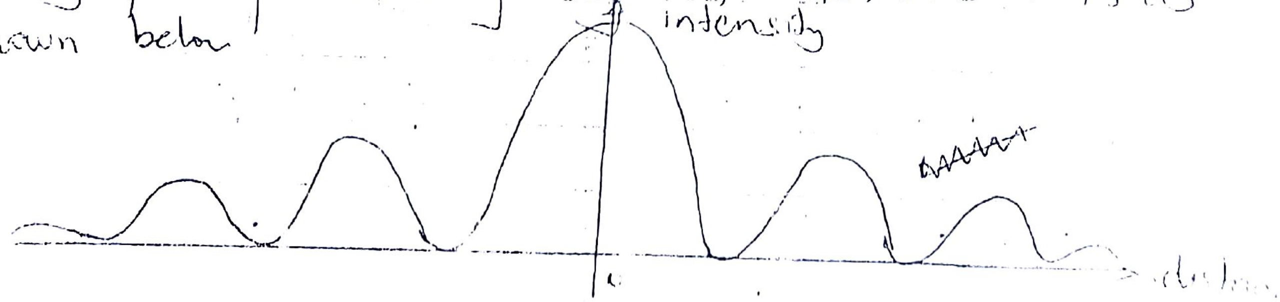
4 (a) Diffraction is the spreading of (light) waves beyond their geometrical boundaries leading to interference

(b)



Consider straight wavefront incident on a narrow gap AB. Each point on the wavefront in the gap act as a secondary source of wavelets that propagate in the forward direction.

At, O, to each of the wavelet there is another wavelet which has travelled an equal path length and so all the wavelets arrive in phase. Constructive interference occurs and this is a position of the central bright band. Outwards from O, and increasing number of wavelets arrive out of phase and hence the bright band reduces in intensity. Between the bright bands, all corresponding wavelets arrive out of phase and interference destructively forming dark bands. The graph of intensity against distance O is as shown below



(06)

(c) $\lambda = 0.5 \times 10^{-6}$ $\qquad d = \frac{1}{600{,}000}$

$\sin\theta = \frac{n\lambda}{d}$

$1 = 1 \times n \times 0.5 \times 10^{-6} \times 600000$

$n =$

(04)

90

$n = 3$

d (i) Plane of polarisation of light is one in which the electric vector of the polarised light varies or vibrates (02)

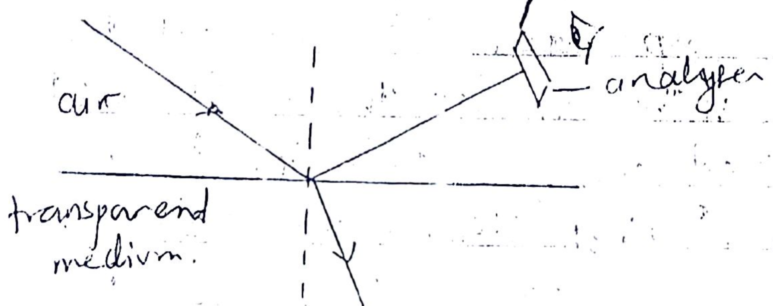
(ii) From Brewster's law

$i_p = \tan^{-1}(n)$ ½

$= \tan^{-1}(1.3)$ ½

$= 52.4^\circ$ ½ (02)

e (i)



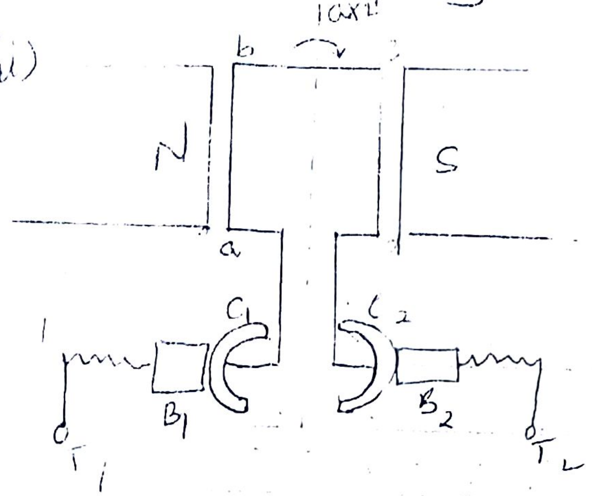
A narrow beam of light is made incident on a transparent medium ½. The reflected light is observed through a polaroid ½. The angle of incidence is varied ½. At each angle of incidence, the polaroid is rotated about the axis along the light incident on it. At one angle of incidence, the light gets cut off from the observer as the polaroid ½ is rotated. The reflected ray is now completely ½ plane polarised. (03)

(ii) - Stress analysis
- determination of concentration of sugar in a solution (02)

⑨

5a (i) A dynamo converts mechanical energy to electrical energy while a motor converts electrical energy to mechanical energy

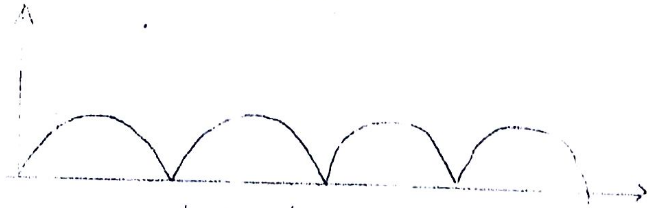
(ii)



abcd - rectangular coil
$C_1 C_2$ - halves of split ring commutator
$B_1 B_2$ - carbon brushes
$T_1 T_2$ - output terminals
N S - north and south poles of a strong permanent magnet

The coil is rotated with uniform angular frequency. As it rotates it cuts through the lines of magnetic flux producing an induced emf in it. When the coil passes the vertical position, the induced emf in the coil changes direction and at same time the commutator halves change contacts i.e. C_1 to B_2 and C_2 to B_1. So the emf at the terminals T_1 and T_2 remains in the same direction

The variation of the output voltage with time is as shown below



(iii) The peak value of induced emf increases with increase in - The no. of turns of the coil
- the area of the coil
- The strength of the magnetic field
- The frequency of rotation of the coil

(iv) To convert a d.c generator to an a.c generator the ends of the rectangular coil are connected to a pair of slip rings instead of the commutators

b (i) Let F_1 and F_2 be the forces exerted on the long wire due to currents in CD and AB respectively

$$F_1 = \frac{\mu_0 I_1 I_2}{2\pi r_1} \times CD$$

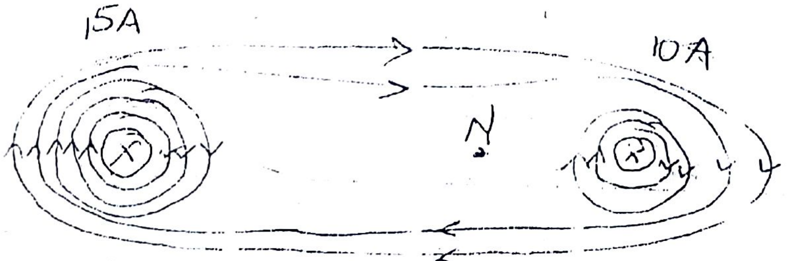
$$= \frac{4\pi \times 10^{-7} \times 10 \times 15 \times 5 \times 10^{-2}}{2\pi \times 2 \times 10^{-2}} = 7.5 \times 10^{-5} N$$

$$F_2 = \frac{\mu_0 I_1 I_2}{2\pi r_2} \times AB = \frac{4\pi \times 10^{-7} \times 10 \times 15 \times 5 \times 10^{-2}}{2\pi \times (2+3) \times 10^{-2}} = 3 \times 10^{-5} N$$

Net force $= F_1 - F_2 = 7.5 \times 10^{-5} - 3.0 \times 10^{-5} = 4.5 \times 10^{-5} N$

toward CD

(ii)



pattern

N - neutral point

direction

[deducted if field lines of 15A are not > than 10A]

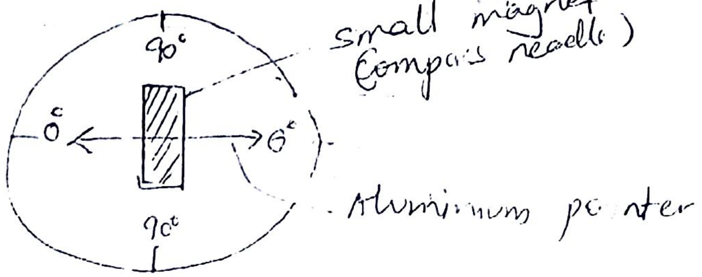
A neutral point is a place (point or axis) where two magnetic fields are equal and opposite and the resultant force is zero.

Question 6:

b(i) (i) Magnetic meridian is a vertical plane in which a freely suspended magnet sets itself. (01)
OR a vertical plane containing the earth's magnetic axis

(ii) Magnetic variation is the angle between the magnetic and geographical meridians. (01)
OR angle btn the earth's magnetic axis and geographical axis

b) It consists of a small compass needle (a small magnet) which is pivoted on a vertical axis and carries a light aluminium pointer. (can be screwed on clamp)
Pointer can rotate over a circular scale.



The deflection magnetometer is used to compare two magnetic fields flux densities one being the horizontal component of the earth's flux density B_H.
The two fields i.e B_H and any other field B to be compared are arranged at right angles to each other. The compass needle then sets at angle θ to its initial direction when it was in the field B_H alone. The needle now points in the direction of the resultant field of B_H ...
The angles of deflection θ_1 and θ_2 of the needle are measured. The average deflection $\theta = \frac{\theta_1+\theta_2}{2}$ ...
The ratio $\frac{B_e}{B_H}$ = $\tan\theta$ is obtained

(12)

(c) $B_c = \frac{\mu_0 NI}{2r} = \frac{4\pi\times10^{-7}\times4\times0.35}{2\times5.5\times10^{-2}}$

$= 1.6\times10^{-5}$ T (due E or W)

Let the resultant field be B_R

$\Rightarrow B_R = \sqrt{B_C^2 + B_H^2}$

$= \sqrt{(1.6\times10^{-5})^2 + (1.6\times10^{-5})^2}$

$= 2.26\times10^{-5}$ T

$\tan\theta = \frac{B_C}{B_H} = \frac{1.6\times10^{-5}}{1.6\times10^{-5}} = 1$

$\Rightarrow \theta = 45°$

d(i) Self induction is the generation of emf in a circuit (coil) due to change in ~~circuit~~ current in the same circuit and mutual induction is generation of an emf in a circuit (coil) due to change in current in an adjacent but separate circuit

(ii) - Ohmic loss - minimised by use of thick copper wires
- Eddy currents - minimised by use of laminated core
- Hysteresis loss - minimised by use of magnetically soft material
- Magnetic flux leakage - minimised by winding secondary coil on the primary coil

(iii) When a load is connected to the secondary a current flows in it. The current flows in such direction as to reduce the flux in the core. This reduces the back emf in the primary and hence the current increases.

(13)

) Root mean square (rms) value of an alternat voltage is the steady voltage which when maintained across given resistor dissipates electrical energy in the resistor at the same rate as the alternating voltage

) (i) $w = 2\pi f$

$120\pi = 2\pi f$

$\Rightarrow f = 60\,Hz$

$V = V_0 \sin wt$
$V = 20 \sin 120\pi t$ } Comparing the two equations

(01)

(ii) $\langle P \rangle = \frac{V_{Rms}^2}{R} = \frac{V_0^2}{2R}$

$= \frac{20 \times 20}{2 \times 100}$

$= 2W$

$\langle P \rangle = \frac{V_{rms}^2}{R}$, but $V_{rms} = \frac{V_0}{\sqrt{2}}$

$\langle P \rangle = \left(\frac{V_0^2}{2R}\right)$

$\langle P \rangle = 2W$

(iii) $E_b = -L\frac{dI}{dt}$

But for finite current $V = -E_b$

$V = L\frac{dI}{dt}$ but $V = V_0 \sin 2\pi f t$

$\Rightarrow L\frac{dI}{dt} = V_0 \sin 2\pi f t$

$\Rightarrow I = \frac{V_0}{L}\int \sin 2\pi f t\, dt$

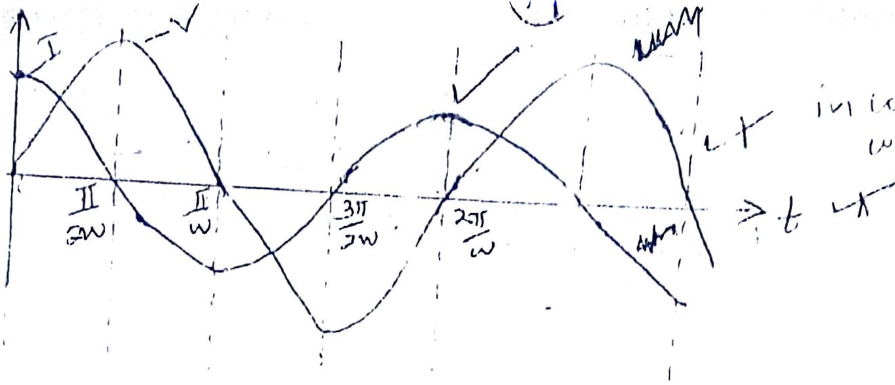
$I = -\frac{V_0}{2\pi f L}\cos 2\pi f t = -\frac{V_0}{2\pi f L}\sin\left(2\pi f t + \frac{\pi}{2}\right)$

$\Rightarrow$ I lags V by $\frac{\pi}{2}$ only

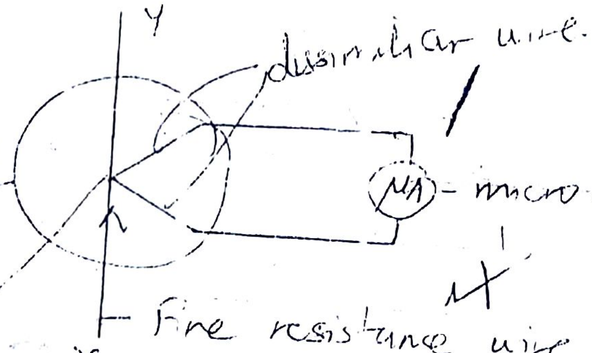
OR

$\frac{V_0}{2\pi f L}\cos(2\pi f t \ldots)$

(ii)



d (i)



Current to be measured is passed through the fine wire XY. The wire heats up due to its resistance. Thermometric Emf therefore develops between the hot and cold junctions giving rise to a direct current through the micro ammeter. The deflection therefore is proportional to the square of the average current

(ii) The fine wire is enclosed in an evacuated glass bulb to shield it from draughts.
If the wire was in the open, some heat would be given out to the surrounding so that the temp. diff btn the hot and cold junctions (hence resulting ...) would not be proportional to the power dissipated in the ...

(e) $X_c = \frac{1}{2\pi f C} = \frac{10^6}{2\pi \times 40 \times 60}$

Voltage $V_{rms} = I_{rms} \times X_c$

$= \frac{2 \cdot 2 \times 10^6}{2\pi \times 40 \times 60} = 146\,V$

QUESTION 8:

8(a)(i) Electrical resistivity is defined as the resistance across opposite faces of a 1m cube of a material

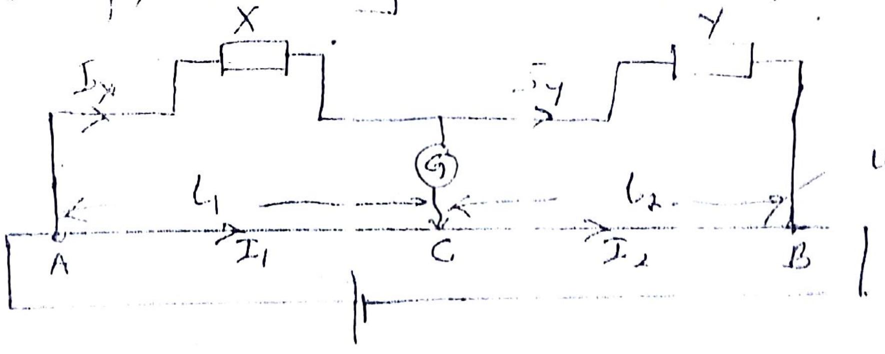
(ii) Length – Increase in length leads to longer path for electrons. This means more collisions will occur with the metal ions. This leads to a reduction in current and hence increases in resistance.

- Temperature – Increase in temperature increases the amplitude of vibration of the ions. This increases the rate of collision between the electrons and the ions. This will reduce the amount of current flowing, implying a higher resistance

(iii) $T_2 > T_1$

At temperature T_1 the gradient is higher than that at T_2 (or at each voltage, the current flowing at temp T_1 is higher than that flowing at temp T_2). This implies that the resistance is lower than that at T_2. The higher the temp, the higher the resistance

b(i)



uniform resistance wire

(16)

At balance, the galvanometer shows no deflection and,

$\Rightarrow I_X = I_Y$ and $I_1 = I_2$

The p.d across X = p.d across AC ✓

$\Rightarrow I_X X = I_1 r l_1$ ✓ (i)

Also, the p.d across Y = P.d across CB

$I_Y Y = I_2 r l_2$ ✓ (ii)

Dividing (i) by (ii) gives ✓ (04)

$$\frac{X}{Y} = \frac{l_1}{l_2}$$ ✓

(ii) - X must be chosen such that the balance point is near the middle of the wire AB. ✓

- After determining the balance lengths l_1 and l_2, X and Y should be interchanged in order to get the average values of the balance length

- The resistance wire AB should not be scrapped by jockey. This is to avoid spoiling uniformity of the wire

(c) Let the combined resistance of P and X be R

$$\Rightarrow \frac{R}{Q} = \frac{l_1}{l_2}$$

$$\frac{R}{Q} = \frac{56.7}{33.3} ✓ \Rightarrow R = 4\,\Omega ✓$$

Since P and X are in parallel

$$\Rightarrow R = \frac{5X}{5+X} ✓ = 4$$

$$\Rightarrow X = 20\,\Omega ✓$$

from $\frac{XA}{l}$ ✓ $= \frac{20 \times 1.0 \times 10^{-6}}{1.0 \times 10^{-3}}$ ✓ $= 2 \times 10^{-2}\,\Omega\,m$

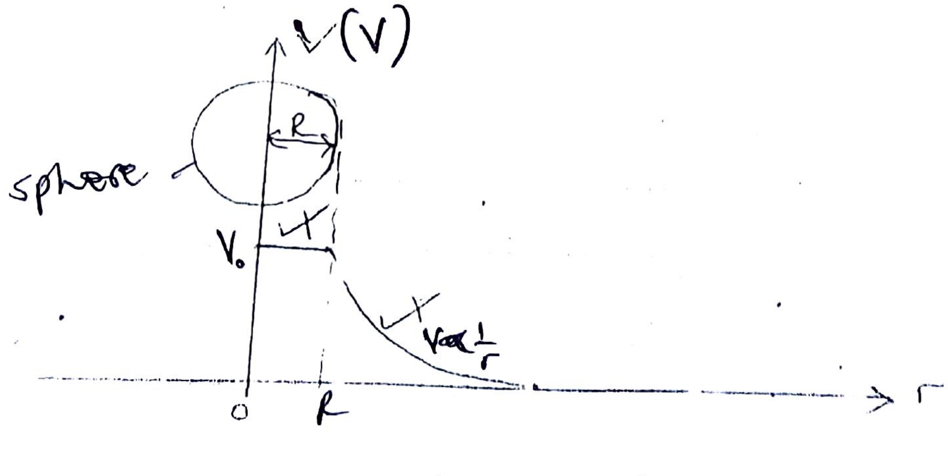
(d) When a p.d is applied across a conductor, the free electrons are accelerated in the direction of the field. As they move, they collide with the metal ions which retard the motion. On average therefore, the electrons move with a steady velocity. 4/4

7a (i) Equipotential surfaces is one on which the electric potential is the same (or constant) at all points. The work done to move a charge from one point to another along the surface is zero. This implies that the electric field is perpendicular to the surface.

(ii) The surface of a charged conductor
OR. The surface of the earth
OR An imaginary surface containing points equidistant from a point charge.

b (i) Coulomb's law states that the force between two point charges is directly proportional to the product of the magnitudes of the charges and inversely proportional to the square of the distance between them.

(ii)



Within the sphere, the electric potential is constant b'se there is no net charge inside. The potential V_0 inside is equal to the potential at the surface.
Outside the sphere, the potential is inversely proportional to the distance r from the centre of the sphere.

(iii) $\uparrow F = EQ$ ✓

S

$\downarrow mg$ ✓

since the sphere is stationary

$\therefore F = mg$.

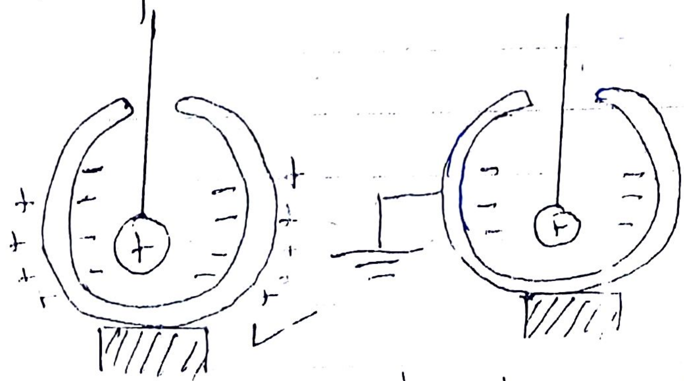
$\Rightarrow EQ = mg$ ✓ where Q is the charge on the sphere.

$E = \frac{V}{d}$ ✓ $\therefore Q = \frac{mgd}{V}$

$Q = \frac{4\times10^{-3} \times 9.81 \times 30 \times 10^{-2}}{5000} = 5.3\times10^{-6}\,C$

$= 5.3\,\mu C$

(c) (i) Electric field intensity at a point is the force exerted on 1C of positive charge placed at a point in an electric field.

(ii) 

The test material is suspended in an almost enclosed conducting can

It induces an equal and opposite charge inside the can and similiar charge ~~to its~~ on the outer walls, such that the net charge inside the can is zero. Any external field ~~only~~ affects charge distribution on the outer surface of the can. Hence the material is shielded from the external field. Electrostatic shielding is the act of protecting a material from the influence of an electric field [or creating an electrically neutral space in an electric field].

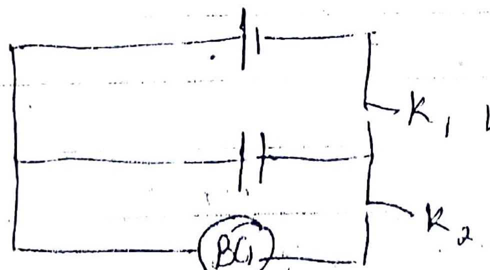
(d) When a neutral metal body is brought near a charged material, opposite charge is induced on the nearer side of the metal, and charge similiar to that of the charged body on the far side. Since the opposite charges are now closer to each other the attraction force between the materials is greater than the repulsion force. Hence the ~~metal~~ metal body is attracted.

10 (a) (i) Capacitance of a capacitor is the ratio of the magnitude of charge on either plates of the capacitor to the potential difference between the plates.

(ii) When a dielectric is inserted between the plates of a charge capacitor, its molecules get polarised. The surfaces of the dielectric thus develop charges opposite to those on the adjacent capacitor plates. An electric field intensity develops between the forces of dielectric in opposition to the applied field. The electric field intensity between the plates therefore reduce implying the reduction in the p.d.

Since the p.d is now less than the terminal p.d. of the battery, more charge is conducted to the capacitor until the p.d is again equal to that of the battery. Hence charge in the capacitor increases.

(iii)

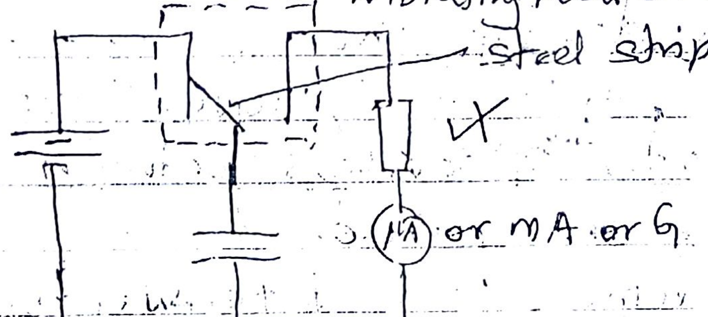


The circuit is set up as above where C is capacitor with air between it plates
Switch K, is closed and after a short time

time its opened and K_2 is closed. The first deflection θ_1 of the ballistic galvanometer (BG) is noted. The test dielectric is now inserted in the capacitor and the procedure is repeated. The first deflection θ_2 is noted. The relative permitivity is now calculated from

$$\varepsilon_r = \frac{\theta_2}{\theta_1}$$

OR



A capacitor is connected in a circuit above. The reed circuit is closed and the reading I of the milliammeter is noted. The switch is opened and a test dielectric is inserted in the capacitor. The switch is closed and the micrometer reading I' is noted. The relative permitivity ε_r is calculated from $\varepsilon_r = \frac{I'}{I}$

b (i) Effective capacitance in parallel
$= 50 + 70 = 120\mu F$

Net capacitance in the network

$$C = \frac{120 \times 40}{120 + 40} = \frac{4800}{160} = 30\mu F$$

Total charge in the network

$Q = CV = 30 \times 9 = 270\mu C$

Pd across the parallel combination

$V_p = \frac{Q}{C_{eff}} = \frac{270 \times 10^{-6}}{120 \times 10^{-6}} = 2.25V$ (05)

∴ charge on the 50μF capacitor

$Q = C_0 V_p = 50 \times 2.25 \times 10^{-6}$

$= 1.125 \times 10^{-4} C$

(ii) Energy stored in the 40μF capacitor

$E = \frac{Q^2}{2C} = \frac{(270 \times 10^{-6})^2}{2 \times 40 \times 10^{-6}}$ (03)

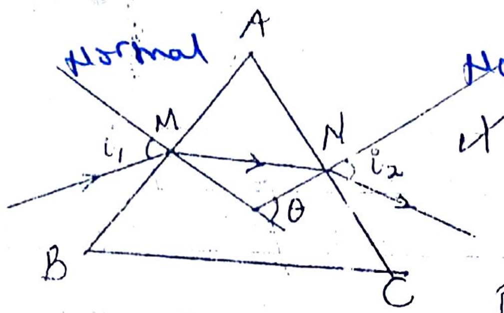
$= 9.11 \times 10^{-4} J$

(c) On a pointed charged conductor, there is high charge density at the sharp point. The electric field intensity there is therefore very high. This causes air molecules around the sharp point to get ionised creating positive and negative ions. (03)

The charge similiar to that on the conductor is repelled while the opposite charge is attracted to the sharp point and neutralises some of the charge on the conductor.

24

2(b)



The prism is placed on a plane sheet of paper on a soft board and its outline is drawn. The prism is removed and a normal is drawn at M on side AB of the prism. A line is drawn making angle i_1 to the normal. The prism is placed back on its outline, and two pins P_1, P_2 are placed on the line drawn as above. Looking through side AC, two other pins P_3, P_4 are placed on the paper so that they appear to be in straight line with the images of $P_1 P_2$.

The prism and the pins are removed. (05)
A line is drawn through pin marks $P_3 P_4$ to meet side AC at N. A normal to AC is drawn at N to meet normal through M. The angle θ between the normals is measured and is the angle of the prism.

END