LABORATORY MANUAL

SEMESTER - SECOND

B.TECH

ENGINEERING PHYSICS
LAB - II

Name of the Student ____

Registration No. ________ **Batch No.** ___________ **Branch** ____________________

School of Aeronautics (Neemrana)

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(Approved by Director General of Civil Aviation, Govt. Of India , All India Council for Technical Education, Ministry of HRD, Govt of India & Affiliated to Rajasthan Technical University. Kota, Rajasthan)

School of Aeronautics (Neemrana)

CERTIFICATE

This is to certify that Mr./ Ms.______________________________

Registration Number ________________________________

of B.Tech (   ) has satisfactorily completed the term of the subject, Engineering Physics Lab-II, prescribed by Rajasthan Technical University, Kota.

Dated: ____________ **Signature of Faculty**

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EXPERIMENT - 1
SPECTROMETER

OBJECT
To determine the dispersive power of a material of prism using Spectrometer

APPARATUS
Spectrometer, Prism, Mercury Vapor Lamp etc.

FORMULA
The dispersive power of the prism is given by

$$w = \frac{\mu_b - \mu_g}{\mu_a - 1}$$

Where, $$\mu_{av} = \frac{\mu_b + \mu_g}{2}$$

$$\mu_b = \frac{\sin\left(\frac{A + D_B}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

$$\mu_G = \frac{\sin\left(A + D_g\right)}{\sin\left(\frac{A}{2}\right)}$$

A = angle of the prism

Dg = angle of minimum deviation for green colour

Db = angle of minimum deviation for blue colour

THEORY
A spectrometer is used to measure the necessary angles. The spectrometer consists of three units: (1) collimator, (2) telescope, and (3) prism table. The prism table, its base and telescope can be independently moved around their common vertical axis. A circular angular scale enables one to read angular displacements (together with two verniers located diametrically opposite to each other).

In the experiment, we need to produce a parallel beam of rays to be incident on the prism. This is done with the help of a collimator. The collimator has an adjustable rectangular slit at one end and a convex lens at the other end. When the illuminated slit is located at the focus of the lens (See Fig. 1), a parallel beam of rays emerges from the collimator. We can test this point, with the help of a telescope adjusted to receive parallel rays. We first prepare the telescope towards this purpose as follows:

Setting the eyepiece

Focus the eyepiece of the telescope on its cross wires (for viewing the cross wires against a white background such as a wall) such that a distinct image of the crosswise is seen by you. In this context, remember that the human eye has an average "least distance of distinct vision" of about 25 cm. When you have completed the above eyepiece adjustment, you have apparently got the image of the cross wire located at a distance comfortable for your eyes. Henceforth do not disturb the eyepiece.

Setting the Telescope

Focus the telescope onto a distant (infinity!) object. Focusing is done by changing the separation between the objective and the eyepiece of the telescope. Test for the absence of a parallax between the image of the distant object and the vertical cross wire. Parallax effect (i.e. separation of two things when you move your head across horizontally) exits, if the cross-wire and the image of the distant object are not at the same distance from your eyes. Now the telescope is adjusted for receiving parallel rays. Henceforth do not disturb the telescope focusing adjustment.

Setting the Collimator

Use the telescope for viewing the illuminated slit through the collimator and adjust the collimator (changing the separation between its lens and slit) till the image of the slit is brought to the plane of cross wires as judged by the absence of parallax between the image of the slit and cross wires.

Optical leveling of the Prism

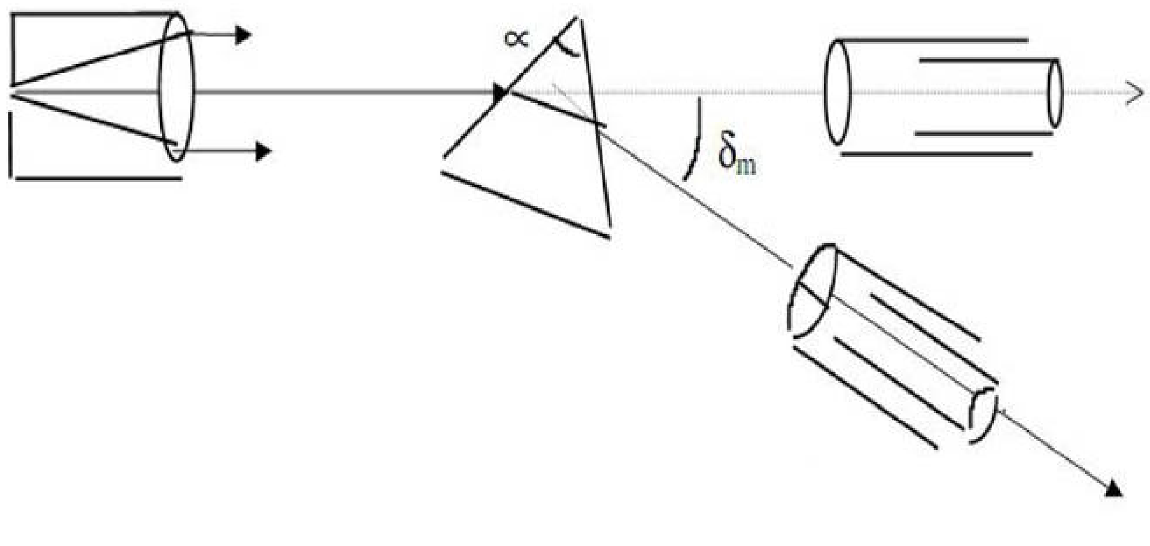
The prism table would have been nearly leveled before uses have started the experiment. However, for your experiment, you need to do a bit of leveling using reflected rays. For this purpose, place the table with one apex at the center and facing the collimator, with the ground (non-transparent) face perpendicular to the collimator axis and away from collimator. Slightly adjust the prism so that the beam of light from the collimator falls on the two reflecting faces symmetrically (Fig. 2) when you have achieved this lock the prism table in this position. Turn the telescope to one side so as to receive the reflected image of the slit centrally into the field of view. This may be achieved by using one of the leveling screws. The image must be central whichever face is used as the reflecting face. Similarly, repeat this procedure for the other side.

Finding angle of minimum deviation (D_m)

Unlock the prism table for the measurement of the angle of minimum deviation (D_m). Locate the image of the slit after refraction through the prism as shown in Fig. 3. Keeping the image always in the field of view, rotate the prism table till the position where the deviation of the image of the slit is smallest.

At this position, the image will go backward, even when you keep rotating the prism table in the same direction. Lock both the telescope and the prism table and to use the fine adjustment screw for finer settings. Note the angular position of the prism.

In this position the prism is set for minimum deviation. Without disturbing the prism table, remove the prism and turn the telescope (now unlock it) towards the direct rays from the collimator. Note the scale reading of this position. The angle of the minimum angular deviation, viz, Dm is the difference between the readings for these last two settings.



Minimum deviation geometry

OBSERVATIONS VERNIER CONSTANT OF THE SPECTROMETER = ...

For angle of prism A :

S.No.	Vernier	Telescope reading		Difference,24	A (deg)
		1st position	2nd position		
1	V_1				
2	V_2				

Mean A = ...

For Minimum Deviation , D_m

Line	0	Vernier	Minimum Deviation ray	Direct ray	Difference,D_m
Violet	1	V_1			
Red	2	V_2			

Dispersive power (w):-

Angular rotation for a given wavelength is called dispersive power of the material of a prism

Reading $$\mu_v = \frac{\sin\left(\frac{A+Dv}{2}\right)}{\sin\left(\frac{A}{2}\right)} \quad , \quad \mu_r = \frac{\sin\left(\frac{A+D_r}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

$$w = \frac{\mu_v - \mu_r}{\mu_{av} - 1} \quad Where \quad \mu_v \frac{\mu_v + \mu_r}{2}$$

PRECAUTION

1. Take the readings without any parallax errors.
2. The focus should be at the edge of green and blue rays.

RESULT

The dispersive power of a material of prism using spectrometer is

w =

QUESTIONS

1. Will the angle of minimum deviation change , if prism is immersed in water?

2. Does the angle of minimum deviation change with colour?

3. What is Dispersion ?

4. What is Angular Dispersion ?

5. What is Dispersive Power ?

6. Can you determine refractive index of liquid using this method ?

7. Which source of light are you using ? Is it monochromatic ?

8. What is an eyepiece ?

9. What is Prism ?

10. What is the relation between angle of incidence and angle of Deviation ?

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EXPERIMENT - 2
TELESCOPE

Object

To determine the resolving power of a telescope and then verify its expression.

APPARATUS USED

Telescope with a rectangular adjustable slit, a black cardboard with narrow white strips on it., travelling microscope and meter scale.

FORMULA USED

The theoretical and practical resolving power are given by

Theoretical resolving power= 2/a

Practical resolving power= d/D

Where λ = Mean wavelength of light used

a = Width of the rectangular slit for just resolution of two objects.

d = Separation between two objects

D = distance of the objects from the objective of the telescope.

Hence for a limiting angle of resolution , we have

$$\frac{\lambda}{a} = \frac{d}{D}$$

THEORY

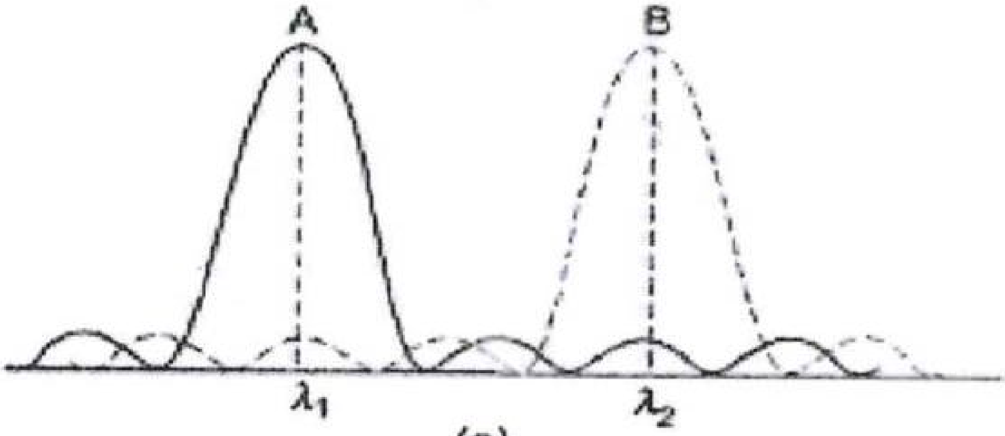
The resolving power of a telescope may be defined as the inverse of the least angle subtended at the objective by two distant point objects which are just resolved. The smaller the value of this angle, the higher is the resolving power of the telescope. This angle is a measure of the limit of resolution of the telescope which can be defined as the smallest angle subtended at the objective of the telescope by the two objects, which are just resolved by the telescope.

For a telescope fitted with a rectangular aperture, the angle of resolution is given by

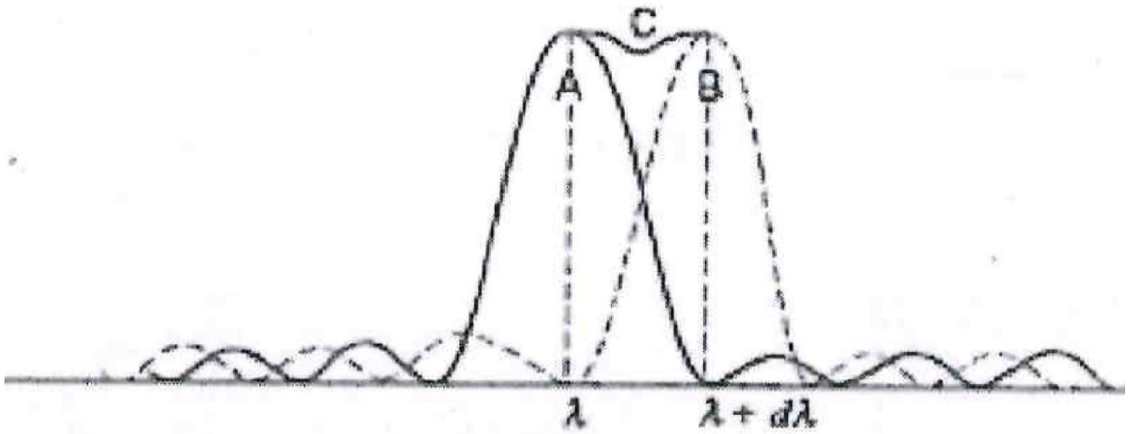
$$\theta = \frac{\lambda}{D} = \frac{d}{a}$$

Rayleigh Criterion of Resolution

To express of the resolving power of an optical instrument as a numerical value, Lord Rayleigh proposed an arbitrary criterion. According to it two equally bright sources can be just resolved by an optical instrument when their distance apart is such that in the diffraction pattern, the maximum due to one falls on the minimum due the other and vice-versa.



(a)



(b)

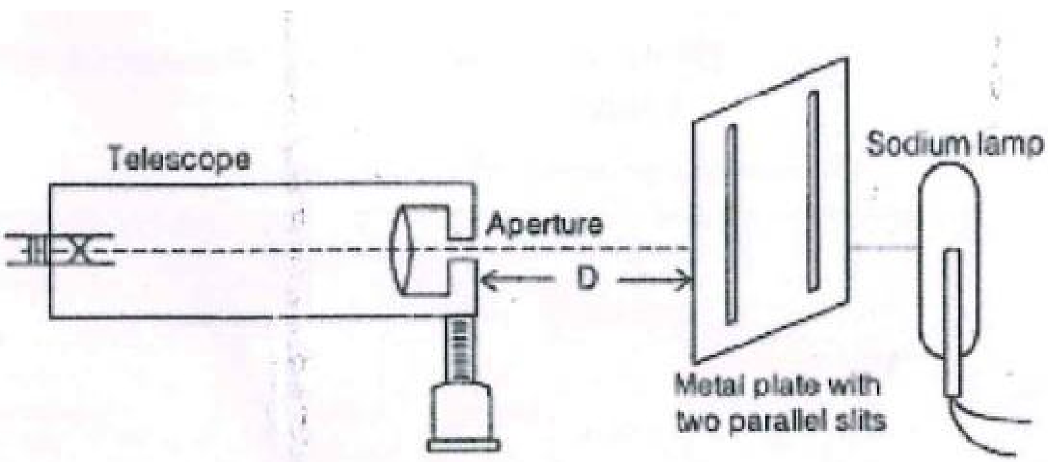


Fig. 2

PROCEDURE

i. Mount the black painted glass plate carrying two parallel slits on a stand such that the slits are vertical. Illuminate the slits by placing a monochromatic source of light between them.

ii. Now mount the telescope another stand at a distance of about 4 or 5 from the plate and at the same height as the slits such that the axis of the telescope is horizontal and normal to the metal plate.

iii. Now open the slit with the help of micrometer screw and move the telescope in the horizontal direction such that the images of two vertical sources are in the field of view of the eyepiece.

iv. Gradually reduce the width of the slit till the two images just cease to appear separate. Note down the reading of the micrometer screw. Again close the slit completely and note down micrometer reading. The difference of the two reading gives the width a of the aperture just sufficient to resolve the two images. If the slit is not provided with micrometer arrangement the slit is gradually reduced till the images cease to appear two. Take out the slit and measure its width with the help travelling microscope.

v. Measure the separation between pair of object slits with the help of a travelling microscope which gives d.

vi. Measure the distance between the metal plate & objective of the telescope which gives d

vii. Repeat the experiment 4 or 5 times for different values of D.

OBSERVATIONS

Mean wave length of sodium light used, $\lambda = 5893 X 10^{-8}$cm

Table for width (a) of rectangular a aperture (slit) when micrometer arrangement is used.

Table- 1

Least count of the micrometer screw=......cm.

S.L. No.	Distance D cm	Reading of micrometer screw When images of the slit cease When aperture (slit) is closed						Width of slit a=x-y	Theoretical resolving power
		M.S. reading cm	V.S. reading	Total reading X cm	M.S. reading cm	V.S. reading	Total reading Y cm		
1.		....	....	...	....	....	....	....	....
2.		....	....	....	....	....	....	....	....
3.		....	....	....	....	....	....	....	....
4.		....	....	....	....	....	....	....	....
5.		....	....	....	....	....	....	....	....

Table for width (a) of rectangular a aperture (slit) when micrometer arrangement is used.

Table- 2

S.L. No.	Distance D cm	Reading of microscope One End			Other End			Width of slit a=x-y
		M.S. reading cm	V.S. reading	Total reading X cm	M.S. reading cm	V.S. reading	Total reading Y cm	
1.		....	....	...	....	....	....	....
2.		....	....	....	....	....	....	....
3.		....	....	....	....	....	....	....
4.		....	....	....	....	....	....	....

Table for the separation between the two objects (d)

Table- 3

Least count of the travelling microscope= ....cm

S.L. No.	Distance D cm	Reading of micrometer screw One End			Other End			Distance between two objects d=Y-X	D cm	Theoretical resolving power
		M.S. reading cm	V.S. reading	Total reading X cm	M.S. reading cm	V.S. reading	Total reading Y cm			
1.		....	....	...	....	....	....	....	....	....
2.		....	....	....	....	....	....	....	....	....
3.		....	....	....	....	....	....	....	....	....
4.		....	....	....	....	....	....	....	....	....
5.		....	....	....	....	....	....	....	....	....

Result

The theoretical and practical resolving power of the telescope is shown in the table.

S. No.	Distance D cm	Theoretical resolving power (2/a)	Practical resolving power (d/D)	Difference
1.	....	....	....	....
2.	....	....	....	....
3.	....	....	....	....
4.	....	....	....	....

Precautions and sources of error

1. Plate of two parallel slits must be mounted in stand such that slits remain vertical.
2. Slits on plate and adjustor aperture must be parallel to each other.
3. While taking reading by micrometer be careful that backlash error in it is avoided.
4. The position of just coinciding of two images and that of just disappearance of light in telescope must be set very carefully.
5. The distance 'D' between the glass plate of object slits and rectangular aperture should be measured accurately.

QUESTIONS

1. What is mean by resolving power of a telescope?

2. What is Rayleigh criterion of resolution?

3. On what factor does the resolving power of telescope depend?

4. What do you mean just resolved?

5. When does the resolution of two images possible?

6. Why are telescope fitted with objectives of large diameter?

7. Does resolving power of telescope depend on focal length of objective of eyepiece?

8. What is the resolving power of a normal eye?

9. What is the use of employing objectives of large focal lengths in telescope?

10. Do you know where the largest telescope is installed?

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EXPERIMENT- 3

CAREY FORTSER'S BRIDGE

OBJECT

To determine the resistance per unit length of carey foster's bridge wire and specific resistance of the material of the given wire using carey foster's bridge.

APPARATUS REQUIRED

Carey foster's bridge, Battery, copper strip, galvanometer, plug key, given wire whose specific resistance is to be determined, resistance box, connecting wires and screw gauge.

FORMULA USED

The resistance per unit length of Carey's bridge wire (p) is related to the difference between two nearly equal resistance connected in the outer gaps of a carey foster's bridge as,

$$X - Y = p(L_2 - L_1)$$

Where,

X	=	Resistance connected,
y	=	Resistance of copper strip connected to the right gap
p	=	Resistance per unit length of the bridge wire.
L_1, L_2	=	Length of balance point on the bridge wire measured from the left reference zero before and after interchanging the X and Y resistances.

The specific resistance (k), of material of a given wire can be calculated from the formula.

$$k = \frac{R\pi r^2}{L}$$

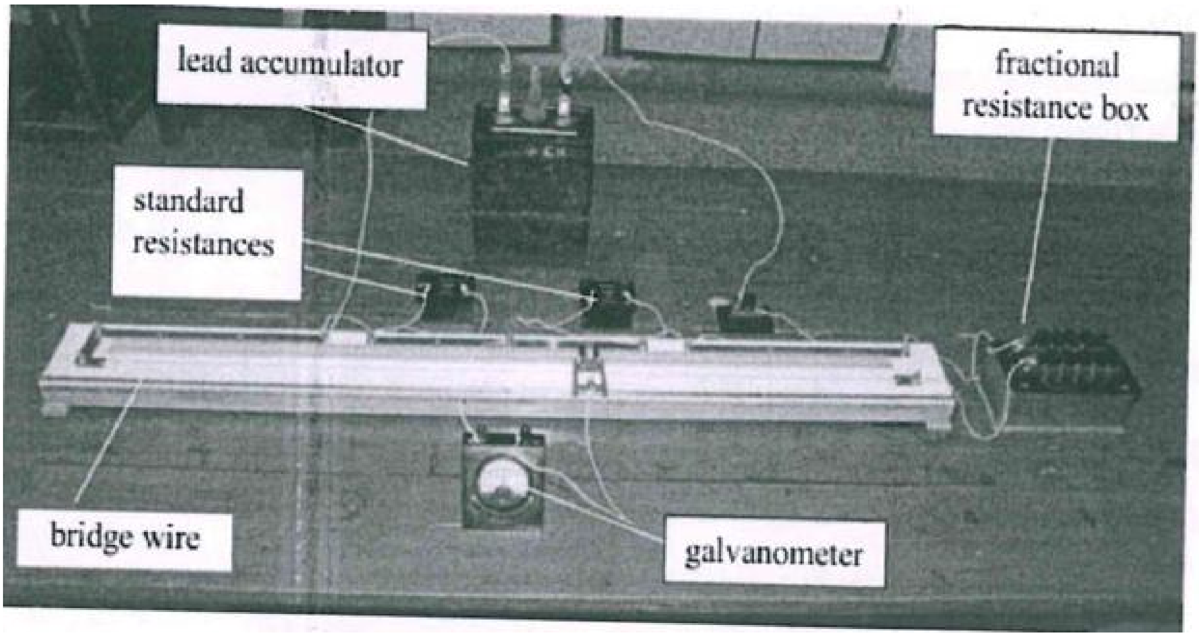
Where,

R	=	resistance of the given wire
L	=	length of the given wire
r	=	radius of the given wire

The resistance of the given wire

$$R = X -_p (L_2^{'} - L_1^{'})$$

Where, L_2^1 and L_2^1 are the balance points measured from left reference zero before and after interchanging the resistance introduced (X) and given wire in place of the copper strip (Y)



PROCEDURE

(A) Method for determination of the resistance per unit length of the of the bridge wire

1. The standard resistance is kept in the outer left gap for X and thick copper strip in the outer right gap for (figure) (1). The ratio arms P and Q can be obtained by connecting the lower terminal of the rheostat to the points A and C and its upper terminal kept at the middle and connected to the sliding contact tot he galvanometer G.

2. The key (K) is closed and the jockey is then made to touch the bridge wire near its ends. The deflections in the galvanometer in the two cases must be in opposite directions. However, If only one-sided deflection is observed then the connections should be rechecked and screws properly tightened, seeing that the ends of the connecting wire are perfectly clean.

3. Introduce some resistance X in the resistance box and by sliding the jockey null point is obtained. The distance of null point L_1 from left reference zero ends is noted.

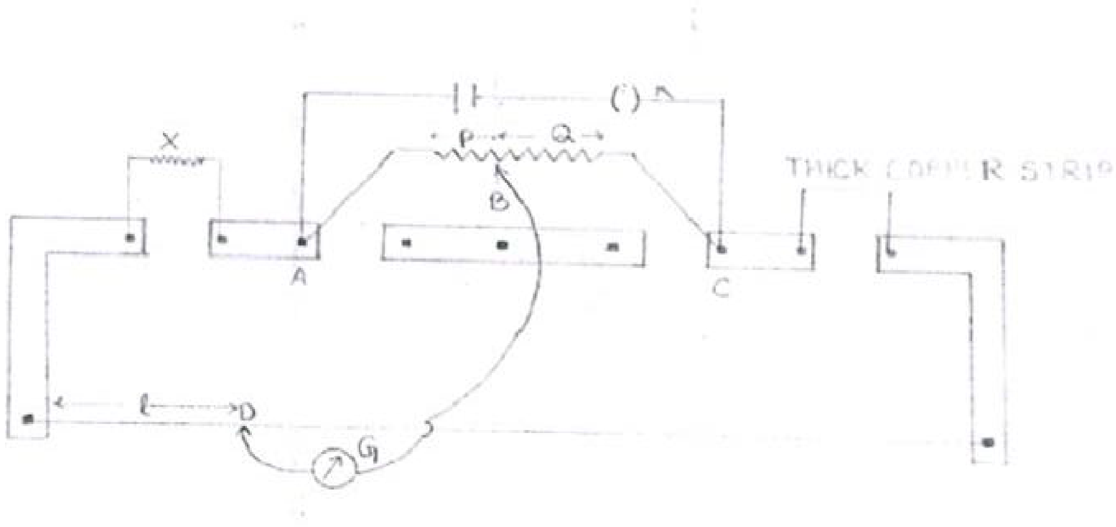
4. Now interchange the position of resistance box and the copper strip. Again the balance is obtained for the same applied resistance in the box. Let the null point from the left reference zero be L_2.

5. Change the value of X by 1 ohm and obtain different sets of observation as described in above steps.

6. Calculate the value of p separately by talking y+0 for each set using the formula

$$p = \frac{X}{(L_2 - L_1)}$$

7.



(B) Method for determining the resistance of the given wire

The experiment is repeated exactly in the same manner as started above by replacing the copper strip with the given wire and retaining the same resistance X. The resistance of the given wire R, is then calculated by the value of p by,

$$R = X - (L_2^{'} - L_1^{'})$$

Take different sets by changing by the value of resistance in the resistance box.

(C) Determination of the length and diameter of the given wire

1. The length of the resistance wire between the terminals, is measured by a meter scale and its mean radius is obtained by measuring its diameter at places in two mutually perpendicular directions by a screw gauge.

2. Having obtained the values of the specific is calculated by using equation (2) given above.

OBSERVATIONS

(A) Observation for determination of p

S. No.	Standard resistance used (x)	Distance of null point from the left end of bridge wire		(L_2-L_1)cm.	$p = \frac{X}{(L_2 - L_1)}\ \Omega cm$
		Resistance X in left gap and copper strip in right gap (L_1 cm.)	Resistance X in right gap and copper strip in Left gap (L_2 cm.)		
1.					
2.					
3.					
4.					

The mean value of = ...Ω cm^{-1}

OBSERVATIONS

(B) Observation for determination of resistance of the given wire.

S. No.	Standard resistance used (x)	Distance of null point from the left end of bridge wire		(L_2-L_1) cm.	Resistance of the wire $R = X - p(L_2^{'} - L_2^{'})\Omega$
		Resistance X in left gap and copper strip in right gap ($L_1^{'}$ cm.)	Resistance X in right gap and copper strip in left gap ($L_2^{'}$ cm.)		
1.					
2.					
3.					

QUESTIONS

1. What is resistance?

2. What is specific resistance?

3. What is the effect of temperature on resistance?

4. In what materials the resistance decreases with increase in temperature?

5. If the radius of wire is doubled will the specific resistance change?

6. Why is the resistance wire wire doubled before winding over the bobbin?

7. What is the principle of Carey Foster Bridge?

8. What is the principle of Wheatstone Bridge?

9. When is Carey Foster Bridge most sensitive?

10. Why the resistance for inner ratio arms be equal?

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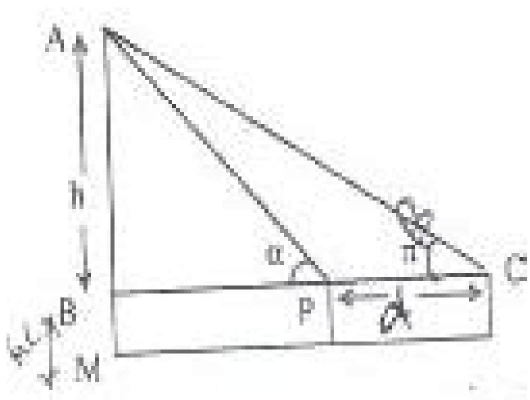
EXPERIMENT - 4
SEXTANT

OBJECT
To determine the height of the tank or building or tower or any object with the help of a sextant..

APPARATUS REQUIRED
1. Sextant
2. Measuring tape
3. A rigid clamp stand
4. Chalk (to mark)

THEORY
Let H be the height of a thank MA whose height is to be remained using sextant. Now mark a reference point B on the all of the tank at the eye level.

Let α and β are the angles subtended by the top A of tank at point P and C positions-



Δ In BPA-

$$\tan\alpha = \frac{BA}{BP} = \frac{h}{BP}$$

$$BP = \frac{h}{\tan\alpha} = h\cot\alpha$$

In Δ BCA-

$$\tan\beta = \frac{BA}{BC} = \frac{h}{BC}$$

$$BC = \frac{h}{\tan\beta} = h\cot\beta$$

Now d=BC-BP

Put the value from equation (1) and (2), we get-

d=h $d = h(\cot\beta - \cot\alpha)$

$$h = \frac{d}{\cot\beta - \cot\alpha}$$

This equation (3) shows the height from the reference mark.

The actual height of the tank MA-

MA=AB+BM

$H = h + h_c$

Where h_c is the height of the sextant above the ground M.

DESCRIPTION OF APPARATUS

Sextant

Sextant is an instrument which enables us to determine the angular separation between two distant point object at the plane of observations.

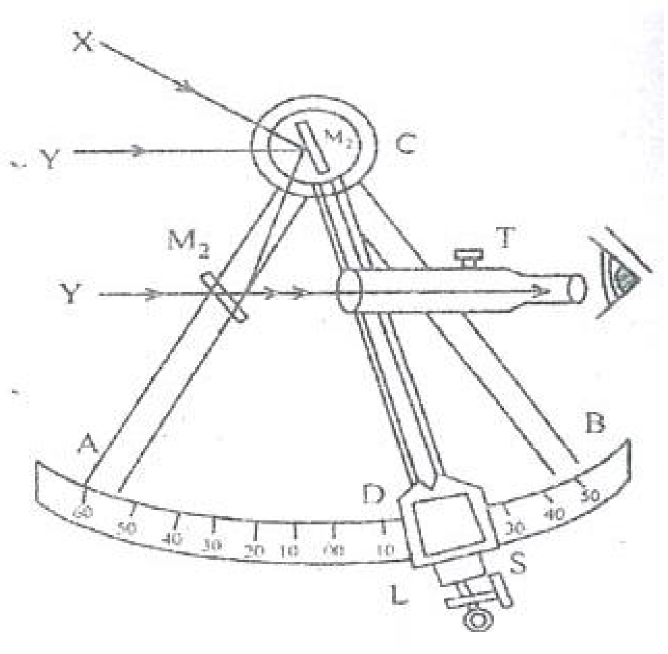
If the distance of one of the points from the sextant is know the distance between the two points can be calculated.

The schematic diagram of sextant is shown in Fig. 1.2. It consists of a graduated arc AB connected to two fixed radial arms BC and AC which meet at a point C which is centre of circle of which the arm forms a part.

The arm CD is called **Index arm**, which is free to rotate round an axis passing through C have a plane glass M_1, Called the **Index glass** at the end of C Fixed in a plane perpendicular to the plane of scale.

At the other end of the index ar**m** at D, there is a vernier scale V which can be slide along the main scale. A tangent screw S is provided for fine adjustment of the vernier as shown in Figure.

The glass plate M_2 known as the **horizon glass**, is fixed on the arm AC also kept normal to the plane of circular arc in such a manner that when the index arm is at zero, M2 is parallel to the glass M1. Lower half of this plate (M_2) is silver polished and other half is kept transparent. A Gallein telescope T is fixed to the arm BC with its axis parallel to the plane of scale and passing through the centre of the horizon glass. A screw is provided at the sides of the telescope to move it in a plane perpendicular to the plane of the arc.

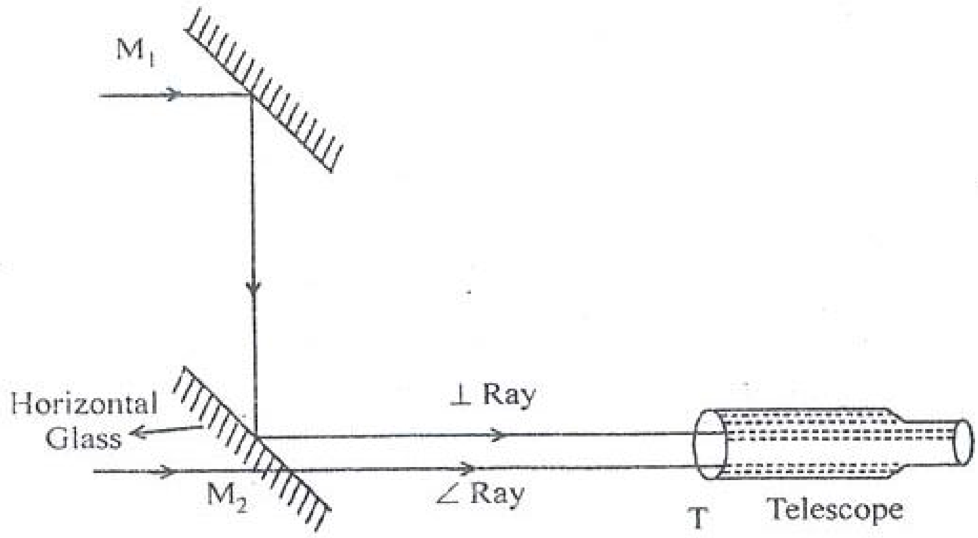


WORKING OF SEXTANT

Sextant is based on the principle that "the deviation produced in ray by successive reflections from two inclined mirrors is constant for all angle of incidence and is twice the angle between the mirrors."

When the arm CD occupies the position CB, the planes of Glass M_1 and M_2 are parallel to each other. This gives the zero position of the circular scale AB. If the telescope is pointed towards a distant object coinciding with each other. One image is seen through the transparent portion while the other is due to the rays which have been doubly reflected from glasses M_1 and M_2.

If the glasses are parallel, the rays will be parallel and the two images will coincide as shown in Figure.



FORMULA

The height of the tank or building or tower can be given by-

$$h = \frac{d}{\cot\beta - \cot\alpha} + h_c$$

Where α and β are the angles subtended by the top at the positions of the sextant, distance apart and h_c is the height of the reference point at the same level of the sextant.

PROCEDURE

1. First find the least count of sextant by taking the value of one divisions of main scale and total number of vernier divisions as shown by example in observation.
2. Put a horizontal line as a reference point B on the tank at the eye level on the vertical wall of the building.
3. Now mark four positions on ground on d=1,2,3 & 4 meter by using measuring tape at equal distance between them.
4. Put sextant (with stand) at position I meter and see this mark B through the transparent portion of the horizontal glass by telescope with its plane vertical and point the telescope towards the reference mark, so that in the left half of the field of view, cross mark is seen.
5. Now rotate the movable arm (index arm) of the sextant so that reference mark is also seen till the right half of the field of view adjust with the help of fine screw. So that reference mark in two halves is coinciding.
6. Note down the reading of sextant. This is called zero error reading.
7. Movable arm is rotated gradually till the image of the upper mark or top of the building whose height is to be determined, in the mirror M_2 is at the same level as the image of the reference mark as seen directly. In this position the reading on the scale is noted.
8. Take this observation. It is called elevation reading. The difference between zero reading and elevation reading gives angle of elevation.
9. Repeat this procedure for the distance 2, 3 and 4 meter respectively and take readings.

OBSERVATION

Least count of the sextant

value of one division of main scale=................min

Total number of divisions on the vernier scale=..........

Least count of the sextant=................sec.

Zero error of Sextant= ....

Generally in sextant

5 division of vernier scale=4 division of Main scale

$\therefore$ I division of vernier scale = $\frac{4}{5}$ division of Main scale

$\therefore$ I division of main scale is $\frac{1}{5}$ min.

or least count is $\frac{1}{5}$ * 60 sec = 12 sec

For Determination of α , β and γ

S.L. No.	Main scale Reading (Degrees)	Vernier scale reading (Minutes)	Difference	
1				α
2				β
3				γ

CALCULATIONS

(A) d_1 = ...

$$h_1 = \frac{d_1}{\cot\beta - \cot\alpha}$$

(B) d_2=

$$h_2 = \frac{d_2}{\cot\beta - \cot\gamma}$$

(C) d_3 = ...

$$h_3 = \frac{d_3}{\cot\alpha - \cot\beta}$$

Mean h= $\frac{h_1 + h_2 + h_3}{3}$

Result

The height of given object H =............................

Actual height measured by measuring tape H =................................

Percentage Error = $\frac{s\tan dardvalue - Experimentalvalue}{s\tan dardvalue} * 100$

=..............................%

PRECAUTIONS

1. The zero reading changes from place to place. So every measurement of elevation angle, zero reading should be determined separately.
2. The two glasses M_1 and M_2 must be made parallel to each other and perpendicular to the plane of the arc with the help of screw.
3. Index glass and horizon glass should be parallel at zero reading position.
4. The reference mark and different place of observation should be in the straight line.
5. While taking observation, two images should overlap properly.
6. The axis of the telescope should be parallel to the plane of the circular scale.
7. The index glass and the horizon glass may not be parallel in zero reading.
8. The plane of index glass may not be perpendicular to the plane of the circular arc.
9. The centre of graduate arc and of the moving arm may not coincide.

QUESTIONS

1. What is sextant and why it is called sextant?.

2. What is the basic principle of sextant?.

3. Is the incident ray fixed here as glass is rotated?

4. Why adjustments must satisfy for the glass in sextant ?

5. Give functions of the screw attached with glasses M_1 and M_2?

6. What are the uses of light filters (colored glasses) in this experiment?

7. What types of telescope is fitted with sextant?

8. Is the actual angle subtended by the arc appears to be an acute angle?

9. How is this anomaly explained?

10. Why two images seen when the sextant is pointed towards an object?

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EXPERIMENT - 5
OPTICAL FIBRE

OBJECT

To measure the numerical aperture of an optical fibre.

APPARATUS

1) Laser source
2) Transmitter
3) Optical fibre
4) NA
5) Reading lamp

THEORY

When a light ray is incident at one end of the fibre, because of the small radius of the core. Light ray going into the core makes a nearly glancing angle incidence on the wall. As result the angle of incidence on the cylinder surface of fibre becomes greater than the critical angle and total internal reflection takes place due to light ray going from core medium (high n) towards cladding layer (low n).

Since the angle of incidence and reflection are equal, the light undergoes multiple reflections and propagates along the fibre from one end to another end, even fibre is complicated.

Structure of Optical Fibre

An Optical fibre is a cylindrical dielectric wave guide which guides light within it in a direction parallel to its axis.

An Optical fibre is a hair thin fibre made of glass, quartz or transparent plastic having a radius of the order of micrometer (10^{-6}m).

A bundle of such thin fibres form a light pipe. The fibres in the light pipe must be optically isolated from each other.

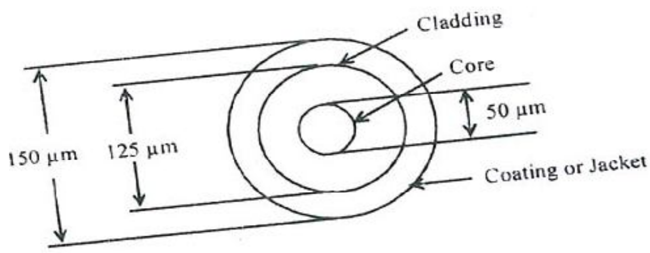
A practical optical fibre has in general three coaxial components.

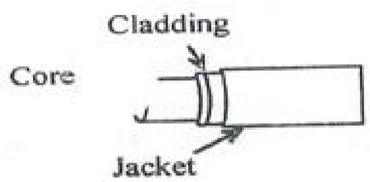
i. Core
ii. Cladding
iii. Coating

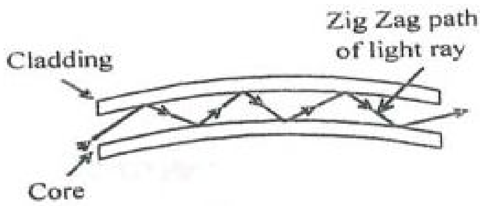
The innermost region is light guiding region known as core. A coaxial middle region known as the lading whose optical properties are different from the core surrounds the core. The outermost region called the coating or jacket. Coating protects the cladding and core from moisture and other environment dangers.

The purpose of cladding is to make the light to be confined to the core, so the refractive index of cladding ($n_{cladding}$) is always lower than that of the core (n_{core}), i,e. $n_{clad} < n_{core}$.

Optical fibre are constructed, either as a single fibre or a flexible bundle or a cable. A fibre bundle a number of fibres in a single jacket. Each fibre carries light independently.



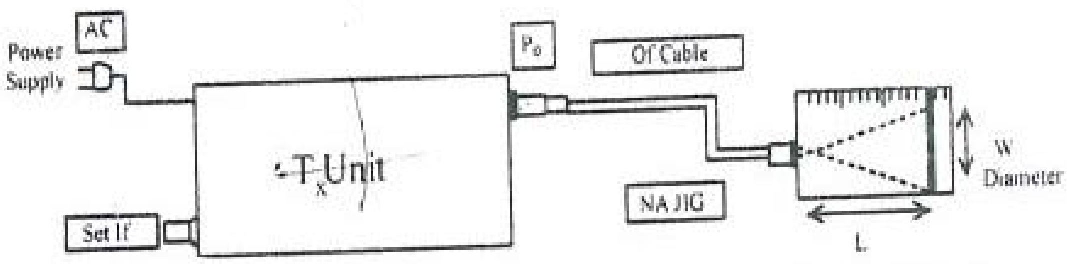




Optical Fibre

DESCRIPTION OF APPARATUS

Figure represents an experimental set up for measurement of numerical aperture. In this experiment, a laser source is fixed on one end and connected through power supply. One end of optical fibre cable is connected through T_x unit and other end is connected at NA JIG as shown in figure. After determination of diameter (W) and distance (L), numerical aperture can be determined.



FORMULA

Numerical Aperture of any optical fibre system is a measure of how much light can be collected by the optical system. It is the product of the refractive index of the incident medium and the sine of the maximum ray angle and given by:

NA= $n_1 \sin\theta_{max}$

Where, n_1 is refractive index of the medium from which light incident.

For air medium $n_1 = 1$

NA= $\sin\theta_{max}$

NA can compute by the formula

NA = = $\sin\theta_{max} = \sqrt{\dfrac{W}{4L^2 + W^2}}$

Where L= distance of NA from Laser source

W= diameters of circles on NA

PROCEDURE

i. First find the diameter of the circle on NA

II. Connect one end of the fibre optic to P_0 of $T_\times$ Unit and the other end to the NA JIG.

iii. Plug the AC mains. Light through the laser diode appear at the end of the fibre on the NA JIG. Turn the set if knob clockwise to set P_0 maximum. The light intensity of laser diode should increase.

iv. Hold the NA card and fall laser light spot on different circles one by one and take the reading of distance from NA JIG to NA card. This is measurement of L for different circles.

v. Put the value of L and W in formula and computer NA and θ

OBSERVATIONS

S.No.	L(cm)	W(cm)	NA	θ (degree)

CALCULATIONS

Put the different values of L and W, calculate NA and θ

$$\sin\theta_{\max} = \sqrt{\frac{W}{4W^2 + L^2}}$$

RESULT

The NA of optical values fibres is between ....& ......for which θ is between ......& ....

PRECAUTIONS

i) Do not look directly at laser beam because it is hazardous to the eyes.

ii) The laser source is to be switched off after taking observations.

iii) Properly adjust the position of N.A.

QUESTIONS

1. What is an optical fibre?

2. What is the basic principle of optical fibre?

3. Give the basic structure of optical fibre.

4. What do you mean by acceptance angle?

5. What do you mean by numerical aperture?

6. On what factors numerical aperture depends?

7. Give the importance of optical fibre.

8. Give the applications of optical fibre.

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EXPERIMENT - 6

I-H CURVE USING CRO

OBJECT

To determine the ferromagnetic constants, retentivity, permeability and susceptibility by tracing I-H curve using CRO.

APPARATUS REQUIRED

1) Hysteresis loop tracer
2) Sample holder
3) Sample
4) Cathode ray oscilloscope

THEORY

When a ferromagnetic material is above a certain temperature (called curie temperature), the exchange coupling of substance suddenly disappears. The substance therefore starts behaving as paramagnetic.

According to curie law, the intensity of magnetization (1) of a magnetic material is (i) directly proportional to magnetic induction (B) and (ii) inversely proportional to the temperature (T) of the material.

i.e. I $\propto$ B and I $\propto \frac{I}{T}$

Combining these factors, we get I $\propto \frac{B}{T}$

as B $\propto$ H magnetic intensity or B = μ H

$$\therefore I \propto \frac{H}{T} or \frac{I}{H} \propto \frac{I}{T}$$

$$i.e. \qquad X_m \propto \frac{I}{T}$$

$$or \qquad X_m = \frac{I}{H}$$

Where X_m is magnetic susceptibility of a magnetic material which is defined as the ratio of the intensity of magnetization (I) induced in the material to the magnetizing force (H) applied.

Magnetic permeability (μ) is defined as the magnetic induction per unit magnetic field which is constant for a material.

$$\mu = \frac{B}{H}$$

If the medium were replaced by vacuum then

$$\mu_0 = \frac{B_0}{H}$$

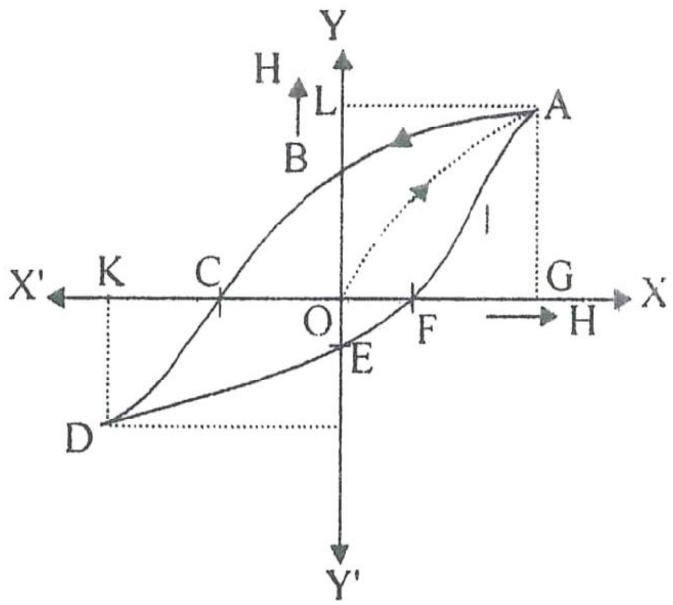
Where μ_0 is the permeability of vacuum.

Now $\frac{\mu}{\mu_0} = \mu_r$ which is the relative permeability of the material defined as the ratio of magnetic permeability of the material (μ) and magnetic permeability of free space (μ_0).

When a magnetic material is placed in a magnetizing field of magnetic intensity H, the material gets magnetized. The total magnetic induction B in the material is the sum of magnetic induction B_0 in vacuum produced by the magnetic intensity and magnetic induction B_0 due to magnetization of the material, therefore.

$$B = B_0 + B_m$$

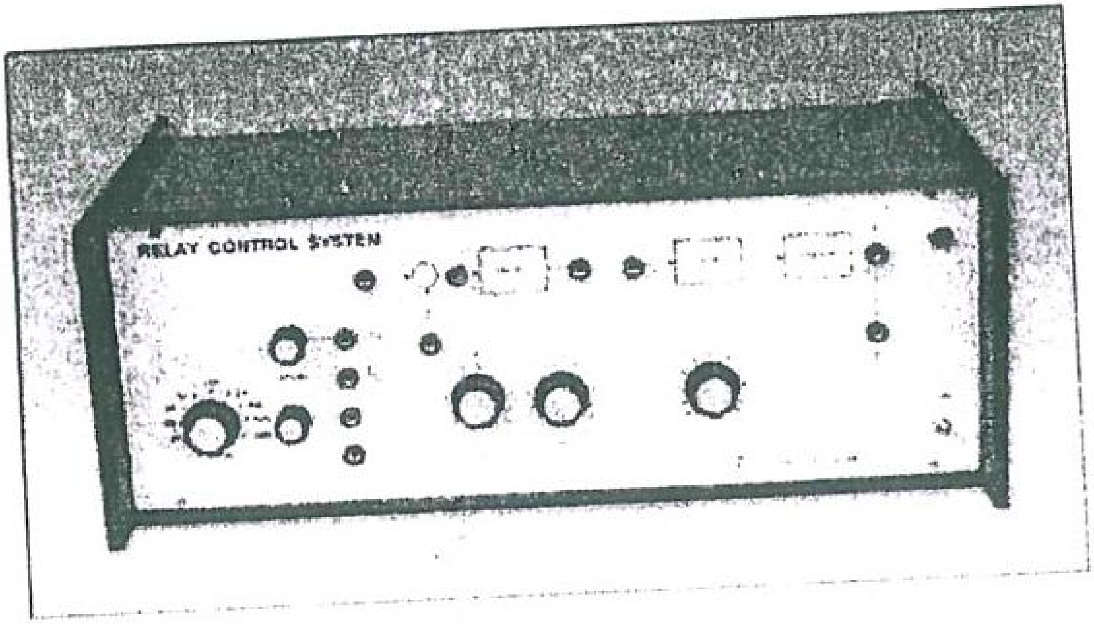
$$\begin{aligned} or \qquad B &= \mu_0 H + \mu_0 I \\ &= \mu_0 (H + I) \\ &= \mu_0 (H + X_m I) \\ \mu H &= \mu_0 H (1 + X_m) \\ \mu_r &= \frac{\mu}{\mu_0} = 1 + X_m \end{aligned}$$

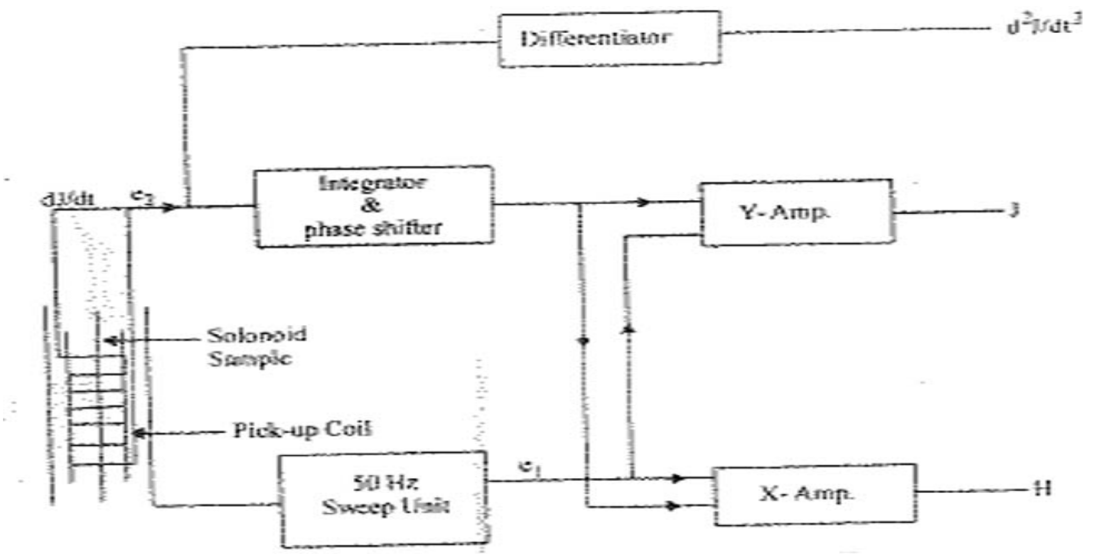


When magnetic field intensity (H) increase and magnetization I is recorded and a graph is plotted between I and H, we have a closed loop called magnetic hysteresis loop.

In the Figure , When the strength of magnetic field is maximum (i.e. OG) the intensity of magnetization is also maximum (=OL). As the strength of the field is reduced to zero (at0), the intensity of magnetization des not reduce to zero, but has a value = OB. Thus some magnetic is left in the specimen. The value of intensity of magnetization of a material, when the magnetizing field is reduced to zero is called retentivity or residual magnetism of the material.

As the strength of the magnetic field is increase in the opposite direction, the intensity of magnetization reduces and becomes zero at C. Thus to reduce the residual magnetism or retentivity to zero, we have to apply a magnetizing field=OC, in the opposite direction. This value of the magnetizing field is called coercivity of the material.





When a cylindrical sample is placed co-axially in a periodically varying magnetic field shall be picked up corresponding to applied field H is e_1, then

$$e_1 = C_1 H$$

The magnetic flux linked with pickup coil of area A_c due to sample of area A_s is

$$\phi = \mu_0 (A_c - A_s) H + A_s B$$

$$= \mu_0 A_c H - A_s (B - \mu_0 H)$$

$$\phi = \mu_0 A_c H - A_s 1$$

The single e_2 induced in the pickup coil shall be

$$e_2 = \frac{d\phi}{dt} = A_s \frac{dt}{dt}$$

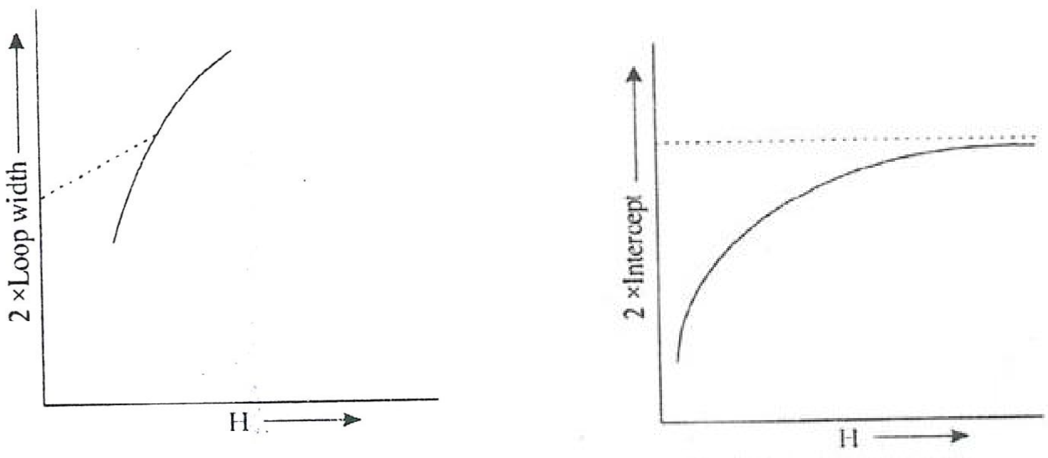
Thus picking up e_2 and e_1 and feeding along x and y of the CRO shall display hysteresis I-H loop.

From obtained hysteresis loop (figure) one can find

Retentivity = $\frac{1}{2}$ intercept on y-axis

$$= \frac{1}{2}(2ey)my$$

Susceptibility $\mu = \mu_0 (1 + x)$ The typical variation is loop width. intercept and tip height are shown in figure.



PROCEDURE

i) Set the electrical connections of the I-H loop tracer.

ii) Without loading the sample into the solenoid coil, calibrate the instrument as per procedure laid down by the supplier.

iii) Now place the ferromagnetic material, which is in the form of cylindrical rod. along the axis of solenoid will within and pick coil.

iv) Now adjust the knob of magnetic field of the hysteresis loop tracer to such a minimum value so that loop is formed in CRO screen. Note down the loop width CD, intercept AB=2ey and tip to tip height - 2ey.

v) Plot the magnetic field in steps and note down the loop width CD, intercept AB and tip to tip height - 2ey.

vi) Plot the graphs for loop width, intercept and tip to tip against applied magnetic permeability are determined.

vii) From these graph retentivity, susceptibility, saturation magnetization and magnetic permeability are determined.

viii) Record observations in the Table.

OBSERVATIONS

S.L. No.	Magnetic Field (Gauss)	Loop width CD (mm)	Tip to tip height ey' (mV)	2x Intercept ey (mV)
1				
2				
3				
4				
5				
6				
7				

CALCULATIONS

Loop width = ...mm

Tip to tip height = ...mv

2x Intercept = ...(mv)

a) Retentivity from B-H loop = $\frac{1}{2}(2ey)$

b) Permeability $\mu_0(1+x)$

c) Susceptibility $x = \frac{1}{H} = slopeofB - Hcurve$

RESULT

i) B-H curve for the given ferromagnetic material ....is traced on the paper.

ii) The magnetic constant are:

a) Retentivity = ...

b) Permeability=.................

c) Susceptibility= ....

PRECAUTIONS

1. Handle CRO very carefully.
2. First of all adjust the hysteresis loop tracer then switch on the CRO.
3. Before taking reading, calibrate the instrument.
4. All magnetic materials should be kept away from the exp.
5. The B-H loop should be stable.
6. The magnetic current in the primary coil of the solenoid should be large enough to properly magnetize the given material.

QUESTIONS

1. Define terms (i) magnetic induction (ii) Intensity of Magnetic susceptibility?

2. What is meant by hysteresis?

3. Does magnetic susceptibility of ferromagnetic material depend on temperature??

4. What is cure temperature?

5. What is the order of values of magnetic susceptibility for the paramagnetic and ferromagnetic material??

6. What is intensity of magnetization?

7. What is relative permeability?

8. What is magnetizing field?

9. What is unit of magnetization?

10. What is the value of μ_0 ?

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EXPERIMENT - 7

CHARGING AND DISCHARGING OF A CONDENSER

OBJECT

To study the charging and discharging of condenser and to determine its time constant.

APPARATUS REQUIRED

i) DC Rectifier

ii) Condensers of fairly large capacity (100, 500 0r 2000 μ F) of electrolytic type

3) Resistors of high value (1,10, 50, 100kΩ) of carbon film type.

4) Voltmeter of more than one range (2.5, 5, 10 or 20 volts)

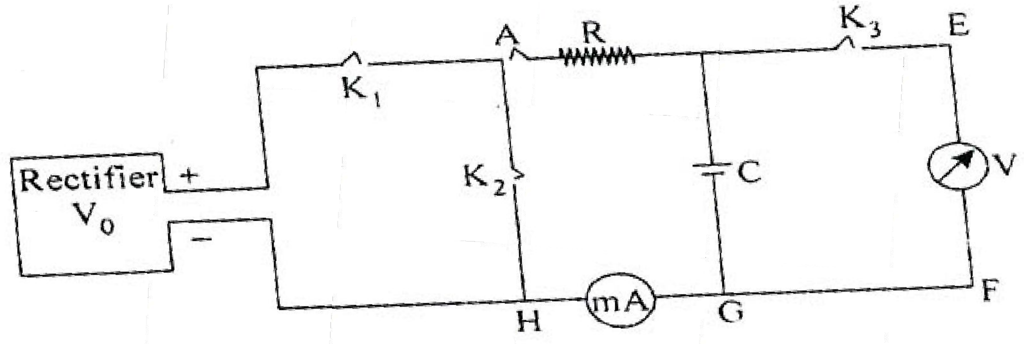
5) Milliammeter (5,10,25 milli ampere.)

6) Plug keys

7) Switch stop watch

All the above mentioned apparatus is provided on the board made by U.L.P.

THEORY



After making connections as shown in figure. If plug is put in key 1, condenser c starts charging slowly. If q is the charge acquired by it at any instant t then.

$$q = q_0\left(1 - e^{-t/RC}\right)$$

The potential difference between its plates would be

$$V = V_0\left(1 - e^{-t/RC}\right)$$

and the value of charging current would be

$$I = \frac{dq}{dt} = \frac{q_0}{RC} e^{-t/RC}$$

or $$I = I_0 e^{-t/RC}$$

t = 0, q = q and V=0 then I = I_0

When t=, ∞ q = q_0 and V = V_0 then I = 0

After fully charging the condenser, the plug is removed from K1, the condenser starts discharging through R. This process is represented by the following equations.

$$q = q_0 (1 - e^{-1/RC})$$

$$v = v_0 \left(1 - e^{-1/RC}\right)$$

$$I = I_0 e^{-t/RC}$$

q, V and I are corresponding values of charges, potential difference and current at any time t white q_0, V_0 and I_0 are their corresponding maximum value. In this process when t = 0, q = q_0, V = V_0 and I =I_0 when t= ∞, q = 0, V = 0 and I = 0.

FORMULA

$$q = q_0 (1 - e^{-1/RC})$$

$$v = v_0 \left(1 - e^{-1/RC}\right)$$

$$I = I_0 e^{-t/RC}$$

q **=** Charge on condenser at any time t. Time recorded from t = 0.
R = effective resistance in the circuit if external resistance R is large, it is taken equal to that.
C = Capacity of condenser in farads
V = Potential difference between the two ends of the condenser at t.
V_0 = Maximum Potential difference between the two plates of the condenser. In the end. it is equal to potential difference of external source.
I = Charging current at any time t.
I_0 = Maximum value of current

PROCEDURE

i) At it is some what difficult to simultaneously note the values of V and I with time, first study the variation in V and then the variation in I if only V is to be studied only voltmeter should be put in the circuit while if only variation in / is t be noted only ammeter should be taken. However both have been shown in the diagram.

ii) Make connections as shown in figure to have time constant large high values of R and C. let R be = 50 KΩ and C = 500 μ F.

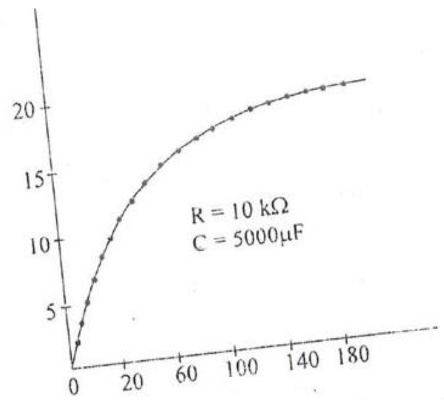
A potential difference of 20 to 25 volts is applied in the circuit with the help of rectifier. For obtaining large capacity electrolytic condenser is taken which is marked + and - on its two ends. It is important to note that only + pole of the source is to be connected to + end of the condenser. In diagrams usually such condensers are shown by one straight line. Denotes the + ve end.

A) o find relation between V and while charging

i) There is no need of ammeter in this experiment. Put plugs in key K_1 and K_3. Current starts flowing. Simultaneously start the stop watch.

ii) Go on nothing the reading in voltmeter after every 5 or 10 seconds, till the reading in voltmeter becomes almost constant.

iii) Draw a graph between V and t taking V on y-axis. This curve will be like an exponential curve as shown in figure.



B) To determine time constant

i) At a point on the graph which corresponds to the maximum voltage, draw a tangent. It would give V_0. This line will be parallel to axis of X.

ii) A graph if drawn between q and t will also be of the same type.

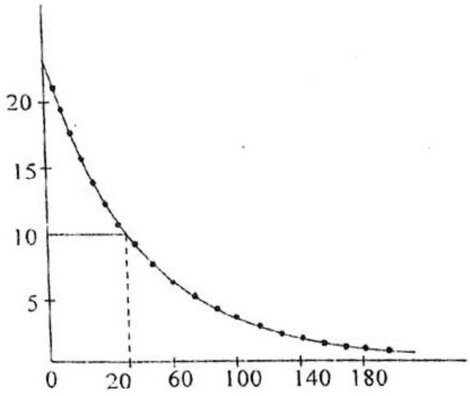
C) To find relation between V and t while discharging

i) Remove plug from key K_1, it disconnects condenser from the external source of potential difference. Now put plug in K_2, so that C starts discharging. Simultaneously starts the stop watch. Again note down the values of p.d. across C after every 5 or 10 seconds till the p.d. drops to almost zero.

ii) Plot a graph between V and t on the same or the other graph paper. This will also be like a exponential curve. Hence the value of V varies from V_0 to Zero.

iii) Plot a graph between V and t on the same or the other graph paper. This will also be like a exponential curve. Hence the value of V varies from V_0 to zero.

iv) Find time corresponding to $\frac{V_0}{2}$. It gives τ (half life) Then the time constant t=$\frac{\tau}{0.693} = RC$



OBSERVATIONS

R = ... Ω C = ... μ F

Least count of voltmeter = ...

A) For V and t

SL. No.	While Charging		While Discharging	
	Time in sec.	Voltmeter reading in volts	Time in sec.	Voltmeter reading in volts
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

CALCULATIONS

Draw graph between V and T while charging and discharging. See Fig. 5.2 and 5.3 Determine Time τ corresponding $\frac{V_0}{2}$, and then calculate t by the formula $t \frac{\tau}{0.693}$. This would come out to be = RC

RESULT

i) Graph between V and t are o exponential nature.

ii) Time constant t = ... RC ....

PRECAUTIONS AND SOURCE OF ERRORS

i) While charging condensers carefully see their +ve and -ve poles.

ii) Select such values of R and C so that time constant is large.

iii) Use stop watch of small least count to measure time.

QUESTIONS

1. What is condenser?

2. What is the meaning of capacity?

3. What is the unit of capacity?

4. What is time constant? In this experiment what is the time constant?

5. Why is time constant should be large in the experiment?

6. What is the effect of resistance on true of charging and discharging?

7. For quick discharging what is the value of time constant?

8. When the capacity of a conductor is equal to one farad?

9. The capacity of a condenser depends upon what factors?

10. Define dielectric constant.

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EXPERIMENT - 8
DETERMINATION OF HIGH RESISTANCE

OBJECT

To determine the resistance by the method of leakage, using a ballistic galvanometer.

APPARATUS REQUIRED

i) A ballistic galvanometer
ii) Lamp and scale arrangement
iii) A standard condenser (of the order of 1 to 10 microfarad)
iv) High resistance which is to be determine of the order of mega ohms.
v) A stop watch
vi) There condenser keys

THEORY

If a charge condenser is put across a high resistance, the charge being to leak, by determine the rate at which the charge leaked for a time t sec. through the high resistance R. Thus we have.

$$Q = Q_0 e^{-t/CR}$$

Where C is the value of the capacity.

Let the first throw in the ballistic galvanometer due to the charge Q and Q_0 be ϕ and ϕ_0 respectively. Then we have

$$Q = K\phi\left(1 + \frac{\lambda}{2}\right)$$

$$Q_0 = K\phi_0\left(1 + \frac{\lambda}{2}\right)$$

Where K and λ are respectively the galvanometer constant and logarithmic decrement, From (3) and (2), we get

$$\frac{Q}{Q_0} = \frac{\phi}{\phi_0}$$

From (1) and (4), we get

$$\frac{\phi}{\phi_0} = e^{-t/RC}$$

or $$\log_e \frac{\phi_0}{\phi} = \frac{t}{CR}$$

$$R = \frac{t}{C.\log\left(\frac{\phi_0}{\phi}\right)}$$

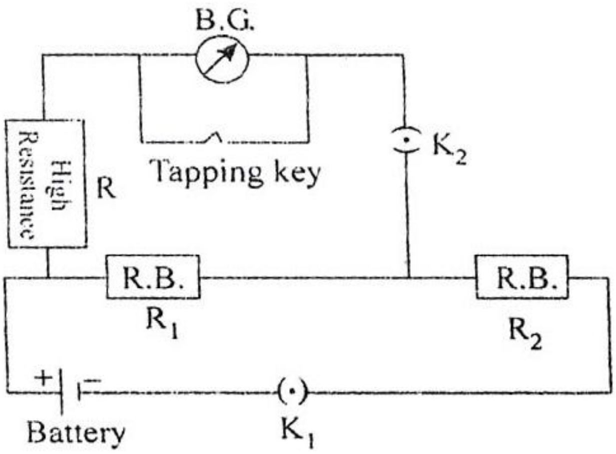
DESCRIPTION OF THE APPARATUS

A ballistic galvanometer is employed to measure the quantity of charge passing through it. It differs from a moving coil suspended type of galvanometer in the following respects.

i) Its period of oscillation is very large. It is realized in practice by taking its coil of as large a moment of inertia as practicable.

ii) The electromagnetic damping of coil is reduced to minimum. It is done by winding the coil on a non conducting frame.

iii) The whole quantity of charge, which is measured passed before its coil appreciably moves from zero-position i.e. the throw is independent of the duration of the impulse. Very small currents should ne allowed to enter a ballistic galvanometer because it is very sensitive. It is achieved in practise by making a potential divider arrangement as shown in Figure.



FORMULA

$$R = \frac{t}{2.3026\,C\log_{10}\frac{\phi_0}{\phi}}$$

t = Time for which the charge of the capacitor is allowed to leak through the high resistance.

R = Unknown Resistance which is to be determined.

ϕ_0 = First throw in the ballistic galvanometer when the fully charged capacitor is allowed to stand for the some time t and then discharged through B.G.

ϕ = First throw of the light when the fully charged capacitor is first charged through R for a time t and then discharged through B.G.

C = Capacity of the condenser.

PROCEDURE

(A) To set the ballistic galvanometer

i) Usually, you would find the galvanometer in more or less a set position. Assuming that it is correctly set, following procedure is recommended.

ii) Release its coil with the help of clamping arrangement.

iii) With the help of spirit level, level it properly, usually it stands on three adjustable legs.

iv) Opposite the galvanometer, at a distance of one meter or so, keep your lamp and scale arrangement.

v) See carefully whether the lamp is to be lighted by a 6 volt line or a 220 volt line. Accordingly light it.

vi) Adjust the high of the lamp and the scale so that a spot of light after getting reflected from the galvanometer falls on the scale.

vii) Focus it by adjusting the lens fitted in the lamp. It is more convenient to first get the spot of light on an opaque screen near the galvanometer, and then move it till the scale.

viii) Now look carefully towards the galvanometer coil. See that it hangs symmetrically without touching its pole pieces.

ix) Slightly blow into the galvanometer or gently touch its terminals so that its coil is slightly deflected and begins to oscillate. See that the coil oscillates freely and the spot of light returns to its zero and initial position.

Thus the galvanometer is ready and set for the experiment. (If galvanometer given to you is already set, do not disturb it unnecessarily).

(B) To determine θ and θ_0

i) Make connections as shown in figure. Put the ballistic galvanometer B.G. the capacity C and the high resistance R in parallel to the accumulator E through the key K_3, K_2 and K_1 respectively.

ii) Keeping the Key K_2 and K_3 open, press K_1. This charges the condenser to say Q_0. Raise K_1 and press K_3. Consequently the charge Q_0 passes through B.G. Note down the first throw in B.G. gives ϕ_0

iii) Keeping K_2 and K_3 open, again press K_1 for the same time as was done in the previous case, so that the condenser is again charge to $Q_{2.}$ Now keeping K_3 and K_1 open, plug in K_2 and simultaneously start the stop watch.

let the charge leak through R. After a certain time t (start with 5 sec.) Which is measured by a stop watch, open the key K_2 and press K_3, and note down the first throw ϕ in B.G. Evidently it corresponds to charge Q.

iv) Repeat the above procedure as described in step 3, taking different leakage times. Start with 5 sec and go up to 30 sec. in steps of value of 5 sec. each. Every time note the corresponding value of the first throw ϕ.

v) In each case, calculate $\log\frac{\phi_0}{\phi}$

vi) Draw a graph between $\log\frac{\phi_0}{\phi}$ and t which will be almost a straight line.

vii) Determine the slope of the graph at many places and calculate the mean value of $\frac{\log\frac{\phi_0}{\phi}}{t}$, and knowing the value of C, determine R by relation (5).

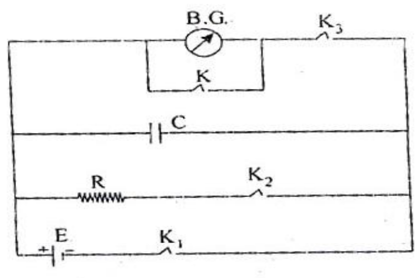


Fig.6.2

OBSERVATIONS

Capacity of the condenser (C) = ... μf

SL. No.	First throw corresponding to Q_0 (in mn)	Time for leakage t in sec.	First throw corresponding to Q_ϕ (in mn)	$\frac{\phi_0}{\phi}$	$\log_{10}\frac{\phi_0}{\phi}$	$\frac{t}{\log_{10}\frac{\phi_0}{\phi}}$	$\frac{t}{mean = \log_{10}\frac{\phi_0}{\phi}}$

CALCULATIONS

In drawing the graph plot $\log\left(\frac{\phi_0}{\phi}\right)$ a log y-axis and t about x-axis. Obtain the value of $\frac{t}{\log\left(\frac{\phi_0}{\phi}\right)}$

at three to four places and determine the mean value of $\frac{t}{\log\left(\frac{\phi_0}{\phi}\right)}$ =.....or determine the slope

of the straight line curve between $\log_{10}\left(\frac{\phi_0}{\phi}\right)$ and t.

Substituting the values of C, and $\frac{t}{\log_{10}\left(\frac{\phi_0}{\phi}\right)}$ in equation (5), calculate the value of R.

RESULT

The value of resistance R= .... mega ohm.

PRECAUTIONS AND SOURCES OF ERRORS

1. Connections should be tight so that there is no leakage of charge.

2. The key should be of high resistance to make them proof.

3. The leakage resistance of the condenser should be very high. otherwise its resistance should have to be accounted for.

4. Care should be taken in nothing down the first throw, as the discharge is very quick , A slight mistake may appreciably affect the result.

5. If the resistance of the condenser is not negligible, it should be determine separately and necessary corrections should be made in the determine og high resistance.

QUESTIONS

1. What is moving coil galvanometer?

2. What is the use of ballistic galvanometer?

3. Why only low current is allowed to flow in a ballistic galvanometer?

4. Define time constant.

5. What is the significance of time constant?

6. Why this method is suitable for measurement of high resistance only?

7. What is order of resistance one can determine by this method?

8. Why the charge should not leak through the keys and the capacitor?

9. Explain the different between dead beat galvanometer and ballistic galvanometer.

10. Why the tapping key is connected in parallel tot he ballistic galvanometer?

Signature of C.I./Principal **Signature of Faculty/Instructor**