FIGURE NO.

Heaven's Light is our Guide

Department of Physics
Rajshahi University of Engineering & Technology

Experiment Name (1st Year / Odd Semester –EEE/ME/ETE/MTE/ECE/BECM)

1. DETERMINATION OF THE VALUE OF ACCELERATION DUE TO GRAVITY (g) BY MEANS OF A COMPOUND PENDULUM
2. DETERMINATION OF THE REFRACTIVE INDEX OF THE MATERIAL OF A PRISM BY A SPECTROMETER
3. MEASUREMENT OF THE RESISTANCE OF A WIRE BY MEANS OF POST OFFICE BOX
4. DETERMINATION OF THE FREQUENCY OF A TUNING FORK BY MELDE'S APPARATUS
5. DETERMINATION OF THE RADIUS OF CURVATURE OF A PLANO CONVEX LENS BY NEWTONS RING METHOD
6. DETERMINATION OF THE WAVELENGTH OF SODIUM LIGHT BY A PLANE DIFFRACTION GRATTING WITH THE HELP OF A SPECTROMETER
7. DETERMINATION OF THE SPECIFIC ROTATION OF SUGAR SOLUTION BY MEANS OF POLARIMETER
8. DETERMINATION OF THE RESISTANCE OF A GALVANOMETER COIL BY HALF DEFLECTION METHOD
9. DETERMINATION OF THE GALVANOMETER CONSTANT
10. MEASUREMENT OF e/m OF AN ELECTRON USING AN ELECTRON BEAM DEFLECTION TUBE

N.B.

1. Students must have to do at least **04 (Four)** of the above experiments
2. Make a **rough loose sheet** for each experiment
3. Students are advised to write (a) Name, (b) Theory with figure, (c) Required Apparatus and (d) Data Table of the assigned experiment in the rough loose sheet before coming into the lab. Otherwise they will not be allowed to enter into the lab
4. Keep preparation for **Table Viva** everyday. This may be your final lab viva
5. Make a **fair note book** for your final examination and complete it regularly. In fair note book write down the followings: (a) Name of the experiment with date, (b) Theory with figure, (c) Required Apparatus, (d) Procedure, (e) Data Table, (f) Calculations, (g) Results (Percentage of error, if necessary) and (h) Precautions and Discussion
6. Always keep some graph papers (8.5 inch x 11.5 inch) with you
7. **Cell phone** are not allowed during sessional class.(Cell phone must be in swtiched off mode. Keep it within your own bag in your own responsibility)

Determination of the value of acceleration due to gravity, g by means of a compound pendulum.

THEORY (In brief): (Please follow books and other references to get details)

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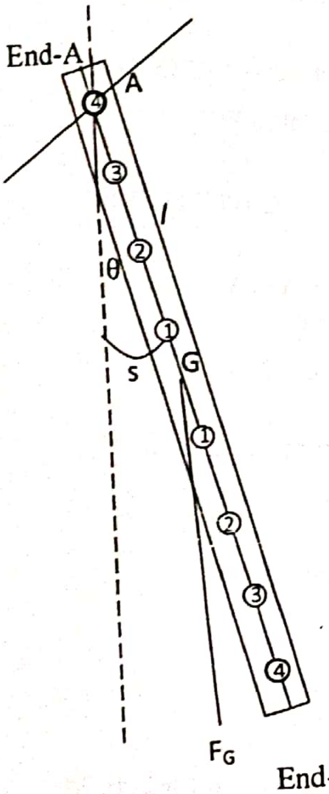

Fig1: Compound pendulum

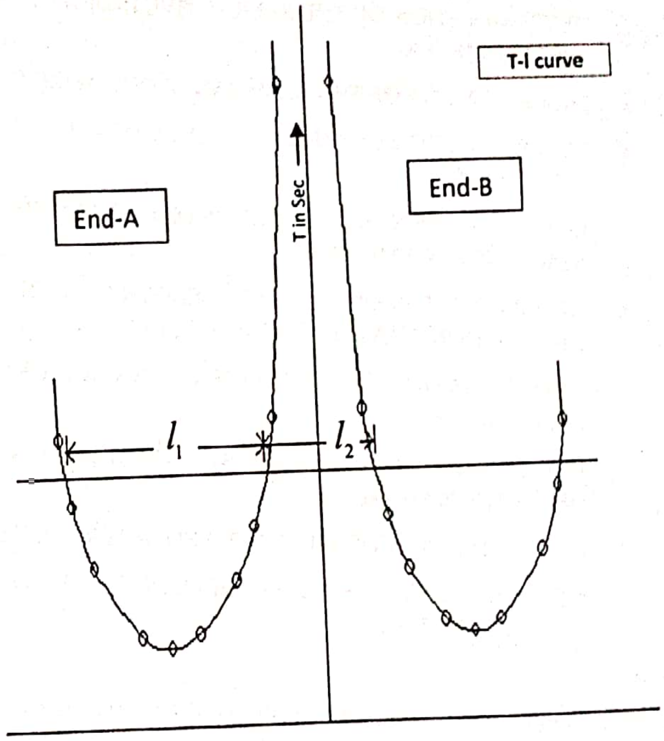

Fig 2: $T \sim l$ curve

Compound pendulum is a rigid body of any shape free to turn about a horizontal axis. The centre of gravity at distance l from A is denoted by G. The pendulum experiences a restoring angular momentum. At an angle θ from the mean position the restoring angular momentum,

$$M = mg\, l \sin\theta \qquad (1)$$

Here, mg is force and $l\sin\theta$ is the distance from the axis of rotation.

From the Newton's law of motion for a rotary motion

Torque= moment of inertia × angular acceleration, is given by

$$-mg\, l \sin\theta = I_A\alpha \tag{2}$$

Where, I_A is the moment of inertia relative to axis of rotation and α is the angular acceleration.

In a compound pendulum there are two axes. One is point of suspension and another is centre of gravity of a pendulum. So from parallel axis theorem we can write.

$$I_A = I_G + ml^2 \tag{3}$$

I_G corresponds to the moment of inertia relative to the axis at the centre of gravity G.

$$I_G = mk^2 \tag{4}$$

Where k is called the radius of gyration. So Eq. (3) can be written as.

$$I_A = I_G + ml^2$$

$$I_A = mk^2 + ml^2$$

$$I_A = m(k^2 + l^2) \tag{5}$$

A simple solution of the differential Eq. (1) exist only for small amplitude θ, Where $\sin\theta \approx \theta$. Eq. (1) is then equal to an equation of oscillation.

$$\alpha = \frac{mgl}{I_A}\theta \tag{6}$$

with the following solution.

$$\theta(t) = \theta_0(t)\cos(\omega t+\gamma) \tag{7}$$

Here, $\theta_0(t)$= initial amplitude and $\theta(t)$= amplitude at time t

This describes a harmonic oscillation with amplitude θ_0 and angular velocity

$$\omega = \sqrt{\frac{mgl}{I_A}} = \sqrt{\frac{gl}{I_A}} \tag{8}$$

The corresponding oscillation Time period is given by

$$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{k^2+l^2}{gl}} \tag{9}$$

The time-period of oscillation of a compound pendulum is given by,

$$T = 2\pi\sqrt{\frac{l^2 + k^2}{lg}} \tag{10}$$

Eq. (10) can be written in the quadratic form as

$$l^2 - \frac{T^2 g}{4\pi^2} l + k^2 = 0 \tag{11}$$

If l_1 and l_2 are the distances i.e. the roots of Eq. (11) for the same time-period T, then we can write $l_1 + l_2 = \frac{T^2 g}{4\pi^2}$ (12)

and $l_1 l_2 = k^2$ (13)

Eq. (12) can be rearranged to the form

$$g = \frac{4\pi^2 (l_1 + l_2)}{T^2} \tag{14}$$

By measuring the values of $L = (l_1 + l_2)$ and T graphically, g may be calculated from Eq. (14).

Required Apparatus:

A compound pendulum, stop-watch, meter scale and knife edge etc.

Procedure:

1. The center of gravity of the pendulum was determined.
2. The distance of each of the holes from the centre of gravity was measured.
3. Time for 20 oscillations, t was recorded twice for each of the holes used as point of suspension.
4. A graph of T versus L was plotted (Fig.2).The values of l_1 and l_2 taken for the same T.

Experimental Data:

Table : Data for time-period

End	No. of holes	Distance between point of suspension and centre of gravity l in cm	Time for ( ) oscillations, t in sec.			Time-period T in sec.
			t_1	t_2	Mean, t	
A	1					
	2					
	....					
	.....					
	10					
B	1					
	2					
	...					
	...					
	10					

Result:

g = ... m sec^{-2}

Percentage of error =

FIGURE NO.

Precautions & Discussion:

1. Amplitude of oscillation was kept within 4^0.
2. The knife-edge was made horizontal for every reading.
3. Error due to the curved knife-edge, yielding the support and resistance of air were avoided as far as possible.
4. Stop watch was used to measure time.
5. Distances between the point of suspension and C.G were measured carefully.

FIGURE NO.________

DETERMINATION OF THE GALVANOMETER CONSTANT.*

Theory

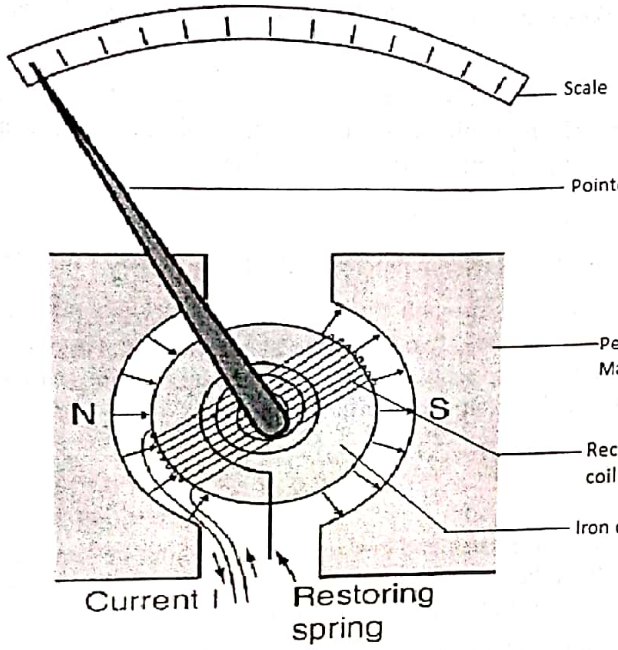

Fig. 1: Internal diagram of a galvanometer

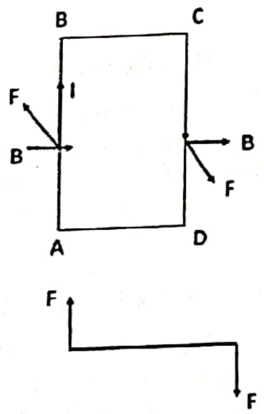

Fig. 2 Torque on the coil

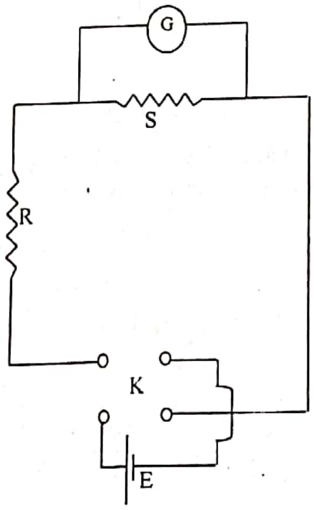

Fig. 3. Circuit diagram for determining galvanometer constant

A galvanometer is a sensitive meter used to detect and measure very small electric current. It is the basic meter for measuring direct current. By the addition of its simple parts, it can be used as an ammeter or voltmeter as device.

* This manual is just a guideline for students. For details, please go through books and other references. Students can draw only the data table from manual. Please write detail theory from textbook. Procedure, precautions and discussion must be written with past tense and passive form.

FIGURE NO.________________

It consists of a rectangular coil of a large number of turns of copper wire wound over a metallic frame. The coil is suspended between the poles N and S of U-shaped permanent magnet. A soft iron cylinder is placed inside the coil.

Moving coil galvanometer works on the principle that a current carrying coil placed in a magnetic field experiences a torque.

Let the length and breadth of the rectangular coil respectively be l and b, the magnetic induction or flux density of the stationary be B, number of the turns of the coil be n and current in the coil be i_g ampere. So, force acting on the vertical arms AB and CD is,

$$F = ni_g lB$$

Here the lines of action of the two forces remain perpendicular to the plane of the coil.

Again, although the same current flows through the two vertical arms but they are opposite to each other. So the two forces acting on the two arms are equal, parallel and opposite. Hence, the force will create a couple on the coil to rotate the coil from its equilibrium position. This couple is called deflecting couple. So, the moment of deflecting couple,

$$C_1 = F \times b = ni_g lB \times b = ni_g AB$$

where $A = l \times b =$ area of the coil.

Due to this deflecting couple the coil rotates and consequently a torsion develops on the suspended wire. The elastic property of the suspended wire tends to release the torsion and creates a couple in the opposite direction. It is called restoring couple.

More the tension on the suspended wire more will be the restoring couple. So the moment of the restoring couple is proportional to the angle of deflection, i.e.,

$$C_2 \propto d$$

or

$$C_2 = \tau d$$

τ is called turning constant. Its value depends on the length, breadth and material of the suspended wire. In equilibrium these two moments of the couple are equal and opposite.

$$C_1 = C_2$$

or

$$ni_g AB = \tau d$$

or

$$i_g = \frac{\tau d}{nAB}$$

or

$$i_g = kd \,\ldots\ldots\ldots (1)$$

Here, $k = \frac{\tau}{nAB}$ is a constant. It is called the galvanometer constant.

With the circuit arrangement shown in the Fig. 2 the galvanometer current i_g can be calculated using the equation

$$i_g = \frac{ES}{R(S+G)+SG} \ldots\ldots\ldots (2)$$

FIGURE NO.______________

where E is the e.m.f. of the cell used, S the shunt resistance, R the series resistance, G the galvanometer resistance

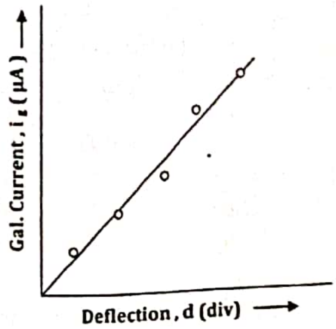

Fig. 3. i_g~d plot to determine k.

It is apparent from Equation (1), the $i_g \sim d$ plot will be a straight line, the slope of which gives the galvanometer constant k.

Required Apparatus

Galvanometer, resistance boxes, cell, commutator, connecting wires, etc.

Procedure

1. Connections were made as shown in the Fig. 2.
2. For several combinations of R and S, the galvanometer deflections d were measured.
3. The galvanometer currents i_g were calculated using Equation (2).
4. The calculated i_g were plotted against the corresponding deflections d.
5. The galvanometer constant k was calculated from the $i_g \sim d$ plot.

Experimental Data

Table 1: Miscellaneous data.

Galvanometer resistance G (Ω)	EMF of the cell E (V)

FIGURE NO.________________

Table 2: Data for the galvanometer deflection *d*.

No. of obs.	Shunt resistance S (Ω)	Series resistance R (Ω)	Deflection for, d (div)			Galvanometer current Ig (μA)
			Direct Current	Reverse Current	Mean	
1						
2						
3						
4						
5						
6						

FIGURE NO.________________

K calculation from graph:

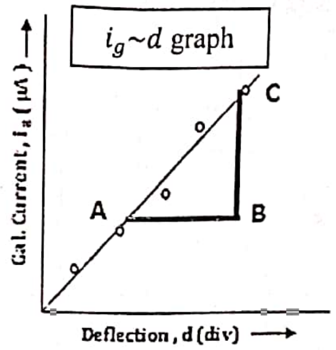

Fig. 4. i_g~d graph.

From graph, k = $\frac{BC}{AB}$

Along deflection axis, 1 small division=.....(unit)

BC =........ small division

=........ small division x value of 1 small division (unit)

= .... (unit)

Along galvanometer current axis, 1 small division=.....(unit)

AB =........ small division

=........ small division x value of 1 small division (unit)

= .... (unit)

Results

$k = \cdots \mu A/\text{div}$ (from calculations)

$k = \cdots \mu A/\text{div}$ (from graph)

Precautions and Discussion

1. Keys in the resistance boxes R and S were kept tight, otherwise any stray resistance can entail the calculation of i_g.
2. Proper choice of the values of R and S were essential not only to protect the galvanometer against high current but also to produce reasonable deflection in the galvanometer.
3. As the angle of deflection was directly proportional to the current i_g so a linear scale was used to measure currenyt i_g and hence i_g was convenient to take readings.
4. When current flows through the coil, it was deflected but comes to equilibrium state without any oscillation.

FIGURE NO.____________

DETERMINATION OF THE RESISTANCE OF A GALVANOMETER COIL BY HALF DEFLECTION METHOD.*

Theory

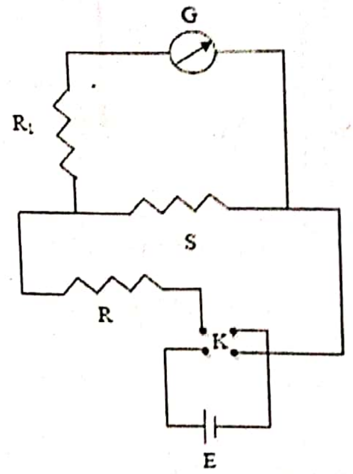

Fig. 1. Circuit diagram for the determination of galvanometer resistance.

The resistance of a conductor is defined as the ratio of the potential difference applied to the points of that conductor and the current flowing through it. The resistance of a galvanometer coil can be found in the following way:

In the arrangement as shown in Fig. 1, S, $(G + R_1)$ are joined in parallel the equivalent resistance is given by

$$R_{eq} = \frac{S(G+R_1)}{(G+R_1+S)}.$$

If i_g be the main current, the potential difference V across the shunt S is given by

$$V = i_g R_{eq}$$

$$V = i_g \frac{S(G+R_1)}{(G+R_1+S)}$$

$$= \frac{i_g S}{1 + \frac{S}{(G+R_1)}}.$$

When S is very small compared to the galvanometer resistance, we can neglect the ratio $\frac{S}{(G+R_1)}$. Hence

$$V = i_g S$$

which is independent of the resistance in the galvanometer and the potential difference V between ends of shunt resistance S remains nearly constant for all values of R_1. Thus if $R_1 = 0$, the current through the galvanometer is given by

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FIGURE NO.________________

$$i_g = \frac{V}{G} = kd \ldots\ldots\ldots (1)$$

where d is the deflections of the pointer and k is the galvanometer constant.

If now a resistance R_1 is introduced in the galvanometer circuit such that the deflection reduces to $\frac{d}{2}$ i.e. half of the previous deflection then

$$i'_g = \frac{V}{G + R_1} = \frac{kd}{2} \ldots\ldots\ldots (2)$$

where i'_g is the new galvanometer current in the changed circumstances.

Dividing Equation (1) by (2), we have

$$\frac{G + R_1}{G} = 2$$

or

$$G + R_1 = 2G$$

or

$$G = R_1 \ldots\ldots\ldots (3)$$

Hence by simply measuring R_1, G can be found out.

Required Apparatus

Battery, galvanometer, resistance boxes, commutator, connecting wires, etc.

Procedure

1. Connections were made as shown in Fig. 1 keeping the shunt resistance $S = 0.2\ \Omega, 0.5\ \Omega$ and $0.7\ \Omega$.
2. With $R_1 = 0\ \Omega$, galvanometer deflection was taken around 12–20 divisions by adjusting the series resistance R.
3. Then the deflection was made half introducing a suitable value of R_1.
4. The second and third operations were repeated for three times.

FIGURE NO.________

Experimental Data

Table 1: Data for the galvanometer resistance.

No. of obs.	Series resistance R (Ω)	Shunt resistance S (Ω)	Direction of current	R_1 (Ω)	Deflection (div)	G (Ω)	Mean G (Ω)
1		0.2	Direct				
			Reverse				
2		0.2	Direct				
			Reverse				
3		0.5	Direct				
			Reverse				
4		0.5	Direct				
			Reverse				
5		0.7	Direct				
			Reverse				

Result

$G = \cdots\ \Omega$

Precautions and Discussion

1. Shunt resistances were kept necessarily very small compared to the galvanometer resistance.
2. The series resistance R was never be made equal to zero when the circuit was closed otherwise the galvanometer became damaged.
3. The plugs of the resistance boxes were made fairly tight.
4. Deflection of the galvanometer was kept within the scale.
5. For steady deflection a storage battery was used.
6. Both theory and experiment showed that this method gave satisfactory value only when resistance of the galvanometer was very high in comparison with the shunt resistance. Thus very low resistances of the shunts were preferred.

Determination of the Refractive Index of the material of a Prism by Spectrometer.

Theory (N.B.This is just a guideline, for details please go through books and other references) :

Let a ray PQ be the incident on the first face (AB) of a prism and then after passing through the prism, finally emerges out through the other face (AC) in the direction (RS). Let i_1 and r_1 be the respective angles of incidence and refraction at the first face of the prism and r_2 and i_2 be the corresponding quantities for the second face. Now the deviation of the ray is given by the angle $\angle SOT$,

$$\delta = (i_1 - r_1) + (i_2 - r_2) \qquad (1)$$

But in the minimum deviation position, the ray passes symmetrically through the prism so that $i_1 = i_2$ and $r_1 = r_2$

Therefore the angle of the minimum deviation

$$\delta_m = 2(i_1 - r_1) \qquad (2)$$

But $\angle LMR = r_1 + r_2 = 2r_1 = A \qquad (3)$

i.e. $r_1 = A/2$ where A = angle of prism

From eq^n (2) and eq^n (3) we get

$$i_1 = (A + \delta_m)/2$$

Hence the refractive index of the material of the prism (for a particular color) is given by

$$\mu = \frac{\sin\left(\frac{A+\delta m}{2}\right)}{\sin\frac{A}{2}}$$

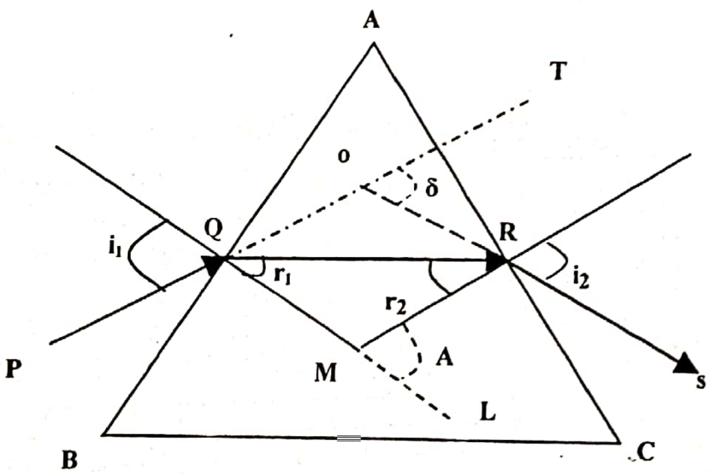

Fig.1: Refraction mechanism through the prism

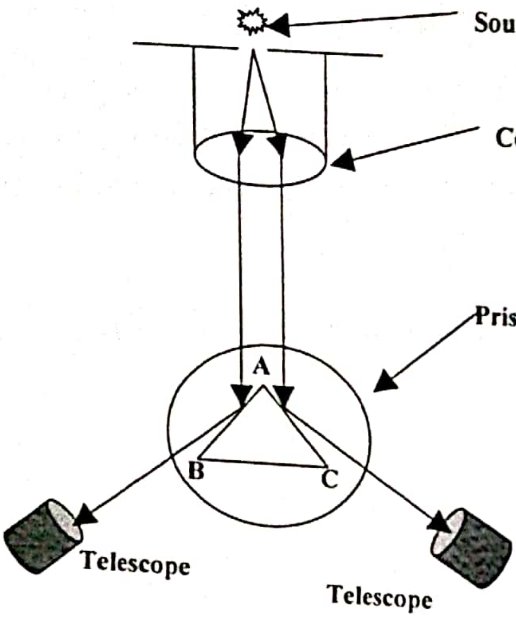

Fig.2: Measurement of the prism angle, A.

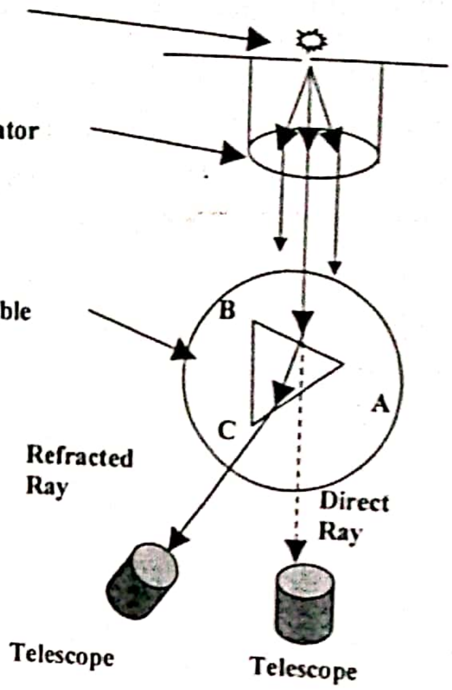

Fig.3: Measurement of the angle of minimum deviation, δ_m

Experimental Data:

Table I: Data for the angle of prism A

Vernier constant (V.C) : ………… deg.

No. of Obs	Vernier No.	Reading of the reflected images: Left side: Main scale reading (M) in deg.	No. of Vernier divisions (D)	Vernier scale reading V= (D × V.C.) in deg.	Total reading, P= (M+V) in deg	Right side: Main scale reading (M) in deg.	No. of Vernier divisions (D)	Vernier scale reading V= (D × V.C.) in deg.	Total reading, Q= (M+V) in deg	A= (P~Q)/2 in deg	Mean A in deg.
1	1										
	2										
2	1										
	2										
3	1										
etc.	2										

FIGURE NO. ____________

Table II: Data for the angle of minimum deviation δ_m

No. of Obs	Vernier No.	Reading at minimum deviation position				Direct reading				δ_m = P~Q in deg.	Mean, δ_m in deg.
		Main scale reading (M) in deg.	No. of Vernier divisions (D)	Vernier scale reading V= (D ×V.C.) in deg.	Total reading, P= (M+V) in deg	Main scale reading (M) in deg.	No. of Vernier divisions (D)	Vernier scale reading V= (D ×V.C.) in deg.	Total reading, Q= (M+V) in deg		
1	1										
	2										
2	1										
	2										
3	1										
etc.	2										

Calculations:

Result:

$\mu = \ldots\ldots$

Percentage of error =

Precautions and Discussion:

1. The source should be kept in front of the collimator to make the image bright.
2. The cross-wire should be made coincident with the same edge of the slit image.
3. Parallax error should be avoided.
4. The telescope should be rotated in the same direction to avoid backlash error.
5. The width of the slit image should be made as narrow as possible.
6. Readings should be taken carefully to ascertain whether the zero of the main scale crossed from one position to the other.

Note: This manual is just a guide line for student. Student must follow books for writing text and draw figure and table from manual. Procedure, precautions and discussion must be written with past tense and passive form.

Name of the experiment: Measurement of the resistance of a wire by means of post office box.

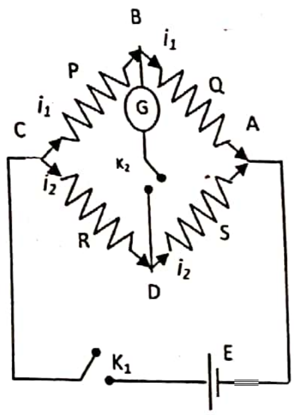

Fig. 1. Diagram of a Wheatstone's Bridge Circuit

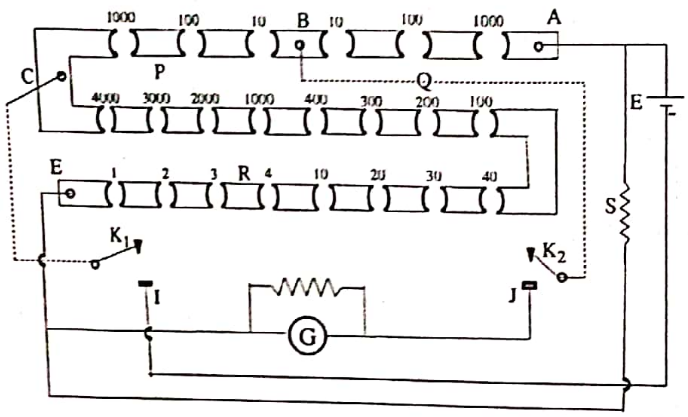

Fig. 2. Diagram of a Post Office Box with battery and galvanometer

Theory:

The post office box is form of Wheatstone's bridge used for making rapid measurements of resistances with no high degree of accuracy. A Wheatstone's network consists of four resistances P, Q, R and S arranged in series as shown in Fig. 1. The circuit BD includes a galvanometer and the circuit CA contains a cell. The resistances are so adjusted that there is no deflection of the galvanometer in making and breaking the circuit BD. The current i on coming at C divides out into two portions, one i_1 flowing the branch CB and the other i_2 flowing along the branch CD. As there is no current along BD, the currents in the branches BA and DA must also be i_1 and i_2 respectively.

Let V_c and V_a be the potentials at C and A. As no current flows along BD, the points B and D are at the same potential, let it be V. Applying Ohm's law at the various branches, we have

$$\frac{V_c-V}{P}=i_1=\frac{V-V_a}{Q} \text{ and } \frac{V_c-V}{R}=i_2=\frac{V-V_a}{S}$$

Hence we can write, $\dfrac{V_c-V}{V-V_a}=\dfrac{P}{Q}=\dfrac{R}{S}$, or $\dfrac{P}{Q}=\dfrac{R}{S}$

If now the battery and the galvanomter interchange their positions, the condition for no current through the galvanometer reduces to

$$\frac{P}{R}=\frac{Q}{S} \text{ or, } \boxed{\frac{P}{Q}=\frac{R}{S}}$$

This shows that if $\frac{P}{Q}$ equals $\frac{R}{S}$ there will be no current through the galvanometer whether it is connected across B and D and battery across C and A or vice versa. As such the points B, D and C, A are called conjugate. It is evident from the relations $\frac{P}{Q}=\frac{R}{S}$ that the condition for balance is not affected by the resistances in series with the battery and the galvanometer. Changes in this resistance do not alter the condition for balance but affects the sensitivity of the arrangement.

Required Apparatus:

P.O. Box, unknown resistance, zero-centre galvanometer, cell, commutator, connecting wires etc.

Procedure:

See books (Advance Practical Physics by K. Din & Practical Physics by Giasuddin Ahmad).

Experimental Data:

Table: Data for measurement of unknown resistance

Resistance in ohms			Direction of deflection	Inference
Arm Q	Arm P	Third arm R		
		0		The unknown resistance lies between .... ohms
		Infinity		
10	10			
				The unknown resistance lies between ....ohms
10	100			
				The unknown resistance is ....ohms
10	1000			

Result :

$S =$ .... Ω

Precautions and Discussion:

1) The battery circuit should be completed before the galvanometer circuit to avoid the effect of self induction.

2) The battery key should be closed for that minimum time which is required to find a null point.

3) The battery circuit should be open for about two minutes before taking up the next determination of the null point.

4) Every plug of the P.O. box should be given a turn within its socket to remove the oxide film between the surface of contact. This film, if any, introduces extra resistances.

5) If the galvanometer gives the deflection in the same direction for all resistances, then the connections are taken to be wrong.

6) Due to looseness of the plugs, sometimes the value of the resistance determined with a higher ratio does not tally with that determined with lower ratio. All the plugs, other than those opened are kept tight.

7) Leclanche's cell should be used in experiments with P.O. box. If a storage cell is used with P.O. box, it should always be connected in series with a rheostat of at least 100 ohms resistance so as obtain a limiting current of 20 mill amperes. Otherwise, a strong current may flow through the resistance coils and damage them.

8) The position of the null point does not change when the positions of the galvanometer and the battery are interchanged. This means that the position of the null point is independent of the resistances of the galvanometer and the battery.

9) The sensitiveness of the bridge is affected by the resistance of the galvanometer and battery; the lower their resistances, the greater are the sensitiveness of the bridge. To increase the sensitiveness, the galvanometer or the battery whichever has the greater resistance should be placed between the junction of the two arms having greater resistance and the junction of two arms having smaller resistance.

FIGURE NO. ____________

Determination of the Frequency of a Tuning Fork by Melde's Experiment

Theory (N.B.This is just a guideline, for details please go through books and other references):

Let one end of the string is attached to one prong of the fork F, and other end passes over a small pulley and is attached to a scale pan S. The string will be set into vibration by setting the tuning fork into vibration. As a result waves will proceed along the length of the string and will be reflected back on reaching the fixed end of the string. The superposition of the direct and reflected waves will form stationary waves, in which the extreme fixed ends of the string will always be nodes and in between them there may be one or more antinodes depending on the tension to which the string is subjected or the length of the string and the plane of vibration either perpendicular or parallel to the length of the string. The vibration may be in two different arrangements: transverse arrangements and longitudinal arrangement. In transverse arrangement, the plane of vibration of the fork perpendicular to the length of the string (Fig.1), and the frequency of the fork (N) is equal to the frequency of the string (n). And in longitudinal arrangement, the plane of vibration of the fork parallel to the length of the string (Fig.2), and its frequency N is equal to twice that of the string i.e. N=2n.

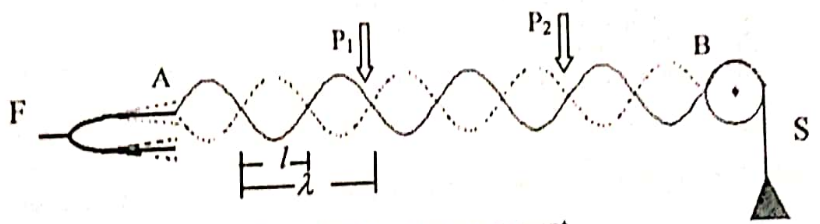

Fig. 1. Transverse arrangement

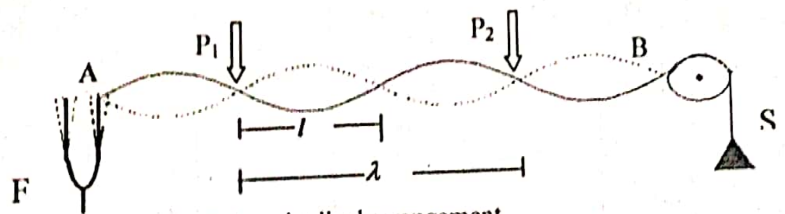

Fig. 2. Longitudinal arrangement

For the transverse arrangement, $$N = n = \frac{1}{\lambda}\sqrt{\frac{T}{m}} \qquad (1)$$

and for the longitudinal arrangement, $$N = 2n = \frac{2}{\lambda}\sqrt{\frac{T}{m}}, \qquad (2)$$

where, T is the tension, m is the mass per unit length and λ is the wavelength of the stationary wave set up in the string.

The tension T is given by

$$T = (w + w_1) \times g, \qquad (3)$$

where, w and w_1 are, respectively, the mass of the scale pan and mass on the scale pan.

Required Apparatus:

Melde's Apparatus. String, Weight box, Balance etc.

Experimental Observations

Miscellaneous Data:

(i) Mass of the scale pan, w = ... gm
(ii) Length of the string, L = ...cm.
(iii) Mass of the string, M=.... gm
(iv) Mass per unit length m=M/L =.... gm/cm

Table 1. Data for frequency of the transverse arrangement

No. of obs.	Mass on the scale pan, (w_1) gm	Tension, T= $(w+w_1)g$ dynes	Total no. of loop between the points P_1 and P_2, (k)	Distance between the points P_1 and P_2, (d) cm	Wave-length $\lambda = \frac{2d}{k}$ cm	Mass per unit length (m) gm/cm	Frequency of the string, $n = \frac{1}{\lambda}\sqrt{\frac{T}{m}}$ Hz	Frequency of the fork, $N=n$ Hz
1								
2								
3 etc.								

Table 2. Data for frequency of the longitudinal arrangement

No. of obs.	Mass on the scale pan, w_1 gm	Tension, $T=(w+w_1)g$ dynes	Total no. of loop between the points P_1 and P_2, *(k)*	Distance between the points P_1 and P_2, (d) cm	Wave-length $\lambda = \frac{2d}{k}$ cm	Mass per unit length (m) gm/cm	Frequency of the string, $n=\frac{2}{\lambda}\sqrt{\frac{T}{m}}$ Hz.	Frequency of the fork, $N=2n$ Hz
1								
2								
3 etc.								

NB: Students please be careful: Avoid fractional loops

Results: N =....... Hz (For transverse arrangement)

N =....... Hz (For longitudinal arrangement)

Precautions & Discussion:

1.You should avoid fractional loop. To get complete loop you should increase or decrease the load on the scale pan or adjust the distance between the points A and B.

2. The length between the pulley and the scale pan should be kept as short as possible. Otherwise you will have to add the mass of that portion of the string to get the correct tension.

3. The total number of loops may be increased or decreased by decreasing or increasing the load on the scale pan.

DETERMINATION OF THE RADIUS OF CURVATURE OF A PLANO-CONVEX LENS BY NEWTON'S RING APPARATUS.*

Theory

When a parallel beam of monochromatic light of wavelength λ is incident on a combination of L_1 and P_1 as shown in Fig.1, a part of it is reflected from the lower surface of the lens, and a part after refraction through the film between L_1 and P_1 is reflected back from the surface of the plate P_1. These two reflected rays are in the condition to interfere and give rise to a system of alternate dark and bright rings with O, the point of contact (between L_1 and P_1) as center of the rings.

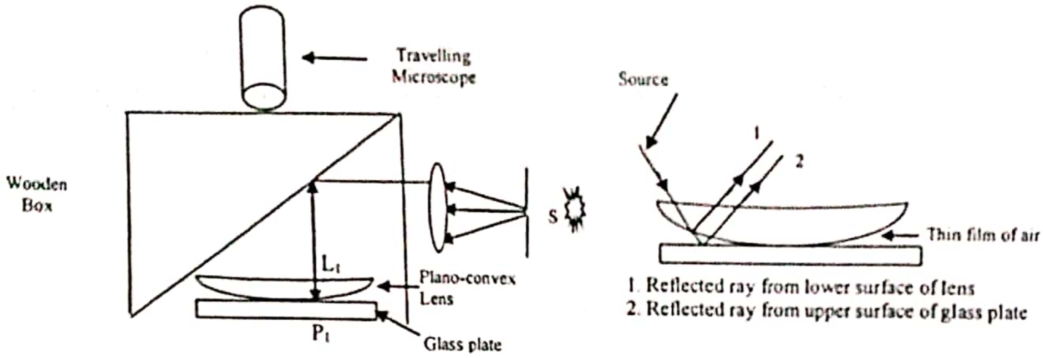

Fig. 1: Experimental setup to find Newton's Ring

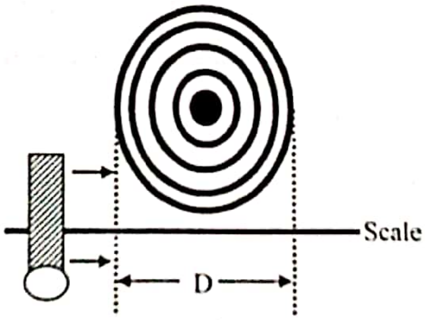

Fig. 2: Observed Newton's Rings.

Let D_n and D_{n+p} be the diameters of the n^{th} and $(n+p)^{\text{th}}$ bright or dark rings for normal incidence.

Diameter of the n^{th} dark ring is

$$D_n = \sqrt{4n\lambda R} \ldots\ldots\ldots (1)$$

And diameter of the $(n+p)^{\text{th}}$ dark ring is

$$D_{n+p} = \sqrt{4(n+p)\lambda R} \ldots\ldots\ldots (2)$$

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By subtracting Equation (1) from (2) the wavelength λ of the incident monochromatic light is given by the equation

$$R = \frac{D_{n+p}^2 - D_n^2}{4p\lambda} \quad \dots\dots\dots (3)$$

where λ is known (for Na-light, $\lambda \approx 5893$ Å). Then by measuring the diameter D_n and D_{n+p} of the n^{th} and $(n+p)^{\text{th}}$ bright or dark rings, the value of R can be determined.

Required Apparatus

Plano-convex lens, plane glass sheets, travelling microscope, wooden box, sodium flame arrangement, etc.

Procedure

Write yourself (past tense with passive voice).•

Experimental Data

Table 1: Readings for diameters of the rings.

Least count (LC) = ⋯ cm.

Ring no.	Readings of the microscope								Diameter $D = (L - R)$ (cm)	D^2 (cm^2)
	Left side				Right side					
	MSR S (cm)	CSD D (div)	CSR $C = (D \times \text{LC})$ (cm)	TR $L = (S + C)$ (cm)	MSR S (cm)	CSD D (div)	CSR $C = (D \times \text{LC})$ (cm)	TR $R = (S + V)$ (cm)		
1										
2										
3										
…										

[NB: MSR = main scale reading, CSD = circular scale division, CSR = circular scale reading, TR= total reading.]

Calculations

From data:

Consider diameters of any two arbitrary rings

For example, n^{th} ring is 3rd ring and $(n+p)^{\text{th}}$ ring is 5th ring, then $p = (5 - 3) = 2$

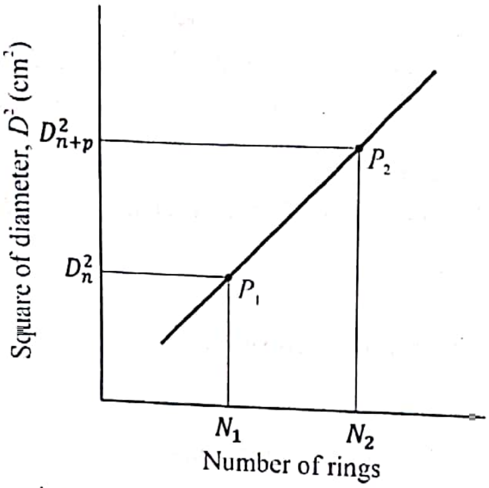
$$R = \frac{D_{n+p}^2 - D_n^2}{4p\lambda}$$

Putting the values of D, p and λ, the radius of curvature R can be determined.

• Ref: Advanced Practical Physics by K Din, and Practical Physics by Giasuddin Ahmad

From graph:

Equation (3) can be written as $D_{n+p}^2 - D_n^2 = (4\lambda R)p$, this equation is comparable with $y = mx + c$. Here, $y = D_{n+p}^2 - D_n^2$, $4R\lambda = m$, $p = x$ and $c = 0$.



But, Equation (3) can be written as

$$R = \frac{m}{4\lambda} \dots\dots\dots (4)$$

where slope $m = \frac{P_2N_2 - P_1N_1}{N_1N_2} = \frac{D_{n+p}^2 - D_n^2}{p}$

Finding P_2N_2, P_1N_1 and N_1N_2 from the graph, the value of R can be determined from Equation (4).

Results

$R = \cdots$ cm (from calculations)

$R = \cdots$ cm (from graph)

Precautions and Discussion

1. Backlash error should be avoided.
2. Diameter should be measured very carefully.
3. The cross wire of travelling microscope should be set mid-way between the outer and inner edges of a ring to avoid error.

DETERMINATION OF THE WAVELENGTH OF SODIUM LIGHT BY PLANE DIFFRACTION GRATING.*

Theory

A parallel beam of light of wavelength λ, coming out from a collimator falls normally on a plane diffraction grating. The grating is placed vertically on a prism table, a series of diffracted images of the collimator slit will be observed on both sides of the direct image.

The equation of interference maxima (that is the grating equation) can be written as,

$$(a+b)\sin\theta = n\lambda \ldots\ldots\ldots (1)$$

Here, θ = angle of deviation; $(a+b)$ = grating element, and n = order number $(0,1,2,3,\ldots)$.

Since $(a+b)=\frac{1}{N}$, where N is the grating constant i.e. number of lines or ruling or grooves or scratches per cm of the grating surface

$$\sin\theta = nN\lambda$$

or

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

or

$$\lambda=\frac{\sin\theta}{nN}\ldots\ldots\ldots (2)$$

The wavelength λ can be determined from Equation (2) by the known values of N, the order (n) and the diffraction angle (θ).

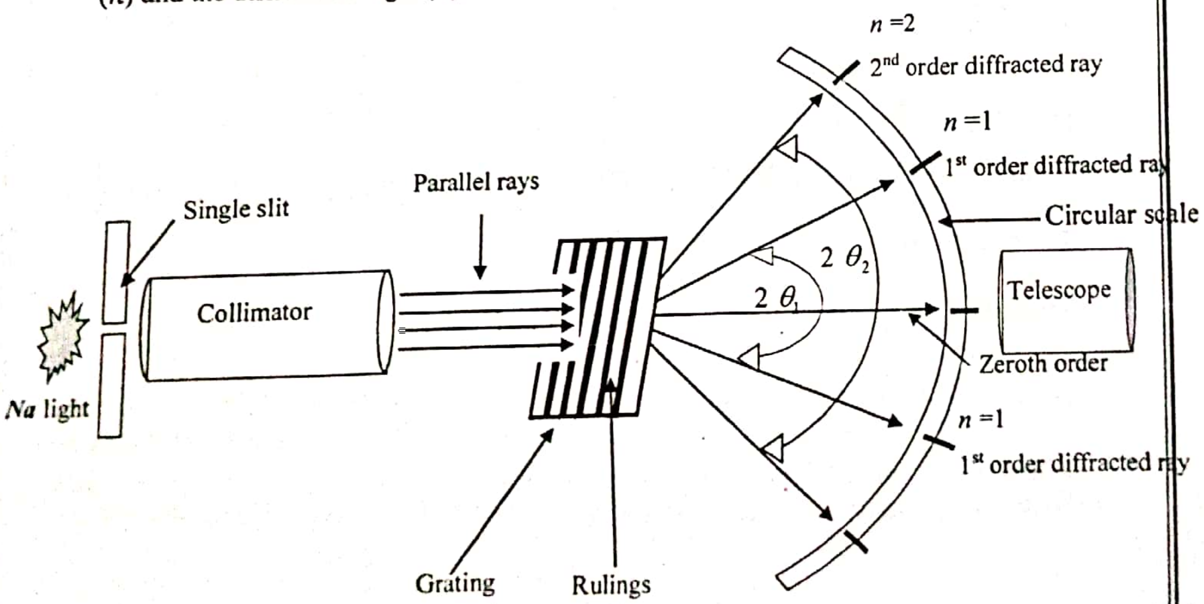


Fig. 1: Diffraction mechanism through grating.

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igure No.:

Required Apparatus
Spectrometer, Na light, grating, spirit level, etc.

Procedure
Write yourself (past tense with passive voice).

Experimental Data
Table 1: Data for the angle of diffraction.
Vernier constant (VC) = ⋯ deg.

Order no.	Vernier	Readings for the diffracted images								$2\theta =$ $(P \sim Q)$ (deg)	θ (deg)	Mean θ (deg)
		Left side				Right side						
		MSR M (deg)	VSD D (div)	VSR $V =$ $(D \times \mathrm{VC})$ (deg)	TR $P =$ $(M + V)$ (deg)	MSR M (deg)	VSD D (div)	VSR $V =$ $(D \times \mathrm{VC})$ (deg)	TR $Q =$ $(M + V)$ (deg)			
1	scale A											
	scale B											
2	scale A											
	scale B											

MSR = main scale reading, VSD = vernier scale division, VSR = vernier scale reading, TR= total reading

Calculations

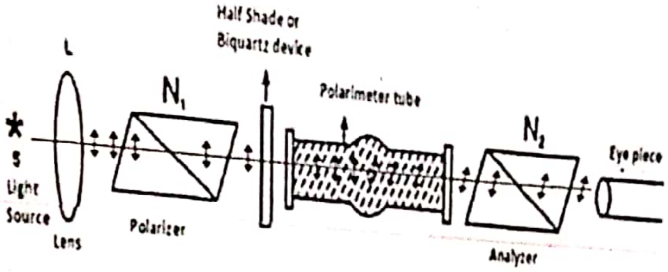
Results
$\lambda = \cdots$ Å

Percentage of error = ⋯

Precautions and Discussion
Write yourself (past tense with passive voice).

DETERMINATION OF THE SPECIFIC ROTATION OF SUGAR SOLUTION BY USING A POLARIMETER.*

Theory



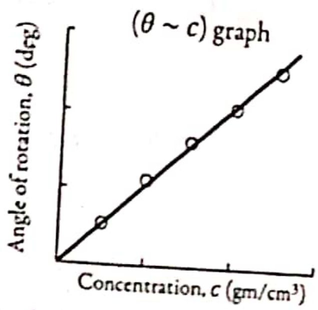


Fig. 1: Arrangement inside the Polarimeter. Fig. 2: $(\theta \sim c)$ graph.

[NB: Students should plot angle of rotation versus concentration (not strength) curve.]

The specific rotation of a solution is a characteristic physical property of a given optically active molecules. If the specific rotation of a compound is positive, the compound is said to be dextrorotatory, if negative, it is referred to as levorotatory. The substances that rotate the plane of vibration to the right are called right-handed or dextrorotatory and the substances that rotate the plane of vibration to the left are called left-handed or levorotatory. The angle of rotation produced to the plane of vibration by an optically active substance in solution is proportional to

1. the thickness of the solution
2. the concentration of the solution or the density of the active substance in the solvent and
3. the nature of the substance.

Thus we can write

$$\theta \propto lc$$

or

$$\theta = Slc$$

or

$$S = \frac{\theta}{lc}$$

where θ is the angle of rotation produced, l is the length of the solution in decimeters, c is the concentration of the solution and $c = \frac{m}{V}$ gm/cm³, where m is the mass of sugar in grams dissolved in water, V is the volume of sugar solution, S is a constant called specific rotation and depends upon the nature of the solution.

$$\boxed{\text{If } l \text{ is in decimeter then } S = \frac{\theta}{lc}.}$$

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If $l = 1$ decimeter ($10\ cm$) and $c = 1$ gm/cm³ then $S = \theta$.

In our experiment, usually we measure l in cm and the concentration of the sugar solution is not unit concentration. In that case,

$$\text{Specific rotation} = \frac{\text{Rotation produced by 1 decimeter length of the solution}}{\text{Density of the solution in gm/cm}^3} = \frac{\theta/\left(\frac{l}{10}\right)}{c}$$

$$= \frac{10\theta}{lc}$$

where l is the length expressed in centimeters.

$$\boxed{\text{If } l \text{ is in centimeter then } S = \frac{10\theta}{lc}.}$$

Now the angles of rotation, θ for different values of known concentrations, c of a solution can be measured with the help of a polarimeter. If a graph is plotted with θ against c, then the graph will be a straight line. The polarimeter is thus calibrated.

Required Apparatus

Polarimeter, balance, measuring cylinder, sugar, beaker, thermometer and a source of light.

Procedure

Write yourself (past tense with passive voice).

Experimental Data

Weight of empty watch glass, $m_1 = \cdots$ gm

Weight of watch glass and sugar, $m_2 = \cdots$ gm

Weight of sugar, $(m_2 - m_1) = \cdots$ gm

Length of the sugar solution, $l = \cdots$ cm

[NB: Students should note that vernier scale is divided into 20 divisions.]

Table 1: Data for determining angular rotation.

No. of obs	Strength of the solution (%)	Concentration of sugar solution (gm/cm³)	Reading with water P (deg)					Reading with solution Q (deg)					Angular rotation $(Q-P)$ (deg)	Mean angular rotation (deg)	Specific rotation S (deg)
				MSR (deg)	CSD (div)	CSR (deg)	TR (deg)		MSR (deg)	CSD (div)	CSR (deg)	TR (deg)			
			Scale A					Scale A							
			Scale B					Scale B							
			Same reading					Scale A							
								Scale B							
								Scale A							
								Scale B							
								Scale A							
								Scale B							

[NB: MSR = main scale reading, CSD = circular scale division, CSR = circular scale reading, TR= total reading.]

Calculations

Length of the sugar solution, $l = \cdots$ cm

[NB: l is the length of the sugar solution, it is not the length of the tube.]

Concentration = $\frac{mass}{volume} = \cdots \text{gm/cm}^3$

So for a 20% solution, Specific rotation, $S = \frac{10\theta}{lc} =$

For 15% solution, —

For 10% solution, —

For 5% solution, —, etc.

Calculate in a similar manner the specific rotation from θ and corresponding to point of the graph.

Results

$S = \cdots$ (from graph)

$S = \cdots$ (from calculation)

Precautions and Discussion

1. The polarimeter tube should be well cleaned.
2. Water used should be dust free.
3. Whenever a solution is changed, rinse the tube with the new solution under examination.
4. There should be no air bubble inside the tube.
5. Reading should be taken when halves of the field of view becomes equally illuminated.
6. The temperature of the solutions should be maintained constant during the experiment since the rotation depends on the temperature of the solution.
7. The rotation also depends on the wavelength. Hence Na-light of wavelength $\lambda = 5893$ Å is to be employed to find the rotation.

Figure No. ....

FIGURE NO.________

Measurement of e/m of an electron using an electron beam deflection tube.

Theory:

When a current is passed through the filament it becomes hot, and the electrons gain enough energy to escape the filament. This process is called thermionic emission.

When a charged particle moves through a region in which both electric and magnetic fields are present, the resultant electromagnetic force experienced by the particle is given by the Lorentz force law,

$$\vec{F} = q(\vec{E} + \vec{v} \times \vec{B}) \quad (1)$$

where,

q is the charge of the particle
$\vec{v}$ is the velocity of the particle
$\vec{E}$ is the electric field intensity
and $\vec{B}$ is the strength of the magnetic field

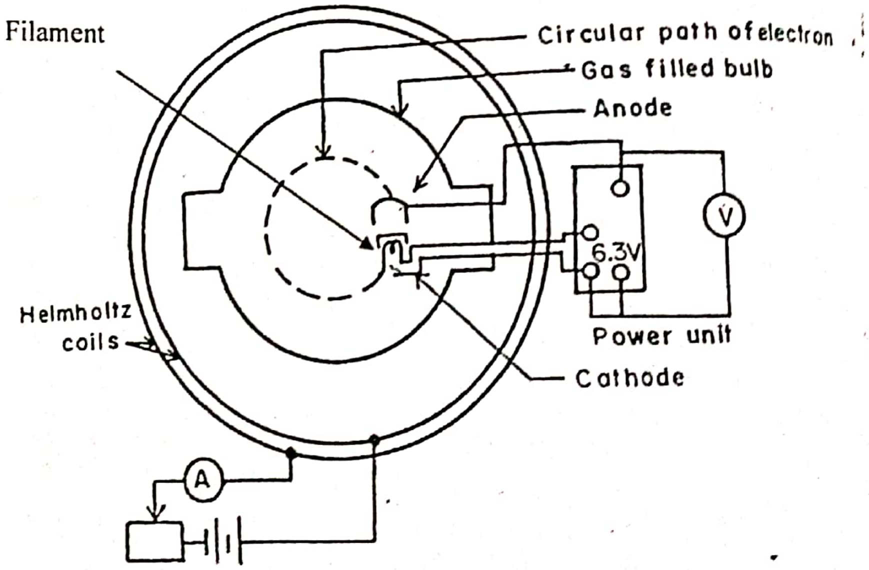

Fig.1: Electron beam deflection tube.

If the charged particle is an electron of charge e and moves in a direction inclined at an angle θ to the direction of the magnetic field B, then in the absence of the electric field,

$$\vec{F} = e(\vec{v} \times \vec{B}) \quad (2)$$

The magnitude of the force is,

$$F = evB \sin\theta \quad (3)$$

If $\theta < 90°$, the electron will move in a helical path.
If $\theta = 90°$, we get

$$F = evB$$

The force is maximum and acts in a direction perpendicular to both the magnetic field and the direction of motion of the electron. As a result, the electron moves in a circular path with a constant speed v. The magnitude of the centripetal force, which arises due to the circular motion of the electron, will be equal to evB. If m is the mass of the electron and r is the radius of its circular path, then

$$\frac{mv^2}{r} = evB$$

$$v = \frac{eBr}{m} \quad (4)$$

If the electron is initially accelerated by an applied potential difference V_a, then we have

$$eV_a = \frac{1}{2}mv^2 \quad (5)$$

Substituting $v = \frac{eBr}{m}$ in equ.(5), we get,

$$\frac{e}{m} = \frac{2V_a}{B^2r^2} \quad (6)$$

The magnetic field is set up by a pair of Helmholtz coils which produces a fairly uniform magnetic field near its centre. The value of B in this region is given by

$$B = \mu_0\left(\frac{4}{5}\right)^{3/2}\frac{ni}{a} = 8.99 \times 10^{-7}\frac{ni}{a} \quad (7)$$

Where,

n= number of turns in each of the pair of coils
i = current in the coil
a = radius of the coil
μ_0= permeability of the empty space ($\mu_0 = 4\pi \times 10^{-7}\frac{wb}{Amp\text{-}m}$)

The value of e/m can be obtained from eqs.(6) and (7). A graph of r^2 versus V_a will be a straight line (Fig.2). The value of e/m can be calculated from the slope of the straight line.

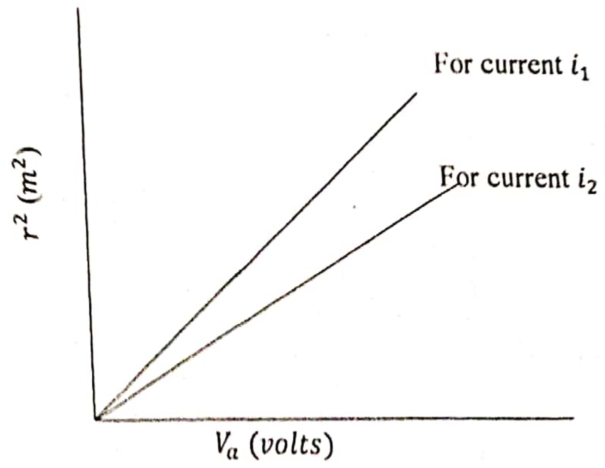

Fig.2: r^2 versus V_a graph

Required Apparatus:

Electron beam deflection tube with Helmholtz coils, power supply.

Procedure:

1. Set the apparatus on a level table.
2. With the power switch off, connect the line cord to the connect line voltage power.
3. Turn on power switch. 20 minutes warm-up time is recommended before taking measurement.
4. Turn the voltage adjust control up to 200V and observe the bottom of the electron gun.
5. Turn the current adjust control up and observe the circular deflection of the beam.
6. Measure the diameter of the path of the electron. Keeping the coil current fixed (say, i=1.00 A), gradually increase the value of the applied potential difference when electron paths of increasing diameters will result. Measure the diameters of the paths and record the corresponding values of V_a.
7. Change the coil current to another value (i=1.25 A, 1.50 A etc.) and repeat the procedure (6).
8. Draw a graph with voltage as the abscissa and the corresponding square of the radii of the electron paths as the ordinate for each coil current.

Experimental Data:

Number of turns in each of the pair of coils, $n = 132$
Coil radius, $a = 0.1475\ m$

Table 1: Data for determination of e/m for different coil current.

Coil current, i (A)	Magnetic field, B (T)	Accelerating voltage, V_a (V)	Diameter, d (m)	Radius, $r = d/2$ (m)	r^2 (m^2)	e/m (C/Kg)

FIGURE NO.________________

Result:

$e/m =$ ………. (from calculation)
$e/m =$ ………. (from graph)
Percentage of error = (standard value of e/m is $1.7588 \times 10^{11}\ C/Kg$)

Precautions and Discussion:

1. Care should be taken to determine B as accurately as possible.
2. The path of the electrons should be made as circular as possible.
3. Parallax error should be avoided while taking reading for the diameter.
4. If the anode voltage is too high, tube lifetime will be shortened. Do not raise the voltage higher than necessary. Usually a few hundred volts (maximum 275 V) will be enough.

N.B. :

- **BE CAREFUL! This is a high voltage equipment. Keep yourself safe during experimental observation.**
- **Do not raise the accelerating voltage higher than 275V and the coil current higher than 2 A.**
- **Warm-up time: 20 minutes**