Dr. SANJAY KUMAR SINGH
Dept. Of Physics
J. J. College Ara

Q. Define charge sensitivity and current sensitivity of a moving coil ballistic Galvanometer. How it is observed through corrected for damping.?

Ans

Charge Sensitivity of a Ballistic Galvanometer:-

The charge sensitivity of a ballistic galvanometer is defined as the throw in mm produced on a scale placed 1 mt away from galvanometer mirror when 1 μc charge passes through it.

When a charge 'q' passes through a ballistic galvanometer, it given an angular impulse to the coil which set in oscillation.

As we know

$$q = \frac{T}{2\pi} \frac{C}{NBA} \phi_0 \quad \text{------- (1)}$$

where T is the time period of oscillation of coil, 'C' be the restoring torque per unit twist in the suspension, 'N' be the number of turns in the coil. 'B' be the magnetic induction of the radial magnetic field 'A' be the area of the coil and ϕ_0 be the angle of throw of the coil.

Suppose the scale is placed at a distance D from the galvanometer mirror. As the coil rotates through angle ϕ_0, the reflected beam is turned through $2\phi_0$. Let the spot of light deflects through a distance 'd' on the scale, then

$$2\phi_0 = \frac{d}{D}$$

$$\text{or} \quad \phi_0 = \frac{d}{2D}$$

Let d is in mm and D = 1 mt = 1000 mm, then

$$\phi_0 = \frac{d}{2000}$$

$\therefore \quad q = \frac{T}{2\pi} \frac{c}{NBA} \cdot \frac{d}{2000}$

let q is in micro coulomb then

$q \times 10^{-6} = \frac{T}{2\pi} \frac{c}{NBA} \frac{d}{2000}$

So that $\frac{d}{q} = (2 \times 10^{-3}) \frac{2\pi}{T} \frac{NBA}{c}$

Here $\frac{d}{q}$ is the charge sensitivity of galvanometer

$\therefore$ charge sensitivity $= (2 \times 10^{-3}) \times \frac{2\pi}{T} \cdot \frac{NBA}{c}$ ------ (II)

(ii) Current Sensitivity of a Ballistic Galvanometer:→

The current sensitivity of the galvanometer is defined as the deflection in mm produced on a Scale placed one meter away from one micro amp current flows through it.

If a steady current I produces steady deflection ϕ.

$\therefore \quad I = \frac{c}{NAB} \phi \frac{d}{q} = (2 \times 10^{-3}) \times \frac{2\pi}{T} \frac{NBA}{c}$

Let 'I' is in μA.

$\therefore \quad I \times 10^{-6} = \frac{c}{NBA} \cdot \frac{d}{2000}$

$\therefore \frac{d}{I} = (2 \times 10^{-3}) \frac{NBA}{c}$

Here d/I = current sensitivity.

$\therefore$ current sensitivity $= (2 \times 10^{-3}) \frac{NBA}{c}$ ------ (III)

from eq^n (II) and (III)

charge sensitivity $= \frac{2\pi}{T} \times$ current sensitivity

This is the relation between both.

The motion of the coil is damped due to the viscosity of air and the opposing current induced in the coil and the frame of the coil which I rotates in the field of permanent magnet of the galvanometer. Although we minimise this electro-magnetic damping by winding the coil on a non conducting frame but the damping due to viscosity of air is always present. So the coil oscillates with decreasing amplitude, hence the observed throw of the coil is smaller than its true value ϕ_0 which would have been if damping were entirely absent. Thus the correction is necessary.

Let ϕ_1, ϕ_2, ϕ_3 ..... be the successive throws observed at the end of the first, second, 3rd ---- swings of the coil, such that ϕ_1, ϕ_3 ------ are on one side of the rest position & ϕ_2, ϕ_4 ..... on the other

$$\therefore \frac{\phi_1}{\phi_2} = \frac{\phi_2}{\phi_3} = \frac{\phi_3}{\phi_4} = \text{-----} \; d \qquad \text{where 'd' is const}$$

which is called decrement per half vibration and $\log_e d$ is called lograthemic decrement λ. Therefore

$$\log_e d = \lambda \Rightarrow d = e^{\lambda}$$

Thus for half a vibration, the decrement is

$$\frac{\phi_1}{\phi_2} = \frac{\phi_2}{\phi_3} = \frac{\phi_3}{\phi_4} = \text{-----} \; e^{\lambda}, \text{ so the full vibration}$$

of decrement is $\frac{\phi_1}{\phi_3} = \frac{\phi_1}{\phi_2} = \frac{\phi_2}{\phi_3} = \cdots e^{2\lambda}$ and so on

So it is clear that decrement for a quarter of a vibration. To calculate the true value of ϕ_0 in the absence of damping the I^{st} throw is observed after the coil completes a quarter of vibration. The decrement is

$$\frac{\phi_0}{\phi_1} = e^{\lambda/2} \quad \therefore \phi_0 = \phi_1 e^{\lambda/2} = \phi_1\left(1 + \frac{\lambda}{2} + \cdots\right)$$

$$\therefore \phi_0 = \phi_1\left(1 + \frac{\lambda}{2}\right) \text{ ------ } \text{(IV)}$$

from (I) & (IV) $\quad q = \frac{T}{2\pi} \frac{C}{NBA} \phi_1\left(1 + \frac{\lambda}{2}\right)$

In practice the value of λ is found by ϕ_1 & ϕ_{11}

$$\therefore \frac{\phi_1}{\phi_{11}} = e^{10\lambda} \qquad \therefore \lambda = \frac{1}{10} \log_e \frac{\phi_1}{\phi_{11}}$$

Uses of Moving coil Ballistic Galvanometer:-

Moving coil ballistic galvanometer is also used in measurement of capacitance of capacitors, comparison of capacitance of two capacitor and comparison of e.m.f of two cells.