EXPERIMENT

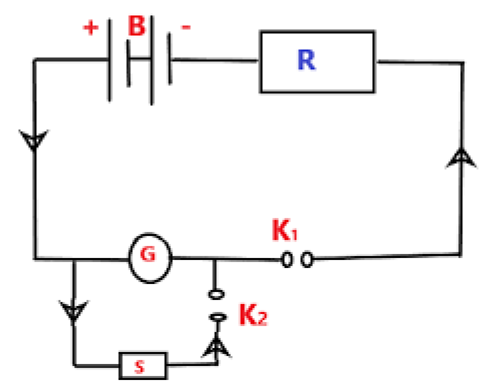
To determine the internal resistance of a galvanometer by half deflection method, and to find its figure of merit.

MATERIAL REQUIRED

A battery, a galvanometer (pointer type), 5000 ohm resistance box, 100 ohm resistance box, two one-way keys, D.C.C. copper wire for making connections and sand paper.

CIRCUIT DIAGRAM

For determination of galvanometer resistance G the circuit is connected as shown in Fig. below.



THEORY

Let the current flowing through the Galvanometer be I and corresponding deflection in it be θ. Then connect the resistance S in parallel with galvanometer and adjust its value so that Battery the deflection in galvanometer becomes half, i.e. θ/2. Now, the current flowing through the galvanometer is I/2 and remaining I/2 is by-passed by the resistance S connected across G. Because the current divides equally between G and S, therefore,

$$G = S \qquad .....(1)$$

The resistance S connected across a part of circuit to reduce current in that part only, is called the shunt.

Another important constant of a Galvanometer is I_g , the full scale deflection current. I_g is that much current-which deflects the Galvanometer pointer from O to maximum deflection on its scale conversion of a Galvanometer into a voltmeter or an ammeter we must know I_g also. To find the value of I_g again refer to Fig. Let the EMF of the battery be E and the value of the resistance connected in series with the Galvanometer and battery be R. Then, the current I flow through the galvanometer which produces a deflection θ in it, is given

$$I = \frac{E}{R+G} = k\theta \qquad .... (2)$$

($\because$ current $\propto$ deflection in galvanometer)

Where E is the E.M.F. of the cell, R is resistance from the resistance box, G is the galvanometer resistance and $\boldsymbol{\theta}$ is the deflection in galvanometer for current I, k is proportionality constant (called figure of merit).

When key K_2 is also closed and the value of shunt resistance S is so adjusted that deflection in the galvanometer becomes $\frac{\theta}{2}$, then resistance of the parallel combination of G and S is $\frac{GS}{G+S}$ and current in the circuit is

$$I' = \frac{E}{R+\frac{GS}{G+S}} = \frac{E(G+S)}{R(G+S)+GS} \quad .....(3)$$

Of this current I', a fraction $\frac{S}{G+S}$ flows through the galvanometer given by

$$I' = \frac{I'S}{G+S} = \frac{ES}{R(G+S)+GS} = k\frac{\theta}{2}$$

or
$$\frac{2ES}{R(G+S)+GS} = k\theta \quad ....(4)$$

Comparing Eqs. (2) and (4), $\frac{E}{R+G} = \frac{2ES}{R(G+S)+GS}$ ......(5)

By solving Eq. (5), we can find G = $\frac{RS}{R-S}$ .....(6)

FIGURE OF MERIT OF A GALVANOMETER

It is defined as the current required to produce a deflection of one division in the scale of galvanometer. It is represented by the symbol k. (It is reciprocal of current sensitivity).

When current I produces a deflection $\boldsymbol{\theta}$ in the galvanometer, then figure of merit is given by using Eq. (1),

$$K = \frac{I}{\theta} = \frac{E}{(R+G)\theta}$$

Or $$k = \frac{E}{(R+G)\theta}$$

If n is the number of division in the galvanometer scale, then current required to produce full scale deflection is given by I_g =nk.

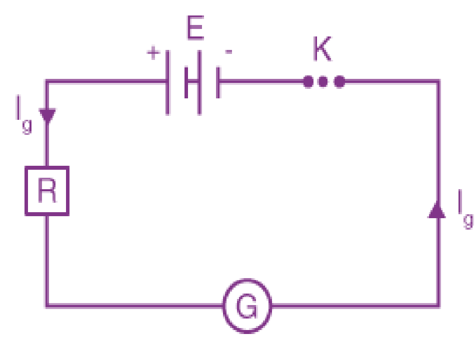


Fig. of merit of galvanometer

PROCEDURE (*Stepwise*)

(a) Resistance of galvanometer by half deflection method

1. Draw the circuit diagram as shown in Fig. and make the connection accordingly.
2. See that plugs of the resistance boxes are tight.

3. Take out the high resistance (say 2000 Ω) from the resistance box R and insert the key K_1 only.
4. Adjust the value of R so that deflection is maximum, even in number and within the scale.
5. Note the deflection. Let it be $\boldsymbol{\theta}$.
6. Insert the key K_2, also and without changing the value of R, adjust the value of S, such that deflection in the galvanometer reduces to exactly half the value obtained in step 5 i.e. $\theta/2$.
7. Note the value of resistance S.
8. Repeat step 4 to 7 three times taking out different values of R and adjusting S every time.

(b) Figure of merit

9. Take one cell of the battery and find its E.M.F. by a voltmeter by connecting +ve of the voltmeter with +ve of the cell and –ve of voltmeter with –ve of the cell. Let it be E.
10. Make connections as in circuit diagram.
11. Adjust the value of R to obtain a certain deflection $\boldsymbol{\theta}$ (say 30 divisions) when the circuit is closed.
12. Note the values of resistance R and deflection $\boldsymbol{\theta}$.
13. Repeat the steps 9 to 13 with both cells of the battery.
14. Find the figure of merit k using the formula.

OBSERVATION

Table 1. Resistance of the Galvanometer by Half Deflection Method

Serial No. Of Obs. (1)	Resistance R (ohm) (2)	Deflection in the Galvanometer $\boldsymbol{\theta}$ (3)	Shunt resistance S (ohm) (4)	Half deflection $\frac{\boldsymbol{\theta}}{2}$ (5)	Galvanometer resistance $G = \frac{RS}{R-S}$ (ohm) (6)
1. 2. 3. 4.					

Table 2. Figure of Merit

Serial No. Of Obs. (1)	Number of Cells (2)	e.m.f. of the cells E(V) or reading of battery eliminator (3)	Resistance from R.B. R (ohm) (4)	Deflection $\boldsymbol{\theta}$ (div.) (5)	Figure of merit $k = \frac{E}{(R+G)\theta}$ (amp./div.) (6)
1. **2.** **3.** **4.**					

Number of divisions in the galvanometer scale, n= …….

CALCULATIONS

1. **Calculation for G**

(i) Calculate G, using formula, $G = \frac{RS}{R-S}$ and write it in column 6 of Table (1).

(ii) Take mean of values of G recorded in column 6 of Table (1).

2. **Calculation for k**

(i) Calculate k, using formula, $k = \frac{E}{(R+G)\theta}$ and write it in column 6 of Table (2).

(ii) Take mean of values of k recorded in column 6 of Table (2).

RESULT

As the difference in actual and measured value of current (as recorded in column 4) is very small, the conversion is perfect.

PRECAUTIONS

1. All the connections should be neat, clean and tight.
2. All the plugs in resistance boxes should be tight.
3. The e.m.f. of cell or battery should be constant.
4. Initially a high resistance from the resistance box (R) should be introduced in the circuit (otherwise for small resistance an excessive current will flow through the galvanometer or ammeter can be damaged).
5. The ammeter used for verification should preferably be of the same range, as the range of conversion.
6. The diameter of the wire to be used for shunt resistance, should be measured accurately.
7. Length of shunt wire used should be neither too small or too large.

SOURCES OF ERROR

1. The screws of the instruments may be **loose**.
2. The plugs of resistance boxes may not be **clean**.
3. The e.m.f. of battery may not be **constant**.
4. The galvanometer divisions may not be of **equal size**.