EXPERIMENT (A)

AIM

To convert the given galvanometer (of known resistance & figure of merit) into an ammeter of desired range & to verify the same.

MATERIAL REQUIRED

A Weston-type galvanometer, a constantan or manganin wire with a diameter of 26 or 30 SWG, a screw gauge, a wire cutter, a 2V battery or accumulator, a one-way key, a rheostat with a range of 200 ohm, a milliammeter with a range of 30 mA and necessary connecting wires and sandpaper.

DIAGRAM

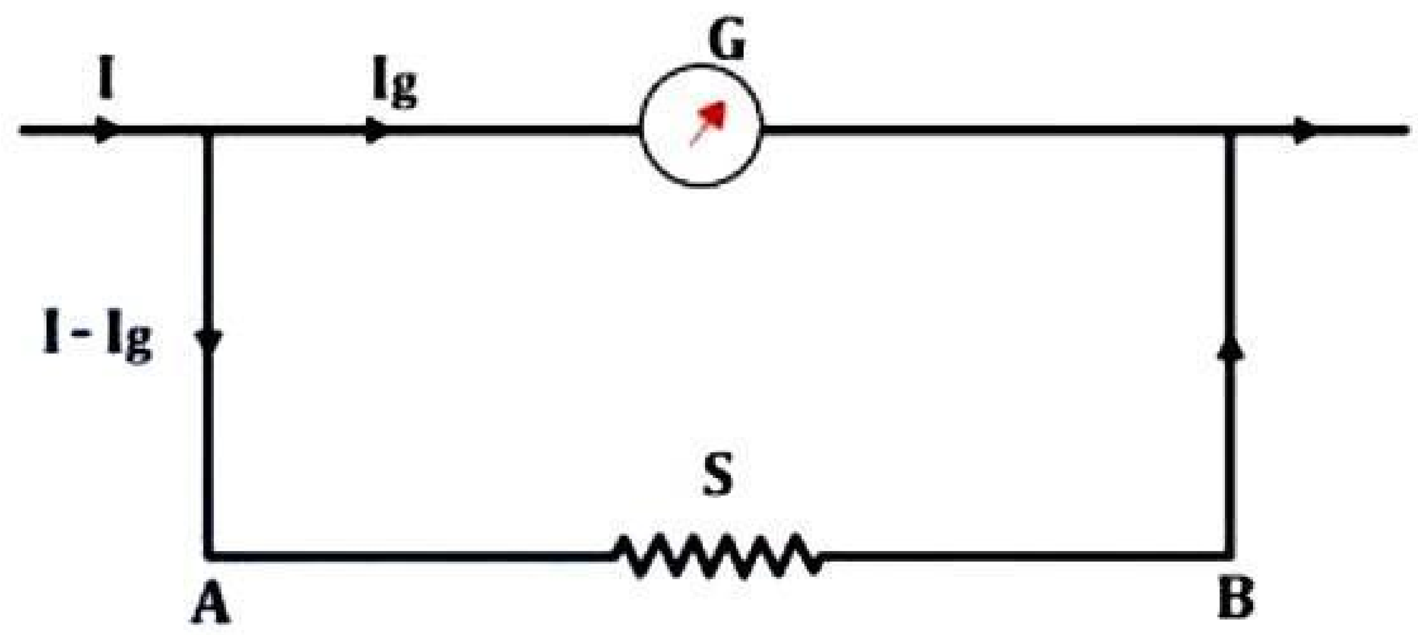

Fig. A shunt resistance S is connected in parallel with a galvanometer in order to convert it into an ammeter

THEORY

1. A galvanometer serves as a sensitive device capable of detecting extremely small currents, typically on the order of 100 μA. To transform the galvanometer into an ammeter for current measurement, a low-resistance shunt (S) is connected in parallel to the galvanometer with resistance G.
2. If I represents the total current in the circuit, the current (I - Ig) is directed through S, where Ig denotes the small current flowing through the galvanometer for full-scale deflection. The instrument is calibrated to directly indicate the current in amperes, making it suitable for use as an ammeter. As G and S are parallel to each other, the potential difference across both remains the same.

   So, $$I_g G = (I - I_g)S$$

   Or $$S = \frac{I_g G}{I - I_g} \quad \text{..............(i)}$$

3. The value of current I_g is given by,

   $$I_g = kN \quad \text{..............(ii)}$$

4. The figure of merit of the galvanometer is represented by k, and the total number of divisions on the galvanometer scale is denoted by N. By substituting $k = \frac{E}{n(R+G)}$ into equation (ii), we derive the expression:

   $$I_g = \frac{EN}{n(R+G)} \quad \text{..............(iii)}$$

5. In this equation, E stands for the electromotive force (e.m.f.) of the cell, n is the deflection of the galvanometer in divisions, and R represents the resistance introduced into the circuit by the resistance box. The calculation of the shunt resistance required to convert the given galvanometer into an ammeter is expressed by the equation:

$$S = \rho\left(\frac{l}{\pi r^2}\right) \quad \text{..............(iv)}$$

6. Here, ρ denotes the specific resistance of the shunt material, l is the length of the shunt resistance and r is the radius of the shunt resistance.

PROCEDURE

1. Determine the galvanometer resistance (G) using the half-deflection method, as outlined in Experiment Number 4.
2. Count the total number of divisions (N) on both sides of zero on the galvanometer scale.
3. Calculate the current (I_g) for full-scale deflection in the galvanometer using the relation $I_g = Nk$, where k represents the figure of merit of the galvanometer.
4. Calculate the shunt resistance (S) using equation (i) with the provided values of I, I_g and G.
5. Obtain a resistance wire, determine its radius with a screw gauge, and using the known specific resistance (ρ) from the constant table, find the length (l) of the wire that corresponds to a resistance equal to S, applying the relation:

$$l = \frac{\pi r^2 S}{\rho}$$

6. Cut a length of the wire that is 2cm longer than the calculated value l. Mark two points on the wire, each 1cm away from the ends. Connect this wire to the two terminals of the galvanometer, ensuring the marked points are just outside the terminal screws.
7. Set up the circuit according to the provided circuit diagram.
8. Insert the key and tune the rheostat to achieve maximum deflection on the galvanometer.
9. Record the readings displayed on the galvanometer scale, along with the corresponding readings on the ammeter.

OBSERVATIONS

1. Using the half-deflection method, find the resistance of the provided galvanometer, denoted as G = ⋯ Ω.
2. Determine the figure of merit for the given galvanometer, represented as k =.......... A division.
3. Count the total number of divisions on both sides of zero on the galvanometer, denoted as N = ...
4. Establish the range of the converted ammeter as I = ... A.
5. Identify the least count of the screw gauge as L.C. = ... mm.
6. Measure the zero error of the screw gauge, denoted as e = ... mm.
7. Specify the diameter of the shunt resistance wire as d_o = ... mm.
8. State the specific resistance of the material of the wire as ρ = ... Ω cm.

For determining the value of G

No. of observation s	Resistance, R(Ω)	Galvanometer deflection, θ(div.)	Resistance, S(Ω)	Half deflection $\frac{\theta}{2}$(div.)	$G = \frac{RS}{R-S}$ (Ω)	Mean (Ω)
1.						

2.						
3.						

For determining k

No. of observations	Resistance introduced by the resistance box, R(Ω)	Galvanometer deflection, n(div.)	Figure of merit, $k = \frac{E}{(G+R)n}$ (amp / div.)	Mean (amp/div.)
1.				
2.				
3.				

No. of observations	Galvanometer readings		Ammeter reading, I(A)	Difference, $(I - I_g)$ (A)
	θ (div.)	I_g(A)		
1.				
2.				
3.				
4.				
5.				
6.				
7.				

RESULTS

1. Confirming the conversion of the provided galvanometer into an ammeter with the given range is validated, as the difference $(I - I_g)$ is extremely small.
2. To transform the provided galvanometer into an ammeter with the specified range ...., the resistance of the shunt wire, S = ... And length of that wire, *l* = ... cm.

PRECAUTIONS

1. Ensure all connections are securely tightened.
2. Maintain a constant electromotive force (e.m.f.) for the cell.
3. Utilize a high-resistance resistance box.
4. Connect the exact length of the shunt wire in parallel to the galvanometer.

SOURCES OF ERROR

1. Be cautious to prevent coiling or overlapping of different parts of the shunt wire.
2. Verify using an ammeter with the same range as the conversion range.

VIVA- VOCE

Q 1. What type of galvanometer is available in laboratories?

Ans. The laboratory galvanometer is a Weston Galvanometer. It has a pivoted coil.

Q 2. Why the scale of the galvanometer has zero in the middle?

Ans. A needle at zero in the middle can deflect on both sides.

Q 3. Do we have a positive and negative terminal in a galvanometer?

Ans. No, a galvanometer has no positive or negative terminals. The pointer can deflect on either side from zero in the middle.

Q 4. Why the divisions of a galvanometer scale are equally spaced?

Ans. Deflection in the pointer is proportional to the current passed. The number of divisions in deflection will be proportional to the current passed. $I \propto= \emptyset$.

Q 5. Define the figure of merit of a galvanometer.

Ans. The quantity of current required to produce a deflection of one division in the galvanometer is called the figure of merit of the galvanometer. It is represented by the symbol k. Its unit is ampere per division.

Q 6. Define the current sensitivity of a galvanometer.

Ans. The deflection produced in the galvanometer when a unit current is passed through it is called the current sensitivity of the galvanometer.

Q 7. How are 'figure of merit' and 'current sensitivity' related to each other?

Ans. They sire reciprocal, $S_1 \propto 1/k$

Q 8. Why the galvanometer is called a moving coil galvanometer?

Ans. Because in this galvanometer, the coil moves (deflects), while the magnet remains fixed.

Q 9. Is there any moving magnet galvanometer?

Ans. Yes, the tangent galvanometer is called a moving magnet galvanometer.

Q 10. Why is a tangent galvanometer, called a moving magnet galvanometer?

Ans. Because in a tangent galvanometer, the magnet (a small pivoted magnetic needle) moves (deflects), while the coil remains fixed.

RESISTANCE OF A GALVANOMETER

Q 11. What do you mean by the resistance of a galvanometer?

Ans. The resistance of the coil of a galvanometer is called the resistance of the galvanometer. It is represented by the symbol G.

Q 12. How do you determine the resistance of a galvanometer?

Ans. The resistance of a galvanometer is determined by the half-deflection method.

Q 13. Why is this method called the half-deflection method?

Ans. It is so because the deflection is made half by using a shunt resistance S.

Q 14. Under what conditions do G = S?

Ans. G = S, only when series resistance R is very high.

AMMETER

Q 15. What is an ammeter?

Ans. An ammeter is a device (instrument) for measuring large electric currents in circuits.

Q 16. How is an ammeter used in a circuit?

Ans. An ammeter is used in series in a circuit.

Q 17. Why is an ammeter used in series in a circuit?

Ans. The whole current to be measured is passed through it.

Q 18. What are the required properties of an ammeter?

Ans. An ammeter must have a very small resistance (zero, if possible) and a large current carrying capac- -ity.

Q 19. Why should an ammeter have a very small resistance?

Ans. So that when put in series in the circuit, it should not reduce much the original current to be meas- ured.

Q 20. Why should an ammeter have a large current carrying capacity?

Ans. So that it may measure large currents.

CONVERSION OF A GALVANOMETER INTO AN AMMETER

Q 21. Why is a galvanometer not suitable to work as an ammeter?

Ans. A galvanometer has more resistance and less current current-carrying capacity than those required by an ammeter. It will damage when a large current flows through it.

Q 22. How is a galvanometer converted into an ammeter?

Ans. A galvanometer is converted into an ammeter by connecting a low resistance in parallel with the galvanometer coil (this parallel low resistance is called a shunt).

Q 23. How the low resistance in parallel (shunt) gives the required properties to the galvanometer?

Ans. The shunt reduces the overall resistance of the ammeter (converted galvanometer) and increases its current-carrying capacity.

Q 24. What is the order of resistance of an ammeter?

Ans. The ammeter resistance is nearly equal to the shunt resistance.

Q 25. What do you understand by the range of an ammeter?

Ans. It is the maximum value of the current that an ammeter can measure.

Q 26. Which has lesser resistance—a 1-ampere range ammeter or a 10-ampere range ammeter?

Ans. The higher the range, the lower the resistance. A 10 A ammeter has lesser resistance.

Q 27. What is a milli-ammeter?

Ans. It is an ammeter that measures current in milli amperes (mA = 10^{-3} A).

Q 28. What is a micro-ammeter?

Ans. It is an ammeter that measures current in microamperes (μA = 10^{-6} A).

Q 29. What is the full name of an ammeter?

Ans. Full name of an ammeter is ampere-meter.

Q 30. Can we increase/decrease the range of an ammeter?

Ans. We can increase the range but cannot decrease the range of the ammeter because for $I < I_g$, the value of shunt resistance becomes negative which cannot be possible.

Q 31. What happens when an ammeter is placed in parallel with the circuit?

Ans. It cannot measure the current in the circuit because it only measures the current which is passing through it.

EXPERIMENT (B)

AIM

To convert the given galvanometer (of known resistance & figure of merit) into a voltmeter of desired range & to verify the same.

MATERIAL REQUIRED

A Weston type galvanometer of known resistance and figure of merit, a resistance box of range 0 to 10kΩ, a battery or accumulator of 5V, a rheostat of range 200Ω, one way key, a voltmeter of range 0 to 3V, connecting wires and sandpaper.

DIAGRAM

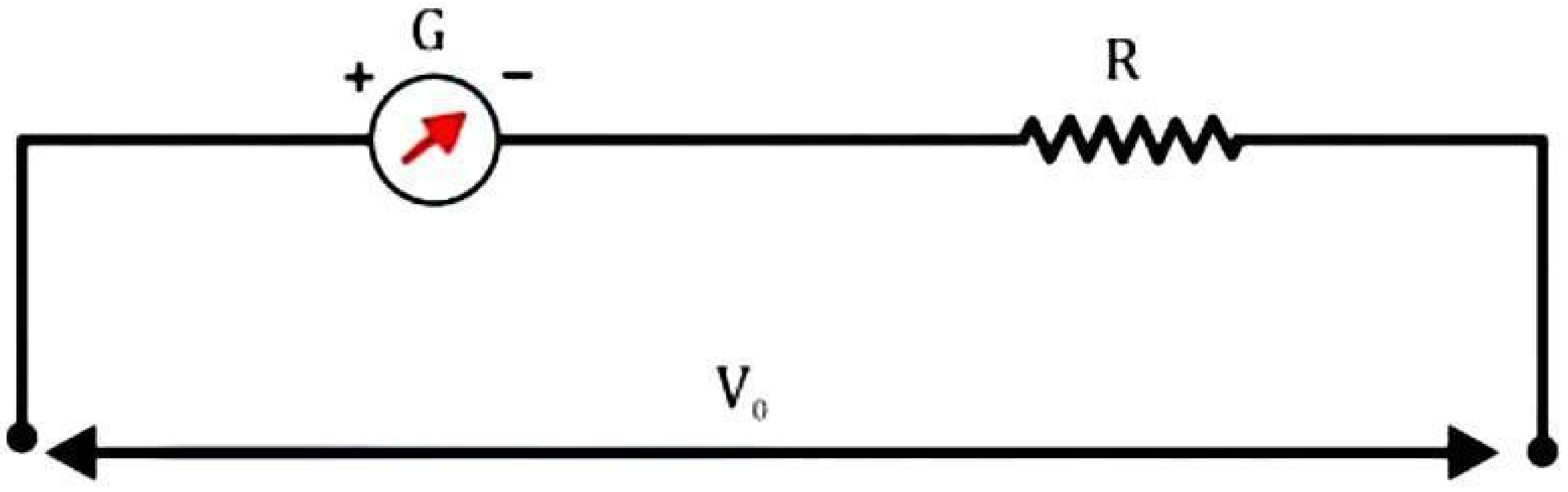

Fig. (a) General principle behind the conversion of a galvanometer into a voltmeter

THEORY

1. By introducing a high-resistance element of an appropriate value in series with a galvanometer, it transforms into a voltmeter. The voltmeter is invariably connected in parallel with the circuit.
2. Consider a galvanometer with resistance G, exhibiting a full-scale deflection for a maximum current I_g. The potential difference across the galvanometer is I_gG. To achieve a desired range of V_0 volts for the converted galvanometer, the total resistance R′ in the circuit is expressed as follows:

$$R' = \frac{V_0}{I_g} \qquad \text{.........(i)}$$

3. Given that the galvanometer's resistance is G and the external resistance R is in series with the galvanometer, the relationship between the total and external resistances is represented as:

$$R' = R + G \qquad \text{.........(ii)}$$

4. By combining equations (i) and (ii), we obtain:

$$R + G = \frac{V_0}{I_g}$$

5. This equation can be rearranged to express R in terms of the desired voltage range V_0, maximum current I_g, and the galvanometer's resistance G:

$$\boxed{R = \left(\frac{V_0}{I_g} - G\right)} \qquad \text{.........(iii)}$$

PROCEDURE

1. Determine the resistance G of the galvanometer using the half-deflection method.
2. Establish connections by linking a cell and a high-resistance box in series with the galvanometer.
3. Set RB to a high resistance value and record the zero reading of the galvanometer.
4. Close the key K, adjust RB for a substantial galvanometer deflection, and note the resistance R introduced by RB along with the galvanometer deflection n in divisions, considering the zero reading.
5. Record the cell's electromotive force (E) and compute the galvanometer's figure of merit (k) using the formula:

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

6. Repeat step 5 for various R values and determine the mean k.
7. Note the divisions on one side of zero on the galvanometer scale and calculate I_g using the relation $I_g = kN$.
8. Use the formula $R = \frac{V}{I_g} - G$ to calculate the series resistance R.
9. Choose a resistance of this value and connect it in series with the galvanometer, converting it into a voltmeter of the specified range.
10. For calibrating the converted galvanometer:
    - **(a)** Establish connections by connecting a cell and a key in series, and the converted galvanometer and a voltmeter with a similar range in parallel with a high-resistance rheostat Rh.
    - **(b)** Close the key K, adjust the rheostat for a large galvanometer deflection and note the readings of the voltmeter and galvanometer.
    - **(c)** Convert the galvanometer deflection into volts and determine the difference between the readings of the two instruments, indicating the error in the converted galvanometer.
    - **(d)** Repeat step (c) multiple times by adjusting the position of the sliding contact of the rheostat.

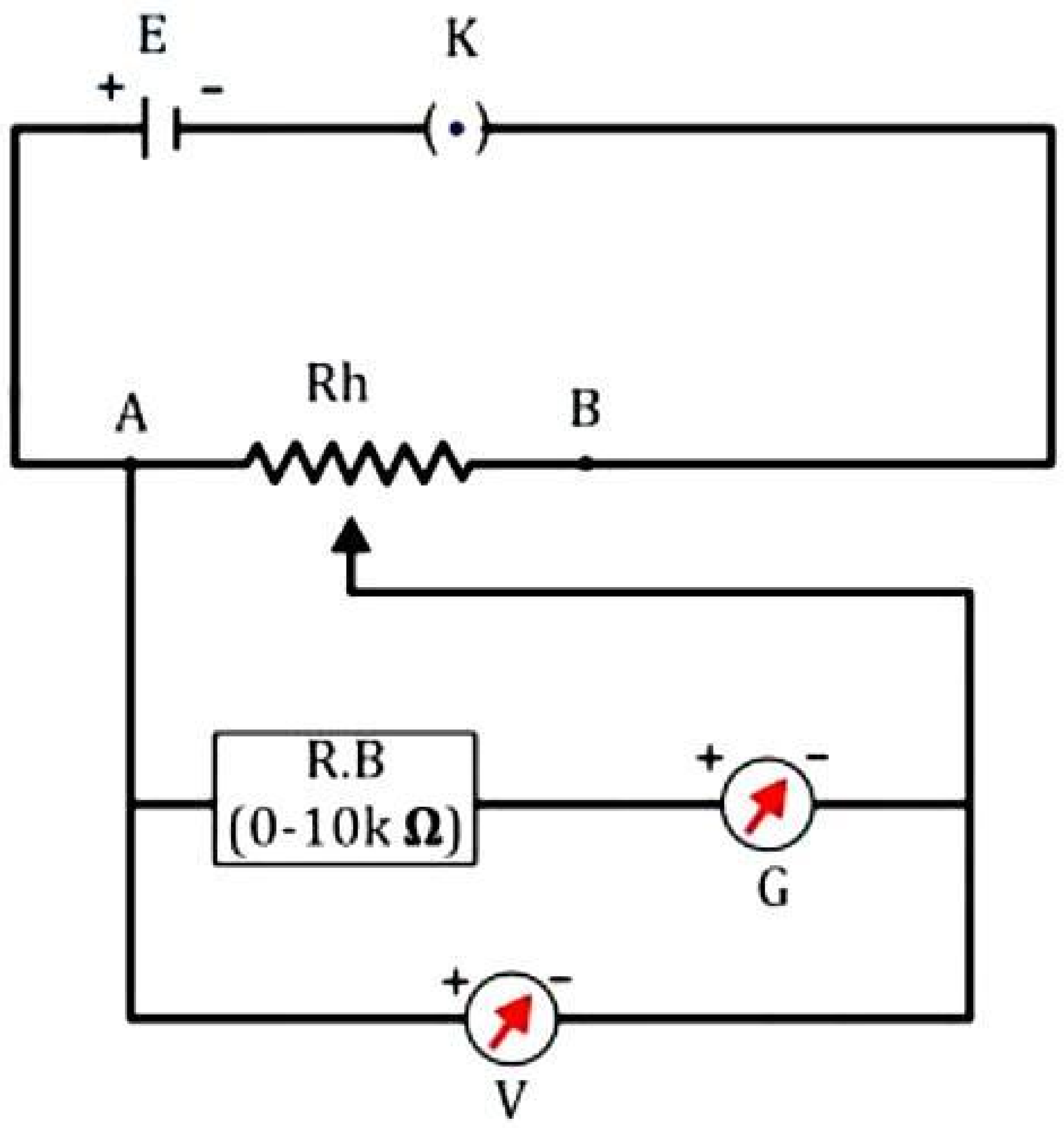

Fig. (b) Circuit diagram for calibration of the converted galvanometer

OBSERVATIONS

1. Record the resistance value of galvanometer G using the half deflection method. The resistance of the galvanometer, $G = \cdots \Omega$.
2. Record the figure of merit value of galvanometer k. The figure of merit for the galvanometer is denoted by $k = \cdots$ ampere/div.

3. Determine the number of divisions on one side of zero on the galvanometer scale as $N = \cdots$ div.
4. Determine the current needed for achieving a full-scale deflection of N divisions, $I_g = kN = \cdots$ ampere.
5. Find the range of the converted voltmeter as $V_o = \cdots$ volt.
6. Calculate the least count of the converted voltmeter as $L.C. = \frac{V_o}{N} = \cdots$ volt/div.

For determining the galvanometer resistance G.

No. of observations	Resistance, $R(\Omega)$	Galvanometer deflection, θ(div.)	Resistance, $S(\Omega)$	Half deflection $\frac{\theta}{2}$ (div.)	$G = \frac{RS}{R-S}$ (Ω)	Mean (Ω)
1.						
2.						
3.						
4.						

For determining the figure of merit of the galvanometer

No. of observations	Resistance, introduced by the resistance box, R (Ω)	Galvanometer deflection, n(div.)	Figure of merit, $k = \frac{E}{n(R+G)}$ (amp/div.)	Mean (amp/div.)
1.				
2.				
3.				
4.				

Calibration of the converted galvanometer

No. of observation s	Galvanometer readings in		Voltmeter readings, V'	Difference, V'-V (volt)
	(Divisions)	(volt)		
1.				
2.				
3.				
4.				
5.				
6.				
7.				

CALCULATION

The calculation for the necessary resistance is given by $R = \frac{V_o}{I_g} - G = \cdots$ ohm.

RESULTS

1. The determined value for the series resistance is $R = \cdots$ ohm.
2. The current required for full-scale deflection is $I_g = \cdots$ ampere.

PRECAUTION

Exercise caution when connecting a resistance box with a high range (= 10,000Ω) and ensure the accurate application of the calculated resistance value (at no point should the resistance in the resistance box be zero or too small). Failure to do so may result in an unreasonably high current flowing through the galvanometer, potentially causing damage.

SOURCE OF ERROR

The wire may be of non-uniform area of cross section.

VIVA- VOCE

Q 1. On what principle does a galvanometer work?

Ans. Works on the principle of converting electrical energy into mechanical energy.

Q 2. What is a voltmeter?

Ans. It is a device used to measure the potential difference between two points of the electrical circuit.

Q 3. How is a galvanometer converted into a voltmeter?

Ans. A galvanometer is converted into a voltmeter by connecting it with high resistance.

Q 4. Can a galvanometer be used to measure heavy currents?

Ans. No

Q 5. What is the resistance of the ideal voltmeter?

Ans. Infinite

Q 6. What are the types of galvanometers?

Ans. The major classifications are- Moving Magnet Type Galvanometer or Moving Coil type Galvanometer. It may be of two types suspended or pivoted type. Further the moving coil galvanometer can be sub-classified in Dead beat, critically damped and Ballistic type Galvanometer.

Q 7. Which one is your galvanometer?

Ans. It is a pivoted type moving coil dead beat galvanometer.

Q 8. How have you recognized it?

Ans. Since there is deflection in galvanometer on flowing current through it and deflection comes to zero slowly on switch off the current. Thus, it is of dead-beat type. Since pointer is connected to coil and it is moving on rotation of coil thus it is of moving coil. Since coil is not suspended but it is pivoted, hence it is pivoted type.

Q 9. How can you recognize the ballistic galvanometer?

Ans. If a small current flow causes multiple deflection in galvanometer on both sides of its zero then it will be a ballistic galvanometer.

Q 10. What are the values of Ig and G for your galvanometer?

Ans. For the present galvanometer, $I_g = 600\ \mu A$ and $G = 60\ \Omega$.

VOLTMETER

Q 11. What is a voltmeter?

Ans. A voltmeter is a device (instrument) for measuring the electric potential difference between two points in a circuit.

Q 12. How is a voltmeter used in a circuit?

Ans. A voltmeter is used in parallel with that branch of the circuit at the ends of which the potential difference is to be measured.

Q 13. Why is a voltmeter used in parallel a circuit?

Ans. The potential difference to be measured is maintained at the terminals of the voltmeter.

Q 14. What are the required properties of a voltmeter?

Ans. A voltmeter must have a very large resistance (infinite, if possible) and a very small current carrying capacity.

Q 15. Why should a voltmeter have a very large resistance?

Ans. So that when put in parallel in a circuit, it should not divert much current from the parallel branch.

Q 16. Why should a voltmeter have a very small current carrying capacity?

Ans. So that it may not withdraw much current from the parallel branch of the circuit.

CONVERSION OF A GALVANOMETER INTO A VOLTMETER

Q 17. Why is a galvanometer not suitable to work as a voltmeter?

Ans. A galvanometer has less resistance and more current-carrying capacity than those required by a voltmeter.

Q 18. How is a galvanometer converted into a voltmeter?

Ans. A galvanometer is converted into a voltmeter by connecting a high resistance in series with the galvanometer coil.

Q 19. How the high resistance in series gives the required properties to the galvanometer?

Ans. The series high resistance increases the overall resistance of the voltmeter (converted galvanometer) and decreases its current-carrying capacity.

Q 20. What is the order of resistance of a voltmeter?

Ans. The voltmeter resistance is of the order of series high resistance (R is in ten thousand, G is in hundreds).

Q 21. What do you understand by the range of a voltmeter?

Ans. It is the maximum value of the potential difference that the voltmeter can measure.

Q 22. Which has more resistance—a 1-volt range voltmeter or a 10-volt range voltmeter?

Ans. Higher the range, the higher the resistance. A 10 V voltmeter has higher resistance.

Q 23. What is a milli-voltmeter?

Ans. It is a voltmeter that measures the potential difference in milli-volts ($mV = 10^{-3}$ V).

Q 24. What is a micro-voltmeter?

Ans. It is a voltmeter that measures the potential difference in micro-volts ($\mu V = 10^{-3}$ V).

Q 25. Does an ordinary voltmeter have infinite resistance?

Ans. No.

Q 26. Name a voltmeter that has infinite resistance.

Ans. The electrostatic voltmeter has infinite resistance. It is also called an electrometer. An electronic voltmeter, called Vacuum Tube Voltmeter (VTVM), has nearly infinite resistance. It makes accurate measurements of potential differences. The potentiometer, at the null point, also acts as an ideal voltmeter (infinite resistance).