Online Workshop
On
"Lectures and Virtual Practical Demonstration"
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Galvanometer/Ammeter

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***Galvanometer*:** A galvanometer is a device used to find direction of current and its magnitude. It has small resistance and is connected in series. A galvanometer can detect only small currents. Thus, to measure large currents it is converted into an ammeter. It can be converted into an ammeter by connecting a low resistance called shunt resistance in parallel to the galvanometer. A galvanometer is a device used to detect feeble electric currents in a circuit. It has a coil pivoted (or suspended) between concave pole faces of a strong laminated horse shoe magnet. When an electric current passes through the coil, it deflects. The deflection is proportional to the current passed. The galvanometer coil has a moderate resistance (about 100 ohms) and the galvanometer itself has a small current carrying capacity (1 mA).

Galvanometer

***Ammeter*:** An ammeter is a measuring device used to measure the electric current in a circuit. At the heart of most analog meters is a galvanometer, an instrument that measures current flow using the movement, or deflection, of a needle. The needle deflection is produced by magnetic force acting on a current-carrying wire. It is a low resistance galvanometer, used to measure current in a circuit. The current to be measured must pass through it, hence it is connected in series combination. An ideal ammeter should have zero resistance. But practically the ammeter has small internal resistance. The measuring range of the ammeter depends on the value of resistance. The ammeter is connected in series with the circuit so that the whole electrons of measured current pass through the ammeter. The power loss occurs in ammeter because of the measured current and their internal resistance. The ammeter circuit has low resistance so that the small voltage drop occurs in the circuit.

Ammeter

***Voltmeter*:** **-** A voltmeter is an instrument that measures the difference in electrical potential between two points in an electric circuit. It is a high resistance galvanometer, used to measure potential difference between two points. It is connected across the component's ends potential difference across which is to be measured. It is in parallel to that component. An ideal voltmeter must have infinite resistance. An analog voltmeter moves a pointer across a scale in proportion to the circuit's voltage, a digital voltmeter provides a numerical display. Any measurement that can be converted to voltage can be displayed on a meter that is properly calibrated, such measurements include pressure, temperature, and flow. In order for a voltmeter to measure a device's voltage, it must be connected in parallel to that device. This is necessary because objects in parallel experience the same potential difference. The instrument which measures the voltage or potential difference in volts is known as the voltmeter. It works on the principle that the torque is generated by the current which induces because of measured voltage and this torque deflects the pointer of the instrument. The deflection of the pointer is directly proportional to the potential difference between the points. The voltmeter is always connected in parallel with the circuit.

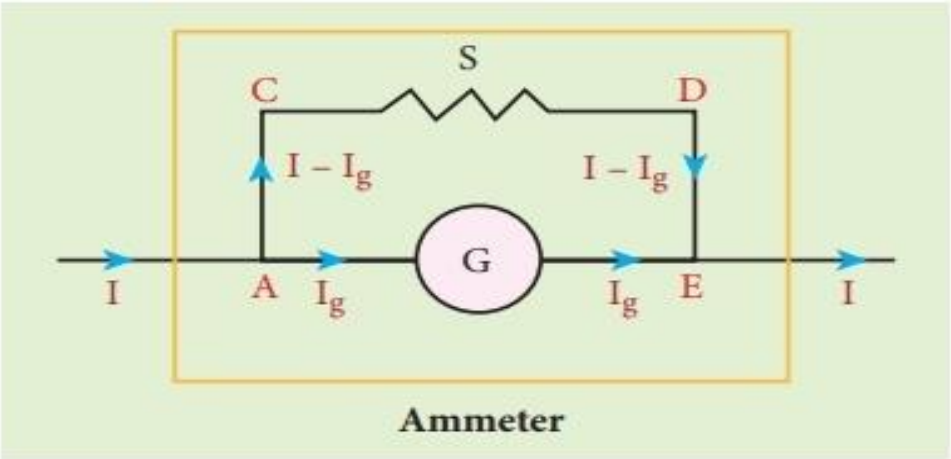
Voltmeter

Conversion of Galvanometer into Ammeter

A galvanometer is very sensitive instrument to detect the current. It can be easily converted into ammeter and voltmeter.

Galvanometer to an Ammeter:-

Ammeter is an instrument used to measure current flowing in the electrical circuit. The ammeter must offer low resistance such that it will not change the current passing through it. So ammeter is connected in series to measure the circuit current. A galvanometer is converted into an ammeter by connecting a low resistance in parallel with the galvanometer. This low resistance is called shunt resistance S. The scale is now calibrated in ampere and the range of ammeter depends on the values of the shunt resistance.



Let I be the current passing through the circuit as shown in Figure. When current I reach the junction A, it divides into two components. Let I_g be the current passing through the galvanometer of resistance R_g through a path AGE and the remaining current $(I - I_g)$ passes along the path ACDE through shunt resistance S. The value of shunt resistance is so adjusted that current I_g produces full scale deflection in the

galvanometer. The potential difference galvanometer is same as the potential difference across shunt resistance.

$$V_{galvanometer} = V_{shunt}$$

$$\Rightarrow I_g R_g = (I - I_g) S$$

$$S = \frac{I_g}{(I - I_g)} R_g \text{ Or}$$

$$I_g = \frac{S}{S + R_g} I \Rightarrow I_g \propto I$$

Since, the deflection in the galvanometer is proportional to the current passing through it.

$$\theta = \frac{1}{G} I_g \Rightarrow \theta \propto I_g \Rightarrow \theta \propto I$$

So, the deflection in the galvanometer measures the current I passing through the circuit (ammeter). Shunt resistance is connected in parallel to galvanometer. Therefore, resistance of ammeter can be determined by computing the effective resistance, which is

$$\frac{1}{R_{eff}} = \frac{1}{R_g} + \frac{1}{S} \Rightarrow R_{eff} = \frac{R_g S}{R_g + S} = R_a$$

Since, the shunt resistance is a very low resistance and the ratio S/ R_g is also small. This means, R_g is also small, i.e., the resistance offered by the ammeter is small. So, when ammeter connects in series, the ammeter will not change the resistance appreciably and also the current in the circuit. For an ideal ammeter, the resistance

must be equal to zero. Hence, the reading in ammeter is always lesser than the actual current in the circuit. Let I_{ideal} be current measured from ideal ammeter and I_{actual} be the actual current measured in the circuit by the ammeter.

Then, the percentage error in measuring a current through an ammeter is

$$\frac{\Delta I}{I}\times 100\% = \frac{I_{ideal} - I_{actual}}{I_{actual}}\times 100\%$$

Key points:

1. An ammeter is a low resistance instrument and it is always connected in series to the circuit.

2. An ideal ammeter has zero resistance.

3. In order to increase the range of an ammeter n times, the value of shunt resistance to be connected in parallel is S =G/n-1

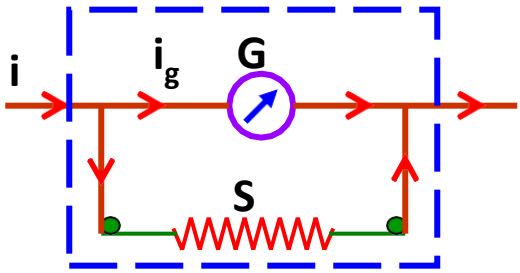
$$S = \frac{G}{n-1}$$

Conversion of Galvanometer to Ammeter

Galvanometer can be converted into ammeter by shunting it with a very small resistance. Potential differences across the galvanometer and shunt resistance are equal.

$$(i - i_g)S = i_g G$$

$$S = \frac{i_g G}{(i - i_g)}$$



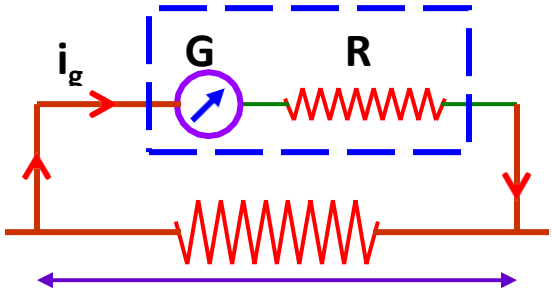
$i_S = i - i_g$

Conversion of Galvanometer to Voltmeter

Galvanometer can be converted into voltmeter by connecting with it with a very high resistance. Potential difference across the given load resistance is the sum of potential difference across galvanometer and potential difference across the high resistance.

$$V = i_g (G + R)$$

$$R = \frac{V}{i_g} - G$$



Resistance of a galvanometer by half deflection method

The resistance of the galvanometer by half deflection method is

$$G = \frac{R.S}{R - S}$$

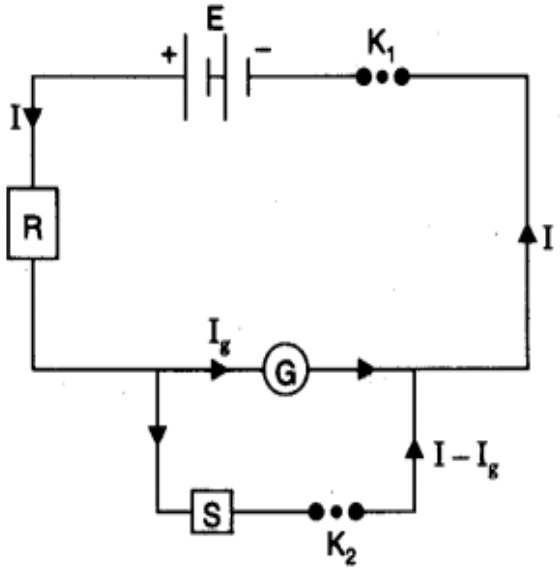
Where R is the resistance connected in series with the galvanometer and S is the shunt resistance. The figure of merit

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

Where E is the e.m.f. of the cell and n is the deflection produced with resistance R. The maximum current pass through the galvanometer

$$I_g = Nk$$

Where N is the total number of divisions on the galvanometer scale on either side is zero.



Resistance of galvanometer.

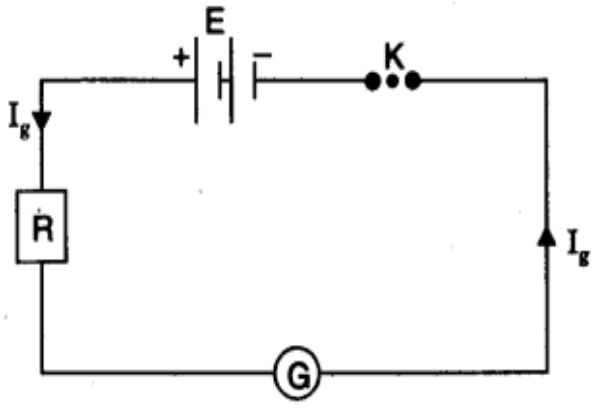


Figure of merit.

Procedure of Resistance of a galvanometer by half deflection method:

- Make the connection as shown in circuit diagram.
- All the plugs of the resistance boxes are tight.
- Take out the high resistance from the resistance box R and insert the key k_1 only.
- Adjust the value of R so that the deflection is maximum, note the deflection.
- 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 exactly half the value obtained previously. Note the value of resistance S.
- For different values of R adjust S every time and note the deflection.

Conversion of Galvanometer into Ammeter

Aim: - To convert a Weston Galvanometer into an ammeter of a given range (0-150mA).

Apparatus used: - A Weston galvanometer, Battery, high resistance box, ammeter of the same range as given for conversion, plug key, resistance wire.

Formula used: - The shunt resistance S required to convert the galvanometer into an ammeter is given by

$$S = \frac{I_g G}{I - I_g}$$

Where I_g = The maximum current that passes through the galvanometer for full scale deflection.

I = Range of the ammeter in which the galvanometer is to be converted.

G= Galvanometer resistance.

The value of I_g is given by

$$I_g = C_S N$$

Where N = Total no. of divisions on the scale of the galvanometer on one side of the zero of scale.

C_S = Current sensitivity or figure of merit and is given by

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

"The current required to produce a deflection of one division in the scale of the galvanometer is known as the figure of merit of the galvanometer."

Where E = e.m.f. of the cell.

R = Resistance introduced (R.B.) in the circuit of galvanometer.

n = Deflection in galvanometer on introducing R in galvanometer circuit.

G = galvanometer resistance.

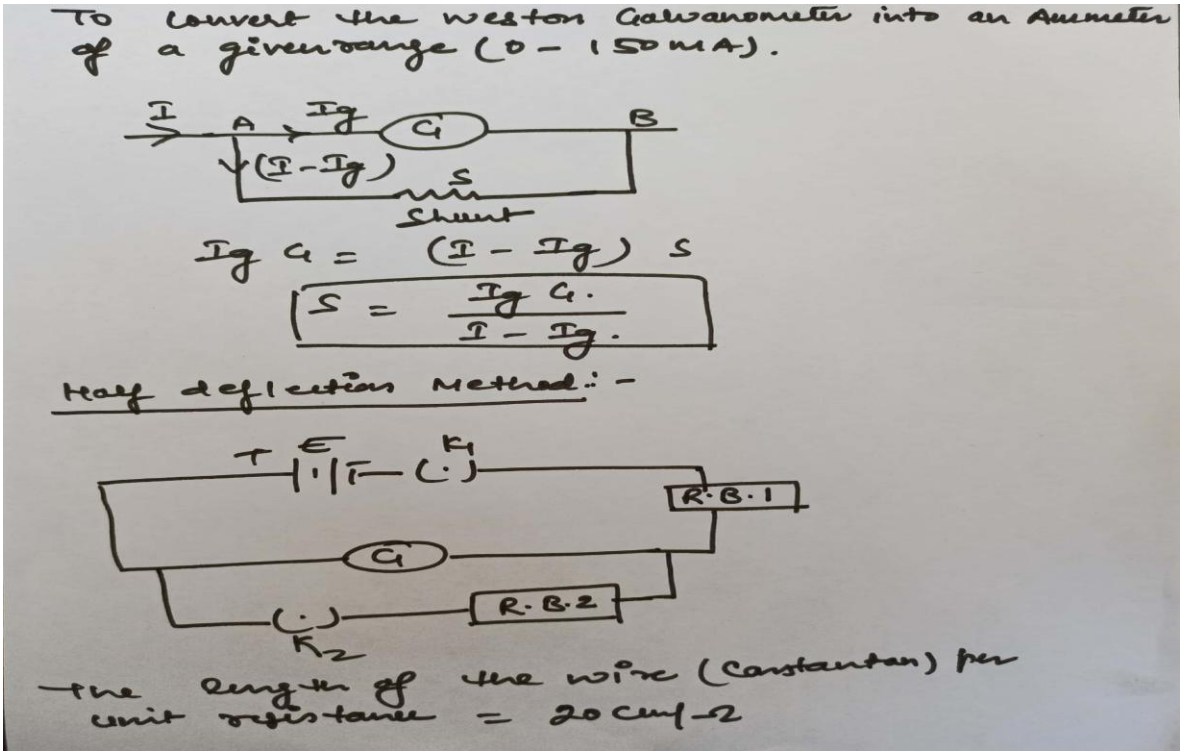
Procedure:

(1) Set up the electrical circuit as shown in figure.

(2) Measure the e.m.f. E of the battery. Note down the initial reading of the galvanometer and adjust the resistance box to a high value.

(3) Close the key and adjust the resistance box to get approximately the full scale deflection. R be the resistance in resistance box to obtain n divisions deflection in galvanometer taking into account the zero readings.

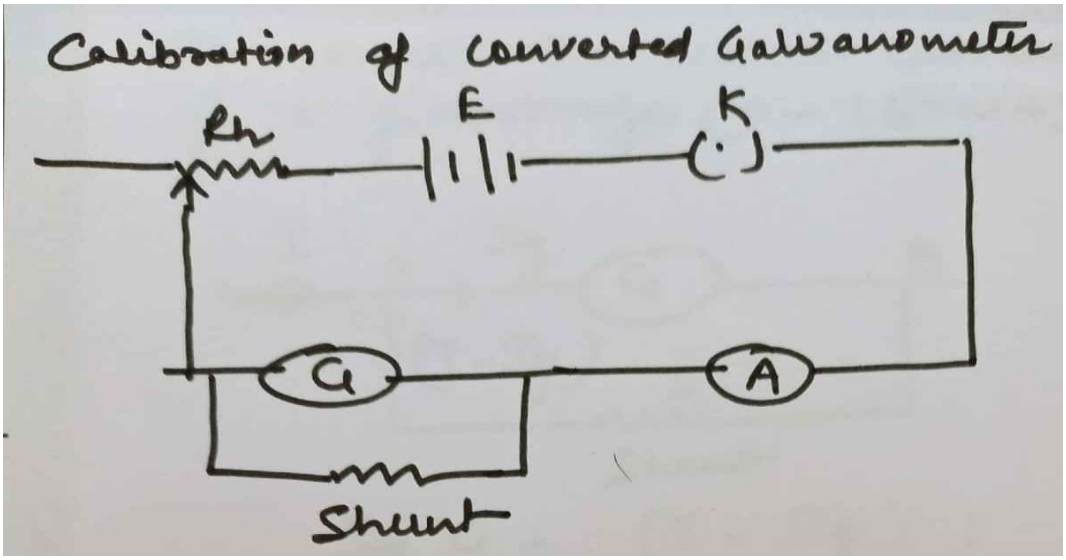
(4) Calculate C_S and I_g.



(i) Determine the galvanometer resistance (G)

S. No.	Resistance introduced in resistance box R ohms	Deflection in galvanometer n	Figure of merit C_S	$I_g = C_S N$ amp	Mean C_S

(ii) Calibration of shunted galvanometer:



Procedure:

(1) Set up the electrical circuit shown in figure.

(2) For a particular setting of R_h close the key and note down the ammeter and galvanometer readings.

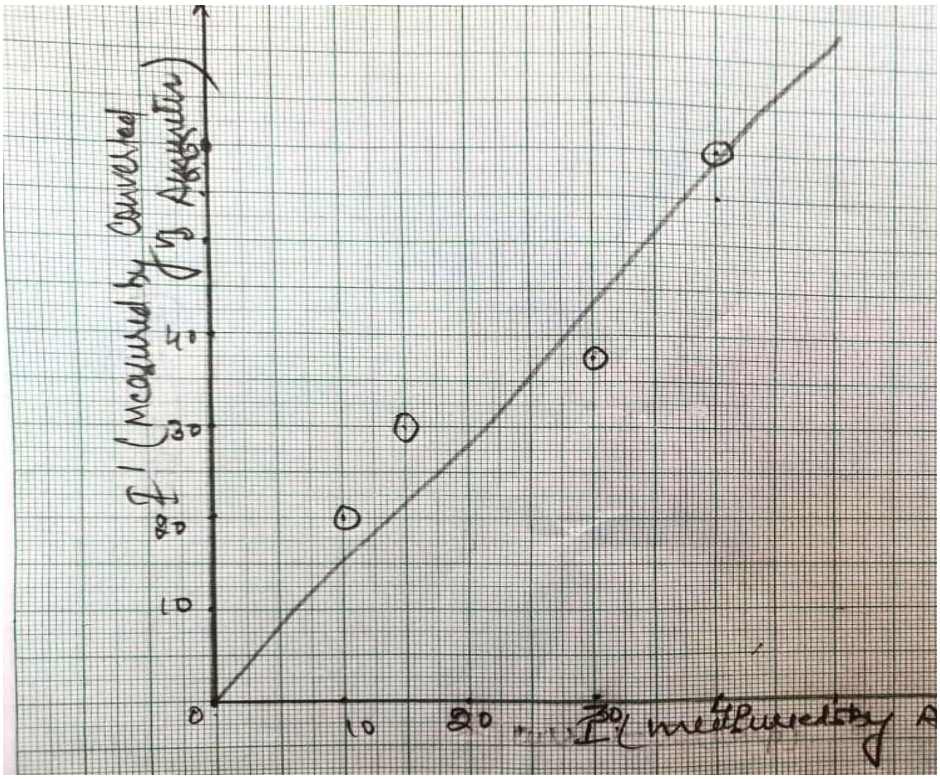
(3) Convert the galvanometer reading into ampere and find the difference between the readings of the two instruments.

(4) Change the value of R_h and repeat the above procedure till the whole range of the converted galvanometer is covered.

(5) Draw the graph taking converted galvanometer readings and the corresponding ammeter readings.

Observation:

S.No.	Reading of shunted galvanometer		Ammeter reading (I') in amp.	Error $(I' - I)$ amp.
	In divs.	In amp (I)		



Graph between shunted galvanometer (I) and Ammeter (I') reading

Result:- The length of shunted wire required to convert the given galvanometer into ammeter of range 0-150 mA is .....

Precautions and Sources of error:-

(1) Accumulator/Battery used should be fully charged.

(2) Galvanometer and ammeter reading should initially be at zero mark.

(3) Ammeter used for calibration of shunted Galvanometer should be nearly of same range.

(4) While connecting the shunt exact length should be connected in parallel to the galvanometer.

(5) The resistance box used in determining the figure of merit should be of high resistance. Before putting the key, it should be kept at high value otherwise the galvanometer may be damaged.