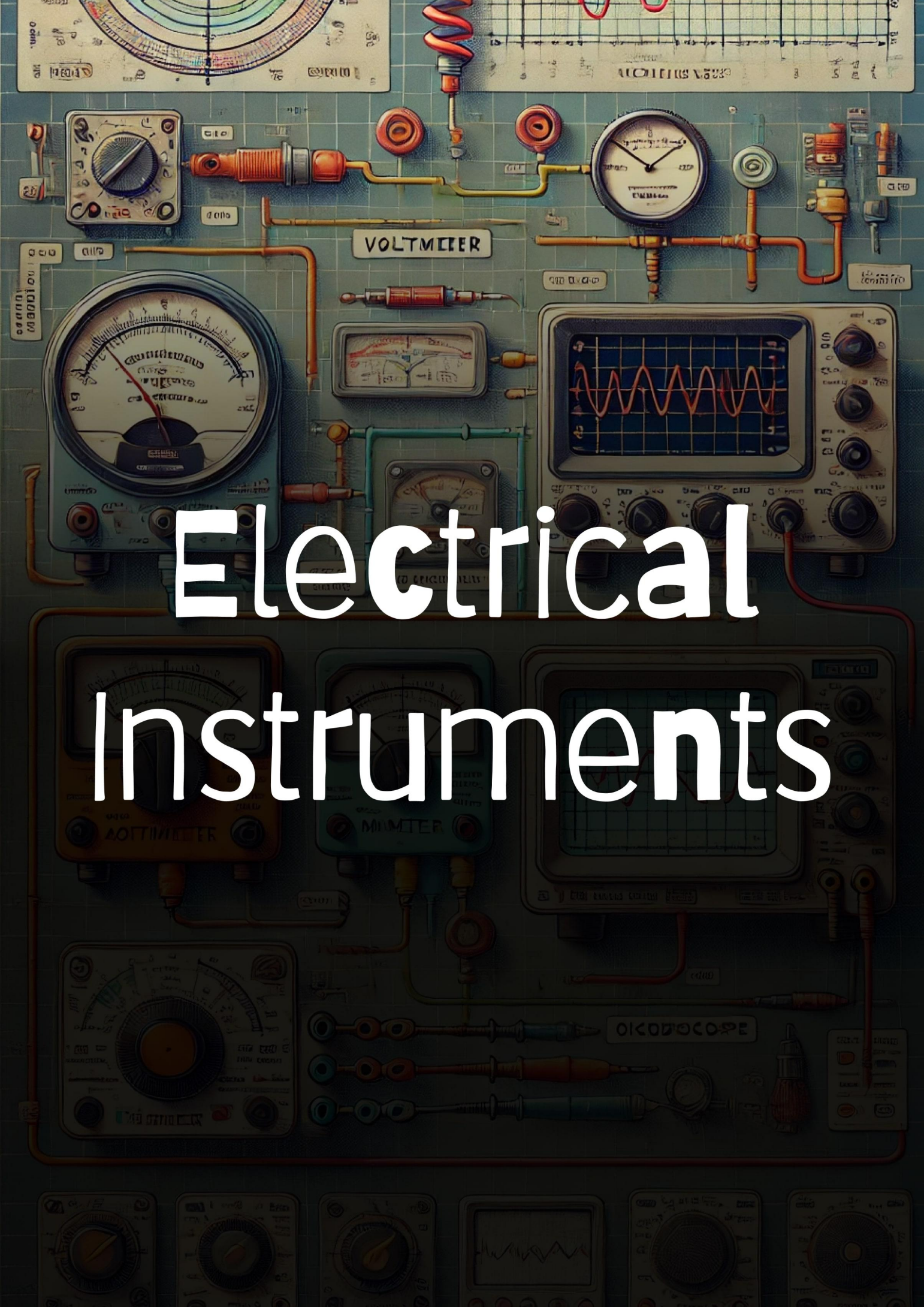


Electrical Instruments

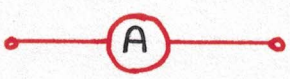
Electrical Instruments

GALVANOMETER

Symbol: 

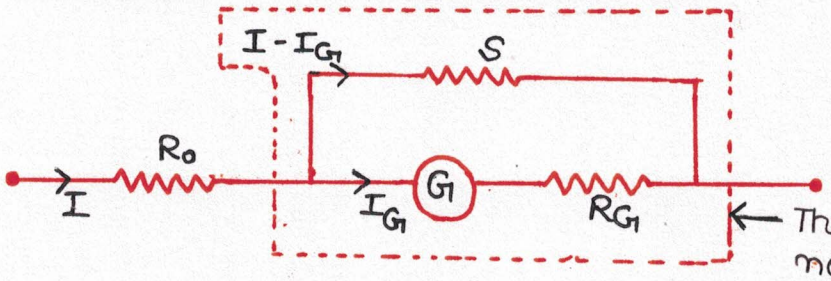
- It has a device for measuring currents.
- It has two terminals and an etched dial with an indicator which can move into a left extreme & a right extreme.
- By default when current is zero, indicator is at the centre of the extremes.
- Depending on the magnitude & the sense of the current, the indicator deflects clockwise or counter clockwise by certain angle.
- Each galvanometer comes with a specified rated current at which it gives the full scale deflection (i_g).

AMMETER

Symbol: 

- It is a device used for measuring currents within a specified range.
- If a ready ammeter is not available, a galvanometer can be converted into an ammeter by attaching a suitable resistance (shunt) in parallel with it.

CONVERTING A GALVANOMETER INTO AN AMMETER



This system is now called "ammeter"

$$I_G R_G = (I - I_G) S$$

$$S = \frac{I_G R_G}{(I - I_G)} \quad ; \quad I > I_G$$

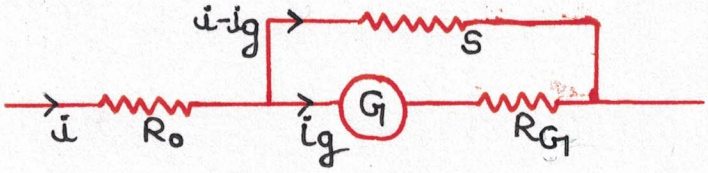
where $I \rightarrow$ range of ammeter
$I_G \rightarrow$ max. current through G
$R_G \rightarrow$ resistance of galvanometer coil

★ If $I \gg I_G$,

$$S \approx \frac{I_G R_G}{I}$$

CALIBERATION FACTOR

The factor with which we need to multiply the reading of galvanometer is called Caliberation factor.



$$(i - i_g)S = i_g R_G \qquad ; i_g < I_G$$

$$i = i_g\left(\frac{R_G + S}{S}\right)$$

$$K = \frac{R_G + S}{S}$$

NOTE: An ammeter is always connected in series & the resistance of an ideal ammeter is equal to zero.

DRAWBACK OF AMMETER

Practically, there is no ideal ammeter. There is some resistance of any ammeter. So Reff of Circuit changes & so correct reading of current cannot be obtained.

Que.) A 1 mA, 25 Ω galvanometer is to be converted into an ammeter of range 2A. Find K and S.

ATQ,

$$I_G = 1\text{mA} = \frac{1}{1000}\text{A} \quad , \quad I = 2\text{A}$$

$$R_G = 25\,\Omega$$

$$S = \frac{I_G R_G}{I - I_G} = \frac{1/1000 \cdot 25}{2 - 1/1000}$$

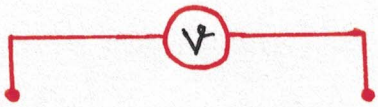
$$S = \frac{25}{1999}$$

$$S \approx \frac{1}{80}$$

$$K = \frac{25 + 1/80}{1/80} = 2000 + 1 \quad , \quad K \approx 2000$$

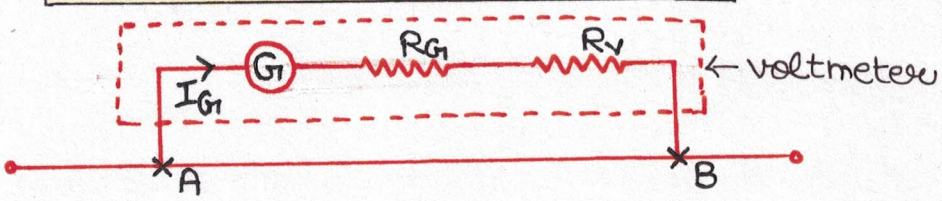
VOLTMETER

Symbol:



- It is a device used for measuring the potential drop b/w two points in a circuit.
- It is always connected in parallel across the element for which we want the potential drop.
- If a standard voltmeter is not available, a galvanometer can be converted into a voltmeter by attaching a suitable resistance in series with the cell.

CONVERTING A GALVANOMETER INTO A VOLTMETER

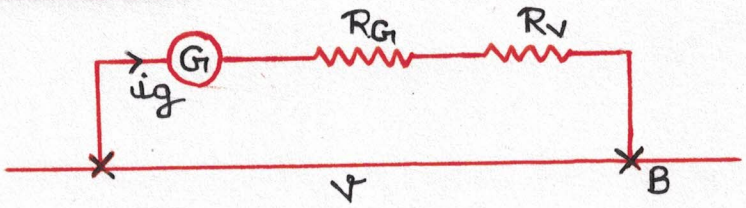


$$V_{BA} = V$$

$$V = I_G (R_G + R_V)$$

$$R_V = \frac{V}{I_G} - R_G$$

CALIBERATION FACTOR



$$V = i_g (R_G + R_V)$$

$$V = K i_g$$

$$K = R_G + R_V$$

Que: A 1Ω, 5mA galvanometer is to be converted into a 5V voltmeter. Find the series resistance & the measured voltage when $i_g = 1mA$.

ATQ, $V = 5V$, $I_G = 5mA = \frac{5}{1000} A$

$R_G = 1\Omega$

$\therefore R_V = \frac{V}{I_G} - R_G$

$$R_V = 5 \times \frac{1000}{5} - 1$$

$$= 1000 - 1$$

$$R_V = 999\ \Omega$$

$$V = i_g (R_G + R_V)$$

when $i_g = 1mA = \frac{1}{1000} A$,

$$V = \frac{1}{1000} (1 + 999)$$

$$V = 1 Volt$$

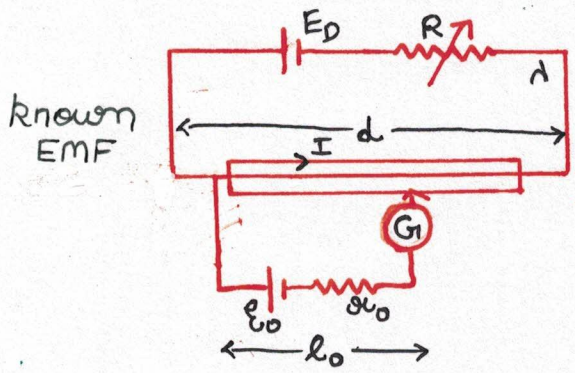
POTENTIOMETER

Potentiometer is just a long piece of wire (typically 10m). We will study the use of potentiometer for the following:

1.) Comparing the EMF of two cells.

2.) Finding the internal resistance of a battery.

USE OF POTENTIOMETER FOR COMPARISON OF EMF OF 2 CELLS



$\varepsilon_D \rightarrow$ Driver Cell EMF

$\varepsilon_0 \rightarrow$ Known EMF

$l_0 \rightarrow$ Null point balance length

$l \rightarrow$ length of potentiometer wire

$\lambda \rightarrow \frac{\text{Resistance of potentiometer}}{\text{Unit length}}$

$R \rightarrow$ rheostat resistance

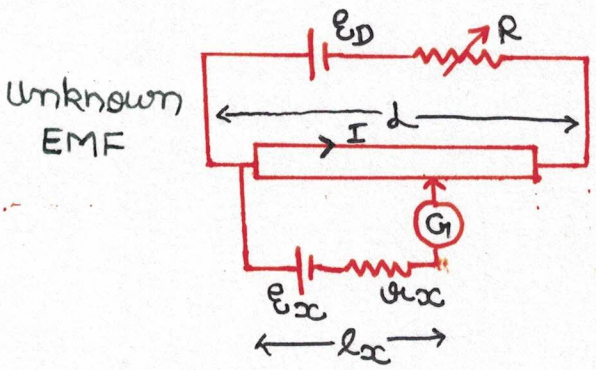
$r_0 \rightarrow$ Known cell resistance

$\varepsilon_x \rightarrow$ EMF of unknown battery

$l_x \rightarrow$ Null point balance length for unknown battery

$$\varepsilon_0 = I \lambda l_0$$

$$I = \frac{\varepsilon_0}{\lambda l + R}$$



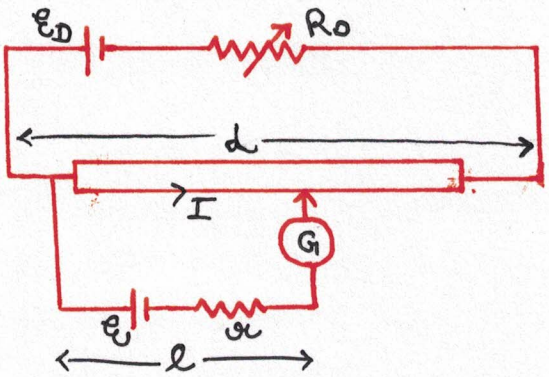
$$E_x = I \lambda l_x$$

$$I = \frac{\varepsilon_D}{\lambda l + R}$$

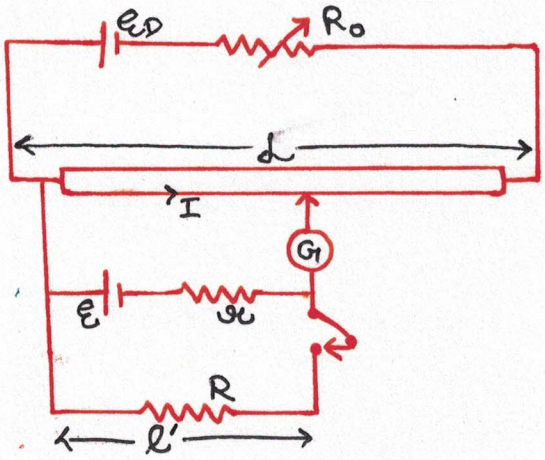
$$\therefore \frac{\mathcal{E}_x}{\mathcal{E}_0} = \frac{l_x}{l_0}$$

$$\boxed{\mathcal{E}_x = \mathcal{E}_0 \frac{l_x}{l_0}}$$

USING A POTENTIOMETER FOR CALCULATING INTERNAL RESISTANCE OF CELL



$$\mathcal{E} = I\lambda l \quad -(1)$$



$$i = \frac{\mathcal{E}}{R+r}$$

$$\mathcal{E} - ir = I\lambda l' \quad -(2)$$

$$\mathcal{E} - \left(\frac{\mathcal{E}}{R+r}\right) r = I\lambda l'$$

$$\frac{\mathcal{E}R}{R+r} = I\lambda l' \quad -(3)$$

Adding (1) & (3)

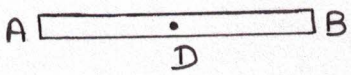
$$\frac{R+r}{R} = \frac{l}{l'}$$

$$\frac{r}{R} = \frac{l-l'}{l'}$$

$$\left(r = R\left[\frac{l}{l'} - 1\right] \right)$$

Que: $\mathcal{E}_D = 6V$, $R_0 = 0$, $L = 100cm$,
$\mathcal{E} = 4V$, $r = 1\Omega$
Potential of right end of potentiometer = 0, Find

(a) Null point length (AD)



(b) V_{BD}

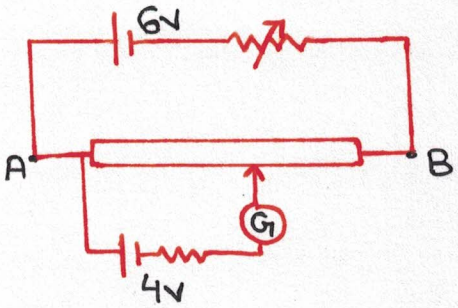
(c) If E was instead 7.5V. What will be the answer to part (a)

(a) 66.67 cm

(b) $2V = 6 - 4$

$V_{AB} = 0 \Rightarrow 6 - 4 = 2$

(c) No such point exists



Que: $\mathcal{E}_D = \mathcal{E}$, $\mathcal{E}_x = \mathcal{E}/2$, $L = 600cm$,
$R_0 = r$, $r_e = 15r$, $r_{\mathcal{E}_x} = r$

(a) If the jockey touches the potentiometer wi at $\ell' = 560cm$ What will be current in the galvanometer.

(b) What is null point length.

(a) $14r(x+y) + rx - \frac{\mathcal{E}}{2} = 0$

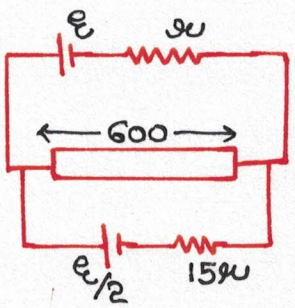
$15rx + 14ry = \frac{\mathcal{E}}{2}$ — (1)

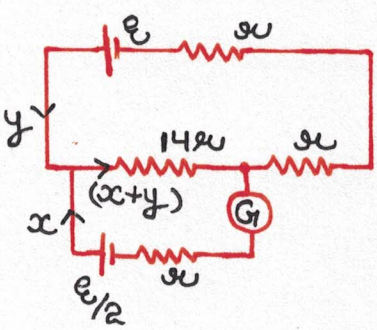
$14r(x+y) + 2ry = \mathcal{E}$

$14rx + 16ry = \mathcal{E}$ — (2)

Using (1) & (2)

$x = \frac{3\mathcal{E}}{22r}$





(b) $I = \frac{\mathcal{E}}{16r}$

Let x = null point length

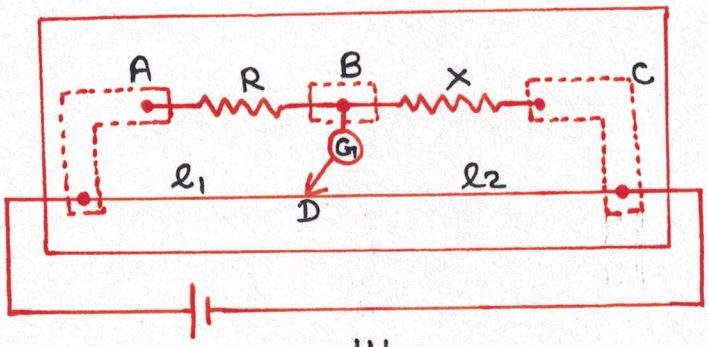
$V = I\left(\frac{x}{L} \times 15r\right) = \frac{\mathcal{E}}{2}$

$x = \frac{\mathcal{E}L \cdot 16r}{30r \cdot \mathcal{E}} = \frac{8L}{15} = \frac{8}{15} \times 600^{40}$

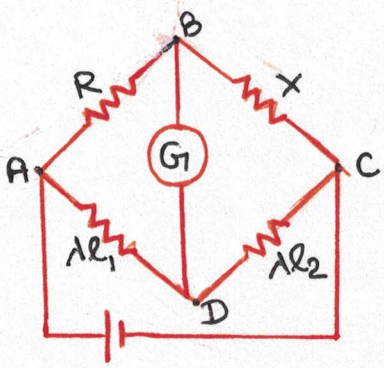
$x = 320cm.$

METER BRIDGE

Device based on the principle of wheat-stone bridge. Typically it is a one-meter long wire mounted on a board provided with three terminals for connecting as shown in the fig.



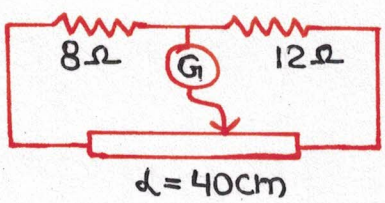
$R \rightarrow$ known resistance
$\ell_1 \rightarrow$ Null pt. length
$X \rightarrow$ unknown resistance
$\lambda \rightarrow$ resistance of meter wire per unit length



$$\frac{R}{X} = \frac{\lambda \ell_1}{\lambda \ell_2}$$

$$\left(X = R\frac{\ell_2}{\ell_1}\right)$$

Que.)

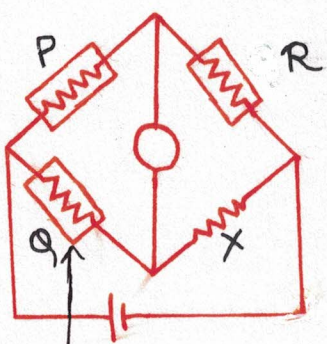


$$\frac{12}{8} = \frac{\ell}{40-\ell}$$

$$480 - 12\ell = 8\ell$$

$$\ell = 16\text{cm}$$

POST OFFICE BOX



resistance box (resistance with integral value of resistance)

$$\frac{P}{Q} = \frac{R}{X}$$

$$X = R\frac{Q}{P}$$