Galvanometer → detection of current

$$I = \frac{nm\varepsilon}{nr + mR}$$

$$I = \frac{nm\varepsilon}{(\sqrt{nr} - \sqrt{mR})^2 + 2\sqrt{nrmR}}$$

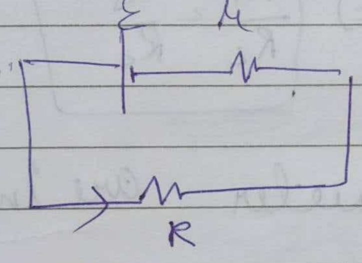
for $I = I_{max}$

$\Rightarrow \sqrt{nr} = \sqrt{mR}$

$$R = \frac{nr}{m}$$

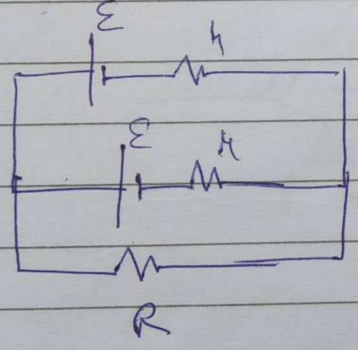
$$\boxed{R = r_{eq}}$$

R = nr/m



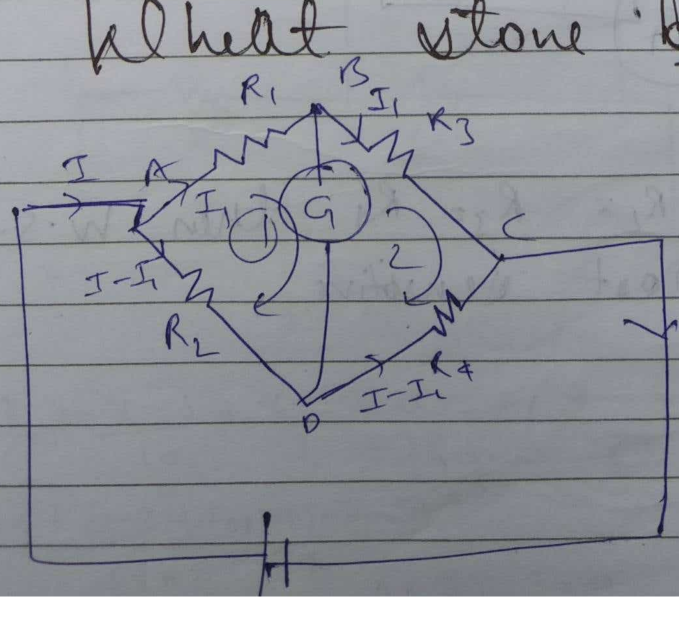
$R = r$.

for $I = I_{max}$ or power developed to be Max^m.



$R = \frac{r}{2}$

Wheat stone bridge



if $V_B = V_D \Rightarrow I_g = 0$

$\Rightarrow$ Deflection in Galvano. is Zero

$\Rightarrow$ W.S.B is called balanced

loop ①: $-I_1 R_1 + R_2(I - I_1) = 0$

$$I_1 R_1 = R_2(I - I_1) \quad \text{— (I)}$$

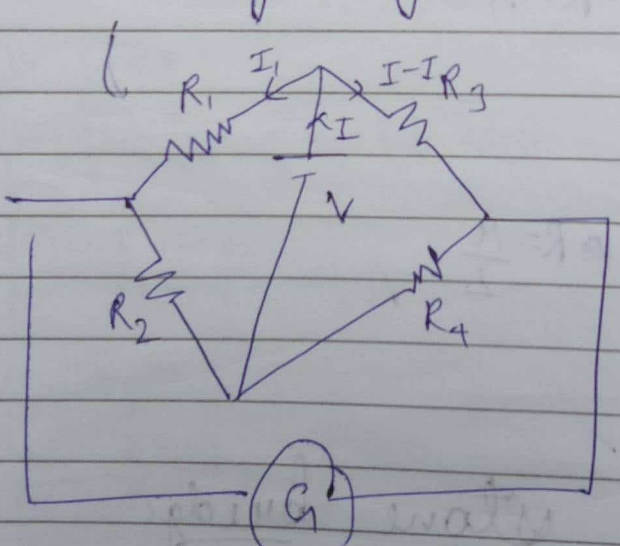
loop ② – $-I_1 R_3 + (I - I_1) R_4 = 0$

$$I_1 R_3 = R_4(I - I_1) \quad \text{— (II)}$$

(I) ÷ (II)

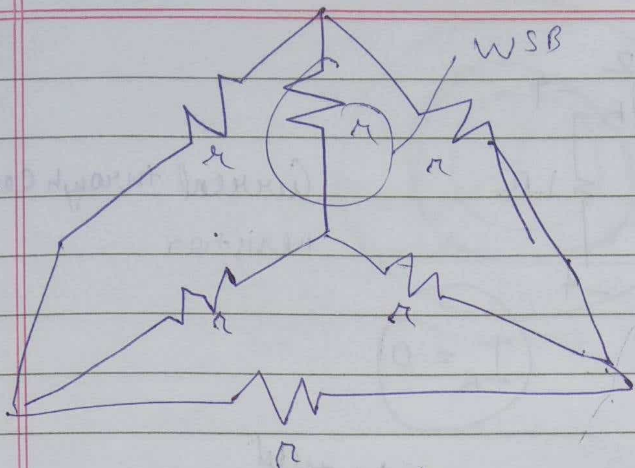
$$\frac{R_1}{R_3} = \frac{R_2}{R_4} \Rightarrow \boxed{\frac{R_1}{R_2} = \frac{R_3}{R_4}}$$

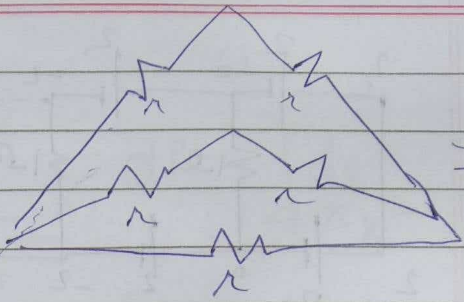
→ battery & galvanometer are interchangable



→ if $R_1 = R_2 = R_3 = R_4$ then W.S.B is most sensitive

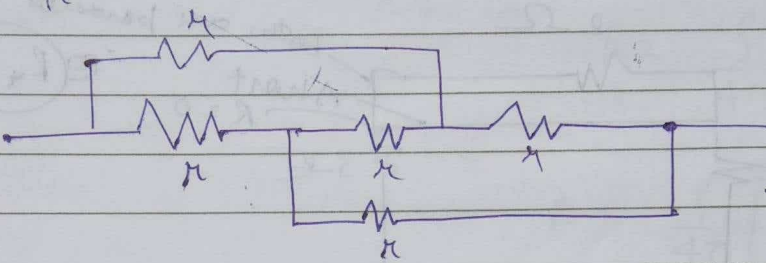
*





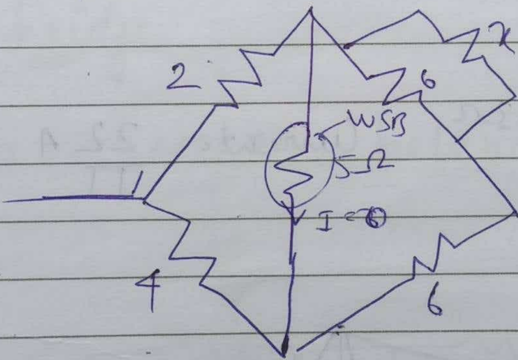
$= \frac{r}{2}$

*



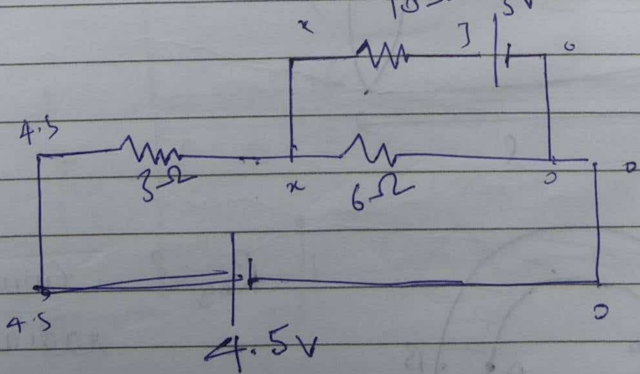
$\simeq$ r

*



$(x = 6)$

*



Current through 10Ω

$\frac{x}{6} + \frac{x-3}{10} + \frac{x-4.5}{3} = 0$

$5x + 3x - 9 + 10x - 45 = 0$

$18x = 54$

$x = 3, \; I = 0$

$(x-4.5)3 + 6x + (x-3)10 = 0$

$19x - 13.5 - 30 = 0$

$19x = 43.5$

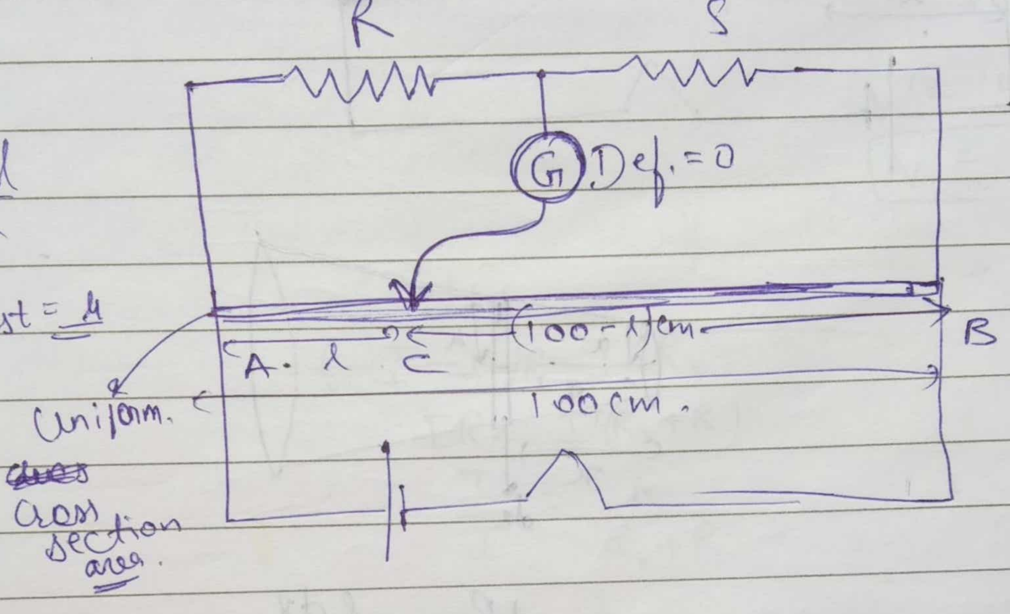
$x = 43$

Meter bridge

It is based on balanced wheatstone bridge

$R = \frac{\rho l}{A}$

$\frac{R}{l} = const = \frac{\rho}{A}$



In balanced cond^n

$\frac{R}{R_{AC}} = \frac{S}{R_{CB}}$

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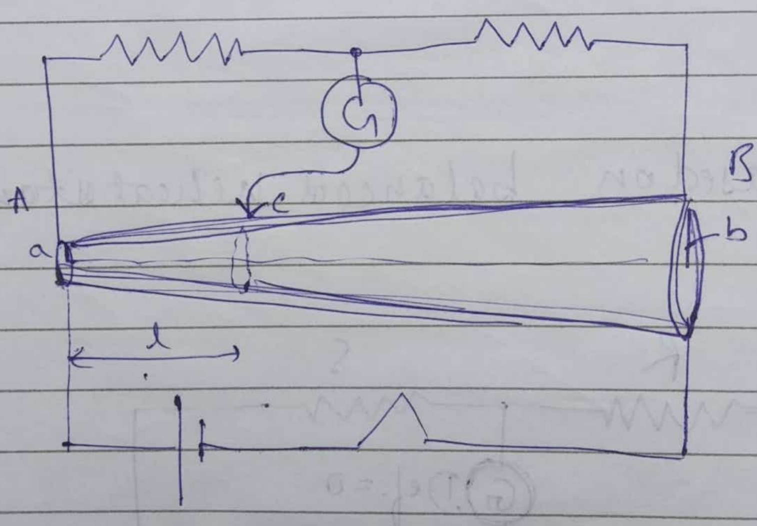
$$\frac{R}{\cancel{x}l} = \frac{S}{(100-l)\cancel{x}}$$

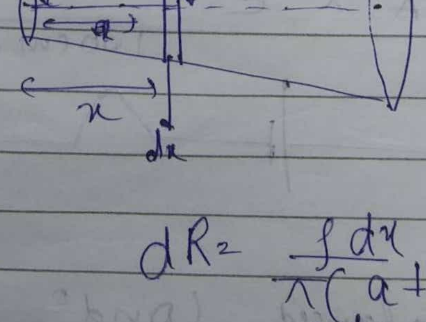
$$\boxed{S = \left(\frac{100-l}{l}\right)R}$$

Eg— $l = 100\,cm$, $R = 100\,\Omega$ $S = ?$

$$S = \left(\frac{100-l}{l}\right)R = \frac{60}{40} \times 100\,\Omega = 150\,\Omega$$

*





$$dR = \frac{\rho\,dx}{\pi\left(a + \frac{b-a}{L}x\right)^2}$$

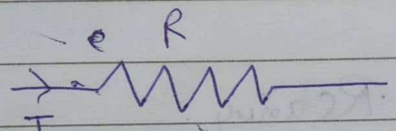
$$R_{ac} = \frac{\rho}{\pi}\int_0^l \frac{dx}{\left(a + \frac{b-a}{L}x\right)^2}$$

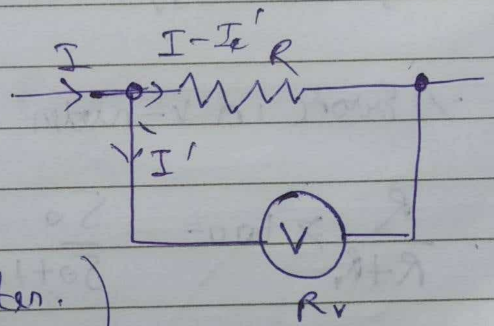
$$R_{CB} = \frac{\rho}{\pi} \int_{l}^{L} \frac{dx}{a + \left(\frac{b-a}{L}\right)x}$$

Potentiometer

→ It is used to measure Potential diff b/w 2 points

→ It measures more accurately as compared to the voltmeter because it does not draw current from the circuit





$V = IR$

(ideally V-meter: $R_v = \infty$, then $I' = 0$)

Reading of V-meter = $V' = (I - I')R$

$V' = IR - I'R$

$$\boxed{V' = V - I'R}$$

also

$$(I - I')R = I'R_v$$

$$IR = I'(R_v + R)$$

$$\frac{I'}{I} = \frac{R}{R_v + R}$$

Error in V-meter reading:

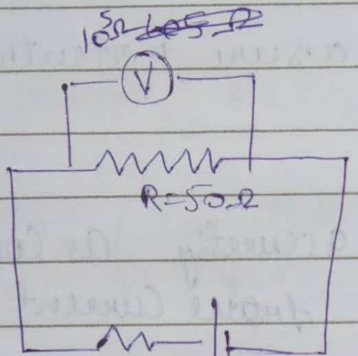
$V - V'$

$$\%\ \text{Error} = \frac{V - V'}{V} \times 100$$

$$\frac{I'R}{IR} \times 100$$

$$\% \text{ Error} = \frac{R}{R+R_v} \times 100$$

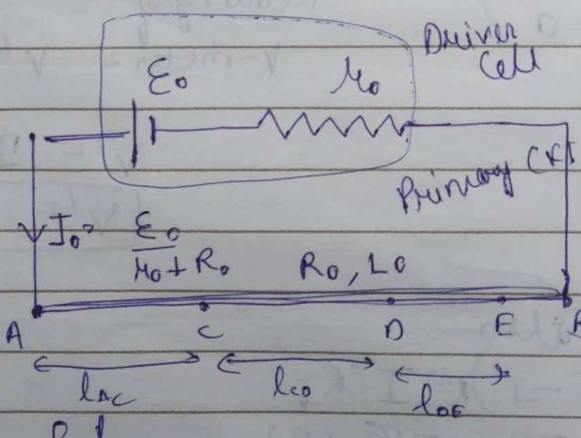
Eg



% Error in V-meter Reading

$$\frac{R}{R+R_v} \times 100 = \frac{50}{50+10^5} \times 100 \ \%$$

* Potentiometer



$$R = \frac{\rho l}{A}$$

A = const.

$R \propto l$ $\quad R_{AC} \propto l_{AC}$

$$R_0 \propto L_0$$

$$R_{AC} = \frac{l_{AC} R_0}{L_0}$$

V/m → $\boxed{x = \frac{I_0 R_0}{L_0}}$ = potential gradient

$V_{AC} = I_0 R_{AC} = \left(\frac{I_0 R_0}{L_0}\right) l_{AC} = x\, l_{AC}$

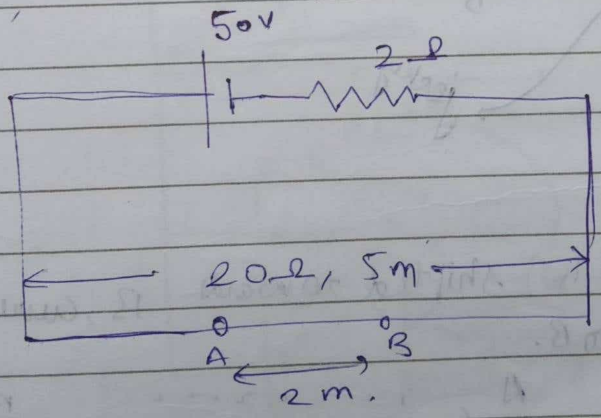
$V_{CD} = I_0 R_{CD} = \left(\frac{I_0 R_0}{L_0}\right) l_{CD}$

$V \propto l$
$V = x\, l$

$V_{DE} = x\, l_{DE}$

→ L_0 is the length of potentiometer wire.

R_0 = Resistance

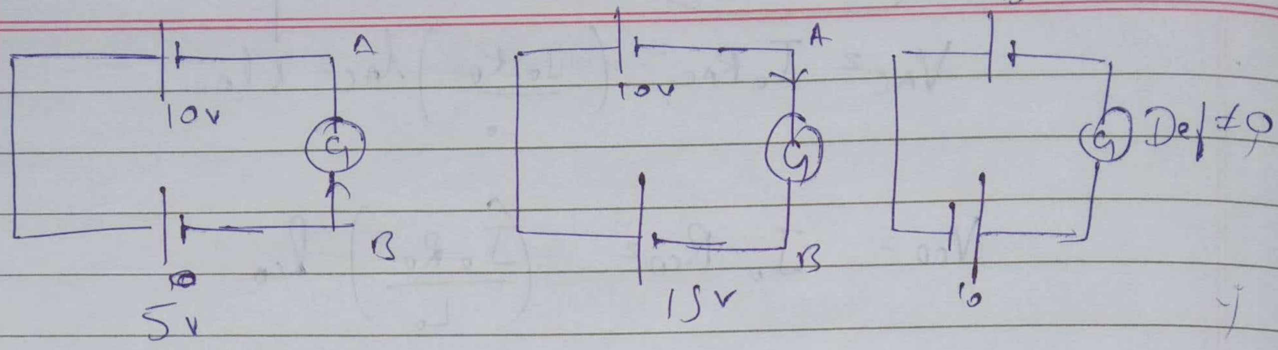


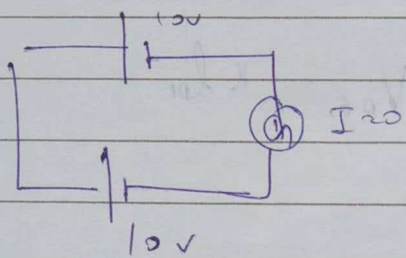
$V_{AB} = ?$

$I = \frac{50}{2+20} = \frac{50}{22}$

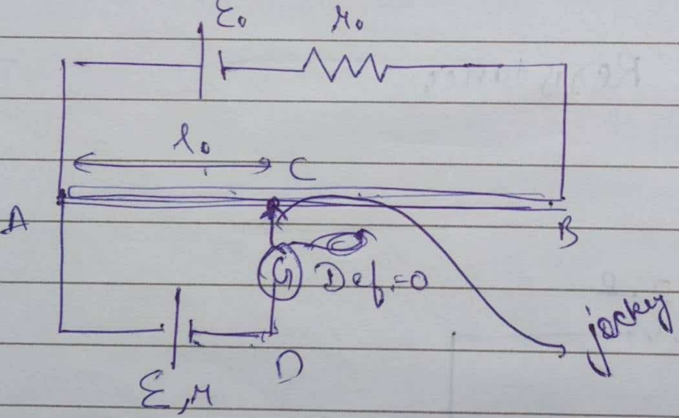
$V_{AB} = \frac{50}{22} \times \frac{20}{5} \times 2 = \frac{200}{11}$ V

*





Eg.



l_0 is balancing length
$E_1 = K l_0$

i) When jockey is shifted towards B, current in Galvano is from D to B.

ii) " " " " " " A, " " " " " B to D

If ($V_{AB} < E$) Then E never balance over potentiometer wire.

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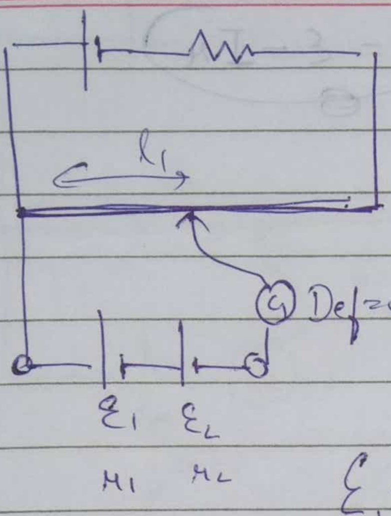
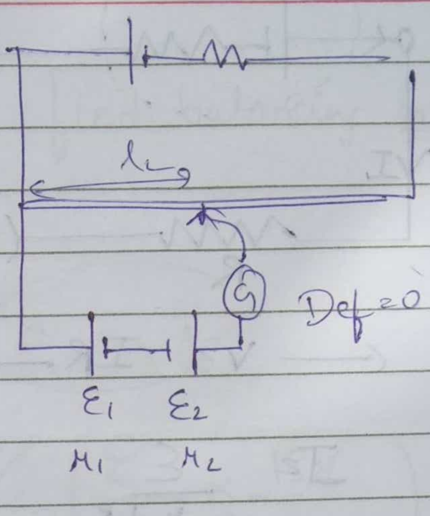


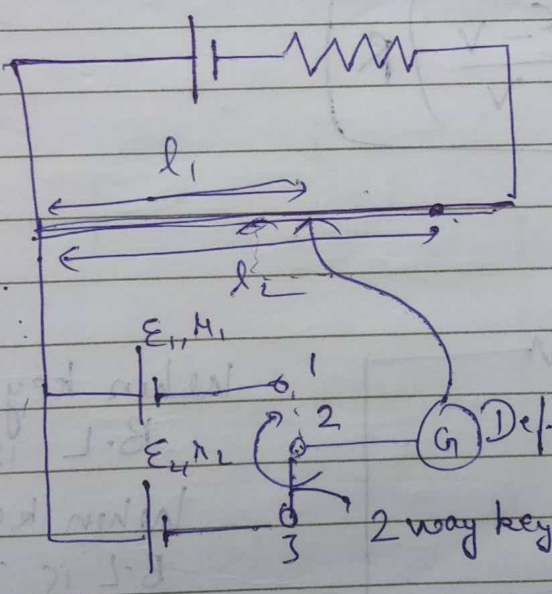


$\frac{\mathcal{E}_1}{\mathcal{E}_2} = ?$

$\mathcal{E}_1 + \mathcal{E}_2 = x l_1$

$\mathcal{E}_1 - \mathcal{E}_2 = x l_2$

Comparision of emf of 2 cells



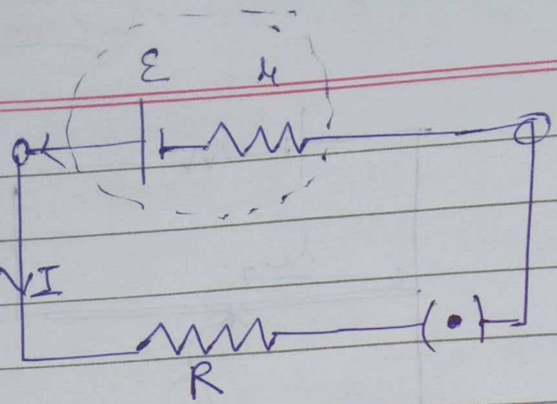
When 1 & 2 are
i) connected & Balance length is l_1 then $\mathcal{E}_1 = x l_1$

ii) if 2 & 3 are - - - - - - - - l_2 then $\mathcal{E}_2 = x l_2$

$$\frac{\mathcal{E}_1}{\mathcal{E}_2} = \frac{l_1}{l_2}$$

If $l_1 > l_2$ then $\mathcal{E}_1 > \mathcal{E}_2$ & vice versa.

Measurement of internal resistance of a cell using potentiometer.



$$V = \varepsilon - Ir$$

$\longleftarrow V = IR \longrightarrow$

$$I = \frac{\varepsilon}{r+R}$$

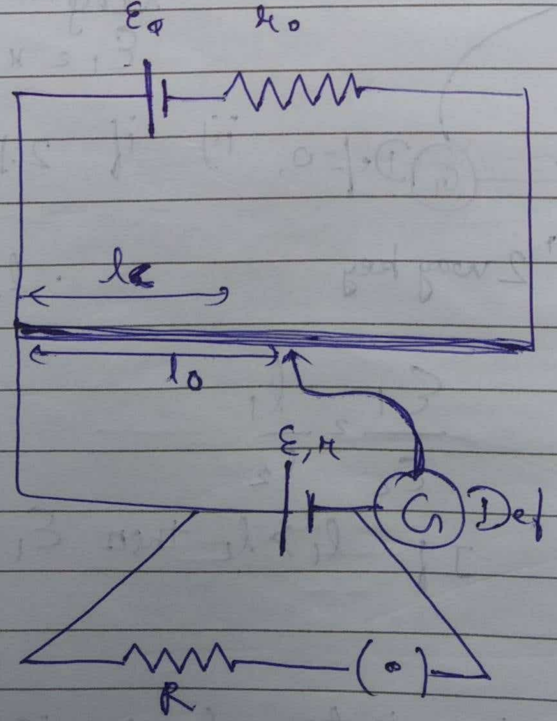
$$Ir + IR = \varepsilon$$

$$Ir + V = \varepsilon$$

$$r = \frac{\varepsilon - V}{I} \quad \left(I = \frac{V}{R}\right)$$

$$\boxed{r = \left(\frac{\varepsilon - V}{V}\right) R}$$

*



When key is open & B.L is l_0 then $\varepsilon = x l_0$

When key is closed & B.L is l_c then $V = x l_c$

$$\therefore r = \left(\frac{\varepsilon - V}{V}\right) R$$

$$r = \left(\frac{l_0 - l_c}{l_c}\right) R$$

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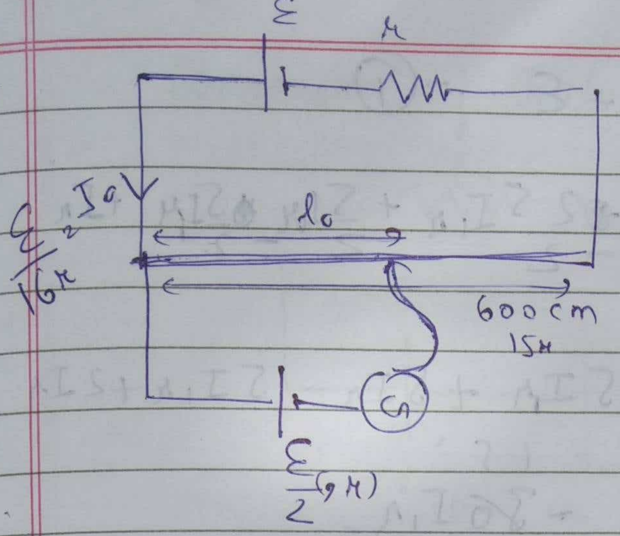
Eg*



find balancing length.

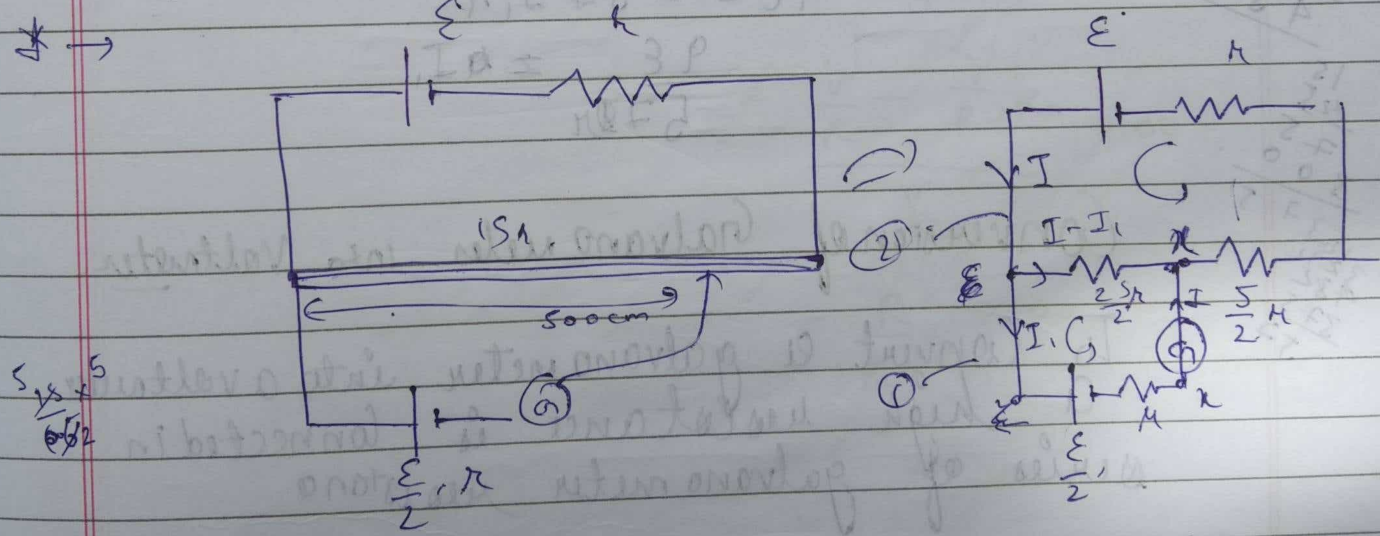
$\varepsilon_0 = x l_0$

$$\frac{\varepsilon}{2} = \left(\frac{\varepsilon}{(r+15r)} \times \frac{15r}{600}\right) l_0$$

$$\frac{600 \times 16}{15 \times 2} = l_0$$

$320\,cm = l_0$

* →



loop ① $-\frac{\varepsilon}{2} - I_1 r + (I - I_1)\frac{25}{2}r = 0$

loop ② $-(I - I_1)\frac{25}{2}r - (I - I_1)\frac{5}{2}r - Ir + \varepsilon = 0$

$$-\frac{\varepsilon}{2} - I_1 r + \frac{25}{2}Ir - \frac{25}{2}I_1 r = 0$$

$25Ir - 27I_1r = \mathcal{E}$ — (1)

(2) $\mathcal{E} = \frac{25}{2}Ir - \frac{25}{2}I_1r + \frac{5Ir}{2} - \frac{5I_1r}{2} + Ir$

$2\mathcal{E} = 25Ir - 25I_1r + 5Ir - 5I_1r + 2Ir$

$2\mathcal{E} = 32Ir - 30I_1r$

$\mathcal{E} = 16Ir - 15I_1r$

$\mathcal{E} = 25Ir - 27I_1r$

$16\mathcal{E} = 400Ir - 432I_1r$

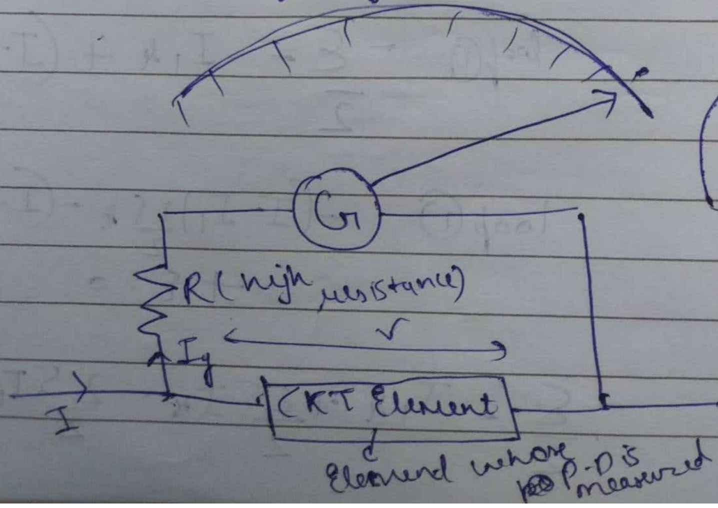
$25\mathcal{E} = 400Ir - 375I_1r$

$-9\mathcal{E} = -57I_1r$

$\frac{9\mathcal{E}}{57r} = I_1$

Conversion of Galvanometer into Voltmeter.

To Convert a galvanometer into a voltmeter. A high resistance is connected in series of galvanometer resistance



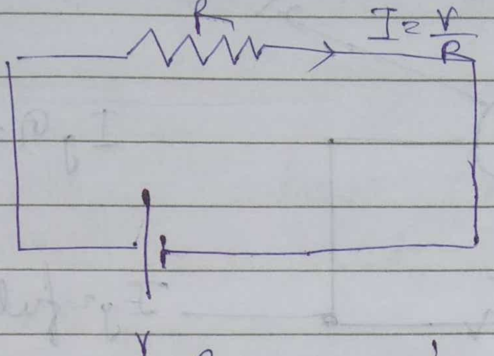
$$V = I_g(R+G)$$

full scale Def. Current = I_g

Voltmeter Resistance $R+G$

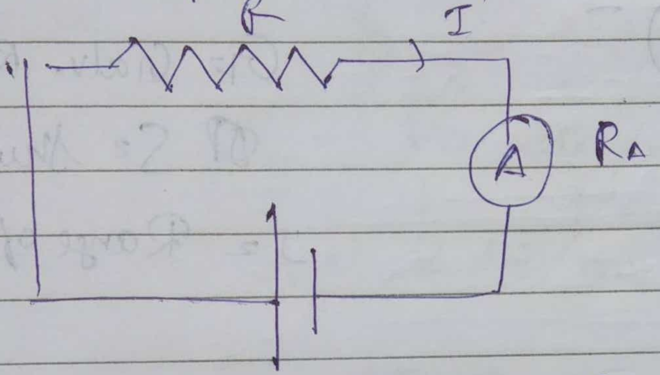
Range of voltmeter = V

Conversion of Galvanometer into Ammeter.



Ideally

$R_A = 0$



$$I' = \frac{V}{R+R_A}$$

% Error

$$= \frac{I - I'}{I} \times 100$$

$$= \frac{\frac{V}{R} - \frac{V}{R+R_A}}{\frac{V}{R}} \times 100$$

$$= \frac{R}{R+R_A} \times 100$$

To convert a Galvanometer into a Ammeter a small resistance is connected in parallel t[o] a Galvanometer which is called shunt.