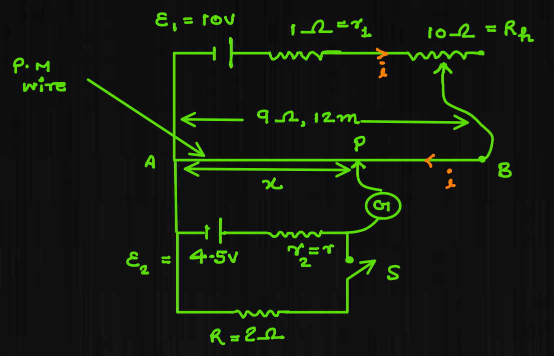
METER BRIDGE

08 August 2020 11:30

Q: In the primary circuit of potentiometer the rheostat can be varied from 0 to 10 Ω. Initially it was at '0' resistance.

a) find the length AP of the wire such that the (G) shows zero deflection.

b) Now the Rheostat is put at the maximum resistance i.e 10 Ω & the switch S is closed. New balancing length is found to 8m. find the internal resistance r of the 4.5 v cell.



∵ Potential gradient of P.M. wire

$\phi = i \times \frac{\rho}{A}$

$\Rightarrow \phi \propto i$

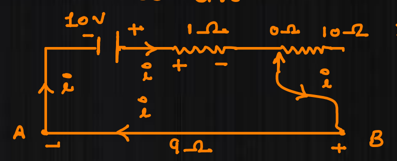
on changing the Rheostat i will change as well as ϕ.

a) when S is open, we are Balancing only the cell.

$\Rightarrow \varepsilon = \phi \times l_{cell}$

$\Rightarrow 4.5 = \phi \times x$ — (1)

for ϕ : openin the sec. circuit.



: $R_h = 0\,\Omega$ (open circuit)

$\because i = \frac{\varepsilon}{R_{wire} + r} = \frac{10}{9+1} = 1A$

$\because \phi = \frac{V_{AB}}{L_{AB}} = \frac{i \times R_{AB}}{L_{AB}} = \frac{1 \times 9}{12}$

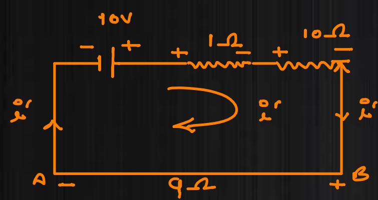
P. Grad of PM wire $\Rightarrow \phi = \frac{3}{4}\ v\cdot m^{-1}$ — (2)

from (1) & (2)

$4.5 = \frac{3}{4} \times x$

$x = 6m$; Balancing length of the cell alone.

b) for new ϕ (as we change the R_h, the current in P.M. will change)



new current in P.M. wire

$i' = \frac{\varepsilon}{\{(R_w + R_h) + r\}} = \frac{10}{20} = 0.5A$

$\therefore$ new P.Grad. of the wire $(\phi') = \frac{V_{AB}}{L_{AB}} = \frac{i' \times R_{AB}}{L_{AB}} = \frac{4.5}{12} \frac{V}{m}$ — (3)

on Balancing the cell again

$\varepsilon = \phi' \times l_c'$

$4.5 = \frac{4.5}{12} \times l_c'$

new Balancing Length of cell $l_c' = 12m$ — (4)

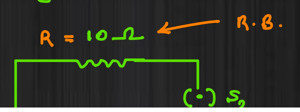
∵ when we balance (cell + R.B) comb.

$r = R \cdot \left\{ \frac{l_c}{l_{c+R.B}} - 1 \right\}$

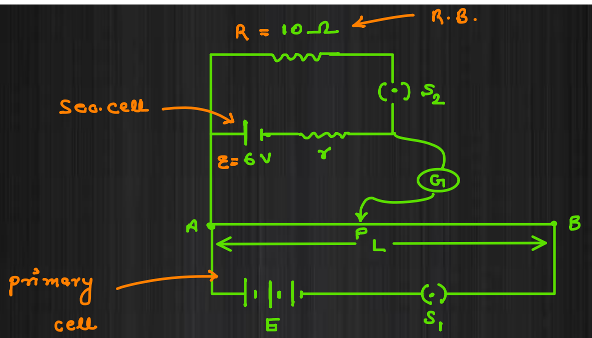
$\therefore r = 2 \times \left\{ \frac{12}{8} - 1 \right\} = \frac{2}{8} \times 4 = 1\Omega$

Q:→ In the arrangement shown in the fig. when the switch S_2 is open, Balancing length is found $\frac{L}{2}$, when the switch S_2 is closed balancing Length becomes $\frac{5L}{12}$, Find:
i) the internal resistance of the cell is 6V.
ii) EMF of the primary cell.

Soln:→



Solⁿ :→



a) Given : $L_c = \frac{L}{2}$ & $L_{c+R.B} = \frac{5L}{12}$

$$\because \quad r = R\cdot\left\{\frac{L_c}{L_{c+RB}} - 1\right\}$$

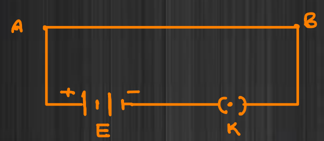
$$= 10\cdot\left\{\frac{L}{2}\times\frac{12}{5L} - 1\right\}$$

$$= 10\left\{\frac{6}{5} - 1\right\}$$

$$= 10\times\frac{1}{5}$$

internal resistance of cell $(r) = 2\,\Omega$

b)



$\because (\Delta V_{AB})_{wire} = (\Delta V_{AB})_{cell}$

$\therefore \quad V_{AB} = E$

$\therefore$ potential Gradient of the P.M. wire

$$\phi = \frac{V_{AB}}{L_{AB}} = \frac{E}{L} \quad \text{—①}$$

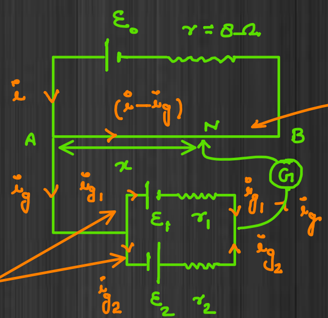
on balancing the Secondary cell ;

$$\varepsilon = \phi \times L_{AN}$$

$$6 = \frac{E}{L}\times\frac{L}{2}$$

EMF of the primary cell $\quad \therefore \quad E = 12$ volt

Q:→ A battery of emf $\varepsilon_0 = 12\,V$ is connected across a 4m long wire having resistance $4\,\frac{\Omega}{m}$. The cells of EMF $\varepsilon_1 = 4V$ & $\varepsilon_2 = 2V$ having internal resistances $r_1 = 6\,\Omega$ & $r_2 = 2\,\Omega$ respectively are connected as shown in the fig. find the Balancing length.



$l_{AB} = 4m$; $\frac{R_{AB}}{L_{AB}} = 4\,\frac{\Omega}{m}$

$\Rightarrow R_{AB} = 4\times L_{AB} = 16\,\Omega$

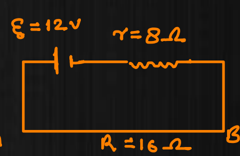
$$\varepsilon_{eq} = \frac{\left|\frac{\varepsilon_1}{r_1} - \frac{\varepsilon_2}{r_2}\right|}{\left(\frac{1}{r_1} + \frac{1}{r_2}\right)}$$

$$= \frac{\left|\frac{4}{6} - \frac{2}{2}\right|}{\left(\frac{1}{6} + \frac{1}{2}\right)} = \frac{\left|\left(\frac{2}{3} - 1\right)\right|}{\frac{4}{6}} = \frac{1}{3}\times\frac{3}{2}$$

$\varepsilon_{eq} = 0.5$ volt —①

EMF of sec. cells

to calculate ϕ opening the sec. circuit ;



$$\because \quad i = \frac{\varepsilon_0}{R + r} = \frac{12}{24} = 0.5\,A$$

$$\Rightarrow \phi = \frac{V_{AB}}{L_{AB}} = \frac{i\times R_{AB}}{L_{AB}} = 0.5\times 4 = 2\,V/m \quad \text{—②}$$

pot grad. of the wire

$\because \varepsilon_{eq} = \phi \times l_{AN}$

$0.5 = 2\times l_{AN}$

$\therefore l_{AN} = \frac{1}{4} = 0.25\,m.$

Meter Bridge :→ it is a device which is used to determine any unknown resistance.

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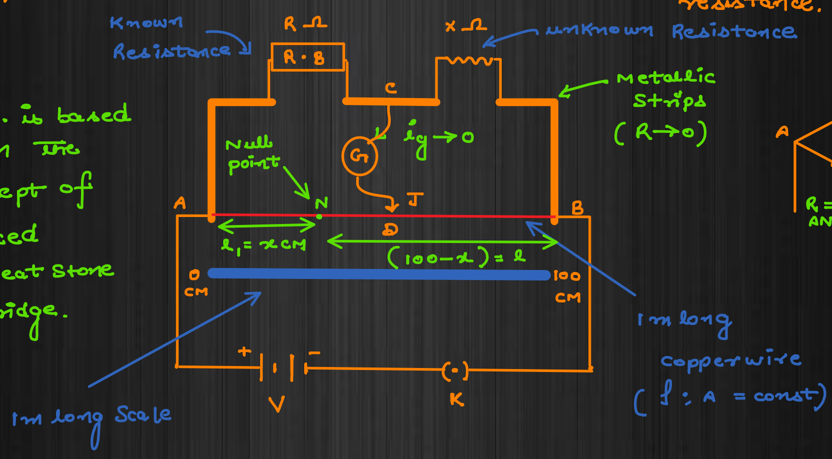
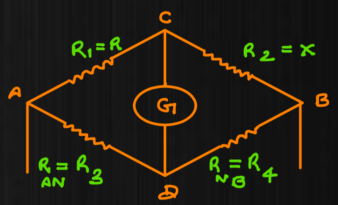
Meter Bridge :→



Concept :→ M.B. is based upon the concept of balanced wheat stone Bridge.



if $\frac{R_1}{R_2} = \frac{R_3}{R_4}$

then $V_C = V_D$; ie $\Delta V_{CD} = 0$

then $i_g = 0$

then the W-S Bridge is balanced.

$$R_{AN} = \frac{\rho . l_{AN}}{A} = \frac{\rho . x}{A} \quad —①$$

$$\& \quad R_{NB} = \frac{\rho \times l_{NB}}{A} = \frac{\rho \times (100 - x)}{A} \quad —②$$

as G shows zero deflection:

⇒ Meter Bridge becomes balanced.

Then : $\frac{R_1}{R_2} = \frac{R_3}{R_4}$

$$\Rightarrow \frac{R}{X} = \frac{R_{AN}}{R_{NB}}$$

from ① & ② : $\boxed{\frac{R}{X} = \frac{l_{AN}}{l_{NB}}}$ or $\frac{R_1}{R_2} = \frac{l_1}{l_2}$

$$\frac{R}{X} = \frac{x}{(100-x)}$$

$$\boxed{X = \frac{R \times (100-x)}{x}} \quad —(*)$$

here : x is the position of Null point from 0cm Mark.

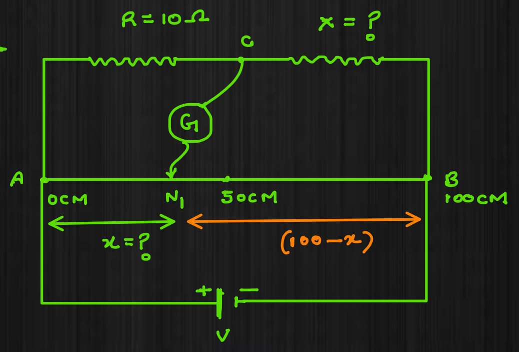
Q:→ for a M.B. the known resistance of 10 Ω & unknown resistance is X Ω. when their places in the M.B. get interchanged, the Null shifts by 10cm. find:

i) Balancing Length in the first case

ii) value of X.

Given : X > 10 Ω.

Sol^n:→ Case ① :→

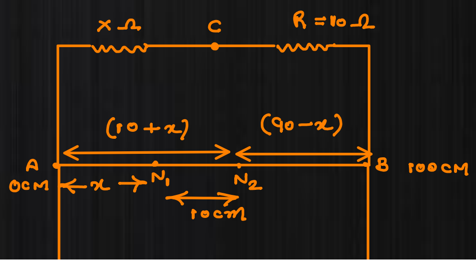


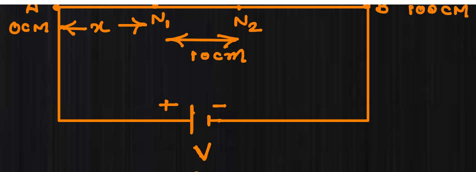
$$\because \frac{R}{X} = \frac{l_{AN_1}}{l_{N_1B}}$$

$$\frac{10}{X} = \frac{x}{(100-x)} \quad —①$$

Case 2:→ when positions of the resistances are interchanged, the position of the new null point further increases by 10cm

as X > R





here; $\dfrac{X}{R} = \dfrac{l_{AN_2}}{l_{N_2B}}$

$$\Rightarrow \frac{X}{10} = \frac{(10+x)}{(90-x)} \quad \text{—} ②$$

from ① & ②

$$1 = \frac{x}{(100-x)} \times \frac{(10+x)}{(90-x)}$$

$$9000 - 190x + x^2 = 10x + x^2$$

$$9000 = 200x$$

$$\therefore x = 45\,\text{cm}. \quad \text{—} ③$$

position of the null point in the initial case

from eqn ①

$$\frac{10}{X} = \frac{45}{(100-45)}$$

$$\Rightarrow X = \frac{10 \times 55}{45}$$

$$= \frac{110}{9}$$

unknown Resistance ⇒ $X = 12.2\ \Omega$