# Potentiometer

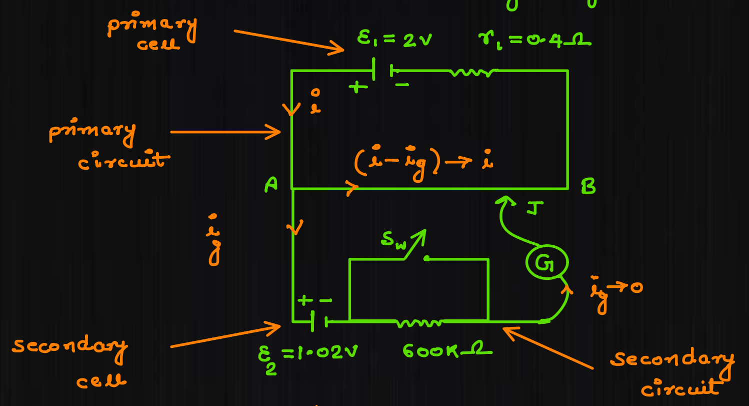
07 August 2020 11:32

Q: The figure shows a potentiometer with a cell of EMF 2V & internal resistance 0.4 Ω maintaining a constant potential differen about the potentiometer wire AB. A Standard (ie ideal) cell of EMF 1.02 V gives a balance point at 67.3 cm Length of the wire. To ensure very low current drawn from the standard cell a very high resistance of 600 kΩ is put in the series with it, which is shortcircuited very close to the balancing point, then the cell is replaced with another cell of EMF ε volts & the null point is found at 82.3 cm. Find:

i) emf ε of the cell

ii) why the 600 kΩ resistance is connected in series

iii) what will the new balancing lengths if the switch is closed.




The 600 kΩ resistance is used to make sure no current pass through the secondary circuit ie: $i_g \to 0$, so the potential gradient of the P.M. wire remain same as before connecting the Jockey on the wire.

for cell 1

$\varepsilon_1 = \varphi \cdot l_1$ — ①

for cell 2

$\varepsilon_2 = \varphi \cdot l_2$ — ②

Potential gratient of the wire

$\varphi = \frac{V}{L} = \frac{\varepsilon}{l_1} = \frac{1.02}{0.673} = 1.52 \frac{V}{m}$ — ✱

from ②/①

$\frac{\varepsilon_2}{\varepsilon_1} = \frac{l_2}{l_1}$

$\varepsilon_2 = \varepsilon_1 \times \frac{l_2}{l_1}$

$= 1.02 \times \frac{82.3}{67.3}$

EMF of the unknown cell $= 1.02 \times 1.22$

$\Rightarrow \varepsilon_2 = 1.25$ volt

if we close the switch, 600 kΩ becomes short circuited as we found the New Null points $\varepsilon_1 = \varphi \times l_1'$ & $\varepsilon_2 = \varphi \times l_2'$

$\because \varphi = $ const & do not change

so $l_1' = \frac{\varepsilon_1}{\varphi} = \frac{1.02}{1.52} = 0.63m$ & $l_2' = \frac{\varepsilon_2}{\varphi_2} = \frac{1.25}{1.52} = 0.82 m$

ie; Balancing length of both the cells will remain same.

Q:→ in the following P.M. circuit comparision of 2 resistances is done. Balance point of the standard resistor R = 10 Ω is at 58.3 cm, while the balance point of the unknown resistance X is found at 68.5cm. Find the value of X if the Null point of the cell is found at 78.4cm.

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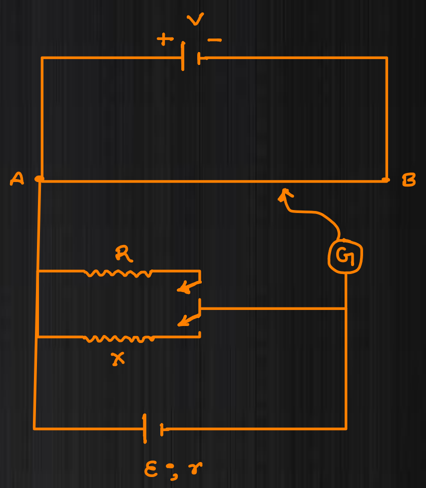
Sol$^n$:→ Given; $l_{cell} = 78.4$ cm




when we connect R with cell & Balance;

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

$$= 10 \times \left\{ \frac{78.4}{58.3} - 1 \right\}$$

$$r = 10 \times 0.34$$

$\therefore\ r = 3.4\,\Omega$ — ①

internal Resistance of the secondary cell

when we balance x with the cell;

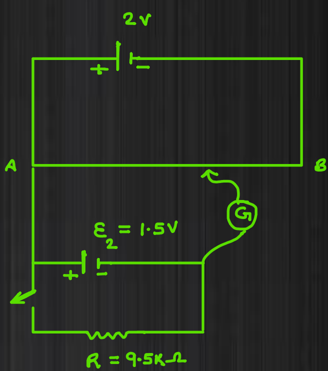
$$r = x \cdot \left\{ \frac{l_c}{l_{C+RB}} - 1 \right\}$$

$$3.4 = x \cdot \left\{ \frac{78.4}{68.5} - 1 \right\}$$

$$3.4 = x \cdot 0.14$$

$$\therefore\ x = \frac{3.4}{0.14} = 24.3\,\Omega$$

Q: In the following P.M. circuit, open circuit balance point of the cell is found at 76.3 cm, when a resistor of 9.5 kΩ is used in parallel with the cell the balance point shifts to 64.8 cm. find the internal resistance of the cell.




$\because\ l_{cell} = 76.3$ cm

& $l_{C+R\cdot B} = 64.8$ cm

$R = 9.5$ KΩ

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

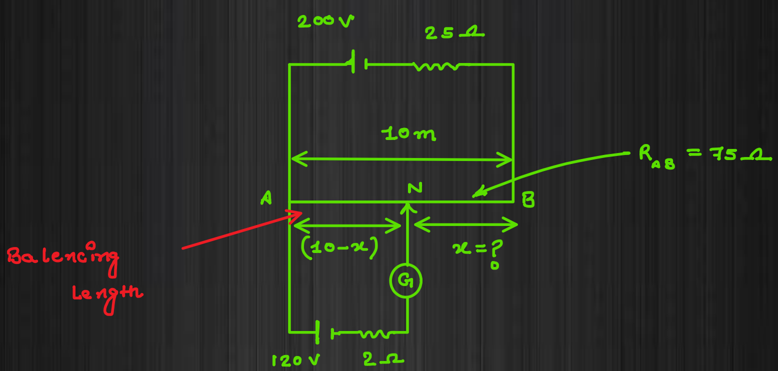
$$= 9.5 \times 10^3 \times \left\{ \frac{76.3}{} \right.$$

$$= 9.5 \times 10 \times 0.18$$

$$= 1.71 \times 10^3$$

$\therefore\ r = 1710\,\Omega$

Q:→ find the value of x, if N is the null point.

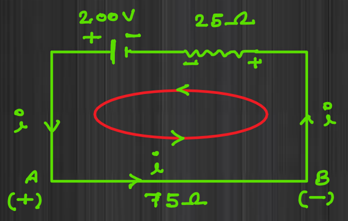



after finding the Null point

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

$$120 = \phi \times (10 - x) \text{ — ①}$$

To find the potential gradient of the P.M wire, considering the primary circuit in open circuit condition considering the primary circuit in open circuit condition of the secondary cell.




$$-75i - 25i + 200 = 0$$

$$\therefore i = \frac{200}{100} = 2A \text{ — ② } ; \text{ current in the primary circuit}$$

$\therefore$ potential gradient of the wire

$$\varphi = \frac{V_{AB}}{L_{AB}} = \frac{i \times R_{AB}}{L_{AB}} = \frac{2 \times 75}{10}$$

$$\therefore \varphi = 15\ V/m \text{ — ③}$$

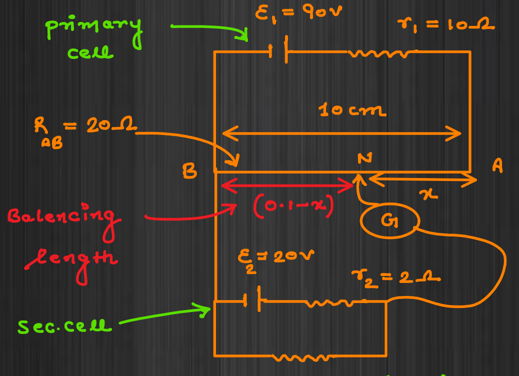
from ① & ②

$$120 = 15 \times (10 - x)$$

$$30 = 15x$$

$$\therefore x = \frac{30}{15} = 2m$$

Q: find the value of $x$, if N is the Null point.




$R = 2Ω$ (R.B.)

$\because$ internal resistance of the secondary cell

$$r = R \cdot \left\{ \frac{l_c}{l_{C+RB}} - 1 \right\} \text{ — ①}$$

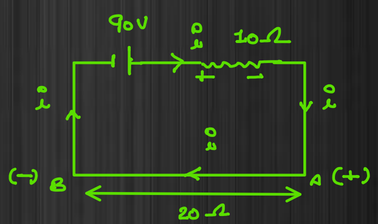
here: $l_{C+RB} = (0.1 - x)$ ; $l_c = ?$

if we balance the sec. cell only;

$$\varepsilon_2 = \varphi \times l_c$$

$$\Rightarrow 20 = \varphi \times l_c \text{ — ②}$$

for potential gradient of the P.M. considering the primary circuit only in the open circuit condition of the sec. circuit.




$$-10i - 20i + 90 = 0$$

$$i = \frac{90}{30}$$

$$\therefore i = 3A \; ; \text{ current in the primary circuit}$$

$\therefore\ i = 3\,A$ ; current in the primary circuit

so potential gradient of the wire

$$\phi = \frac{V_{AB}}{L_{AB}} = \frac{i \times R_{AB}}{L_{AB}} = \frac{3 \times 20}{0.1} = 600\ V \cdot m^{-1} \quad \text{—— (3)}$$

from (2) & (3)

$$20 = 600 \times l_c$$

$$\therefore\ l_c = \frac{20}{600} = \frac{1}{30}\,m \ ; \quad \text{Balancing length of cell.}$$

from (1)

$$2 = 2 \times \left\{ \frac{1}{30 \times (0.1 - x)} - 1 \right\}$$

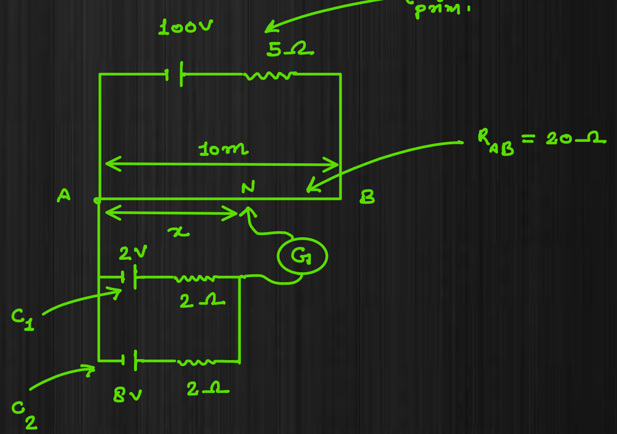
$$1 = \frac{1}{3 - 30x} - 1$$

$$2 = \frac{1}{3 - 30x}$$

$$6 - 60x = 1$$

$$\therefore\ x = \frac{5}{60} = \frac{1}{12} = 0.833\,m = 8.33\,cm.$$

Q:→ find $x$ if N is null point for the combination of cells shown




Soln:→ here; $\varepsilon_{eq} = \dfrac{\left\{ \frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2} \right\}}{\left\{ \frac{1}{r_1} + \frac{1}{r_2} \right\}} = \dfrac{\left( \frac{2}{2} + \frac{8}{2} \right)}{\frac{1}{2} + \frac{1}{2}} = \dfrac{(1+4)}{1} = 5V$ ; equivalent EMF of the cell combination

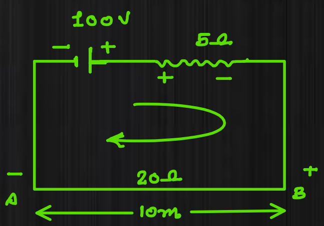
$C_1$ & $C_2$ are in parallel

as this cell combination get balanced

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

$$5 = \phi \times x \quad \text{—— (1)}$$

for the primary circuit in open circuit condition for the cells $C_1$ & $C_2$




$$-5i - 20i + 100 = 0$$

current in P.M. wire $\Rightarrow i = \frac{100}{25} = 4\,Amp$ —— (2)

so potential gradient of the wire

$$\phi = \frac{V_{AB}}{L_{AB}} = \frac{i \cdot R_{AB}}{L_{AB}} = \frac{4 \times 20}{10} = 8\,\frac{V}{m} \quad \text{—— (3)}$$

from (1) & (3)

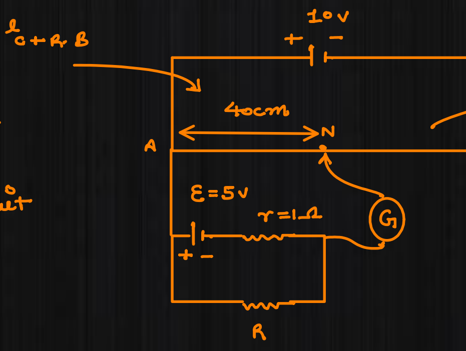
$$5 = 8 \times x$$

$$\therefore\ x = \frac{5}{8}\,m$$

$5 = 8 \times x$

$\therefore \ x = \frac{5}{8} \, m$

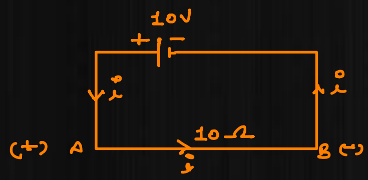
Q: A potentiometer wire AB is 100cm long & has a total resistance of 10Ω. If the Null point is found at 40 cm, if the value of resistance R.




$L_{AB} = 1m; \ R_{AB} = 10\Omega$

Sol$^n$ →

potential gradient of the wire in open circuit condition




$$\phi = \frac{V_{AB}}{L_{AB}} = \frac{10}{1} = 10 \ V \cdot m^{-1} \quad \text{—— (1)}$$

so on Balancing the cell alone;

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

so $l_{cell} = \frac{5}{10} = \frac{1}{2} = 0.5 m$ —— (2)

i.e; Balancing Length of the cell alone.

if we Balance the (cell + R.B) together;

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

$$\Rightarrow 1 = R \cdot \left\{ \frac{0.5}{0.4} - 1 \right\}$$

$$\Rightarrow 1 = R \times \frac{0.1}{0.4}$$

$$\therefore R = 4 \Omega$$