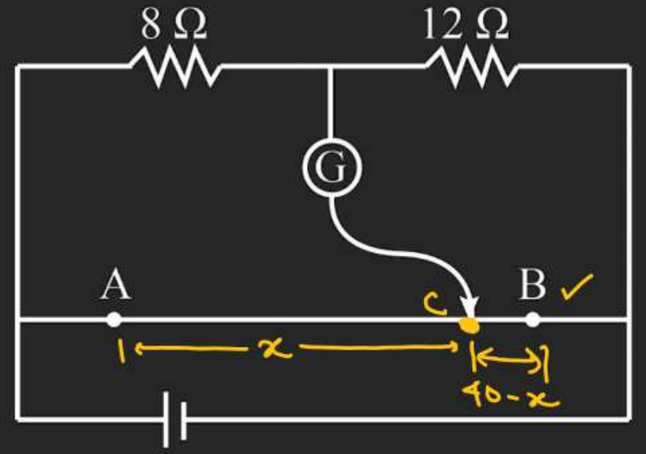
Nishant Jindal

CURRENT ELECTRICITY

Potentiometer and Meter Bridge

Q.1 The wire AB used in a balancing circuit shown in figure is 40 cm long. At what distance from point A the free end of the galvanometer should be connected on AB so that the galvanometer shows zero deflection?



Soln :→

At the time of Null deflection.

$$\frac{8}{R_{AC}} = \frac{12}{R_{CB}}$$

$$\frac{R_{CB}}{R_{AC}} = \frac{12}{8} \Rightarrow \frac{40-x}{x} = \frac{3}{2}$$

$$\Rightarrow 80 - 2x = 3x \Rightarrow 5x = 80 \Rightarrow x = 16\,cm$$

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

$R \propto \ell$

$R_{AC} = \frac{\rho x}{A}$

$R_{CB} = \frac{\rho (40-x)}{A}$

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Another Method :

$$R_{AC} = \left(\frac{\rho l_{AC}}{A}\right)$$

$$V_{AC} = i R_{AC}$$

$$= \frac{1}{10} \times \frac{\rho}{A} \times l_{AC}$$

$$\Rightarrow V_{AC} = \frac{1}{10} \times \frac{15}{2} \times l_{AC}$$

$i = \frac{1}{10}$ Amp.

$R_{AB} = 15$

$\frac{\rho \cdot l}{A} = 15$

$\frac{\rho}{A} = \left(\frac{15}{2}\right)$

At the time of Null deflection.

$V_{AC} = 3$

$\downarrow\downarrow$

$\frac{3}{4} l_{AC} = 3$

$$\boxed{l_{AC} = 4m}$$

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$\left(\frac{V}{L}\right)$ = Potential gradient.

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Q.2 Figure shows a 200 cm potentiometer wire AB with resistance 15Ω. Find the potential gradient of this potentiometer and also find the balancing length for a 3 V cell.

2m

Sol^{n}

$l_{AC} = ??$

$R_{AB} = 15\Omega$

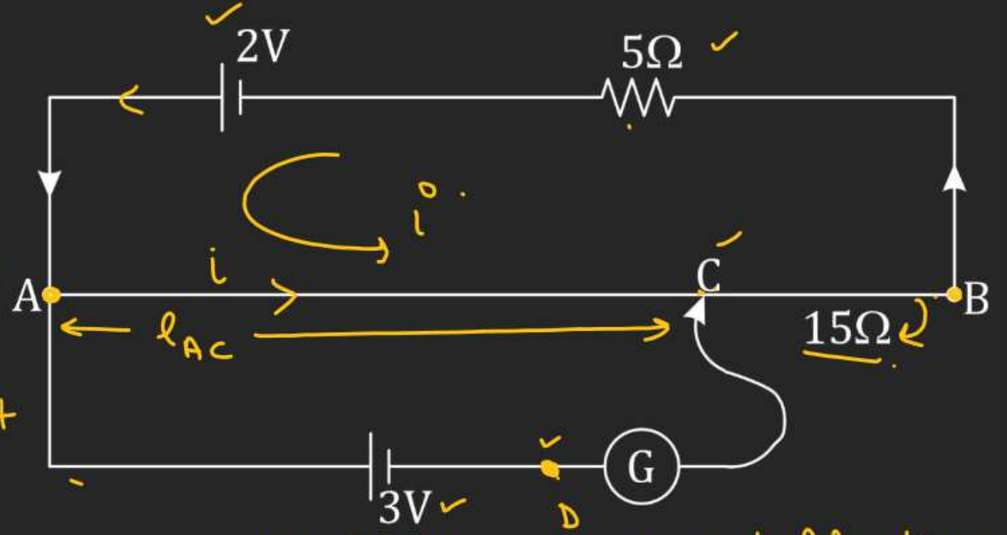
Current in primary Ckt $= \frac{2}{20} = \frac{1}{10}$ Amp

$V_{AB} = i R_{AB} = \frac{1}{10} \times 15 = \frac{3}{2}$ Volt

Potential gradient $= \frac{V_{AB}}{L_{AB}} = \frac{3}{2 \times 200 \times 10^{-2}}$

$= \frac{300}{400} = \left(\frac{3}{4}\ V/m\right)$

(Balancing length not possible)



At the time of Null deflection

$3 = V_{AC} = \frac{3}{4} \times l_{AC}$

$l_{AC} = 4m$

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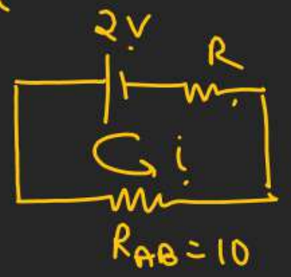
Q.3 A potentiometer wire of length $100\ \text{cm}$ has a resistance of 10Ω. It is connected in series with a resistance and a cell of emf $2\ \text{V}$ and of negligible internal resistance. A source of emf 10mV is balanced against a length of $40\ \text{cm}$ of the potentiometer wire. What is the value of external resistance?

R_{AB}.

l_{AC} Current in primary ckt

$R_{AB} = 10\Omega$



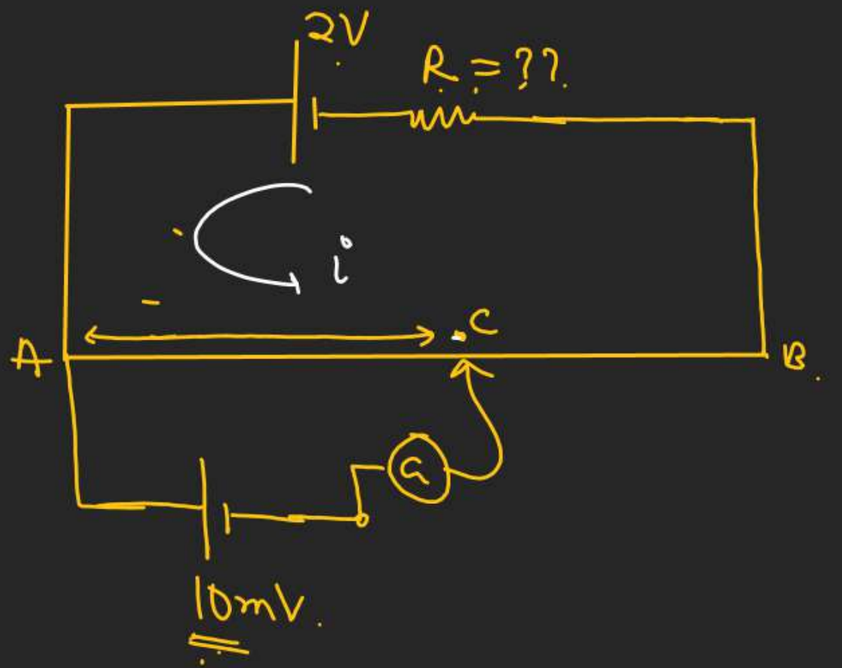
At the time of Null deflection.

$$i = \left(\frac{2}{10+R}\right)$$

$$V_{AC} = (10\times10^{-3})$$

$$V_{AB} = I\cdot R_{AB} = \left(\frac{2}{10+R}\right)\times10 = \left(\frac{20}{10+R}\right)$$

$$\text{Potential gradient} = \frac{V_{AB}}{L_{AB}} = \left(\frac{20}{10+R}\right)\times\frac{1}{1\text{m}} = \left(\frac{20}{10+R}\right)$$



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$\ell_{AC} = 40\,cm$

$$V_{AC} = \left(\frac{20}{10+R}\right)\ell_{AC} = \left(\frac{20}{10+R}\right) \times 40 \times 10^{-2}$$

At the time of null deflection

$$V_{AC} = (10 \times 10^{-3})$$

$$\left(\frac{20}{10+R}\right) \times (40 \times 10^{-2}) = (10 \times 10^{-3})$$

$$\frac{20}{10+R} = \frac{1}{4} \times 10^{-1} = \frac{1}{40}$$

$$800 = 10 + R \Rightarrow R = (800 - 10)$$

$$R = 790\,\Omega$$

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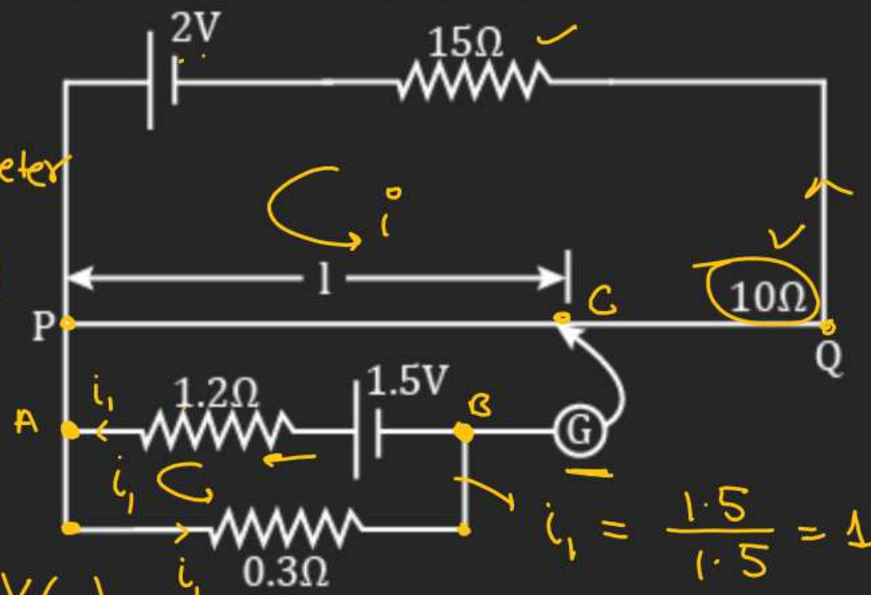
Q.4 Figure shows a potentiometer with length of wire $1\ m$ and resistance 10Ω. In this system find length PC when galvanometer shows null deflection.



Sol^n

$R_{PQ} = 10\Omega$ (Resistance of Potentiometer wire)

V_{PQ} = Potential difference across potentiometer wire

$i = \left[\frac{2}{25}\right]$

Potential gradient $= \frac{V_{PQ}}{L_{PQ}}$

$V_{PQ} = iR_{PQ}$

$= \left(\frac{2}{25}\right) \times 10$

$= \frac{20}{25} = \left(\frac{4}{5}\ V/m\right)$

$V_{PC} = \left(\frac{V_{PQ}}{L_{PQ}}\right) \times l_{PC}$

From ① & ⑪

$= \left(\frac{4\, l_{PC}}{5}\right)$ — ①

At the time of Null deflection

$V_{PC} = 0.3V$ — ⑪

$0.3 = \frac{4}{5} l_{PC}$

$l_{PC} = \frac{0.3 \times 5}{4} = \frac{1.5}{4} = 3.75 \times 10^{-1}$

$= 0.375\ m = 37.5\ cm$ ✓

$i_1 = \frac{1.5}{1.5} = 1\ Amp.$

$V_B + 1.5 - 1.2 i_1 = V_A$

$V_A - V_B = 1.5 - 1.2 \times 1$

$= 0.3\ Volt$

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CURRENT ELECTRICITY

Potentiometer and Meter Bridge

Q.5 The potentiometer wire AB is 600 cm long.

(a) At what distance from A should the jockey J touch the wire to get zero deflection in the galvanometer.

(b) If the jockey touches the wire at a distance 560 cm from A, what will be the current through the galvanometer.

Slider

Sol^{n} let, 'C' be the point of null deflection.

$R_{AB} = 15r$.

$i = \left(\frac{E}{16r}\right)$

$V_{AB} = iR_{AB} = \frac{E}{16r} \times 15r = \left(\frac{15E}{16}\right)$

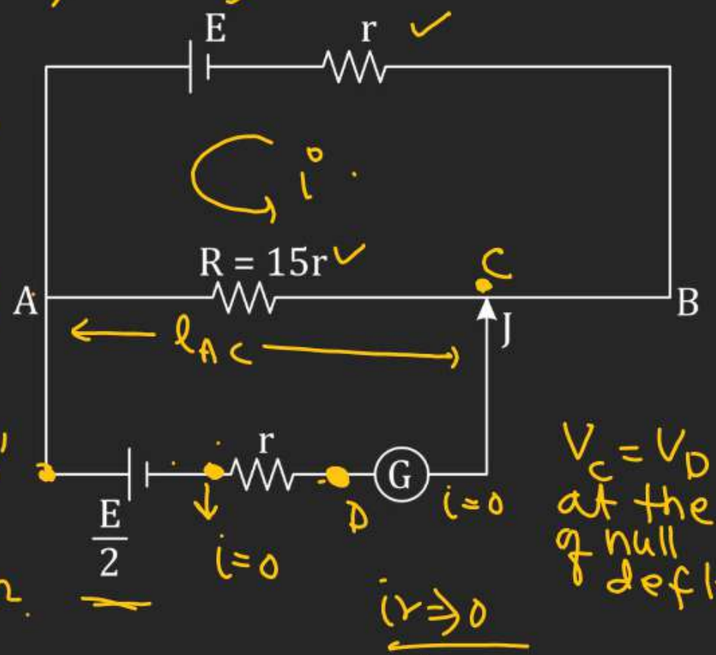
Potential gradient $= \frac{V_{AB}}{L_{AB}} = \left(\frac{15E}{16 \times 6}\right)$

At the time of Null deflection

$\left(\frac{15E}{16\times6}\right) \times l_{AC} = \frac{E}{2} \Rightarrow l_{AC} = \frac{16\times6}{2\times15} = \frac{16}{5}$ m.

V_{AC}

$l_{AC} = 3.2\text{m} = 320\text{cm}$



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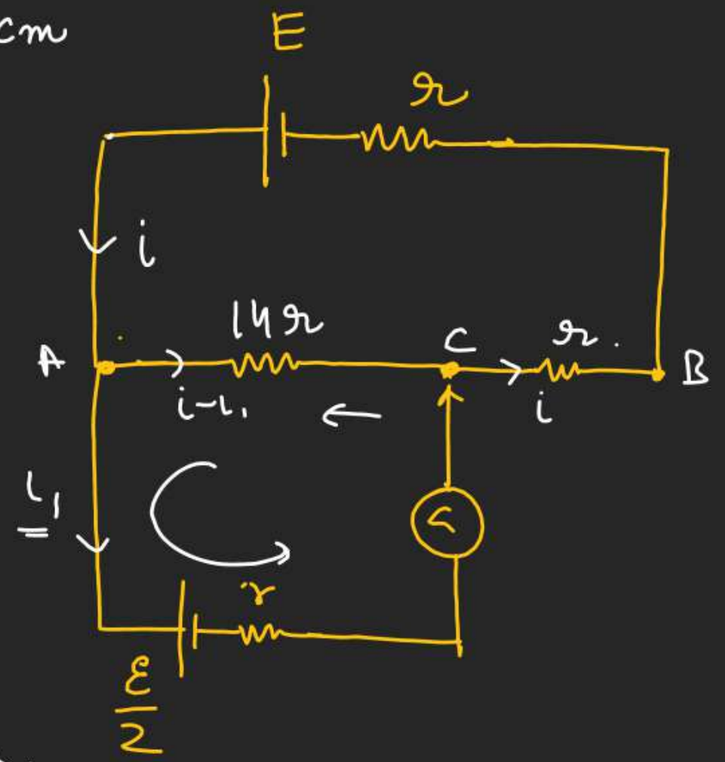
$L_{AB} = 60cm$



(8)

Resistance per Unit length $= \left(\frac{15r}{600}\right)$

Resistance of 560cm wire $= \frac{15r}{600} \times 560$

$= \frac{15r}{60} \times 56$

$= 14r$ ✓

K.V.L in upper loop

$-ir + E - (1-i_1)14r - ir = 0$

$-ir + E - 14ir + 14i_1r - ir = 0$

$E - 16ir + 14i_1r = 0 \quad -(1)$

KVL in lower loop

$-\frac{\varepsilon}{2} - i_1r + (1-i_1)14r = 0$

$-\frac{\varepsilon}{2} - i_1r + 14ir - 14i_1r = 0$

$-\frac{\varepsilon}{2} + 14ir - 15i_1r = 0 \quad -(2)$

$i = ?$

$i_1 = ?$ ✓

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CURRENT ELECTRICITY

Potentiometer and Meter Bridge

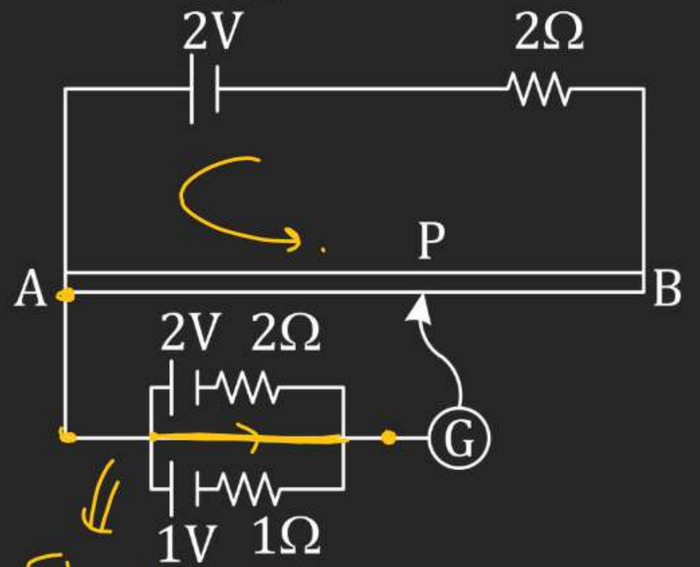
Q.6 A battery of emf $2\ \text{V}$ is connected across a long uniform wire AB of length $1\ \text{m}$ and resistance per unit length $2\Omega\text{m}^{-1}$. Two cells of emf $\varepsilon_1 = 1\ \text{V}$ and $\varepsilon_2 = 2\ \text{V}$ are connected as shown in the fig. If the galvanometer shows no deflection at point P, the distance of point P from point A is equal to :

(A) 0

(B) $50\ \text{cm}$

(C) $100\ \text{cm}$

(D) $25\ \text{cm}$



CURRENT ELECTRICITY

Potentiometer and Meter Bridge

Q.7 A battery of emf $\varepsilon_0 = 12\ \text{V}$ is connected across a $4\ \text{m}$ long uniform wire having resistance $4\Omega/\text{m}$. The cells of small emfs $\varepsilon_1 = 2\ \text{V}$ and $\varepsilon_2 = 4\ \text{V}$ having internal resistance 2Ω and 6Ω respectively, are connected as shown in the figure. If galvanometer shows no deflection at the point N, the distance of point N from the point A is equal to :

(A) $\frac{1}{6}$ m

(B) $\frac{1}{3}$ m3

(C) 25 cm

(D) 50 cm

$R_{AB} = (4\times4) = 16\Omega$

$i = \frac{12}{16+8} = \frac{12}{24}$

$i = \frac{1}{2}$ Amp.

$V_{AN} = \frac{1}{2}\times R_{AN}$

$= \frac{1}{2}\times 4\times l_{AN} = (2l_{AN})$

At the time of Null deflection $\Rightarrow V_{AN} = V_C - V_D$

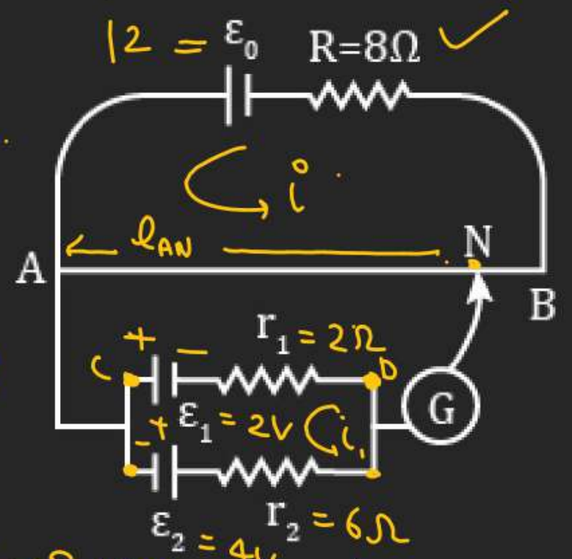
$\Rightarrow 2l_{AN} = \frac{1}{2}$

$\frac{R_{AB}}{L_{AB}} = 4\Omega/\text{m}$, $L_{AB} = 4\text{m}$.

$2 + 4 - 8i_1 = 0$

$\frac{6}{8} = i_1$

$i_1 = \frac{3}{4}$ Amp.



$V_C - \varepsilon_1 + i_1 r_1 = V_D$

$V_C - V_D = \varepsilon_1 - i_1 r_1 = 2 - \frac{3}{4}\times 2$

$= \frac{1}{2}$ Volt.

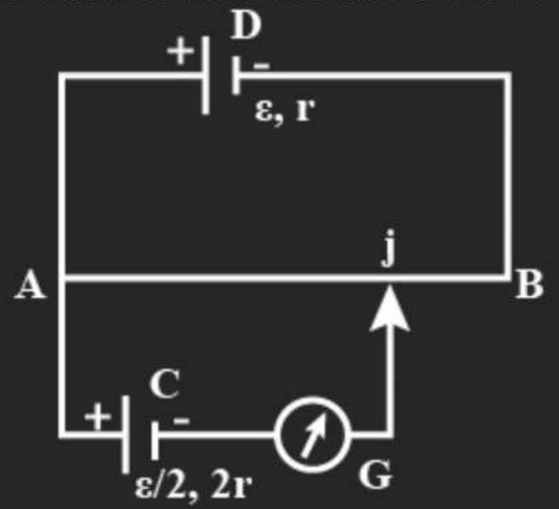
$l_{AN} = \frac{1}{4}\times 100\ \text{cm}$

$= 25\text{cm}$

CURRENT ELECTRICITY

Potentiometer and Meter Bridge

Q.8 In the figure, the potentiometer wire AB of length L and resistance $9r$ is joined to the cell D of emf ε and internal resistance r. The cell C's emf is $\varepsilon/2$ and its internal resistance is $2r$. The galvanometer G will show no deflection when the length AJ is:



(A) $\frac{4L}{9}$

(B) $\frac{5L}{9}$

(C) $\frac{7L}{18}$

(D) $\frac{11L}{18}$

CURRENT ELECTRICITY

Potentiometer and Meter Bridge

Q.9 In the arrangement shown in figure when the switch S_2 is open, the galvanometer shows no deflection for $l = L/2$. When the switch S_2 is closed, the galvanometer shows no deflection for $l = 5L/12$. The internal resistance (r) of $6\ V$ cell, and the emf ε of the other battery are respectively:

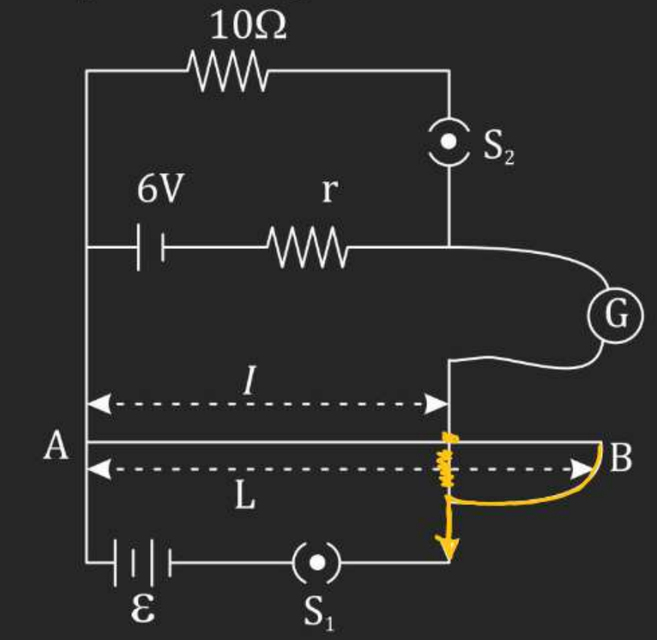
H-W

(A) $3\Omega, 8\ V$

(B) $2\Omega, 12\ V$

(C) $2\Omega, 24\ V$

(D) $3\Omega, 12\ V$

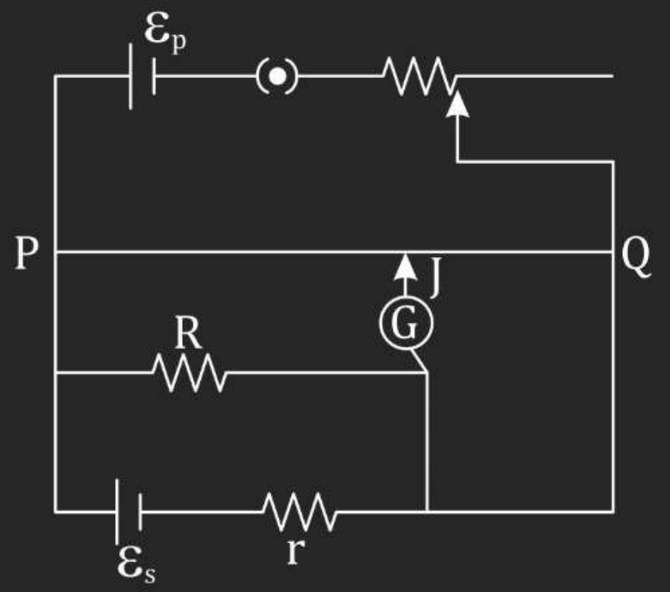


CURRENT ELECTRICITY

Potentiometer and Meter Bridge

Q.10 H.W.

One of the circuits for the measurement of resistance by potentiometer is shown. The galvanometer is connected at point A and zero deflection is observed at length $PJ = 30\ cm$. In second case the secondary cell is changed. Take $\varepsilon_s = 10\ V$ and $r = 1\Omega$ in 1^{st} reading and $\varepsilon_s = 5V$ and $r = 2\Omega$ in 2^{nd} reading. In second case, the zero deflection is observed at length $PJ = 10\ cm$. What is the resistance R (in ohm) is?



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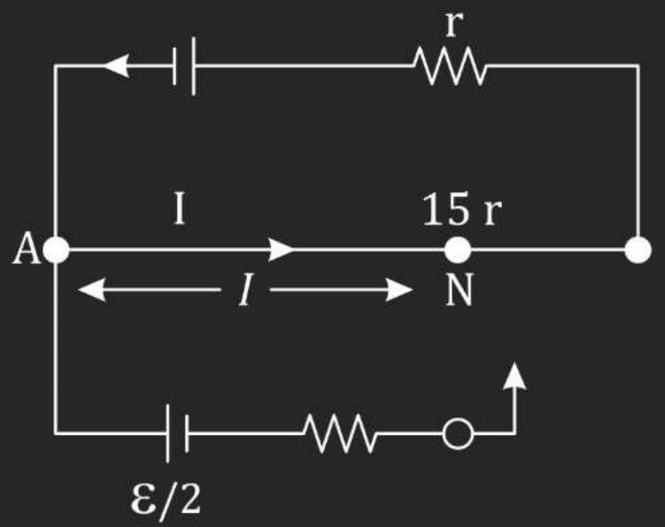
Potentiometer and Meter Bridge

Q.11 Consider the potentiometer circuit arranged as in the Fig (a). The potentiometer wire is $600\ \text{cm}$ long.

H.W.

(i) At what distance from point A should the jockey touch the wire to get zero deflection in the galvanometer?

(ii) If the jockey touches the wire at a distance of $560\ \text{cm}$ from A, what will be the current in the galvanometer?



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Potentiometer and Meter Bridge

Q.12 The wire AB of a meter bridge changes linearly from radius r to $2r$ from left end to right end. Where should the free end of the galvanometer be connected on AB so that the deflection in the galvanometer is zero?

H.W