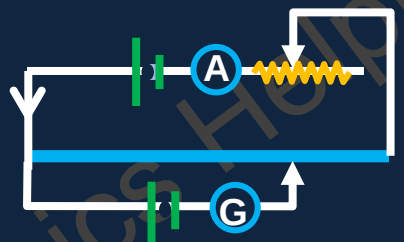
Direct Current - 4

Errors in Potentiometer Experiment

Potentiometer Experiment 1



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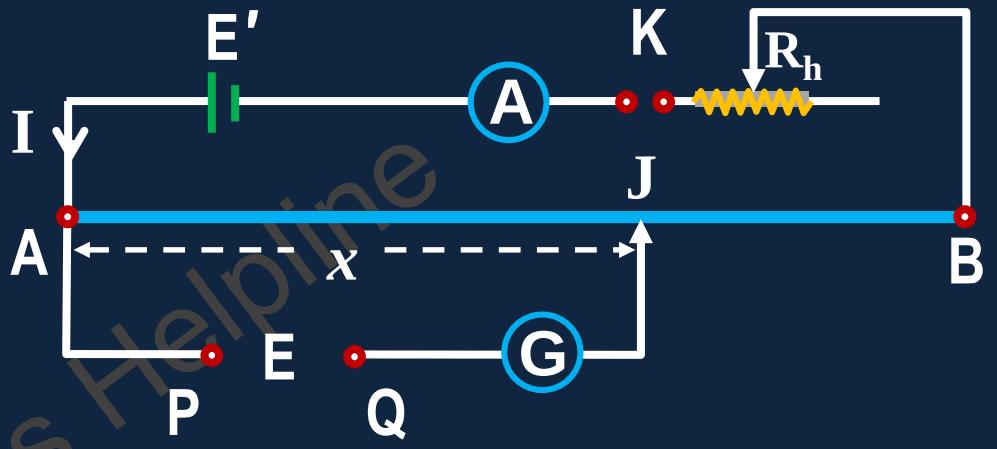
Question : Two students were performing the potentiometer experiment to determine the emf of a cell using the circuit shown in the figure.



The cell was connected between the points P and Q. Due to some error, they both failed to get a null point on the potentiometer wire. As the jockey J was moved from A to B, the galvanometer deflection gradually increased for the first student and it gradually decreased for the second student. State with reason, the possible errors committed by the students.

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CONCEPTS

Principle of Potentiometer

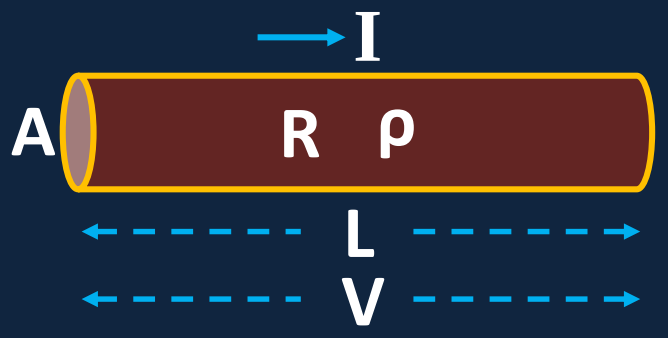
When a constant current (I) flows through a wire of uniform area of cross-section (A), then the potential difference across any segment of it is directly proportional to the length of that segment.

Resistance $R = \frac{\rho L}{A}$ [ρ = resistivity]

Ohm's Law $\Rightarrow V = RI$

$$\therefore V = \frac{\rho L}{A} I$$

$$\Rightarrow \frac{V}{L} = const$$ [ρ , I , A are constants]



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CONCEPTS

The Circuit

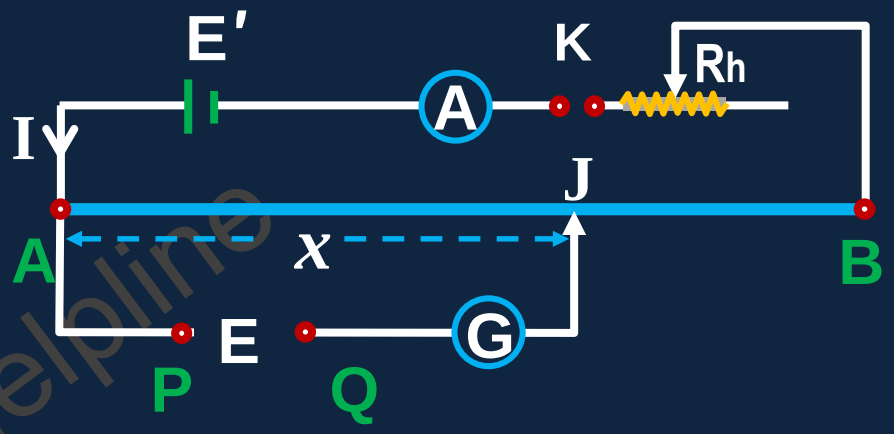
AB = Potentiometer wire of length L

E = emf of cell to be determined

E′ = emf of cell sending current

J = NULL point

AJ = Balancing length



For no deflection in galvanometer , Potential at Q = Potential at J

∴ Potential drop across cell E = Potential drop across wire segment AJ

Potential gradient (V / L) along the wire AB = constant

∴ Potential drop across length x is $E = \frac{V}{L}x$

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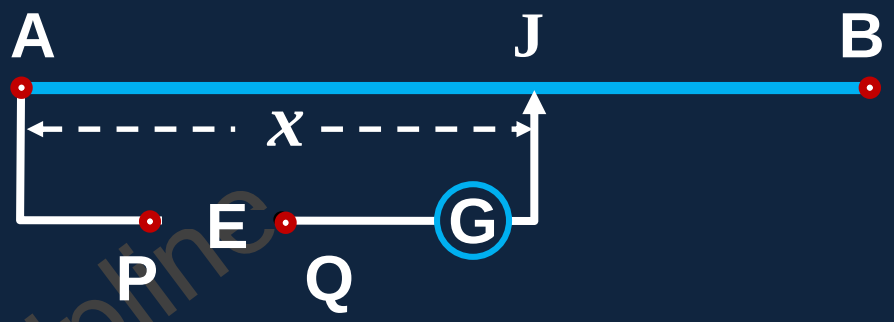
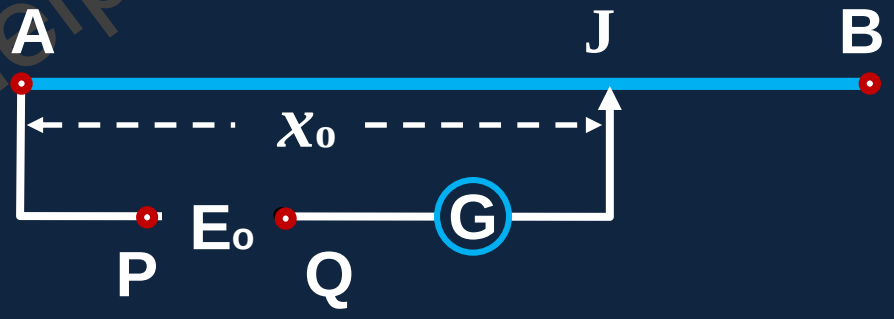
CONCEPTS

Comparison of emf of two cells



For unknown cell E balancing Length = x

$$\Rightarrow E = \frac{V}{L}x$$



For known cell E_o balancing Length = x_o

$$\Rightarrow E_o = \frac{V}{L}x_o$$

$$\Rightarrow \frac{E}{E_o} = \frac{x}{x_o} \Rightarrow E = \frac{x}{x_o}.E_o$$

$\therefore$ **E can be determined knowing** $x,\ x_o\ and\ E_o$

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Errors in Potentiometer Experiment

CONCEPTS

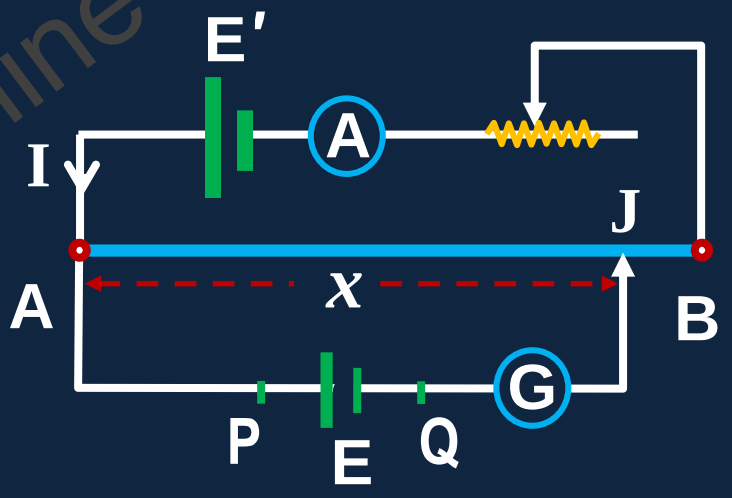
Conditions necessary to get a null point

Condition-1 : $E < V < E'$

To get a null point, emf of the cell E should be less than the potential drop V across AB which is less than the emf of the cell E′.

Condition-2 : +ve terminals of E and E‘ should be connected at A.

Potential should decrease from A to B along the wire and from A to Q through cell E.



Potential drop across AB = V

Let Potential at A = V

Then Potential at B = 0

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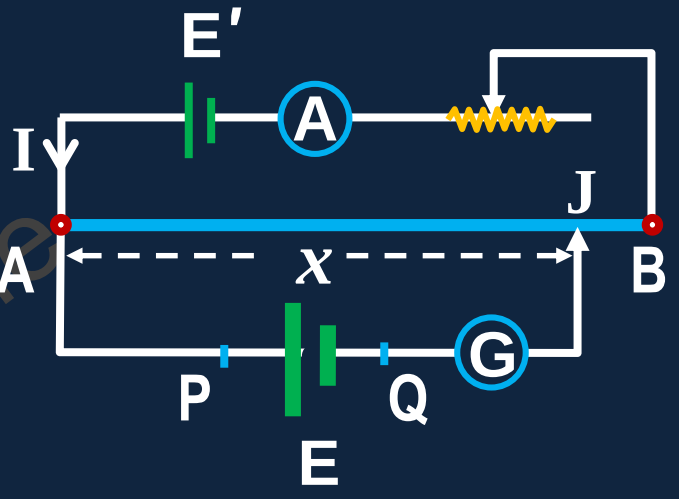

When condition-1 is violated : (E > E′)

Potential at A = V ∴ Potential at Q = (V – E) [< 0]

When J is at A , PD across galvanometer is

$$V_G = V_A - V_Q = V - (V - E) = E \quad [>0]$$

When J is at B , PD across galvanometer is

$$V_G = V_B - V_Q = 0 - (V - E) = E - V \quad [>0 \text{ , as } E > E' > V]$$

Potential difference across Galvanometer decreases from (E) at A to (E – V) at B

∴ Galvanometer deflection gradually decreases but it is never zero.

∴ The second student violated condition-1

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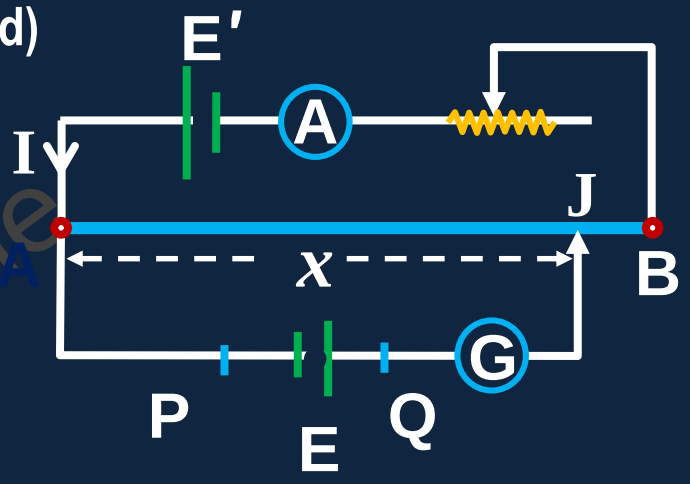
When condition-2 is violated : (E is wrongly connected)



Potential at P = V ∴ Potential at Q = (V + E)

When J is at A , PD across galvanometer is

$$V_G = V_Q - V_A = (V + E) - V = E \quad [>0]$$

When J is at B , PD across galvanometer is

$$V_G = V_Q - V_B = (V + E) - 0 = E + V \quad [>0]$$

Potential difference across galvanometer increases from (E) at A to (E + V) at B

∴ Galvanometer deflection gradually increases but it is never zero.

∴ The first student violated condition-2

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