Meter Bridge

CLASS-XII

SUBJECT : PHYSICS
CHAPTER NUMBER: 03
CHAPTER NAME : CURRENT ELECTRICITY

CHANGING YOUR TOMORROW

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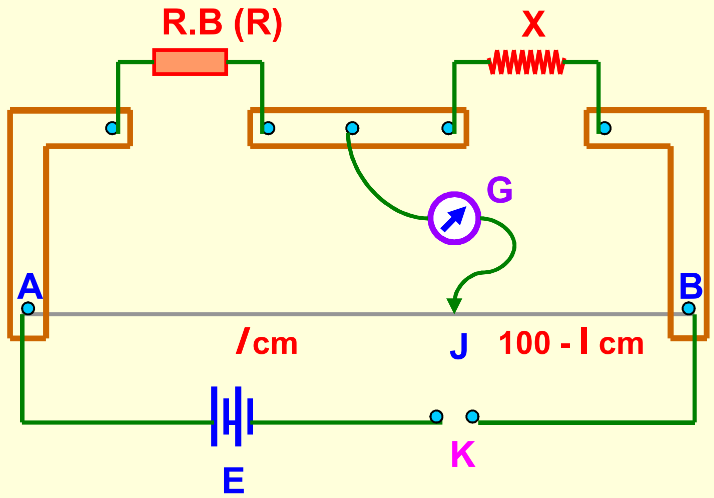
Metre Bridge:

Metre Bridge is based on the principle of Wheatstone Bridge.



When the galvanometer current is made zero by adjusting the jockey position on the metre-bridge wire for the given values of known and unknown resistances,

$$\frac{R}{X} = \frac{R_{AJ}}{R_{JB}} \Rightarrow \frac{R}{X} = \frac{AJ}{JB} \Rightarrow \frac{R}{X} = \frac{l}{100 - l}$$

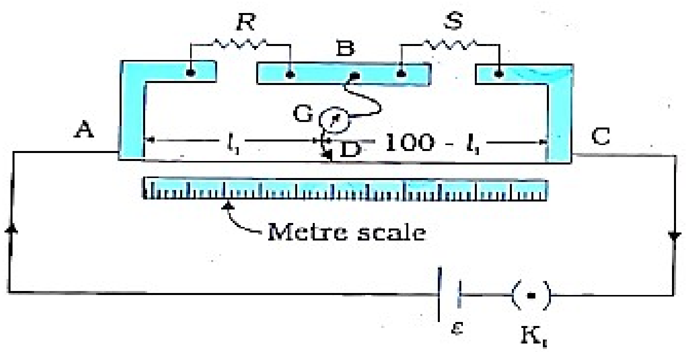
(Since, Resistance α length)

Therefore, $X = R\,(100 - l)/l$

Numerical

Question: Answer the following questions:

a) In the given meter bridge the balance point is found to be at 39.5 cm from the end *A* when the resistor *S* is of 12.5 Ω . Determine the resistance of *R*. Why are the connections between resistors in a Wheatstone or meter bridge made of thick copper strips?



b) Determine the balance point of the bridge above if *R*and *S* are interchanged.

c) What happens if the galvanometer and cell are interchanged at the balance point of the bridge? Would the galvanometer show any current?

Numerical

Solution :

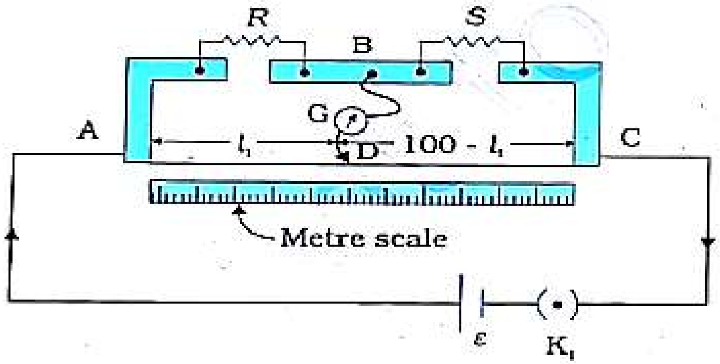
(a) As $\frac{R}{S} = \frac{l_1}{100-l_1} \Rightarrow R = \frac{l_1}{100-l_1}S = \frac{39.5}{60.5} \times 12.5\Omega = 8.16\Omega$

As resistance $R\alpha\frac{1}{A}$ Hence thick copper strips has negligible resistance. So they are used for connections.

(b) If R and S are interchanged then let balancing length becomes l .

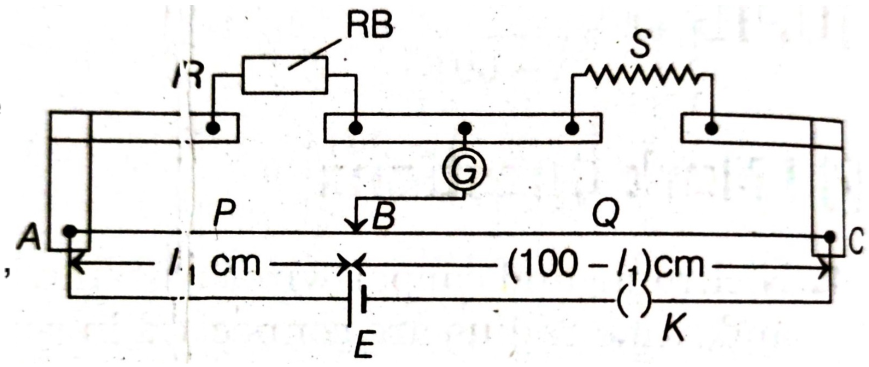
$$\therefore \frac{S}{R} = \frac{l}{100-l} \Rightarrow \frac{12.5}{8.16} = \frac{l}{100-l} \Rightarrow l = 60.5cm$$

(c) If the galvanometer and cell are interchanged there is no effect to balancing condition i.e. current through galvanometer is 0.



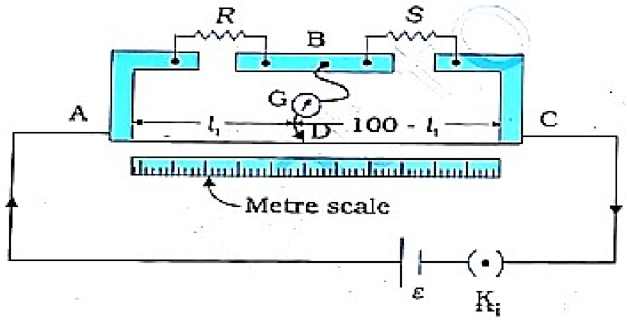
Home Assignment

Question: What is end error in a meter bridge? How is it overcome? The resistance in the two arms of the meter bridge are R = 5Ω and S respectively. When the resistance S is shunted with an equal resistance, the new balance length found to be 1.5 l_1, where l_1 is the initial balancing; length, Calculate the value of S.



HOME ASSIGNMENT

Question: (a) In the given meter bridge the balance point is found to be at $l_1$from the end *A.* When a resistance X is connected in parallel with S the balance point is found to be at l_2 from the end *A. Obtain an expression for S in term of X,* l_1,l_2



Question: Answer the following

a) Why are the connections between the resistor in a meter bridge made of thick copper strips?

b) Why is it generally preferred to obtain the balance point in the middle of the meter bridge wire?

c) Which material is used for the meter bridge wire and why?

Potentiometer-Principle and its applications to measure P.D and for comparing EMF of two cells

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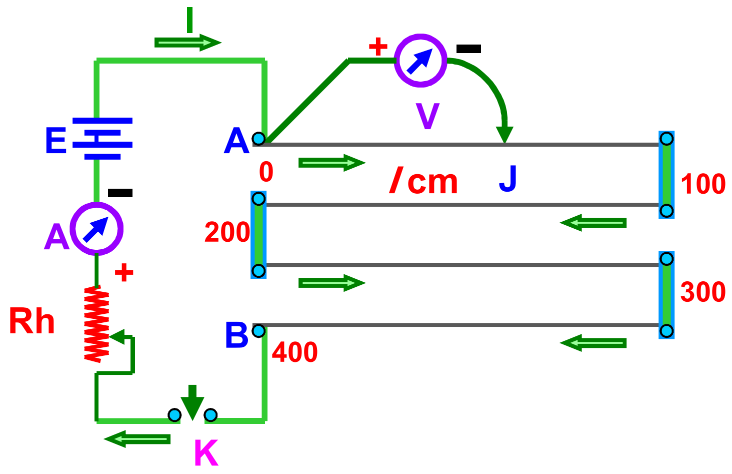
POTENTIOMETER

Principle:

V = I R

= I ρl/A

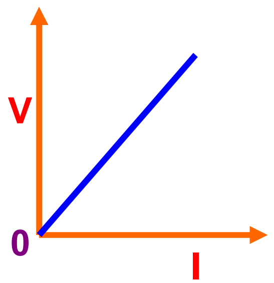
If the constant current flows through the potentiometer wire of uniform cross sectional area (A) and uniform composition of material (ρ), then



V = Kl or V α l

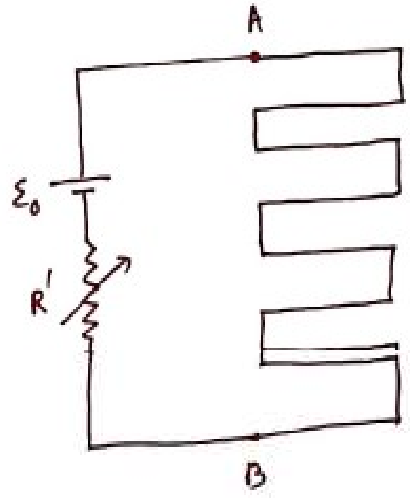
V /l is a constant.

The potential difference across any length of a wire of uniform cross-section and uniform composition is proportional to its length when a constant current flows through it.



The expression for potential drop per unit length :

It contains a long wire AB of length (l_0) and uniform cross-section of area A connected across a cell called as driver cell of emf $(\xi_0)$and a variable resistor of resistance R'



So the resistance of potentiometer wire is

$$R_0 = \rho \frac{l_0}{A}$$

Where ρ = resistivity of potentiometer wire

Current in the driver circuit is

$$I_0 = \frac{\xi_0}{R\prime + R_0} = \frac{\xi_0}{R\prime + \frac{\rho l_0}{A}} = \frac{A\xi_0}{AR\prime + \rho l_0} \text{........(ii)}$$

The potential difference across potentiometer wire is

$V_0 = I_0 R_0$

So potential drop per unit length is $K = \frac{V_0}{l_0} = \frac{I_0 R_0}{l_0} = \frac{I_0 \rho}{A}$ (Using equation (i)) ...(iii)

Sensitivity:

It is a measure of how small voltage be measured by the potentiometer . For this K should be very small

As $K = \frac{I_0 \rho}{A} = \frac{A\xi_0}{AR\prime + \rho l_0} \frac{\rho}{A} = \frac{\rho \xi_0}{AR\prime + \rho l_0}$ (Using equation (ii))

So potentiometer will be more sensitive or K should be very small if

(i) the resistance of the driver circuit is very high

(ii) length of potentiometer wire should be very large

(iii) the wire should be thick.

The advantage of the potentiometer in comparison to a voltmeter is that potentiometer doesn't draw any current from the element whereas the voltmeter draws. So potentiometer measures the exact voltage of the element where the voltmeter measures smaller voltage.

Numerical

Question: A potentiometer circuit uses a driver cell of emf 2 V with internal resistance 0.5Ω and potentiometer wire of resistance 7.5Ω with a length of 400 cm.

a) Calculate the potential drop per unit length

b) Find balancing length for a cell of emf 1 V.

Numerical

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a) Calculate the potential drop per unit length

b) Find balancing length for a cell of emf 1 V.

Solution :

a) $I_0 = \frac{\xi_0}{r+R_0} = \frac{2V}{0.5\Omega+7.5\Omega} = \frac{1}{4}A$

$$\therefore K = \frac{V_0}{l_0} = \frac{I_0 R_0}{l_0} = \frac{0.25\times7.5}{4} V/m = 0.47Vm^{-1}$$

b) $l = \frac{V}{K} = \frac{1V}{0.47Vm^{-1}} = 2.13m = 213cm$

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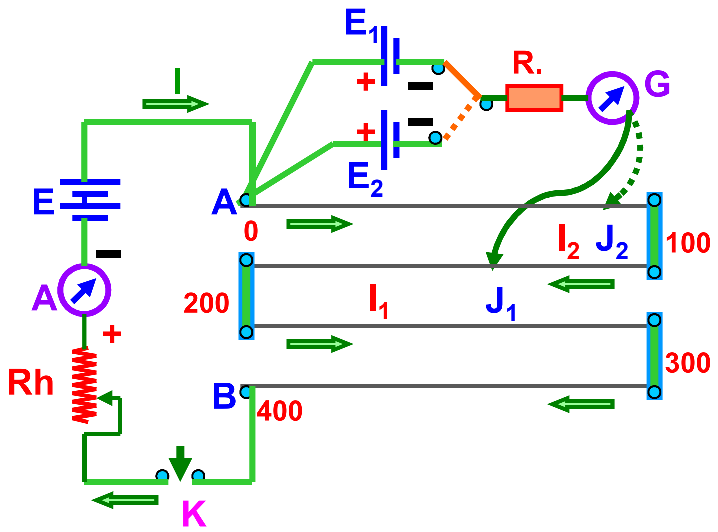
Comparison of emf's using Potentiometer:

The balance point is obtained for the cell when the potential at a point on the potentiometer wire is equal and opposite to the emf of the cell.



$E_1 = V_{AJ_1} = I\rho l_1/A$

$E_2 = V_{AJ_2} = I\rho l_2/A$

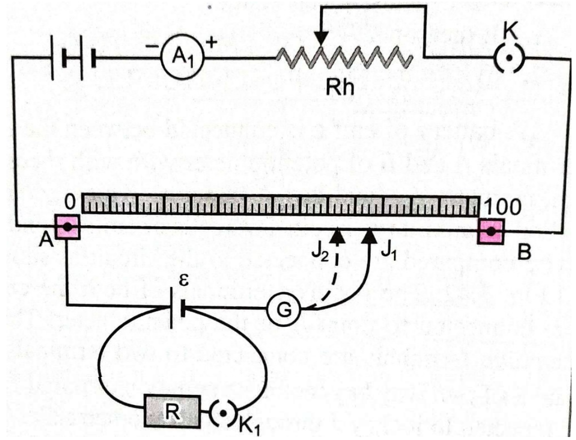
$E_1/E_2 = l_1/l_2$

Note:

The balance point will not be obtained on the potentiometer wire if the fall of potential along the potentiometer wire is less than the emf of the cell to be measured.

The working of the potentiometer is based on null deflection method. So the resistance of the wire becomes infinite. Thus potentiometer can be regarded as an ideal voltmeter.

Determination of internal resistance of a cell



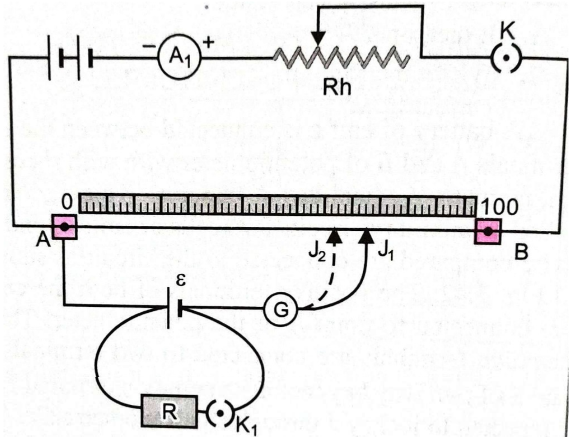
Determination of internal resistance of a cell

When switch K2 is open there is no current in the second circuit at the null point position.

If null point length at this condition is l_1 ,

then $\xi = Kl_1$ ....(i)

When switch K2 is closed there is a current I through the second circuit.



So potential difference across the cell is

$V = IR = \xi - Ir$ ....(ii)

$\Rightarrow \xi = I(R + r)$ ....(iii)

Now null point distance is l_2. So $V = Kl_2$

Dividing equation(i) by equation (iv) we get $\frac{\xi}{V} = \frac{Kl_1}{Kl_2} = \frac{l_1}{l_2}$

Now using equations (ii) and (iii)

$\frac{I(R+r)}{IR} = \frac{l_1}{l_2}$

$\Rightarrow \frac{R+r}{R} = \frac{l_1}{l_2} \Rightarrow R + r = \frac{l_1}{l_2}R \Rightarrow r = \frac{l_1}{l_2}R - R = R\left(\frac{l_1}{l_2} - 1\right)$ r is the internal resistance of the cell and R is the resistance connected across the cell

THANKING YOU

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