Current Electricity

Question1

In a potentiometer experiment, a wire of length 10 m and resistance 5Ω is connected to a cell of emf 2.2 V . If the potential difference between two points separated by a distance of 660 cm on potentiometer wire is 1.1 V , then the internal resistance of the cell is

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Options:

A.

1.6Ω

B.

1.4Ω

C.

1.2Ω

D.

1Ω

Answer: A

Solution:

The length of the potentiometer wire is $L = 10$ m.

The resistance of the potentiometer wire is

$R_\omega = 5\Omega$

The emf of the cell is $E = 2.2$ V

The potential difference across a length of $l = 660$ cm of the wire is $V_l = 1.1$ V.

$l = 660 \text{ cm} = 6.6 \text{ m}$

The potential gradient, $K = \frac{V_l}{l}$

$K = \frac{1.1 \text{ V}}{6.6 \text{ m}} = \frac{1}{6} \text{ V/m}$

The total potential drop across the wire V_ω is

$$V_\omega = K \times L$$
$$V_\omega = \frac{1}{6} \text{ V/m} \times 10 \text{ m} = \frac{10}{6} \text{ V} = \frac{5}{3} \text{ V}$$

Current, $I = \frac{V_\omega}{R\omega} = \frac{\frac{5}{3} \text{ V}}{5\Omega} = \frac{1}{3} \text{ A}$

The current in the main circuit is also given by

$$I = \frac{E}{R_\omega + r}$$
$$r = \frac{E}{I} - R_\omega = \frac{2.2 \text{ V}}{\frac{1}{3} \text{ A}} - 5\Omega$$
$$r = (2.2 \times 3)\Omega - 5\Omega$$
$$r = 6.6\Omega - 5\Omega = 1.6\Omega$$

Question2

When the right gap of a metre bridge consists of two equal resistors in series, the balancing point is at 50 cm . When one of the resisters in the right gap is removed and is connected in parallel to the resistor in the left gap, the balancing point is at

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Options:

A.

60 cm

B.

33.3 cm

C.

25 cm

D.

40 cm

Answer: D

Solution:

First setup:

Let the resistance in the left gap be R', and in the right gap there are two resistors with resistance R, connected in series. So, the right gap has a total resistance of $R + R = 2R$.

The balancing point is at 50 cm. In a metre bridge, the ratio of resistances equals the ratio of the lengths on both sides: $\frac{R'}{2R} = \frac{50}{50}$ So, $\frac{R'}{2R} = 1$ which means $R' = 2R$

Second setup:

Now, one resistor from the right gap is taken out and connected in parallel with the resistor in the left gap.

Now, the left gap contains R' and R in parallel. The resistance of two resistors A and B in parallel is: $R'' = \frac{A \times B}{A+B}$ The parallel resistance is: $R'' = \frac{R' \times R}{R'+R}$

From earlier, we know $R' = 2R$. Substitute this value: $R'' = \frac{2R \times R}{2R+R} = \frac{2R^2}{3R} = \frac{2R}{3}$

Now, the right gap just has R.

Let the new balancing point be l. The bridge principle gives us: $\frac{R''}{R} = \frac{l}{100-l}$ Substitute $R'' = \frac{2R}{3}$: $\frac{\frac{2R}{3}}{R} = \frac{l}{100-l}$ $\frac{2}{3} = \frac{l}{100-l}$

Solve for l: $3l = 2(100 - l)$ $3l = 200 - 2l$ $3l + 2l = 200$ $5l = 200$ $l = 40$ cm

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Question3

The drift speed of electrons in a material is found to be $0.3 \mathrm{~ms}^{-1}$ when an electric field of $2 \mathrm{Vm}^{-1}$ is applied across it. The electron mobility (in $\mathrm{m}^2 \mathrm{~V}^{-1} \mathrm{~s}^{-1}$) in the material is

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Options:

A.

60×10^{-2}

B.

15×10^{-2}

C.

1350×10^{6}

D.

5400×10^{6}

Answer: B

Solution:

Given

- Drift speed, $v_d = 0.3 \mathrm{~m\,s^{-1}}$
- Electric field, $E = 2 \mathrm{~V\,m^{-1}}$

We are to find **electron mobility** μ, where

$\mu = \frac{v_d}{E}$

Calculation

$\mu = \frac{0.3}{2} = 0.15 \mathrm{~m^2\,V^{-1}\,s^{-1}}$

$\mu = 0.15 = 15 \times 10^{-2} \mathrm{~m^2\,V^{-1}\,s^{-1}}$

✅ **Answer: Option B**

$\boxed{15 \times 10^{-2} \mathrm{~m^2\,V^{-1}\,s^{-1}}}$

Question4

The power of an electric motor is 242 W when connected to a 220 V supply. When the motor is operated at 200 V , the current drawn by it is

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Options:

A.

1.21 A

B.

1.1 A

C.

1.5 A

D.

1 A

Answer: D

Solution:

Resistance of motor

$R = \frac{V_1^2}{P_1} = \frac{220^2}{242} = 200\Omega$

Current drawn by the motor

$I = \frac{V_2}{R} = \frac{200}{200} = 1 \text{ A}$

Question5

A voltmeter of resistance 400Ω is used to measure the emf of a cell with an internal resistance of 4Ω. The error in the measurement of emf of the cell is

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Options:

A. 1.01%

B. 2.01%

C. 1.99%

D. 0.99%

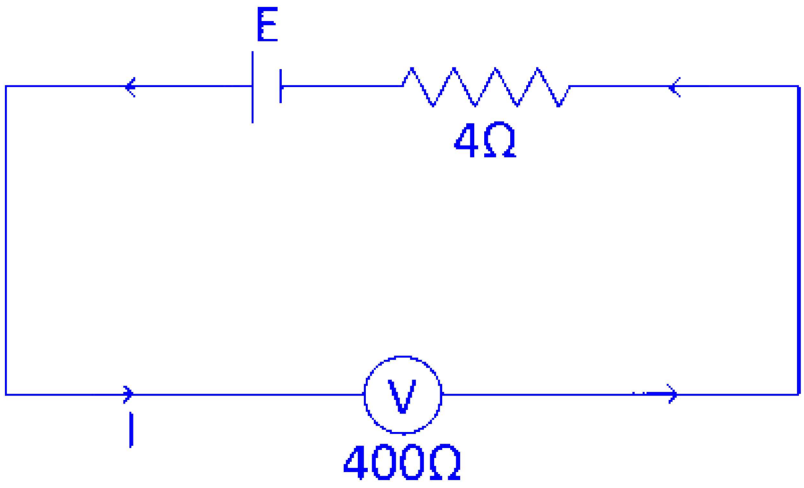
Answer: D

Solution:

Given, $R = 400\Omega$

$r = 4\Omega$

$R_{\text{eq}} = R + r = 404\Omega$



From definition of terminal potential difference,

$V = E - Ir$

We know that, current drawn from the cell,

$I = \frac{E}{R+r}$

Putting value in Eq. (i),

$V = E - \frac{E}{R+r} \times r$

$V = \frac{ER+Er-Er}{R+r}$

$V = \frac{ER}{R+r}$

$V = \frac{E \cdot 400}{404} = \frac{100E}{101}$

$\frac{V}{E} = \frac{100}{101}$

Percentage error in measurement of emf of the cell is,

% error in

$E = \left(\frac{E-V}{E}\right) \times 100 = \left(1 - \frac{V}{E}\right) \times 100$

$$= \left(1 - \frac{100}{101}\right) \times 100 \quad \text{[From Eq. (ii)]}$$

$$= \frac{1 \times 100}{101} = 0.99\%$$

Question6

When two wires are connected in the two gaps of a meter bridge, the balancing length is 50 cm . When the wire in the right gap is stretched to double its lengt ¯ and again connected in the same gap, then the new balancing length from the left. end of the bridge wiu :

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Options:

A. 80 cm

B. 20 cm

C. 33.3 cm

D. 66.6 cm

Answer: B

Solution:

Given, balancing length, $l = 50$ cm

At balancing situating of meter bridge,

$\frac{R}{S} = \frac{1}{100-1} = \frac{50}{100-50}$

$\frac{R}{S} = \frac{1}{1} \Rightarrow R = S$

We know that,

$R = \rho l / A$

When the wire in the right gap is stretched to double its length, its resistance changes.

If the length is doubled, assuming the volume of the wire remains constant, the cross-sectional area will be halved.

$V = A \cdot l \Rightarrow A = \frac{V}{l}$

Given,

$\therefore \quad l' = 2l, A' = \frac{V}{2l} \Rightarrow A' = \frac{A}{2}$

So, the new resistance S' becomes

$S' = \rho \frac{l'}{A'} = \frac{\rho 2l}{\frac{A}{2}} = \frac{\rho \cdot 4l}{A} = 4R$ [from Eq (i)]

Now, the new balancing length is,

$\frac{R}{S'} = \frac{l}{100-l} \Rightarrow \frac{R}{4R} = \frac{l}{100-l}$

$100 - l = 4l$

$5l = 100 \Rightarrow l = 20$ cm

Question7

The resistance of a wire is 2.5Ω at a temperature 373 K . If the temperature coeffficient of resistance of the material of the wire is $3.6 \times 10^{-3}\ \mathrm{K}^{-1}$, its resistance at a temperatrue 273 K is nearly.

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Options:

A. 1.84Ω

B. 2.46Ω

C. 0.82Ω

D. 4.58Ω

Answer: A

Solution:

Given:

The resistance of the wire at temperature $T_1 = 373\,\mathrm{K}$ is $2.5\,\Omega$.

The temperature coefficient of resistance, $\alpha = 3.6 \times 10^{-3}\,\mathrm{K}^{-1}$.

We need to determine the resistance of the wire at a temperature of $273\,\mathrm{K}$.

To find this, we use the formula for resistance change with temperature:

$R = R_0(1 + \alpha \Delta T)$

Where the temperature difference $\Delta T = T_1 - T_2 = 373\,\mathrm{K} - 273\,\mathrm{K} = 100\,\mathrm{K}$.

Given:

$2.5 = R_0\left(1 + 3.6 \times 10^{-3} \times 100\right)$

Calculating R_0:

$R_0 = \frac{2.5}{1.36}$

Thus, the resistance at $273\,\mathrm{K}$ is:

$R_0(\text{at } 273\,\mathrm{K}) = 1.84\,\Omega$

Question8

When two identical resistors are connected in series to an ideal cell, the current through each resistor is 2 A . If the resistors are connected in parallel to the cell, the current through each resistor is

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Options:

A. $4A$

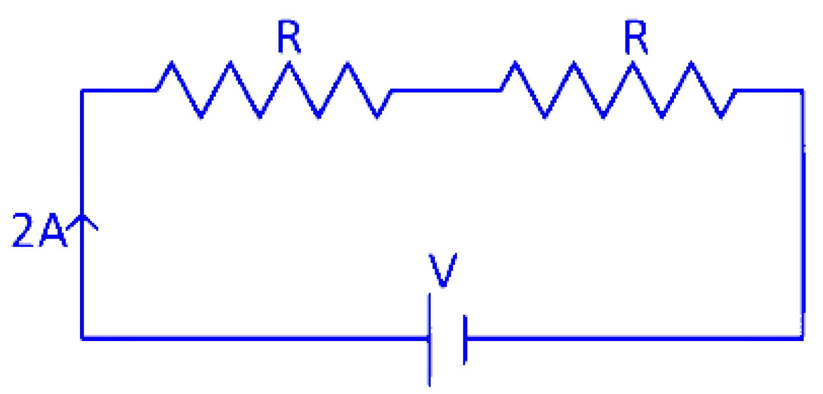
B. $2A$

C. 8 A

D. 1 A

Answer: A

Solution:



Current in the figure 1 using Ohm's law,

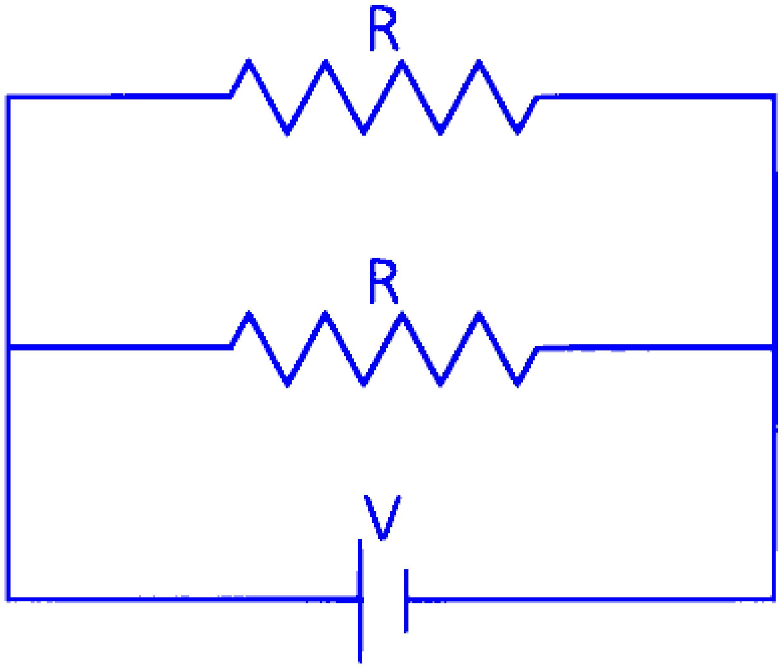
$i=\frac{V(\text{ cell })}{\text{Total resistance}}$

$i=\frac{V}{2R+r}$ [as ideal cell, $r=0$ (internal resistance)]

$2=\frac{V}{2R}$

$\frac{V}{R}=4$

Now, when resistor are connect parallelly



$i=\frac{V(\text{ cell })}{\frac{R}{2}}$

$i=2\frac{V}{R}$

$i=2\times 4\Rightarrow i=8\text{ A}$

Current through each resistor $=4\text{ A}$

Question9

A conductor of length 1.5 m and area of cross-section $3 \times 10^{-5} \mathrm{~m}^2$ has electrical resistance of 15Ω.

The current density in the conductor for an electric field of $21 \mathrm{Vm}^{-1}$ is

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Options:

A. $0.7 \times 10^6 \mathrm{Am}^{-2}$

B. $0.7 \times 10^{-6} \mathrm{Am}^{-2}$

C. $0.7 \times 10^{-5} \mathrm{Am}^{-2}$

D. $0.7 \times 10^5 \mathrm{Am}^{-2}$

Answer: D

Solution:

Given, $L=1.5 \mathrm{~m}$

Area of cross-section

$A=3 \times 10^{-5} \mathrm{~m}^2$

$R=15 \Omega, E=21 \mathrm{~V} / \mathrm{m}$

Curren density, $J=?$

$J=\sigma E=\frac{E}{\rho}$

Question10

The relation between the current i (in ampere) in a conductor and the time t (in second) is $i=12 t+9 t^2$. The charge passing through the conductor between the times $t=2 \mathrm{~s}$ and $t=10 \mathrm{~s}$ is

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Options:

A. 3720 C

B. 3648 C

C. 3600 C

D. 3552 C

Answer: D

Solution:

Charge in term of current is given

$dQ = Idt$

$Q = \int_{t_1}^{t_2} Idt$

$I = 12t + 9t^2, t_1 = 2\text{ s}, t_2 = 10\text{ s}$

$Q = \int_2^{10} 12tdt + \int_2^{10} 9t^2dt$

$\left[\frac{12t^2}{2}\right]_2^{10} + \left[\frac{9t^3}{3}\right]_2^{10}$

$= 6\left[10^2 - 2^2\right] + 3\left[10^3 - 2^3\right]$

$= 6 \times [100 - 4] + 3[1000 - 8]$

$= 6 \times 96 + 3 \times 992$

$= 3552\text{C}$

Question11

The potential difference between the ends of a straight conductor of length 20 cm is 16 V . If the drift speed of the electrons is $2.4 \times 10^{-4} \mathrm{~ms}^{-1}$, the electron mobility in $\mathrm{m}^2 \mathrm{~V}^{-1} \mathrm{~s}^{-1}$ is

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Options:

A. 3.6×10^{-6}

B. 2.4×10^{-6}

C. 2×10^{-6}

D. 3×10^{-6}

Answer: D

Solution:

Given, length of conductor,

$l=20 \mathrm{~cm}=0.2 \mathrm{~m}$

potential difference, $\mathrm{PD}=16 \mathrm{~V}$

drift speed $\left(v_d\right)=2.4 \times 10^{-4} \mathrm{~m} / \mathrm{s}$

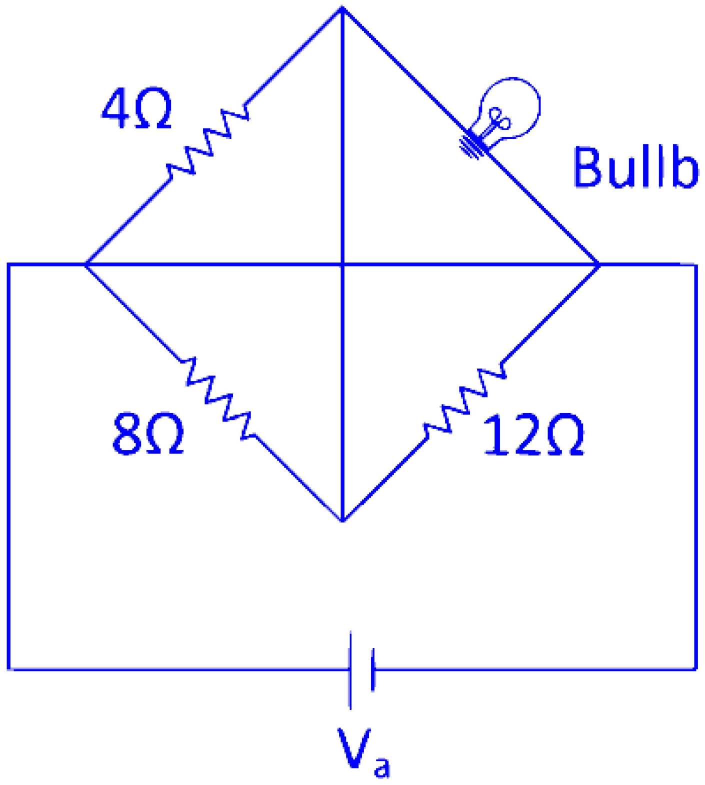
We know that, $E=-\frac{d V}{d r}=\frac{16}{0.2}=80 \mathrm{~V} / \mathrm{m}$

Electron mobility, $\mu=\frac{v_d}{E}=\frac{2.4 \times 10^{-4}}{80}$

$=3 \times 10^{-6} \mathrm{~m}^2 \mathrm{~V}^{-1} \mathrm{~s}^{-1}$

Question12

The potential difference V across the filament of the bulb shown in the given Wheatstone bridge varies as $V=i(2 i+1)$, where i is the current in ampere through the filament of the bulb. The emf of the battery V_a, so that the bridge become balanced is



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Options:

A. 10 V

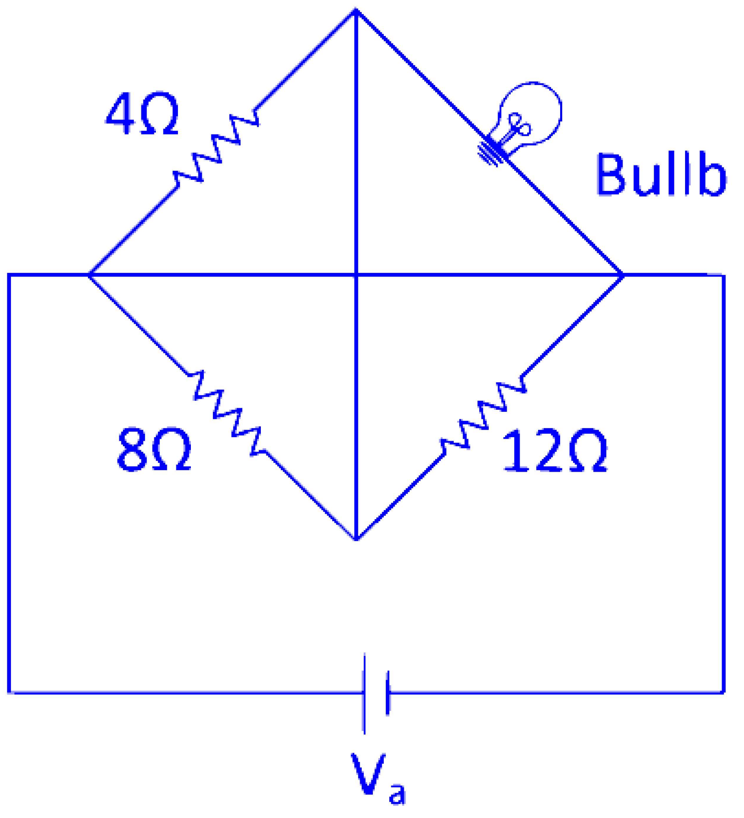
B. 15 V

C. 20 V

D. 25 V

Answer: D

Solution:



For a balanced Wheatstone bridge

$$\frac{4\Omega}{R_{\text{bulb}}} = \frac{8\Omega}{12\Omega}$$

$$R_{\text{bulb}} = 6\Omega$$

Current in upper branch, $i = \frac{V_a}{10}$ A

Potential across bulb, $V = i(2i + 1)$

$$i \times 6 = i(2i + 1)$$

$$\Rightarrow \quad 6 = (2i + 1) \Rightarrow i = \frac{5}{2} \text{ A}$$

Now total voltage across circuit,

$$V_a = i \times (6 + 4) = i \times (10)\text{V}$$

$$= \frac{5}{2} \times 10 \text{ V} = 25 \text{ V}$$

Question13

When the temperature of a wire is increased from 303 K to 356 K , the resistance of the wire increases by 10%. The temperature coefficient of resistance of the material of the wire is

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Options:

A. $2 \times 10^{-3\circ} \mathrm{C}^{-1}$

B. $2 \times 10^{-4\circ} \mathrm{C}^{-1}$

C. $1.1 \times 10^{-3\circ} \mathrm{C}^{-1}$

D. $11 \times 10^{-4} \mathrm{C}^{-1}$

Answer: A

Solution:

Initial temperature of wire,

$T_1 = 303 \mathrm{~K}$

Final temperature of wire, $T_2 = 356 \mathrm{~K}$

Resistance increases % = 10 %

Temperature coefficient $\alpha = ?$

Here, $\alpha = \frac{\left(\frac{\Delta R}{R_0}\right)}{\Delta T} \quad \ldots$ (i)

$\Delta R =$ change in resistance

$R =$ original resistance

$\Delta T =$ change in temperature

$\Delta T = T_2 - T_1 = 356 - 303 = 53 \mathrm{~K} \quad \ldots$ (ii)

from Eq. (i),

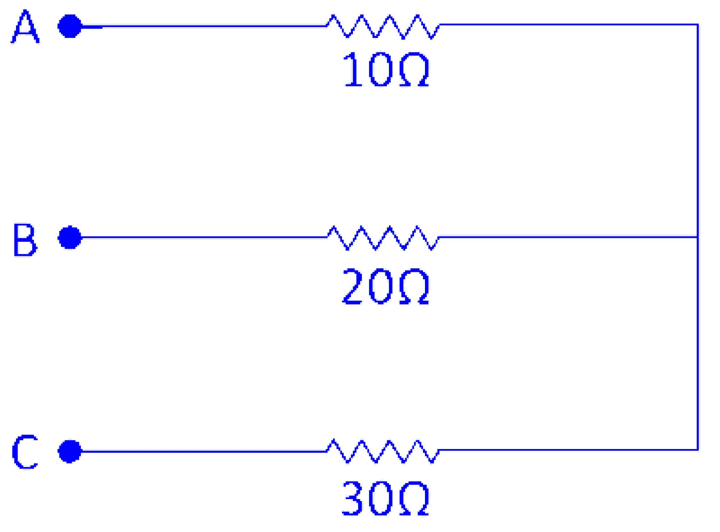
$$\alpha = \frac{0.10}{53} = 1.88 \times 10^{-3} \mathrm{C}^{-1}$$

$\alpha \equiv 2 \times 10^{-3\circ} \mathrm{C}^{-1}$

Thus, temperature coefficient of resistance of the material of the wire is approximately $2 \times 10^{-3\circ} \mathrm{C}^{-1}$.

Question14

Three resistors of resistances $10 \Omega, 20 \Omega$ and 30Ω are connected as shown in the figure. If the points A, B and C are at potentials $10 \mathrm{~V}, 6 \mathrm{~V}$ and 5 V respectively, then the ratio of the magnitudes of the currents through 10Ω and 30Ω resistors is



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Options:

A. 1 : 3

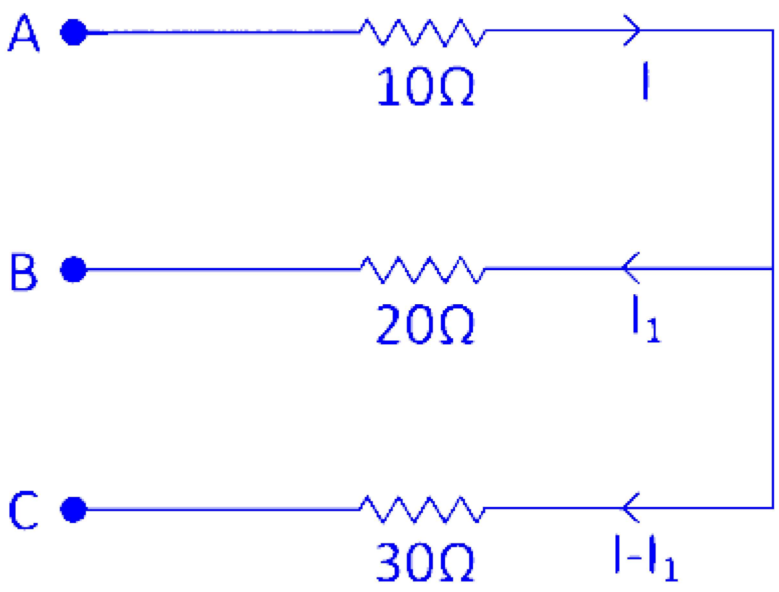
B. 3 : 1

C. 1 : 2

D. 2 : 1

Answer: D

Solution:



Applying KVL from A to B,

$$V_A - 10I - 20I_1 = V_B$$

$$10 - 10I - 20I_1 = 6$$

$$4 = 10\left[I + 2I_1\right] \quad \ldots \text{(i)}$$

Applying KVL from A to C,

$$V_A - 10I - 30I + 30I_1 = V_C$$

$$10 = 40I + 30I_1 + 5$$

$$5 = 40I - 30I_1$$

$$1 = 8I - 6I_1$$

$$I_1 = \frac{8I - 1}{6} \quad \ldots \text{(ii)}$$

Putting the value of I_1 in Eq. (i),

$$4 = 10\left[I + \frac{2}{6}(8I - 1)\right]$$

$$4 = 10\left[I + \frac{8}{3}I - \frac{1}{3}\right] \Rightarrow 4 = 10\left[\frac{11I}{3} - \frac{1}{3}\right]$$

$$1.2 = 11I - 1$$

$$11I = 2.2 \Rightarrow I = \frac{1}{5}$$

Let current in 10Ω is I,

Current in 20Ω is I_1 and

Current in 30Ω is $I - I_1$

$$I_1 = \frac{8I - 1}{6} = \frac{\frac{8}{5} - 1}{6} = \frac{3}{5 \times 6} = \frac{1}{10}$$

$$I - I_1 = \frac{1}{5} - \frac{1}{10} = \frac{1}{10}$$

$$\text{Ratio } \frac{I}{I - I_1} = \frac{1}{5 \times \frac{1}{10}} = 2 : 1$$

Question15

A potentiometer balances at 44 cm when a cell of internal resistance 1Ω is in the secondary circuit. To obtains the balancing point at 40 cm , the resistance to be connected parallel to cell is

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Options:

A. 20Ω

B. 10Ω

C. 30Ω

D. 5Ω

Answer: B

Solution:

Given:

Internal resistance of the cell, $r = 1\,\Omega$

Initial balancing length, $l_1 = 44\,\text{cm}$

New balancing length, $l_2 = 40\,\text{cm}$

Formula:

The internal resistance of the cell can be expressed as:

$r = R\left(\frac{l_1}{l_2} - 1\right)$

Here, R is the external resistance connected parallel to the cell. We know $r = 1\,\Omega$.

Calculation:

$1 = R\left(\frac{44}{40} - 1\right)$

Simplify the expression:

$1 = R\left(\frac{44}{40} - \frac{40}{40}\right)$

$1 = R\left(\frac{4}{40}\right)$

$1 = \frac{R}{10}$

Solve for R:

$R = 10\,\Omega$

Thus, the resistance that needs to be connected in parallel to the cell to achieve the desired balancing point is $10\,\Omega$.

Question16

Two wires made of the same material have lengths in the ratio $2:3$ and radii in the ratio $8:9$. If the same potential difference is applied across the ends of the wires, the ratio of the electric currents flowing through them is

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Options:

A. 5 : 6

B. 6 : 5

C. 4 : 3

D. 32 : 27

Answer: D

Solution:

Given the problem, two wires made of the same material have lengths and radii in specified ratios, and the same potential difference is applied to both. Our goal is to find the ratio of electric currents through the wires.

Given values:

Ratio of lengths of the wires: $\frac{L_1}{L_2} = \frac{2}{3}$

Ratio of radii of the wires: $\frac{r_1}{r_2} = \frac{8}{9}$

Since both wires are made of the same material and experience the same potential difference, we use Ohm's Law:

$V = IR$

This leads to the relationship for the wires:

For the first wire: $V = I_1 R_1$

For the second wire: $V = I_2 R_2$

Equating the two since V is the same:

$I_1 R_1 = I_2 R_2$

This implies:

$\frac{I_1}{I_2} = \frac{R_2}{R_1}$

The resistance R is given by:

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

where:

ρ is the resistivity,

L is the length,

$A = \pi r^2$ is the cross-sectional area.

Thus, for the resistances:

$R_1 = \rho \frac{L_1}{\pi (r_1)^2}, \quad R_2 = \rho \frac{L_2}{\pi (r_2)^2}$

Substituting these into the current ratio equation:

$\frac{I_1}{I_2} = \frac{\rho \frac{L_2}{\pi (r_2)^2}}{\rho \frac{L_1}{\pi (r_1)^2}} = \frac{L_2}{L_1} \times \left(\frac{r_1}{r_2} \right)^2$

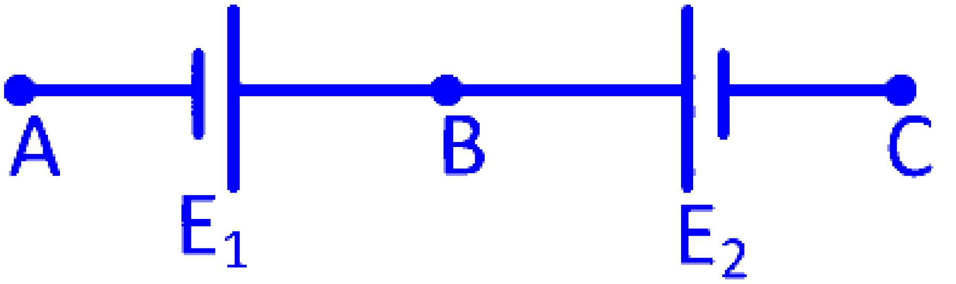
Substitute the given ratios:

$\frac{I_1}{I_2} = \left(\frac{3}{2} \right) \times \left(\frac{8}{9} \right)^2 = \frac{3}{2} \times \frac{64}{81} = \frac{192}{162} = \frac{32}{27}$

Thus, the ratio of current $I_1 : I_2$ is $32 : 27$.

Question17

When a potentiometer is connected between the points A and B as shown in the circuit, balance point is obtained at 64 cm . When it is connected between A and C, the balance point is 8 cm . If the potentiometer is connected between B and C the balance point will be



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Options:

A. 8 cm

B. 56 cm

C. 64 cm

D. 72 cm

Answer: B

Solution:

When the potentiometer is connected between points A and B, the balance point is achieved at 64 cm. When connected between A and C, the balance point occurs at 8 cm. Now, we need to determine the balance point when the potentiometer is connected between B and C.

Calculation

Initial Conditions:

When connected between A and B:

$V_1 = k \times l_1 = 64k$

When connected between A and C:

$V_1 - V_2 = k \times l_2 = 8k$

Solve for V_2:

Rearrange the equation:

$64k - V_2 = 8k$

Solve for V_2:

$V_2 = 64k - 8k = 56k$

Determine the balance point when connected between B and C:

We know $V_2 = k \times l_2$, where l_2 is the distance we need to find.

Therefore:

$k \times l_2 = 56k$

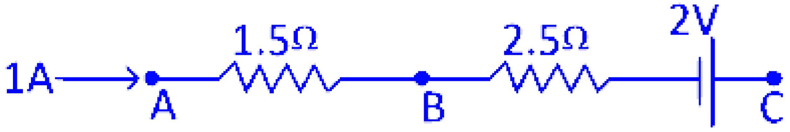
Solve for l_2:

$l_2 = 56$ cm

Thus, the balance point when the potentiometer is connected between B and C will be 56 cm.

Question18

In the given part of a circuit, the potential at point B is zero. Then, the potentials at A and C respectively, are



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Options:

A. -1.5 V, $+2$ V

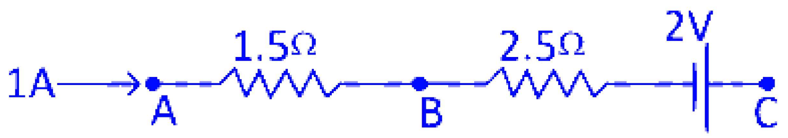
B. $+1.5$ V, $+2$ V

C. $+1.5$ V, $+0.5$ V

D. $+1.5$ V, -0.5 V

Answer: D

Solution:



The direction of current is from A to B which means point A is at higher potential.

For section AB,

$V = IR = 1 \times 1.5$
$V = +1.5$ V at A

Now for section BC

$V = IR \quad$ (at C let potential be X)

$(2V + X) = IR \Rightarrow I = \dfrac{2V + X}{2.5\Omega}$

We know from diagram $I = 1A$

For I to be 1 the V/R ratio should be L.

$\because \quad 2.5 = 2 + X \Rightarrow X = 2 - 2.5$
$\Rightarrow \quad X = -0.5$ V
