Date 07/07/21

Chapter-3

Current Electricity

Exercise

1. Given,
Emf of a storage battery = 12V
Internal resistance of the battery = 0.4 Ω
Here,
The condition for maximum current is that the external resistance should be zero (R = 0)
Hence,
The maximum current drawn from battery

$$I_{max} = \frac{E}{R + r}$$

$$= \frac{E}{0 + r} = \frac{12}{0.4} = 30\ A$$

2. Given,
Emf of a battery = 10V
Internal resistance of the battery = 3 Ω
Current in circuit = 0.5A
∴ Resistance of the resistor will be

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

$$\Rightarrow R = \frac{E}{I} - r.$$

$$= \frac{10}{0.5} - 3 = 20 - 3 = 17\ \Omega$$

The terminal voltage of the ~~mal~~ battery when the circuit is closed will be.

$$V = IR$$

$$= 0.5 \times 17 = 8.5V$$

Date
Page

3a) Given:-

Theree resistors of Resistance 1Ω, 2Ω & 3Ω

They are connected in series.

∴ The total Resistance of the Combination

$$R_{net} = R_1 + R_2 + R_3$$
$$= (1 + 2 + 3)\Omega = 6\Omega$$

b) This Series Connection is now connected to a battery.

Em.f of the battery $= 12V$

∴ Current flowing through the resistor.

$$I = \frac{E}{R_{net}}$$
$$= \frac{12}{6} = 2A$$

So, Now,

The potential drop across each resistor is.

$$V_1 = IR_1$$
$$= 2 \times 1 = 2V$$
$$V_2 = IR_2$$
$$= 2 \times 2 = 4V$$
$$V_3 = IR_3$$
$$= 2 \times 3 = 6V$$

4a) Given,

Three resistores, 2Ω, 4Ω & 5Ω are combined in parallel

The total resistance of the combination.

$$R_{eq} = \frac{R_1 R_2 R_3}{R_1 R_2 + R_2 R_3 + R_1 R_3}$$
$$= \frac{2 \times 4 \times 5}{8 + 20 + 10} = \frac{40}{38} = 1.05\Omega$$

b) Given,
The above Combination is connected to a battery.
Emf of the battery = 20V
Here,
As it is a parallel combination, the potential drop will remain same for all three resistor.
Hence,
The Current through each resistor will be

$$I_1 = \frac{V}{R_1} = \frac{20}{2} = 10A$$

$$I_2 = \frac{V}{R_2} = \frac{20}{4} = 5A$$

$$I_3 = \frac{V}{R_3} = \frac{20}{5} = 4A$$

Hence,
The total current drawn from the battery is.

$$I_{net} = (I_1 + I_2 + I_3)$$
$$= (10 + 5 + 4)A = 19A.$$

OR

$$I_{net} = \frac{E}{R_{eq}}$$
$$= 20 \times \frac{38}{40} = 19A.$$

5- Given;
Room temperature (T_1) = 27°C
Resistance of heating element at T_1 temp. (R_1) = 100Ω
Resistance at T_2 temp. (R_2) = 117 Ω.
The temperature cofficient of the matterial of the resistor (α) = 1.70×10^{-4} °C^{-1}
~~Temper~~

~~Hence,~~
~~The temperature of the heating element will be.~~

$$\cancel{\alpha = \frac{R_2 - R_1}{R_1(T_2 - T_1)}}$$

$$\cancel{\Rightarrow T_2 = \frac{\alpha R_1}{R_2 - R_1} + T_1}$$

$$\cancel{= \frac{1.70 \times 10^{-4} \times 100}{117 - 100} + 27}$$

$$\cancel{= \frac{17 \times 10^{-5} \times 100}{17} + 27}$$

$$\cancel{= 10^{-3} + 27}$$

Hence,
The temperature of the heating element will be

$$\alpha = \frac{R_2 - R_1}{R_1(T_2 - T_1)}$$

$$\Rightarrow T_2 = \frac{R_2 - R_1}{\alpha R_1} + T_1$$

$$= \frac{117 - 100}{1.70 \times 10^{-4} \times 100} + 27$$

$$= \frac{17}{17 \times 10^{-5} \times 100} + 27$$

$$= \frac{1}{10^{-3}} + 27$$

$$= 1000 + 27 = 1027^\circ C$$

6. Given,
Length of a wire = 15m
Area of cross-section of the wire = $6.0 \times 10^{-7} m^2$
resistance measured = 5.0Ω
Current passed through wire = 0

Hence,
The resistivity of the material at the temperature of the experiment will be

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

$$\Rightarrow \rho = \frac{RA}{l}.$$

$$= \frac{\cancel{5} \times \cancel{6.0}^{2} \times 10^{-7}}{\cancel{15}_{3}}$$

$$= 2 \times 10^{-7}\ \Omega\, m$$

7. Given;
Resistance of a silver wire at 27.5°C = 2.1 Ω
Temperature (T_1) = 27.5°C
Resistance at 100°C (R_2) = 2.7 Ω.
Temperature (T_2) = 100°C
Hence,
The temperature coefficient of resistivity of the silver is.

$$\alpha = \frac{R_2 - R_1}{R_1(T_2 - T_1)}$$

$$= \cancel{\frac{100 - 27.5}{27.5(}}$$

$$= \frac{2.7 - 2.1}{2.1(100 - 27.5)}$$

$$= \frac{0.6}{2.1 \times 72.5}$$

$$= \frac{10.2}{0.7 \times 72.5} = 3.\text{[illegible]}9 \times 10^{-3}\ {}^{\circ}C^{-1}$$

8. ~~Pod~~ Given;

Potential supplied = 230V

Initial current drawn. = 3.2 A.

Final steady current drawn = 2.8 A.

Here,

Initial resistance of heating element.

$$R_1 = \frac{V}{I_1}$$

$$= \frac{230}{3.2} = \frac{2300}{32} = 71.87$$

Final resistance of heating element

$$R_2 = \frac{V}{I_2}$$

$$= \frac{230}{2.8} = \frac{2300}{28} = 82.14$$

Room temperature $(T_1) = 27.0^\circ C$

Temperature coefficient of resistance of nichrome

$$\alpha = 1.70 \times 10^{-4} \, {}^\circ C^{-1}$$

Hence,

The steady temperature of the heating element is.

$$\alpha = \frac{R_2 - R_1}{R_1(T_2 - T_1)}$$

$$\Rightarrow T_2 = \frac{R_2 - R_1}{\alpha R_1} + T_1$$

$$= \frac{82.14 - 71.87}{1.70 \times 10^{-4} \times 71.87} + 27$$

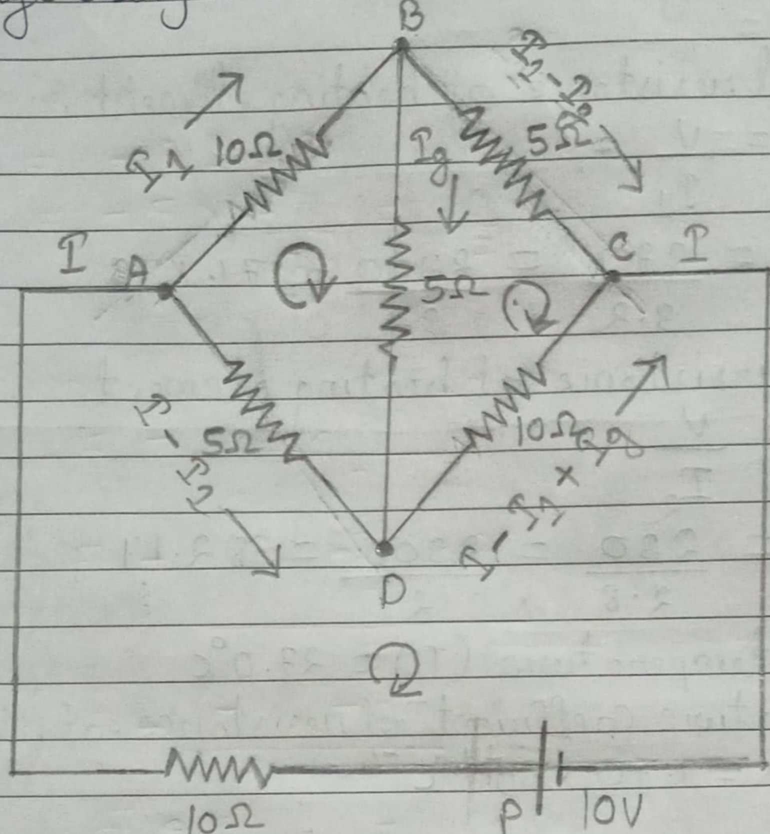
$$= \frac{10.27}{1.70 \times 10^{-4} \times 71.87} + 27$$

$$= \frac{10.27}{122.179 \times 10^{-4}} + 27$$

$$= 840.5 + 27 = 867.5^\circ C$$

Date
Page

9. In the below given figure,
The current is being distributed using the Kirchhoff's law through out the wheatstone bridge ~~using~~ in each resistor.



Here,
In loop ABDA,

$$10I_1 + 5I_g - 5(I - I_1) = 0$$
$$\Rightarrow 10I_1 + 5I_g - 5I + 5I_1 = 0$$
$$\Rightarrow 15I_1 + 5I_g - 5I = 0$$
$$\Rightarrow 3I_1 + I_g - I = 0 \quad \ldots\ldots (1)$$

Now,
In loop BCDB,

$$5(I_1 - I_g) - 10(I - I_1 + I_g) - 5I_g = 0$$
$$\Rightarrow 5I_1 - 5I_g - 10I + 10I_1 - 10I_g - 5I_g = 0$$
$$\Rightarrow 15I_1 - 20I_g - 10I = 0$$
$$\Rightarrow 3I_1 - 4I_g - 2I = 0 \quad \ldots\ldots (2)$$

Now,

Date
Page

In loop ADCPA,

$5(I-I_1) + 10(I-I_1+I_g) + 10I = 10$

$\Rightarrow 5I - 5I_1 + 10I - 10I_1 + 10I_g + 10I = 10$

$\Rightarrow 25I + 10I_g - 15I_1 = 10$

$\Rightarrow 5I + 2I_g - 3I_1 = 2 \quad \ldots\ldots (3)$

Now,
Substracting eqn (1) and (2), we get,

$3I_1 + I_g - I = 0$

$3I_1 - 4I_g - 2I = 0$

$(-) \quad (+) \quad (+)$

$5I_g + I = 0$

$\Rightarrow I = -5I_g \quad \ldots\ldots (4)$

Now,
Substituting the value of I in eqn (3), we get.

$5I + 2I_g - 3I_1 = 2$

$\Rightarrow 5(-5I_g) + 2I_g - 3I_1 = 2$

$\Rightarrow -25I_g + 2I_g - 3I_1 = 2$

$\Rightarrow -3I_1 = 2 + 23I_g$

$\Rightarrow I_1 = -\frac{23I_g + 2}{3} \quad \ldots\ldots (5)$

Now,
Substituting the value of I_1 in eqn (1), we get

$3I_1 + I_g - I = 0$

$\Rightarrow 3 \times \left(\frac{-(23I_g + 2)}{3}\right) + I_g - I = 0$

$\Rightarrow -23I_g - 2 + I_g - I = 0$

$\Rightarrow -I = 2 + 22I_g$

$\Rightarrow I = -(22I_g + 2) \quad \ldots\ldots (6)$

Now,
Equating eqn (4) & (6), we get.

$-5I_g = -(22I_g + 2)$

$\Rightarrow 5I_g = 22I_g + 2$

Date
Page

$\Rightarrow 22 I_g - 5 I_g = -2$

$\Rightarrow 17 I_g = -2$

$\Rightarrow I_g = \frac{-2}{17} A$

Now,

Putting the value of I_g in eq^n (4), we get.

$I = -5 I_g.$

$= -5 \times \frac{-2}{17} = \frac{10}{17} A$

Now,

Putting the value of I_g in eq^n (5), we get

$I_1 = -\frac{23 I_g + 2}{3}$

$= -\frac{23 \times \frac{-2}{17} + 2}{3}$

$= -\frac{(-46 + 34)}{3 \times 17}$

$= \frac{12}{3 \times 17} = \frac{4}{17} A$

Now,

The Current flowing through each branch is.

AB branch:- $I_1 = \frac{4}{17} A$

BC branch:- $I_1 - I_g = \frac{4}{17} + \frac{2}{17} = \frac{6}{17} A$

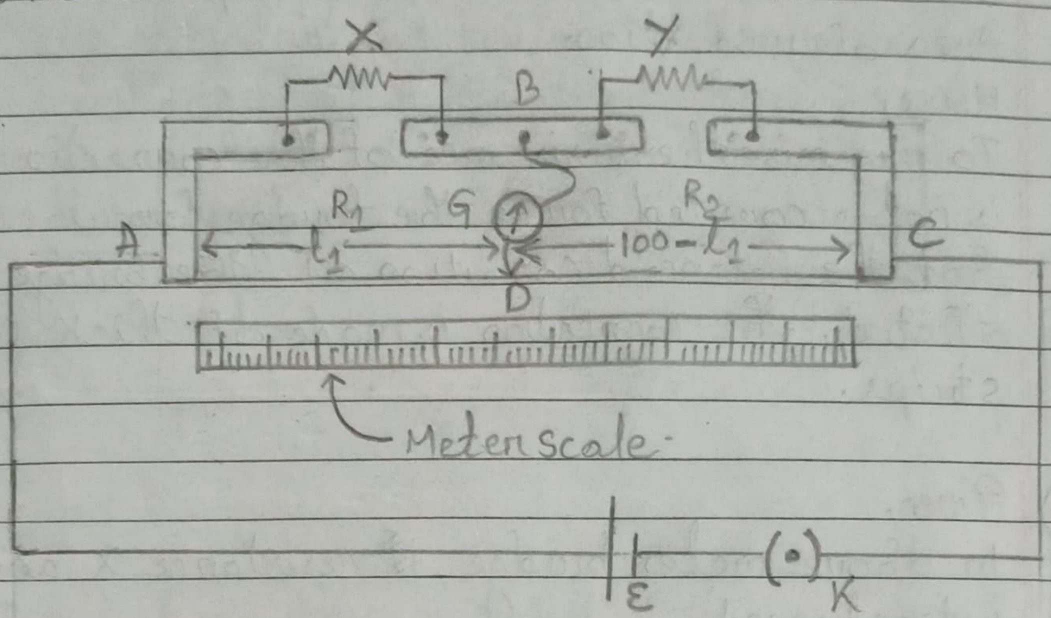
AD branch:- $I - I_1 = \frac{10}{17} - \frac{4}{17} = \frac{6}{17} A$

DC branch:- $I - I_1 + I_g = \frac{10}{17} - \frac{4}{17} - \frac{2}{17} = \frac{4}{17} A$

BD branch:- $I_g = -\frac{2}{17} A$

Date
Page

10. In the given figure below,
A meter bridge is shown with resistors connected of resistance X and Y



a) Here,
The resistance $Y = 12.5\,\Omega$
The balance point from end A i.e., $l_1 = 39.5$ cm
The balance point from end B is.
$100 - l_1 = (100 - 39.5)$ cm $= 60.5$ cm
Hence,
According to the balanced condition of wheatstone bridge,

$$\frac{X}{Y} = \frac{R_1}{R_2} = \frac{l_1}{100 - l_1} \qquad \left[R = \frac{\rho l}{A} \Rightarrow R \propto l\right]$$

$$\Rightarrow \frac{X}{12.5} = \frac{l_1}{100 - l_1}$$

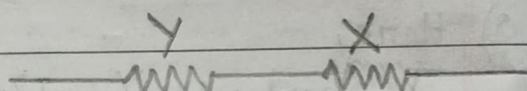
$$\Rightarrow X = \frac{39.5}{60.5} \times 12.5 = 8.16\,\Omega$$

∴ The resistance of X will be $8.16\,\Omega$
Now,
The connection between resistors in a wheatstone or meter bridge is made of thick copper strips

because it increases the Area of cross-section of the wire which decreases the resistance of the wire as resistance is inversly proportional to the Area of crossection.

Hence,
To minimise the resistance of the connection, which is not accounted for in the bridge formulae so that the balanced condition of the bridge is not affected, the connection is made of thick copper strips.

b) Given,
In above meter bridge, resistance X and Y are interchanged.
For this,
Lets consider the new balance point to be l_2 from end A



So, balance point from end C will be $(100-l_2)$ cm,
Hence,
According to the balanced condition of wheatstone bridge,

$$\frac{Y}{X} = \frac{P}{Q} = \frac{l_2}{100-l_2}$$

$$\Rightarrow \frac{Y}{X} = \frac{l_2}{100-l_2}$$

$$\Rightarrow \frac{12.5}{8.16} = \frac{l_2}{100-l_2}$$

$$\Rightarrow 12.5(100-l_2) = 8.16\,l_2$$

$$\Rightarrow 1250 - 12.5 l_2 = 8.16 l_2$$

$$\Rightarrow 20.66\,l_2 = 1250 \Rightarrow l_2 = \frac{1250}{20.66} = 60.5\text{cm}$$

Date
Page

∴ The New balance point of the bridge is 60.5cm. from end A.

c) If the ~~g~~ galvanometer and cell are replaced or interchanged at the balance point of the metre bridge, the galvanometer will show no deflection. ~~Hence~~,
Hence, no current will flow through the ~~g~~ galvanometer so, it will show no current.

11. Given;
Emf of a storage battery = 8.0V
Internal resistance = 0.5 Ω
DC supply given = 120 V.
Resistance of the series resistor = 15.5Ω
Here,
The current flowing through this set up.

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

$$= \frac{120}{15.5} = \frac{1200}{155} = 7.74\,A$$

Hence,
The terminal voltage of the battery during charging,

$$V_B = E + Ir.$$

$$= 8 + (7.74 \times 0.5)$$

$$= (8.0 + 3.87)V = 11.87V.$$

Now,
The purpose of having a series resistor in the charging circuit is to limit the current drawn from the external source.

Date
Page

12. Given,
In a potentiometer arrangement,
Emf of a standard cell = 1.25 V
Balance point found due to ~~this~~ E_1 is $(l_1) = 35.0$ cm
Balance point due to E_2 is $(l_2) = 63.0$ cm.
Here,
E_2 is the emf of another standard cell.
As we know, that
$V = Kl$
So, For Balance point as l_1, potential difference is
$V_1 = Kl_1$
For Balance point as l_2, potential difference is
$V_2 = Kl_2$
Now,
As in a potentiometer, the potential difference at the balance point is equal to the Emf of the standard cell connected.
So,
$E_1 = V_1 = Kl_1$
$E_2 = V_2 = Kl_2$
Hence,
Taking the ratio of the emf of standard cell

$$\frac{E_1}{E_2} = \frac{Kl_1}{Kl_2}$$

$$\Rightarrow \frac{E_1}{E_2} = \frac{l_1}{l_2}$$

$$\Rightarrow E_2 = \frac{E_1 \times l_2}{l_1}$$

$$= 1.25 \times \frac{63.0}{35.0} = 1.25 \times \frac{9}{5} = 2.25V$$

$\therefore$ The emf of the second cell is 2.25V.

Date
Page

13. Given,

The number density of free electrons $= 8.5 \times 10^{28} m^{-3}$

length of a wire $= 3.0 m$

The Area of cross-section of wire $= 2.0 \times 10^{-6} m^2$

Current in wire $= 3.0 A$

Now,

The drift velocity of the free electrons is,

$$I = neAV_d$$

$$\Rightarrow V_d = \frac{I}{neA}$$

$$= \frac{3}{8.5 \times 10^{28} \times 1.6 \times 10^{-19} \times 2.0 \times 10^{-6}}$$

$$= \frac{3}{8.5 \times 3.2 \times 10^{28} \times 10^{-25}}$$

$$= \frac{3}{27.2 \times 10^{3}}$$

$$= 0.11 \times 10^{-3} = 1.1 \times 10^{-4} m/s$$

Now,

The time taken for an electron to drift from one end of the wire to other.

$$V_d = \frac{l}{t}$$

$$\Rightarrow t = \frac{l}{V_d} = \frac{3}{1.1 \times 10^{-4}} = 2.7 \times 10^{4} s.$$

14. Given,

Negative surface charge density of earth $(\sigma) = 10^{-9} Cm^{2}$

Potential difference between top of the atmosphere and surface $= 400 KV$.

Current over the entire globe $= 1800 A$

Radius of the earth $(r) = 6.37 \times 10^{6} m$

Now,
The Area of crossection of the earth.

$A = 4\pi r^2$

$= 4 \times (3.14) \times (6.37 \times 10^6)^2$

$= 12.56 \times 40.57 \times 10^{12}$

$= 509.55 \times 10^{12} m^2$

∴ The charge throughout the earth's surface.

$q = \sigma \times A$

$= 10^{-9} \times 509.55 \times 10^{12}$

$= 509.55 \times 10^3$

Now,
The time required to neutralise the earth's surface is.

$I = \frac{q}{t}$

$\Rightarrow t = \frac{q}{I} = \frac{509.55 \times 10^3}{18 \times 10^2}$

$= 28.308 \times 10$

$= 283.08 s$

15 a) Given;
Emf of each six acid type secondary cell.

$\varepsilon = 2.0 V.$

Internal resistance of the cell $(r) = 0.015 \Omega$

They are connected in series.

External resistance $(R) = 8.5 \Omega$

Now,
As they are in series combination.
The total emf of the cell combination.

$E_{net} = nE$

$= 6 \times 2.0 = 12.0 V$

The total internal resistance of the combination,

$$r_{net} = nr$$
$$= 6 \times 0.015 = 0.09\,\Omega$$

Now,
The current drawn from the supply.

$$I = \frac{E_{net}}{R + r_{net}}$$
$$= \frac{E_{net}}{R} \quad [r_{net} << R]$$
$$= \frac{12}{8.5} = 1.41\,A$$

∴ The terminal voltage across the resistor.

$$V = IR$$
$$= 1.41 \times 8.5 = 11.98\,V$$

b) Given,
Em.f of a secondary cell = 1.9V
Internal resistance of the cell = 380 Ω
Now,
For maximum current, variable resistance, should be equal to zero (R = 0.)
∴ The maximum current that can be drawn from the cell.

$$I = \frac{E}{r}$$
$$= \frac{1.9}{380} = \frac{19}{3800} = \frac{1}{200}$$
$$= 0.005\,A$$

Now,
The cell cannot drive the starting motor of a car because a starter motor requires large current (~100A) for a few second.

Date
Page

16. Given;
Two wires of equal length & same resistance
Here,
Let the length of aluminium wire be l_{Al}
and the length of Copper wire be l_{cu}
So,
The resistance of both wire will be R_{Al} & R_{cu}
$\rho_{Al} = 2.63 \times 10^{-8}\ \Omega m$
$\rho_{cu} = 1.72 \times 10^{-8}\ \Omega m.$
Relative density of Al = 2.7
Relative density of Cu = 8.9
Now,
As we know that, $R = \frac{\rho l}{A}$

So, For Aluminium wire, $R_{Al} = \rho_{Al} \frac{l_{Al}}{A_{Al}}$

& For Copper wire, $R_{cu} = \rho_{cu} \frac{l_{cu}}{A_{cu}}$

Here,
$$R_{Al} = R_{cu}$$
$$\Rightarrow \rho_{Al} \frac{l_{Al}}{A_{Al}} = \rho_{cu} \frac{l_{cu}}{A_{cu}}$$
$$\Rightarrow \frac{\rho_{Al}}{A_{Al}} = \frac{\rho_{cu}}{A_{cu}} \qquad [l_{Al} = l_{cu}]$$
$$\Rightarrow \frac{A_{cu}}{A_{Al}} = \frac{\rho_{cu}}{\rho_{Al}}$$
$$\Rightarrow \frac{A_{Al}}{A_{cu}} = \frac{\rho_{Al}}{\rho_{cu}} = \frac{2.63 \times 10^{-8}}{1.72 \times 10^{-8}}$$
$$= 1.52$$
$$\Rightarrow \frac{A_{Al}}{A_{cu}} = 1.52 \ \frac{2.63}{1.72}$$
From this we can conclude, $A_{Al} > A_{cu}$

Now,
Mass of the wire of aluminium,

$$d_{Al} = \frac{M_{Al}}{V_{Al}}$$

$$\Rightarrow M_{Al} = V_{Al} \times d_{Al}$$
$$= (A_{Al} \times l_{Al}) \times d_{Al}.$$

Now,
Mass of wire of the Copper

$$d_{cu} = \frac{M_{cu}}{V_{cu}}$$

$$\Rightarrow M_{cu} = V_{cu} \times d_{cu}$$
$$= (A_{cu} \times l_{cu}) \times d_{cu}$$

Now,
Taking the ratio of both the masses of wire.

$$\frac{M_{Al}}{M_{cu}} = \frac{A_{Al} \times l_{Al} \times d_{Al}}{A_{cu} \times l_{cu} \times d_{cu}}$$

$$= \frac{A_{Al}}{A_{cu}} \times \frac{d_{Al}}{d_{cu}} \qquad [l_{Al} = l_{cu}]$$

$$= \frac{2.63}{1.72} \times \frac{2.7}{8.9}$$

$$= \frac{7.101}{15.308} = 0.463$$

$$\Rightarrow \frac{M_{Al}}{M_{cu}} = 0.463$$

From this we can conclude that $M_{Al} < M_{cu}$ as their ratio is less than one

i.e., $\frac{M_{Al}}{M_{cu}} < 1$

Hence,
The aluminium wire will be ligher than the copper wire and since aluminium wire is ligher, it is preferred for overhead power cables.

17. From the above table,
It can be concluded that in each observation, the resistance of the resistor made of alloy manganin is nearly same i.e., 19.6 Ω.
And
As we know, According to the ohm's law,
$$\frac{V}{I} = R = \text{Constant}.$$
So, here, manganin is an ohmic conductor, i.e., this alloy obeys ohms law as resistance remains constant throughout the observation.
And
The resistivity of the alloy manganin is nearly independent of temperature.
Hence,
The resistance of the manganin is 19.6 Ω.

~~18.~~

18. a) In this case,
The steady current is flowing through the conductor. So, the current is constant.
But, the conductor has a non-uniform Area of crossection and as all the rest of them i.e., current density, electric field and drift speed depends upon the Area inversely, they are not Constant.
Hence,
The only quantity that remains Constant is current.

b) No, the Ohm's law is not universally applicable for all conducting elements.
Example of non-ohmic conducting elements are ~~Vacc~~ Vaccum diode, semiconductor diode.

Date
Page

c) A low voltage supply from which one needs high currents must have very low internal resistance because for maximum current, the condition is variable resistance $R=0$.
So, the maximum current $I = \frac{E}{r}$.

Here, $I \propto \frac{1}{r}$, So, ~~to~~ with ~~inc~~ decrease in the internal resistance the current will increase.
Hence, they must have low internal resistance in order to get maximum current.

d) A high tension (HT) supply of say, 6 KV must have a very large internal resistance because it will limit the current drawn from the supply. If the circuit is shorted, the current drawn will exceed safety limits, if the internal resistance is not very large.

19. a) Alloys of metals usually have greater resistivity than that of their constituent metals.

b) Alloys usually have much lower temperature coefficients of resistance than pure metals.

c) The resistivity of the alloy manganin is nearly independent of temperature.

d) ~~The~~ The resistivity of a typical insulator (e.g., amber) is greater than that of a metal by a factor of the order of 10^{22}

30. a) Given,

No. of resistors = n.

Resistance of each resistor = R.

Now;

i) To get the maximum resistance, all the n resistors are to be connected in series.

So, that,

The equivalent resistance will be

$$R^{s}_{eq} = n \times R = nR$$

Now,

ii) To get the minimum resistance, all the n resistors are to be connected in parallel.

So, that

The equivalent resistance will be

$$R^{p}_{eq} = \frac{R}{n}.$$

Now,

The ratio of the maximum to minimum effective resistance is.

$$\frac{R^{s}_{eq}}{R^{p}_{eq}} = \frac{nR}{\frac{R}{n}} = \frac{nR \times n}{R} = n^2.$$

b) Given,

Resistance of resistors = $1\Omega, 2\Omega, 3\Omega$

Now,

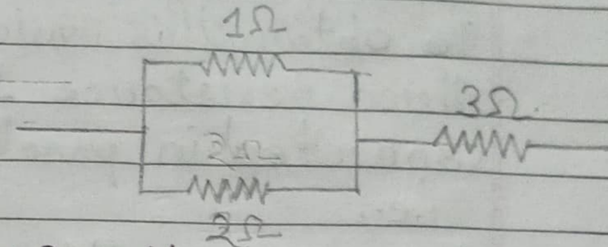
i) Required equivalent resistance, $R_{eq} = (11/13)\Omega$.

So,

To obtain this equivalent resistance, we have to connect the resistors 1Ω & 2Ω in parallel and then their equivalent resistance is to be connected in ~~par~~ series with the resistor of 3Ω resistance.

i.e.,

$$R_{eq} = R_s + R_p$$



$$= 3 + \frac{2\times1}{2+1}$$

$$= 3 + \frac{2}{3} = \frac{9+2}{3} = \frac{11}{3}\ \Omega$$

Now,

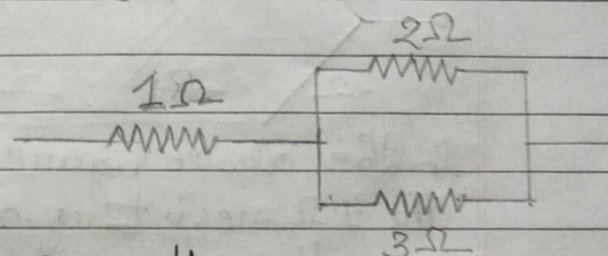
ii) Required equivalent resistance $= (11/5)\Omega$

So,

To obtain this equivalent resistance, the resistors 2Ω & 3Ω are to be connected in parallel. and its effective resistance is to be in series with the resistor of 1Ω resistance.

i.e.,

$$R_{eq} = R_s + R_p$$



$$= 1 + \frac{2\times3}{2+3}$$

$$= 1 + \frac{6}{5} = \frac{5+6}{5} = \frac{11}{5}\ \Omega$$

Now,

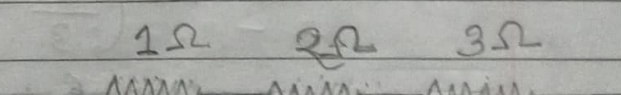
iii) Required equivalent resistance $= 6\Omega$

So

To obtain this equivalent resistance, all the three resistance 1Ω, 2Ω & 3Ω are to be connected in series.

i.e.,

$$R_{eq} = R_1 + R_2 + R_3$$



$$= 1 + 2 + 3$$

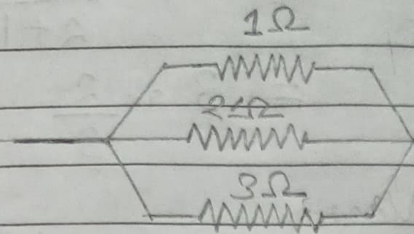
$$= 6\ \Omega.$$

Now,

iv) Required equivalent resistance $= (6/11)\Omega$.

So,
To obtain this equivalent resistance, all the three resistance 1Ω, 2Ω & 3Ω are to be connected in parallel combination.

i.e.,

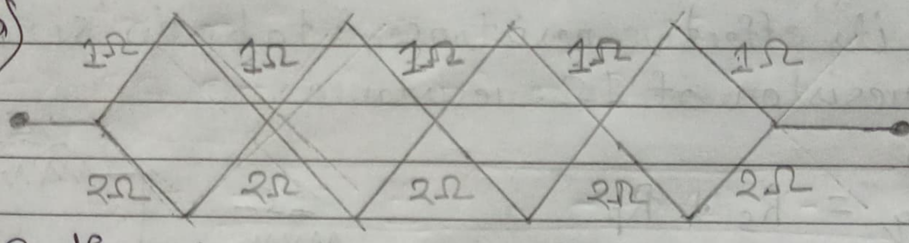


$$R_{eq} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$= \frac{R_1 R_2 R_3}{R_1R_2 + R_2R_3 + R_1R_3}$$

$$= \frac{1 \times 2 \times 3}{2+6+3} = \frac{6}{11}\ \Omega.$$

c) a)



In the above figure;
The 1Ω resistors are all in series and 2Ω resistors are all in series but the equivalent resistance of all 1Ω resistors and all 2Ω resistors are in parallel connection.
Hence,
The equivalent resistance is.

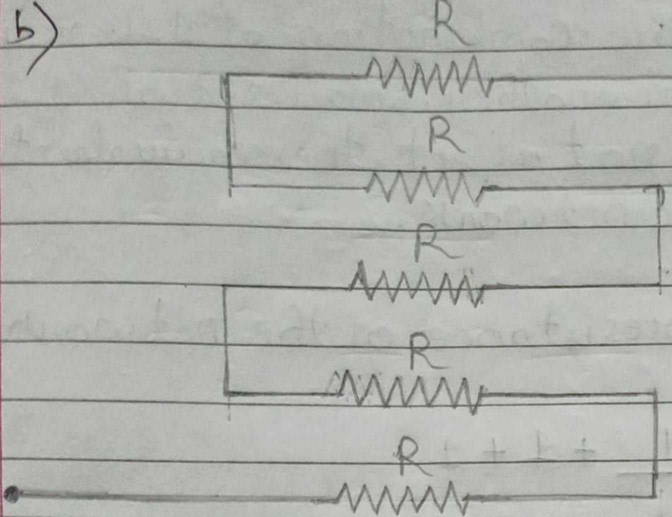
$$R_{eq} = 4 \times \left(\frac{2 \times 1}{2+1} + \frac{2 \times 1}{2+1}\right)$$

$$= 4 \times \left(\frac{2}{3} + \frac{2}{3}\right)$$

$$= 4 \times \left\{\frac{4}{3} = \frac{16}{3}\ \Omega.\right.$$

~~Now,~~
~~b) In the below given figure~~

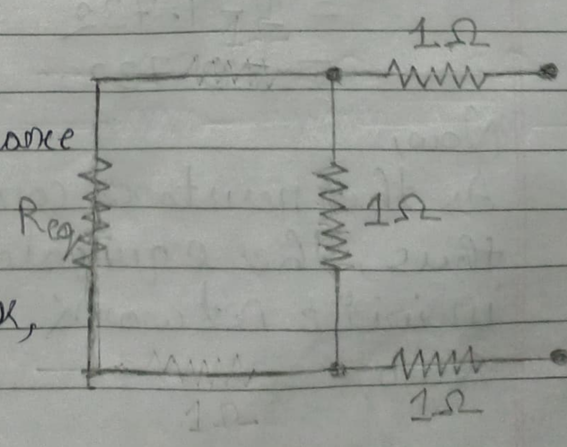
b)



In the above figure,
All the resistors of resistance R. are in series.
connection with each other.
Hence,
The equivalent resistance is:

$R_{eq} = R + R + R + R + R$
$= 5R$

21. Given.
Voltage supplied to the network = 12V
Internal resistance associated = 0.5Ω
Resistance in each resistor = 1Ω.
Here,
It is an infinite network
So, Let consider some part of it as the ~~equivalent~~
effective resistance.
Now,
The equivalent resistance
of the infinite
network be Req.
In this infinite network,
there is a continuous.



repetation of the combination of 1Ω resistors.
So, an addition of another small set of 1Ω resistance will not affect the equivalent resistance of the network.
Hence,
The equivalent resistance of the network is given by,

$$R_{eq} = \frac{R_{eq} \times 1}{R_{eq} + 1} + 1 + 1$$

$$\Rightarrow R_{eq} = 2 + \frac{R_{eq}}{R_{eq} + 1}$$

$$\Rightarrow R_{eq}(R_{eq} + 1) = 2R_{eq} + 2 + R_{eq}$$

$$\Rightarrow R_{eq}^2 + R_{eq} = 3R_{eq} + 2.$$

$$\Rightarrow R_{eq}^2 - 2R_{eq} - 2 = 0.$$

Now,

$$R_{eq} = \frac{-(-2) \pm \sqrt{(-2)^2 - 4 \times (1) \times (-2)}}{2 \times (1)}$$

$$= \frac{2 \pm \sqrt{4 + 8}}{2}$$

$$= \frac{2 \pm \sqrt{12}}{2}$$

$$= \frac{2 \pm 2\sqrt{3}}{2} = 1 \pm \sqrt{3}$$

Case-1

$$R_{eq} = 1 - \sqrt{3} = 1 - 1.732 = -0.732.$$

Case-2

$$R_{eq} = 1 + \sqrt{3} = 1 + 1.732 = 2.732$$

Now,
As the resistance can never be negative so, thus, the equivalent Resistance of the infinite network is $2.732\,\Omega$.
Now,

The Current drawn from 12 V supply.

$$I = \frac{E}{R_{eq} + r}$$

$$= \frac{12}{2.732 + 0.5} = \frac{12}{3.232} = 3.71\,A.$$

22. Given;

Cell of potentiometer = 2.0V.

Internal resistance = 0.40 Ω

Emf of standard cell = 1.02 V

Balance point due to the standard cell

= 67.3 cm length of wire.

So,

$l_1 = 67.3$ cm & $100 - l_1$ is the remaining length.

High resistance provided = 600 K Ω

$= 6 \times 10^5\,\Omega$.

Now,

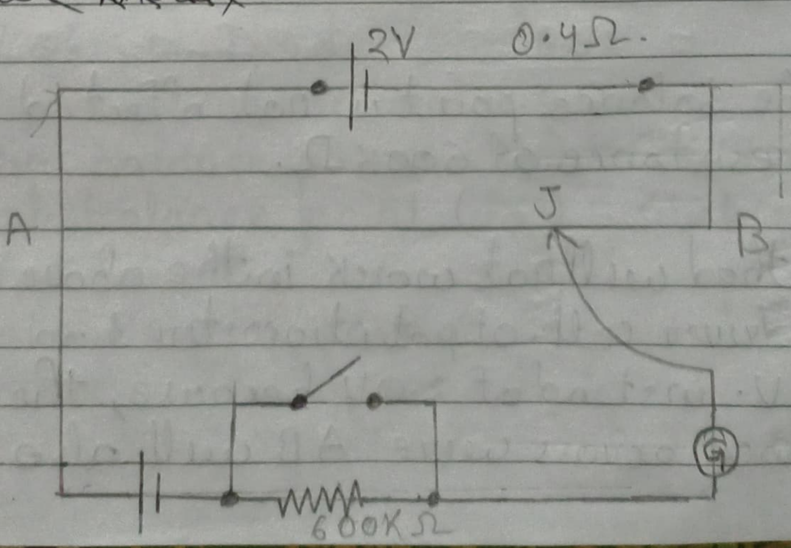
Emf of another standard cell = ε

New Balance point created due to this standard cell = 82.3 cm length of wire

So, $l_2 = 82.3$ cm.

~~Now,~~

i) ~~As we know~~



Now,

a) As we know that,
The emf of the standard cell will be equal to the potential difference V_{AJ} according to the balance point;
Hence,

$$E_1 = V_{AJ_1} = K l_1$$
$$E_2 = V_{AJ_2} = K l_2.$$

So,
The value of the emf ε will be

$$\frac{E_1}{E_2} = \frac{K l_1}{K l_2}$$

$$\Rightarrow \frac{1.02}{\varepsilon} = \frac{l_1}{l_2}$$

$$\Rightarrow \varepsilon = \frac{1.02 \times l_2}{l_1}$$

$$= \frac{1.02 \times 82.3}{67.3} = 1.247\,V.$$
$$\approx 1.25\,V.$$

Now,

b) The purpose of having high resistance of 600 kΩ is to reduce the flow of current through the standard cell so that the balance point is achieved and to ensure the protection of galvanometer;

Now,

c) No, the balance point is not affected by this high resistance of 600 kΩ.

Now.

d) The method will not work in the above situation if the driven cell of potentiometer had an emf of 1.0 V instead of 2.0 V because, the potential difference across wire AB will also be

decrease due this change in emf and it will be less than 1V.
So, Due to this, the emf of the standard cell will ~~be~~ not be equal with the potential difference across AB.
And hence, No, balance point will be obtained in this case on the wire AB.
Now,

c) The circuit, as it is, would be unsuitable; because the balance point for ε of the order of a few mV will be very close to the end A and the percentage error in measurement will be very large.
The circuit can be modified by putting a suitable resistor R in series with the wire AB so that potential drop across AB is only slightly greater than the emf to be measured. Then the Balance point will be very larger in length of the wire and the percentage error will be much smaller.

23. Given;
Emf of driver cell of potentiometer = 2.0 V
Emf of standard cell = 1.5 V.
External resistance = 9.5 Ω.
Initial balance point (l_1) = 76.3 cm.
Final balance point (l_2) = 64.8 cm.
Now,
Before connecting the external resistance
The expression for stand cell was

$$\varepsilon = V = K l_1$$

Now,
The expression for the standard cell is

$$\varepsilon = I(r+R)$$

And the expression for potential difference across the wire AB will be

$$V = IR.$$

Hence,
As we know, the relation for e.m.f in potentiometer

$$\frac{E_1}{E_2} = \frac{l_1}{l_2}$$

$$\Rightarrow \frac{\varepsilon}{V} = \frac{l_1}{l_2}.$$

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

$$\Rightarrow \frac{r+R}{R} = \frac{l_1}{l_2}$$

$$\Rightarrow \frac{r}{R} = \frac{l_1}{l_2} - 1$$

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

$$= \left(\frac{76.3 - 64.8}{64.8}\right) \times 9.5$$

$$= \frac{11.5}{64.8} \times 9.5$$

$$= \frac{109.25}{64.8} = 1.68\,\Omega \approx 1.7\,\Omega.$$

Hence, the internal resistance of cell = $1.7\,\Omega$.