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Home Assignment

Date: 6-7-2021..20 -7-2021

PHYSICS

CH: 3

Current Electricity

NCERT EXCERCISES

EXERCISES

3.1 The storage battery of a car has an emf of 12 V. If the internal resistance of the battery is 0.4 Ω, what is the maximum current that can be drawn from the battery?

3.2 A battery of emf 10 V and internal resistance 3 Ω is connected to a resistor. If the current in the circuit is 0.5 A, what is the resistance of the resistor? What is the terminal voltage of the battery when the circuit is closed?

3.1 **According Question**

EMF of battery $(E) = 12V$
internal resistance of battery $(R) = 0.4\,\Omega$
amount of max. current drawing from battery (I)

A| **Ohm's law**

$$E = IR$$

Rearranging

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

$$\Rightarrow \quad I = \frac{12}{0.4} = 30\,A$$

$\therefore$ max. current drawn $= 30\,A$.

3.2 A battery of EMF 10V and internal resistance $3\,\Omega$ connected to a resistor. If the current in the circuit is 0.5A, what's the resistance of the resistor? What is the terminal voltage of battery when circuit closed?

EMF of battery $(E) = 10V$
Internal resistance of battery $(R) = 3\,\Omega$
Current in circuit $(I = 0.5A)$
Let R be resistance of resistor.

Now

Now using Ohm's Law...

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

$$\Rightarrow R + r = \frac{E}{I} = \frac{10}{0.5} = 20\,\Omega$$

So.

$$R = 20 - 3$$
$$= 17\,\Omega$$

Terminal voltage of resistor (V)

Now

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

$\therefore$ Resistance of resistor = $17\,\Omega$

terminal voltage = $8.5\ V$

is a
rea

circuit is closed?

3.3 (a) Three resistors 1 Ω, 2 Ω, and 3 Ω are combined in series. What is the total resistance of the combination?

(b) If the combination is connected to a battery of emf 12 V and negligible internal resistance, obtain the potential drop across each resistor.

3.3

a) Three resistors $1\Omega, 2\Omega$ and 3Ω combined in series.

Total resistance of combination?

Resistors

$r_1 = 1\Omega$, $r_2 = 2$, $r_3 = 3\Omega$.

The total resistance :- $1\Omega + 2\Omega + 3\Omega = 6\Omega$.

b) If the combination is connected ..... potential drop

I = current, emf of battery $E = 12V$

Total resistance of circuit = $R = 6\Omega$

Ohm's law. $I = \frac{E}{R}$

Substituting values,

$$I = \frac{12}{6} = 2A$$

Current calculated :- 2A

Potential drop across 1Ω resistor = V_1

Value of V_1 obtained ohm's law

$$V_1 = 2 \times 1 = 2V$$

let potential drop across 2Ω resistor = V_2

Value of V_2 obtained ohm's law

$$V_2 = 2 \times 2 = 4V$$

potential drop across 3Ω resistor = V_3

Value of V_3 obtained ohm's law

$$V_3 = 2 \times 3 = 6V$$

~~Potentia drop across 4Ω resistor = V_4~~

~~Value of V_4~~

Potential drop across resistor $r_1 = 1\Omega$, $r_2 = 2\Omega$, $r_3 = 3\Omega$

calculated, $V_1 = 2V$

$V_2 = 4V$

$V_3 = 6V$

each resistor.

3.4 (a) Three resistors 2 Ω, 4 Ω and 5 Ω are combined in parallel. What is the total resistance of the combination?

(b) If the combination is connected to a battery of emf 20 V and negligible internal resistance, determine the current through each resistor, and the total current drawn from the battery.

3.5 At room temperature (27.0 °C) the resistance of a heating element is 100 Ω. What is the temperature of the element if the resistance is found to be 117 Ω, given that the temperature coefficient of the material of the resistor is 1.70×10^{-4} °C^{-1}.

3.6 A negligibly small current is passed through a wire of length 15 m

Q 8.4 a) Three resistors $2\Omega, 4\Omega$ and 5Ω are combined in parallel.
What ... combination?

$r_1 = 2\Omega$, $r_2 = 4\Omega$, $r_3 = 5\Omega$ combined in parallel.

Hence total resistance

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\frac{1}{R} = \frac{1}{2} + \frac{1}{4} + \frac{1}{5}$$

$$= \frac{10 + 5 + 4}{20}$$

$$\frac{1}{R} = \frac{19}{20}$$

∴ Total resistance of parallel combination:

$$R = \frac{20}{19}$$

b) If combination ...... 20V ... battery.

Given emf of battery $E = 20V$
of R_1 $I = I_1$

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

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

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

Current in R_3 = I_3

$$I_3 = \frac{V}{R_1}$$

$$I_3 = \frac{20}{5} = 4A.$$

$\therefore$ Total current =

$$I = I_1 + I_2 + I_3 = 10 + 5 + 4 = 19A.$$

$\Rightarrow$ $\cancel{I_1 + I_2 + I_3}$ Total current = $I = 19A$.

3.5 At room temp. (27.0°C) resistance of a heating element 100Ω. What is temp ... 117Ω ... temp ... resistor $1.70 \times 10^{-4}\,°C^{-1}$.

$$T = 27°C, \quad R = 100\Omega.$$

Increased temp. of filament = T_1

At T_1

$$R_1 = 117\Omega$$

Temp. coefficent of filament's material

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

Now $\alpha = \dfrac{R_1 - R}{R(T_1 - T)} \Rightarrow T_1 - T = \dfrac{R_1 - R}{R\alpha}$

$$T_1 - 27 = \frac{117 - 100}{100(1.7 \times 10^{-4})} \Rightarrow T_1 - 27 = 1000 \Rightarrow T_1 = 1027°C$$

Therefore at 1027°C resistance of element is 117Ω.

3.6 A negligibly small current is passed through a wire of length 15 m and uniform cross-section 6.0×10^{-7} m^2, and its resistance is measured to be 5.0 Ω. What is the resistivity of the material at the temperature of the experiment?

3.7 A silver wire has a resistance of 2.1 Ω at 27.5 °C, and a resistance of 2.7 Ω at 100 °C. Determine the temperature coefficient of resistivity of silver.

3.6 A negligibly small current passed through ... section $6.0 \times 10^{-7} m^2$ resistance measured 5.0 Ω . Resistivity ... exp.?

$l = 15 m$
$A = 6.0 \times 10^{-7} m^2$
$R = 5.0 \Omega$
ρ = material of wire

Now

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

$$= \frac{\cancel{5} \times \cancel{6} \times 10^{-7}}{\cancel{15}_3} = 2 \times 10^{-7} \Omega m$$

$\therefore$ Resistivity of material $= 2 \times 10^{-7} \Omega m$

Q 3.7

$T_1 = 27.5°C$; At T_1 $R_1 = 2.1 \Omega$
$T_2 = 100°C$; At T_2 $R_2 = 2.7 \Omega$

Temp. coefficient of silver = α

Now $\alpha = \frac{R_2 - R_1}{R_1 (T_2 - T_1)} = \frac{2.7 - 2.1}{2.1 (100 - 27.5)}$

$$= \frac{\cancel{0.6}^{0.2}}{\underset{0.7}{\cancel{2.1}} (72.5)} = \frac{0.2}{50.75} = 0.0039$$

i.e. $0.0039 °C^{-1}$

Answer.

resistivity of silver.

3.8 A heating element using nichrome connected to a 230 V supply draws an initial current of 3.2 A which settles after a few seconds to a steady value of 2.8 A. What is the steady temperature of the heating element if the room temperature is 27.0 °C? Temperature coefficient of resistance of nichrome averaged over the temperature range involved is 1.70×10^{-4} °C^{-1}.

3.8 A heating element nichrome... 230V ... 3.2A ... to 27.0°C? ... $1.70 \times 10^{-4}\ °C^{-1}$.

$V = 230$, $I_1 = 3.2\ A$, Initial resistance $= R_1$

$$R_1 = \frac{V}{I} = \frac{230}{3.2} = 71.87\ \Omega.$$

$I_2 = 2.8\ A$, Resistance at steady state $= R_2$.

$$R_2 = \frac{V}{I} = \frac{230}{2.8} = 82.14\ \Omega.$$

Now $\alpha = 1.70 \times 10^{-4}\ °C^{-1}$

Nichrome's temp, $T_1 = 27.0\ °C$

~~Av~~ 11 steady state temp, $T_2 =$

Now

$$\alpha = \frac{R_2 - 1}{R_1 (T_2 - T_1)}$$

$$T_2 - 27\ °C = \frac{82.14 - 71.87}{71.84 \times 1.7 \times 10^{-4}} = 840.5$$

$$T_2 = 840.5 + 27 = 867.5\ °C$$

$\therefore$ Steady temp $= 867.5\ °C$.

involved is 1.70×10^{-4} °C^{-1}.

3.9 Determine the current in each branch of the network shown in Fig. 3.30:

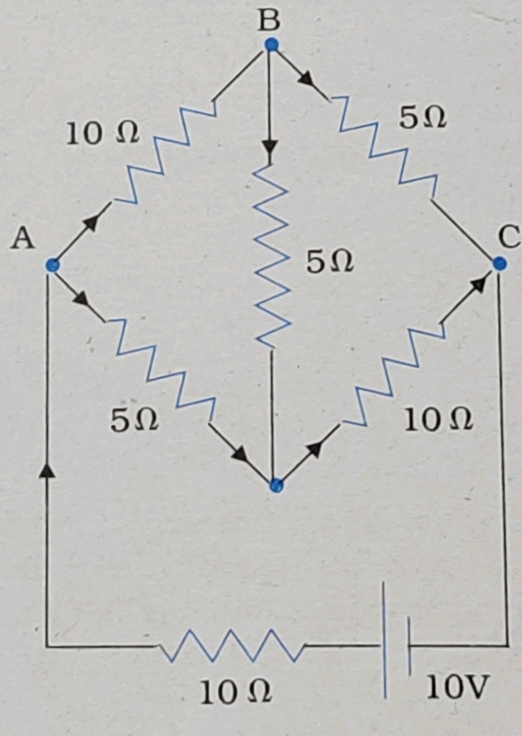
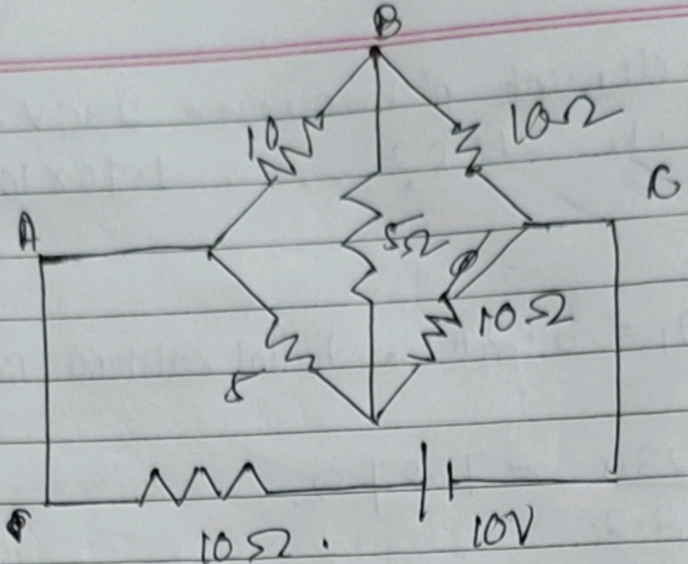
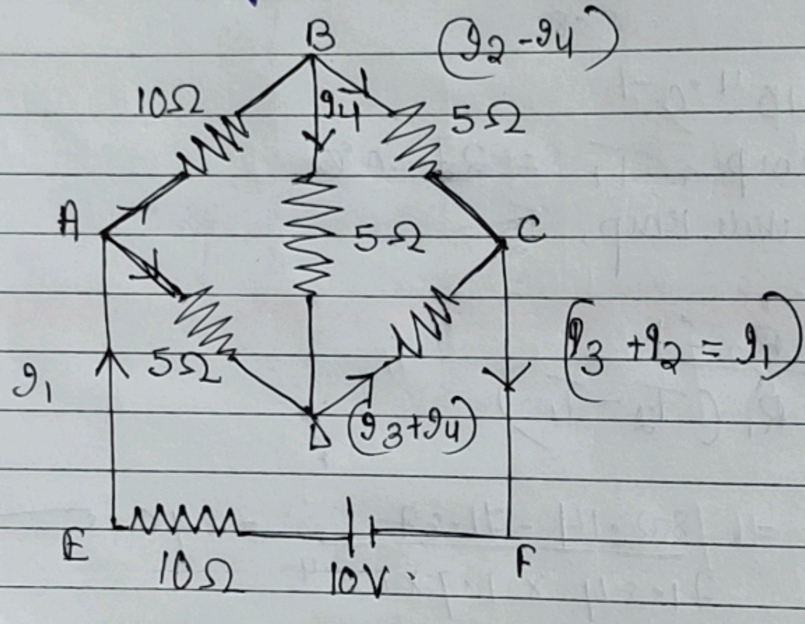


FIGURE 3.30

Q 2.9



Current flowing through diff. branches in circuit :-



I_1 Current flowing through outer circuit.
I_2 " " " branch AB
I_3 " " " " AD
$I_2 - I_4$ " " " " BC
$I_3 + I_4$ " " " " CD
I_4 " " " " BD

for ABDA potential = zero,

$10i_2 + 5i_4 - 5i_3 = 0$

$2i_2 + i_4 - i_3 = 0$

$i_3 = 2i_2 + i_4 \quad \ldots (1)$

for BCDB potential = zero.

$5(i_2 - i_4) - 10(i_3 + i_4) - 5i_4 = 0$

$5i_2 + 5i_4 - 10i_3 + 10i_4 - 5i_4 = 0$

$5i_2 + \cancel{5i_4} - 10i_3 - 20i_4 = 0$

$i_2 = 2i_3 + 4i_4 \quad \ldots (2)$

for ABCFEA potential zero.

$-10 + 10(i_1) + 10(i_2) + 5(i_2 - i_4) = 0$

$10 = 15i_2 + 10i_1 - 5i_4$

$3i_2 + 2i_1 - i_4 = 2 \quad \ldots (3)$

from (I) & (II) $\quad i_3 = 2(i_3 + 4i_4) + i_4 = 4i_3 + 8i_4 + i_4$

$-3i_3 = 9i_4, \; -3i_4 = +i_3 \ldots (4)$

equ^n (4) in equ^n (1), $i_3 = 2i_2 + i_4 \Rightarrow -4i_4 = 2i_2$

Note $i_2 = -2i_4 \quad \ldots (5)$

from fig. :- $i_1 = i_3 + i_2 \ldots (6)$

equ^n (6) in (1)

$3i_2 + 2(i_3 + i_2) - i_4 = 2$

$5i_2 + 2i_3 - i_4 = 2$ ... (7)

equ^n (4), (5) in (7)

$5(-2i_4) + 2(-3i_4) - i_4 = 2$

$-10i_4 - 6i_4 - i_4 = 2$

$17i_4 = -2$

$i_4 = \frac{-2}{17}$ A

equ^n (4), $i_3 = -3(i_4)$

$= -3\left(\frac{-2}{17}\right) = \frac{6}{17}$ A

$i_2 = -2(i_4) = -2\left(\frac{-2}{17}\right) = \frac{4}{17}$ A

$i_2 - i_4 = \frac{4}{17} - \left(\frac{-2}{17}\right) = \frac{6}{17}$ A

$i_3 + i_4 = \frac{6}{17} + \left(\frac{-2}{17}\right) = \frac{4}{17}$ A.

$i_1 = i_3 + i_2 = \frac{6}{17} + \frac{4}{17} = \frac{10}{7}$ A.

current in branch AB $= \frac{4}{17}$ A

BC $= \frac{6}{17}$ A

CD $= \frac{-4}{17}$ A

AD $= \frac{6}{17}$ A

BD $= \left(\frac{-2}{17}\right)$ A

Total current $= \frac{4}{17} + \frac{6}{17} + \frac{-4}{17} + \frac{6}{17} + \frac{-2}{17} = \frac{10}{17}$ A

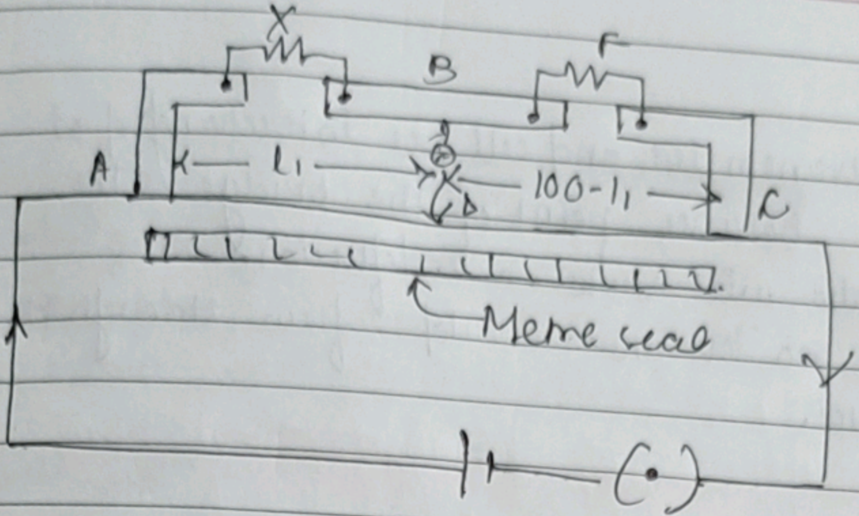
3.10 (a) In a meter bridge [Fig. 3.27], the balance point is found to be at 39.5 cm from the end A, when the resistor Y is of 12.5 Ω. Determine the resistance of X. Why are the connections between resistors in a Wheatstone or meter bridge made of thick copper strips?

(b) Determine the balance point of the bridge above if X and Y 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?

3.11 A storage battery of emf 8.0 V and internal resistance 0.5 Ω is being charged by a 120 V dc supply using a series resistor of 15.5 Ω. What is the terminal voltage of the battery during charging? What is the purpose of having a series resistor in the charging circuit?

3.10



a) Balance point from end A, $l_1 = 39.5$ cm
Resistance of resistor $Y = 12.5\,\Omega$.
Now
$$\frac{X}{Y} = \frac{100-l_1}{l_1}$$
$$\Rightarrow X = \frac{100-39.5}{39.5} \times 12.5 = 8.2\,\Omega$$
∴ Resistance of resistor $= 8.2\,\Omega$.

The connecⁿ b/w resistors in wheatstone or meter bridge made of thick copper strips to minimize resistance which is not taken into action in bridge formula.

b)
If X and Y are interchanged
$\Rightarrow$ l_1 and $100-l_1$ interchanged.
balance point of bridge : $100-l_1$ from A.
~~Val~~ $100-l_1 = 100-39.5 =$ ~~60.5 cm of~~
$= 60.5$ cm from A

c) When galvanometer and cell are interchanged at balance point of the bridge, the galvanometer will show no deflection.
Hence no current would flow through the galvanometer.

8.11

emf of storage battery $\varepsilon = 8.0V$
int. resistance $r = 0.5\Omega$
DC supply voltage $V = 120V$
$R = 15.5\Omega$
Volt. in circuit $= V^{A}$.
R connected storage battery in series -
$V^{A} = V - E$
$V^{A} = 120 - 8 = 112V$

Now $I = V'/(R+r) = 112/(15.5+0.5) = 112/16 = 7A$.
curr flow.

Voltage across R given by $IR = 7 \times 15.5 = 108.5V$

$\Rightarrow V + IR$
$120 - 108.5 = 11.5V$ ∴ Terminal voltage of battery

A series resistor in a charging ~~circu~~ circuit limits current drawn from ext. source.
The current will be extremely high in its absence. This is very dangerous

purpose of having a series resistor in the charging circuit.

3.12 In a potentiometer arrangement, a cell of emf 1.25 V gives a balance point at 35.0 cm length of the wire. If the cell is replaced by another cell and the balance point shifts to 63.0 cm, what is the emf of the second cell?

3. 13 The number density of free electrons in a copper conductor estimated in Example 3.1 is $8.5 \times 10^{28}\ m^{-3}$. How long does an electron take to drift from one end of a wire 3.0 m long to its other end? The area of cross-section of the wire is $2.0 \times 10^{-6}\ m^2$ and it is carrying a current of 3.0 A.

ADDITIONAL EXERCISES

Q12

emf of cell, $E_1 = 1.25$ V
Balance point of potentiometer, $l_1 = 35$ cm
The cell replaced by another cell of emf E_2.
New balance point of potentiometer, $l_2 = 63$ cm

Balance condition

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

$$E_2 = E_1 \times l_2/l_1$$

$$= 1.25 \times \frac{63}{35} = 2.25$$

emf of second cell $= 2.52$ V.

3.13

Number density of free electrons in a copper conductor

$n = 8.5 \times 10^{28} m^{-3}$

$l = 3.0 m$

$A = 2.0 \times 10^{-6} m^2$, $I = 3.0 A$

Now $I = nAeV_d$, $e = 1.6 \times 10^{-19} C$

$V_d = l/t$

$\therefore I = nAe\, l/t = nAel/I = \frac{3 \times 8.5 \times 10^{28} \times 2 \times 10^{-6} \times 1.6 \times 10^{-19}}{3.0}$

$= 2.7 \times 10^4 s$.

ADDITIONAL EXERCISES

. 14 The earth's surface has a negative surface charge density of 10^{-9} C m^{-2}. The potential difference of 400 kV between the top of the atmosphere and the surface results (due to the low conductivity of the lower atmosphere) in a current of only 1800 A over the entire globe. If there were no mechanism of sustaining atmospheric electric

field, how much time (roughly) would be required to neutralise the earth's surface? (This never happens in practice because there is a mechanism to replenish electric charges, namely the continual thunderstorms and lightning in different parts of the globe). (Radius of earth = 6.37×10^6 m.)

3.14

Surface charge density of earth, $\sigma = 10^{-9} C m^{-2}$

I (current over entire globe) $= 1800$ A

Radius of earth, $r = 6.37 \times 10^6$ m

Surface area of earth

$$A = 4\pi r^2$$
$$= 4\pi \times (6.37 \times 10^6)^2$$
$$= 5.09 \times 10^{14} m^2.$$

Charge on earth surface

$$q = \sigma \times A$$
$$= 10^{-9} \times 5.09 \times 10^{14}$$
$$= 5.09 \times 10^5 C$$

Time taken to neutralize earth's surface $= t$.

Current, $I = q/t$ $\quad t = q/I$

$$= \frac{5.09 \times 10^5}{1800} = 282.77 s.$$

3.15 (a) Six lead-acid type of secondary cells each of emf 2.0 V and internal resistance 0.015 Ω are joined in series to provide a supply to a resistance of 8.5 Ω. What are the current drawn from the supply and its terminal voltage?

(b) A secondary cell after long use has an emf of 1.9 V and a large internal resistance of 380 Ω. What maximum current can be drawn from the cell? Could the cell drive the starting motor of a car?

3.16 Two wires of equal length, one of aluminium and the other of

3.15

a)

No. of secondary cells, $n = 6$
emf of each secondary $E = 2.0V$.
Int. resistance of each cell, $r = 0.015\,\Omega$.

Current drawn from supply $= I$.

$I = nE / R + nr = 6 \times 2 / 8.5 + 6 \times 0.015$
$= \frac{12}{8.59} = 1.39A$

∴ Terminal voltage :- $V = IR = 1.39 \times 8.5$
$= 11.87A$.

b)

After a long use, emf of 2ndary cell. $E = 1.9V$
Internal resistance of cell, $r = 380\,\Omega$
$= \frac{E}{r} = \frac{1.9}{380} = 0.005A$ (max. current)

∴ max. current drawn from cell is $0.005A$.
A large current is required to start the motor of a car, the cell can't be used to start a motor.

What maximum current can be drawn from the cell? Could the cell drive the starting motor of a car?

3.16 Two wires of equal length, one of aluminium and the other of copper have the same resistance. Which of the two wires is lighter? Hence explain why aluminium wires are preferred for overhead power cables. (ρ_{Al} = 2.63 × 10^{-8} Ω m, ρ_{Cu} = 1.72 × 10^{-8} Ω m, Relative density of Al = 2.7, of Cu = 8.9.)

3.17 What conclusion can you draw from the following observations on a

3.16

Aluminium ~~Resis.~~ $\rho_{Al} = 2.63 \times 10$

$d_1 - 2.7$

l_1 : length of Al and m_1 : mass of Al

Resistance of Al wire $= R_1$

Area of cross section $= A_1$

Copper $\rho_{Cu} = 1.72 \times 10^{-8}\ \Omega m$

$d_2 = 8.9$

l_2 : length of copper wire $= R_2$

Area of ~~Ao~~ A_2.

Now $R_1 = \rho_1\ l_1 / A_1$ ...(1)

$R_2 = \rho_2\ l_2 / A_2$ ...(2)

given $R_1 = R_2$, $\rho_1 \frac{l_1}{A_1} = \rho_2\ l_2 / A_2$.

$l_1 = l_2$, $\rho_1 / A_1 = \rho_2 / A_2$

$A_1 / A_2 = \rho_1 / \rho_2 = \frac{2.63 \times 10^{-8}}{1.72 \times 10^{-8}} = \frac{2.63}{1.72}$

Mass of aluminium wire, $m_1 = V \times D$

$A_1 l_1 \times d_1 = A_1 l_1 d_1$ ...(3)

" " copper

$A_2 l_2 \times d_2 = A_2 l_2 d_2$ ...(4)

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Dividing eq (3) by equation (4).

$$\frac{m_1}{m_2} = A_1 l_1 d_1 / A_2 l_2 d_2 .$$

for $l_1 = l_2$.

$$\frac{m_1}{m_2} = \frac{A_1 d_1}{A_2 d_2} .$$

for $A_1 / A_2 = \frac{2.63}{1.72}$,

$$\frac{m_1}{m_2} = \frac{2.63}{1.72} \times \frac{2.7}{8.9} = 0.46 .$$

inferred ratio $m_1 < m_2$.

∴ Aluminium lighter than copper,
thus, is preferred for overhead power cables over copper.

Al = 2.7, of Cu = 8.9.)

3.17 What conclusion can you draw from the following observations on a resistor made of alloy manganin?

Current A	Voltage V	Current A	Voltage V
0.2	3.94	3.0	59.2
0.4	7.87	4.0	78.8
0.6	11.8	5.0	98.6
0.8	15.7	6.0	118.5
1.0	19.7	7.0	138.2
2.0	39.4	8.0	158.0

3.17

Current A.	Voltage V	Current A	Voltage V
0.2	2.94	3.0	59.2
0.4	7.87	4.0	78.8
0.6	11.8	5.0	98.6 ← 118.5
0.8	15.7	6.0	~~118.5~~ 138.2.
1.0	19.7	7.0	158.0.
2.0	39.4	8.0	

It can be inferred from table that ratio of voltage with current constant = 19.7.
Manganin is an ohmic conductor
⇒ alloy obeys Ohm's law.
According to Ohm's law, ratio of voltage with current is resistance of conductor.
Hence, resistance of manganin is 19.7 Ω.

3.18 Answer the following questions:

(a) A steady current flows in a metallic conductor of non-uniform cross-section. Which of these quantities is constant along the conductor: current, current density, electric field, drift speed?

(b) Is Ohm's law universally applicable for all conducting elements? If not, give examples of elements which do not obey Ohm's law.

(c) A low voltage supply from which one needs high currents must have very low internal resistance. Why?

(d) A high tension (HT) supply of, say, 6 kV must have a very large internal resistance. Why?

3.19 Choose the correct alternative:

(a) Alloys of metals usually have (greater/less) resistivity than that of their constituent metals.

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

(c) The resistivity of the alloy manganin is nearly independent of/increases rapidly with increase of temperature.

(d) The resistivity of a typical insulator (e.g., amber) is greater than that of a metal by a factor of the order of $(10^{22}/10^{23})$.

3.20 each of resistance R, how will you combine

3.18

a)

When a steady current flows in a metallic conductor of non-uniform cross-section, current flowing through conductor is constant. Current density, electric field and drift speed are inversely proportional to area of cross section.
i.e. They are constant.

b)

No, Ohm's law is not universally applicable for all conducting elements. Vaccum diode semi-conductor is a non-ohmic conductor.
Ohm's law not valid for it.

c)

A/ Ohm's law is ~~not universally~~ law, relation for potential. $V = IR$.
Voltage (V) $\propto$ (I) current.

R is internal resistance of the source.

$I = V/R$.

If V is low, then R must be very low, so that high current can be drawn from source.

d) In order to prohibit current from exceeding safety limit, high tension supply must have a very large internal resistance. Internal resistance not large, then current draw an exceed safety limit in case of short circuit.

3.19

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

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

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

d) The resistivity of a typical insulator greater than that of a metal by a factor of order of 10^{22}.

3-2

a

Cu

Cu

ca

3.20 (a) Given n resistors each of resistance R, how will you combine them to get the (i) maximum (ii) minimum effective resistance? What is the ratio of the maximum to minimum resistance?

(b) Given the resistances of 1 Ω, 2 Ω, 3 Ω, how will be combine them

3.20

a)

~~Total~~

~~Total no. of resistors = n.~~

Resistance of each resistor = R.

case I) Resistor in series, effective resistance R_1 max. denoted by product nR.

Hence, max. resistance's combination, $R_1 = nR$.

case II) n resistors connected parallel, effective resistance (R_2) minimum, given by $\frac{R}{n}$.

∴ minimum combination's resistance = $R_2 = \frac{R}{n}$

case III) Max. to minimum resistance

$$\frac{R_1}{R_2} = \frac{nR}{R/n} = n^2.$$

them to get the (i) [illegible]

3.20 What is the ratio of the maximum to minimum resistance?

(b) Given the resistances of 1 Ω, 2 Ω, 3 Ω, how will be combine them to get an equivalent resistance of (i) (11/3) Ω (ii) (11/5) Ω, (iii) 6 Ω, (iv) (6/11) Ω?

[illegible] uivalent resistance of networks shown in

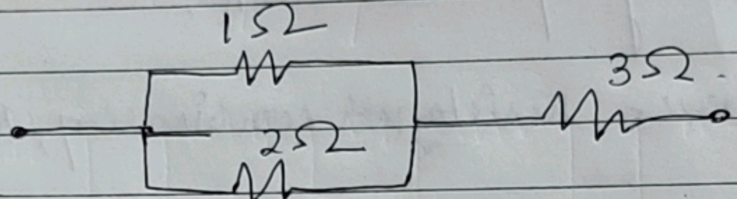
3.20 b)

The resistance of the resistors.

$R_1 = 1\Omega$, $R_2 = 2\Omega$, $R_3 = 3\Omega$.

i. $$R' = \frac{11}{3}\Omega.$$

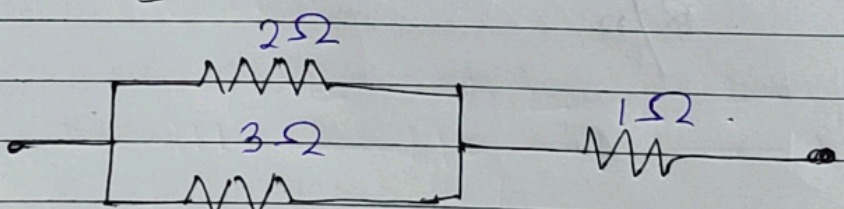
ii. equi



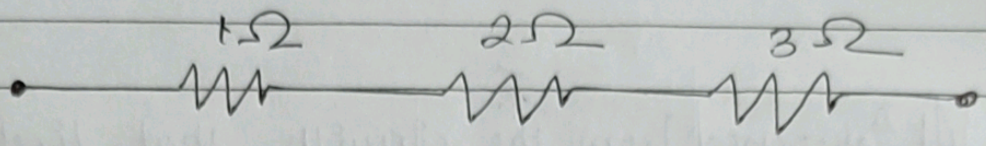
Equivalent resistance of circuit

$$R' = \frac{2\times 1}{2+1} + 3 = \frac{2}{3} + 3 = \frac{2+9}{3} = \frac{11}{3}\Omega.$$

ii. $$R' = \frac{11}{5}\Omega.$$



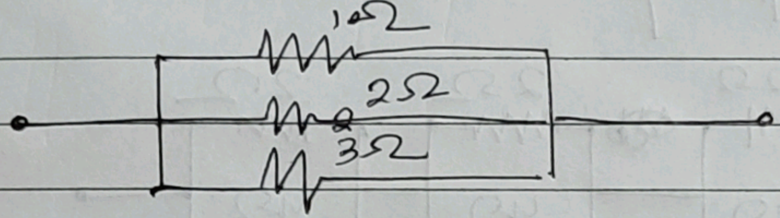
$$R' = \frac{2\times 3}{2+3} + 1 = \frac{6}{5} + 1 = \frac{11}{5}\Omega.$$



Equivalent resistance.

$$R' = 1 + 2 + 3 = 6\,\Omega$$

iv $R' = \frac{6}{11}\,\Omega$



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

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to get an equivalent resistance
Ω, (iv) (6/11) Ω?

3.20 (c). Determine the equivalent resistance of networks shown in Fig. 3.31.

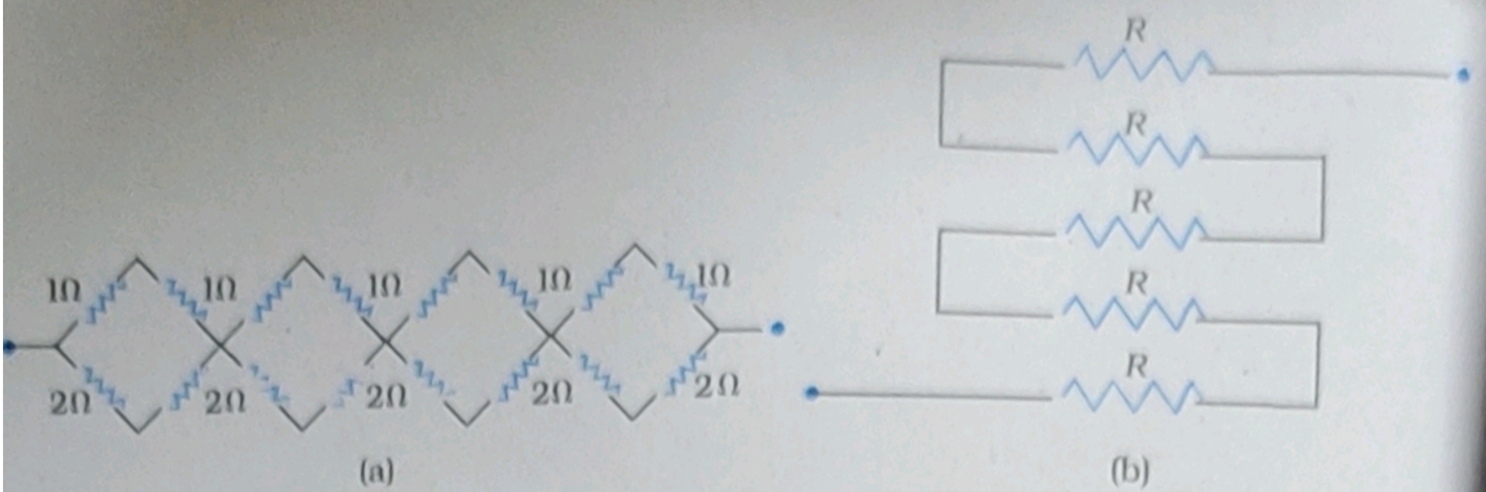


FIGURE 3.31

3.20

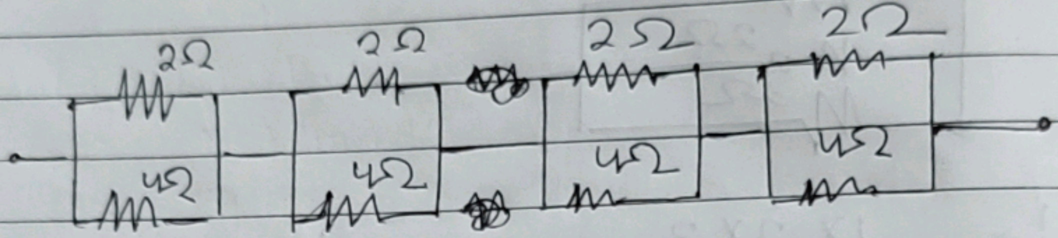
(i) a

It is observed from the circuit that first small loop, two resistors of resistance = 1 Ω each connected in series.

Hence,

equivalent resistance = (2+2) = 4 Ω.

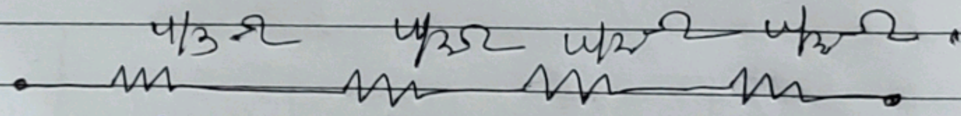
∴ circuit redrawn



2 Ω & 4 Ω are connected in parallel in all 4 loops.

$$R' = \frac{2\times4}{2+4} = \frac{8}{6} = \frac{4}{3}\,\Omega.$$

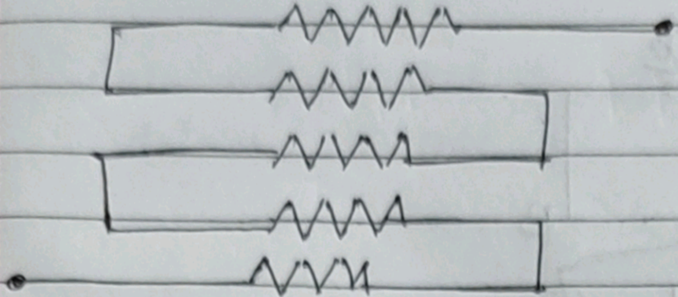
Circuit reduces to.



four resistors connected in series.

∴ equivalent resistance : $\frac{4}{3}\times4 = \frac{16}{3}\,\Omega$

C b)



five resistors of resistance R were connected series.

Hence, equivalent resistance =

$R+R+R+R+R. = 5R.$

3.21 Determine the current drawn from a 12V supply with internal resistance 0.5Ω by the infinite network shown in Fig. 3.32. Each resistor has 1Ω resistance.

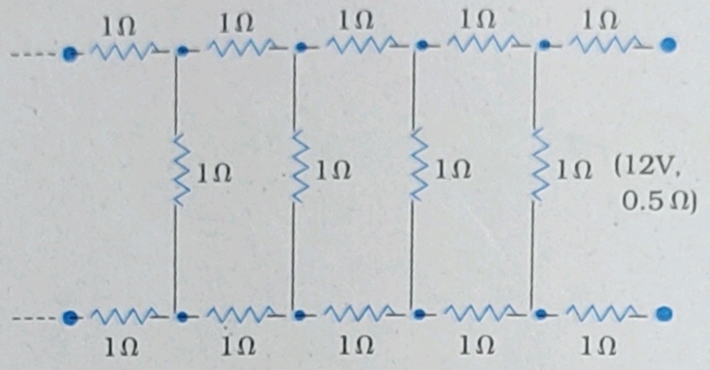
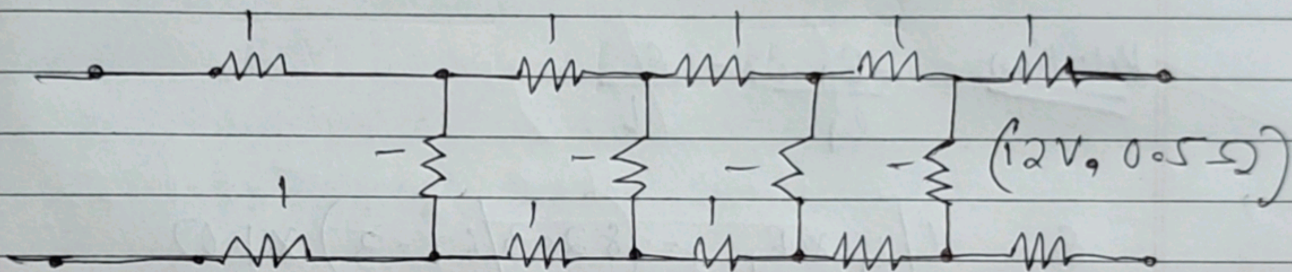


FIGURE 3.32

3.21



Resistance of resistor $R = 1\Omega$.
equi. " " $= R'$
Network infinite.

Now $\therefore R' = 2 + R/(R+1)$
$(R)^2 - 2R - 2 = 0$
$R = 2 \pm \sqrt{4+3}/2$.
$= 2 \pm \sqrt{12}/2 = 1 \pm \sqrt{3}$
Negative value of R' can't be accepted.

So $R' = (1+\sqrt{3}) = 1 + 1.73 = 2.7\,\Omega$.
Int. resistance $= r = 0.5\,\Omega$

Total resistance
$= 2.73 + 0.5$
$= 3.23\,\Omega$.
Supply voltage V
$= 12V$.
~~Ohm's~~.

$\therefore$ Ohm's law, current drawn, $12/3.23 = 3.72$ A.

FIGURE 3.32

3.22 Figure 3.33 shows a potentiometer with a cell of 2.0 V and internal resistance 0.40 Ω maintaining a potential drop across the resistor wire AB. A standard cell which maintains a constant emf of 1.02 V (for very moderate currents upto a few mA) gives a balance point at 67.3 cm length of the wire. To ensure very low currents drawn from the standard cell, a very high resistance of 600 kΩ is put in series with it, which is shorted close to the balance point. The standard cell is then replaced by a cell of unknown emf ε and the balance point found similarly, turns out to be at 82.3 cm length of the wire.

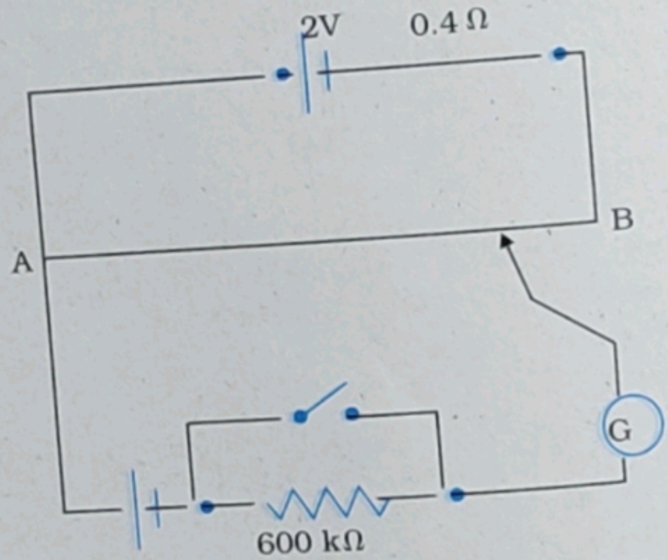


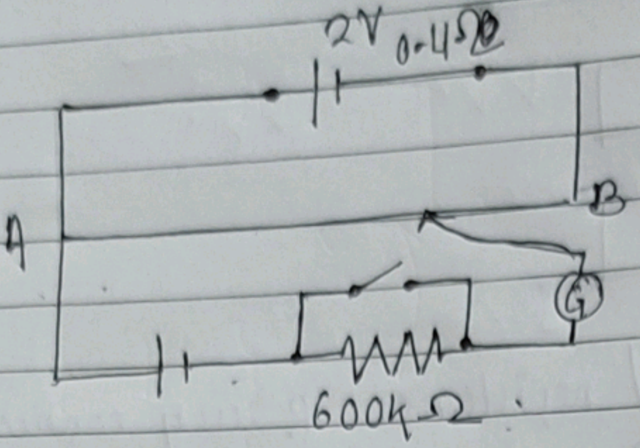
FIGURE 3.33

(a) What is the value ε?
(b) What purpose does the high resistance of 600 kΩ have?

(c) Is the balance point affected by this high resistance?
(d) Would the method work in the above situation if the driver cell of the potentiometer had an emf of 1.0V instead of 2.0V?
(e) Would the circuit work well for determining an extremely small emf, say of the order of a few mV (such as the typical emf of a thermo-couple)? If not, how will you modify the circuit?

Figure 3.34 shows a 2.0 V potentiometer used for the ...

3.22



a) value of $\mathcal{E}$?

$E_1 = 1.02\,V$.

$l_1 = 67.3\,cm$.

$l = 82.3\,cm$.

Relation $\frac{E_1}{l_1} = \frac{\mathcal{E}}{l}$

$\mathcal{E} = l/l_1 \times E_1 = (82.3/67.3) \times 1.02$

$= \underline{1.247\,V}$

Ans.

b)

Purpose of using high resistance of 600 kΩ is to reduce current through galvanometer when movable contact is far from balance point.

c)

Balance point is not affected by presence of high resistance.

d)

Point not affected by internal resistance of driver cell.

e)

~~Apett~~
Method ~~not~~ would not work well for determining extremely small emf.
Circuit unstable, balance point close to end A.
There would be large error.

f).

Given circuit can be modified if a series resistance connected with wire AB.
Potential drop across AB greater than emf measured.
Percentage error be small.

3.23 Figure 3.34 shows a 2.0 V potentiometer used for the determination of internal resistance of a 1.5 V cell. The balance point of the cell in open circuit is 76.3 cm. When a resistor of 9.5 Ω is used in the external circuit of the cell, the balance point shifts to 64.8 cm length of the potentiometer wire. Determine the internal resistance of the cell.

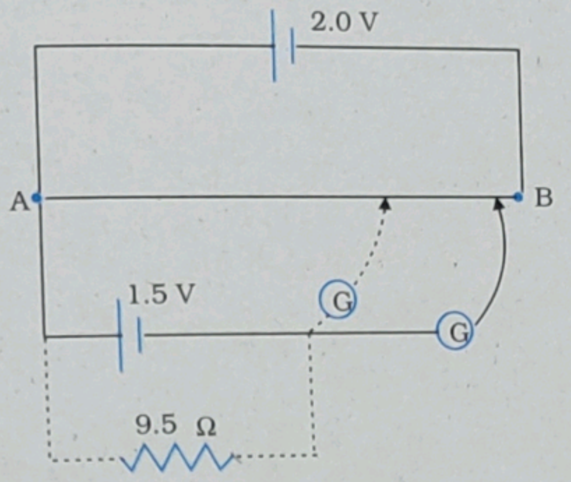
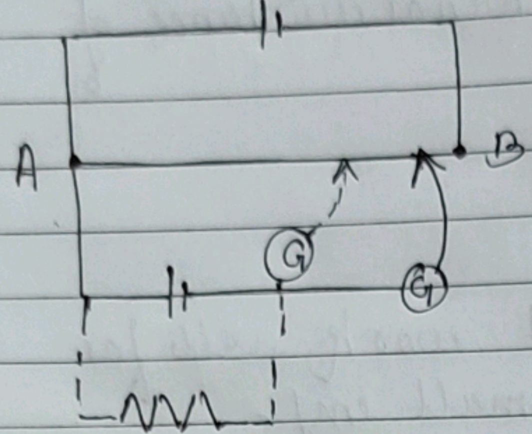


FIGURE 3.34

3.23



Int. resistance = r.
balance point l_1 = 76.3 cm.
ext. resistance (R) = 9.5 Ω.
New balance l_2 = 64.8 cm.
current = I.

Now
$$r = \left(\frac{l_1 - l_2}{l_2}\right) R$$
$$= \frac{76.3 - 64.8}{64.8} \times 9.5 = 1.68\,\Omega.$$

Int. resistance of cell = 1.68 Ω.

THANK YOU !