15/7/21

# Chapter-3 (Current Electricity)

## Exercise

3.1) $E = 12\,V$

$r = 0.4\,\Omega$

According to ohm's law,

$E = Ir$

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

$= \frac{12}{0.4} = 30\,A$

3.2) $E = 10\,V$

$r = 3\,\Omega$

$I = 0.5\,A$

$R = ?$

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

$\Rightarrow 0.5 = \frac{10}{3+R}$

$\Rightarrow R = 20-3$

$= 17\,\Omega$

3.3) a) $R_{eq} = 1+2+3$

$= 6\,\Omega$

b) $R = 6\,\Omega$

$E = 12\,V$

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

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

potential drop across $1\Omega$ resistor $= 2\ V$.
potential drop across $2\Omega$ resistor $= IR = 2 \times 2 = 4\ V$.
potential drop across $3\Omega$ resistor $= 3 \times 2 = 6\ V$.

3.4) a) $\frac{1}{R_{eq}} = \frac{1}{2} + \frac{1}{4} + \frac{1}{5}$

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

$= \frac{19}{20}$

$R_{eq} = \frac{20}{19}\ \Omega$

b) $R = \frac{20}{19}\ \Omega$

$E = 20\ V.$

current through $2\Omega$ resistor $= \frac{V}{R} = \frac{20}{2} = 10\ A$

current through $4\Omega$ resistor $= 5\ A$
current through $5\Omega$ resistor $= 4\ A$

$\therefore$ Total current $= 19\ A.$

3.5) $R_1 = 100\ \Omega$ $\quad R_2 = 117\ \Omega$

$T_1 = 27°C$ $\quad T_2 = ?$

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

Date
Page

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

$\Rightarrow 1.70 \times 10^{-4} = \frac{17}{100(T_2 - 27)}$

$\Rightarrow T_2 - 27 = \frac{17 \times 100}{100 \times 1.70 \times 10^{-4}}$

$\Rightarrow T_2 - 27 = 1000$

$\Rightarrow T_2 = 1027\,°C$

3.6) $l = 15\ m$

$A = 6.0 \times 10^{-7}\ m^2$

$R = 5.0\,\Omega$

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

$= \frac{5 \times 15}{6 \times 10^{-7}}$ $\quad\quad$ $= \frac{5 \times 6 \times 10^{-7}}{15}$

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

3.7) $R_1 = 2.1\,\Omega$

$T_1 = 27.5\,°C$

$R_2 = 2.7\,\Omega$

$T_2 = 100°C$

$\alpha = ?$

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

$= \frac{0.6}{2.1(72.5)}$

$= 0.0039\,°C^{-1}$

3.8) $V = 230\ V$

$I_1 = 3.2\ A$

$I_2 = 2.8\ A$

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

$$= \frac{230}{3.2} = 71.87\ \Omega$$

$$R_2 = \frac{230}{2.8} = 82.14\ \Omega$$

$$\alpha = 1.70 \times 10^{-4}$$

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

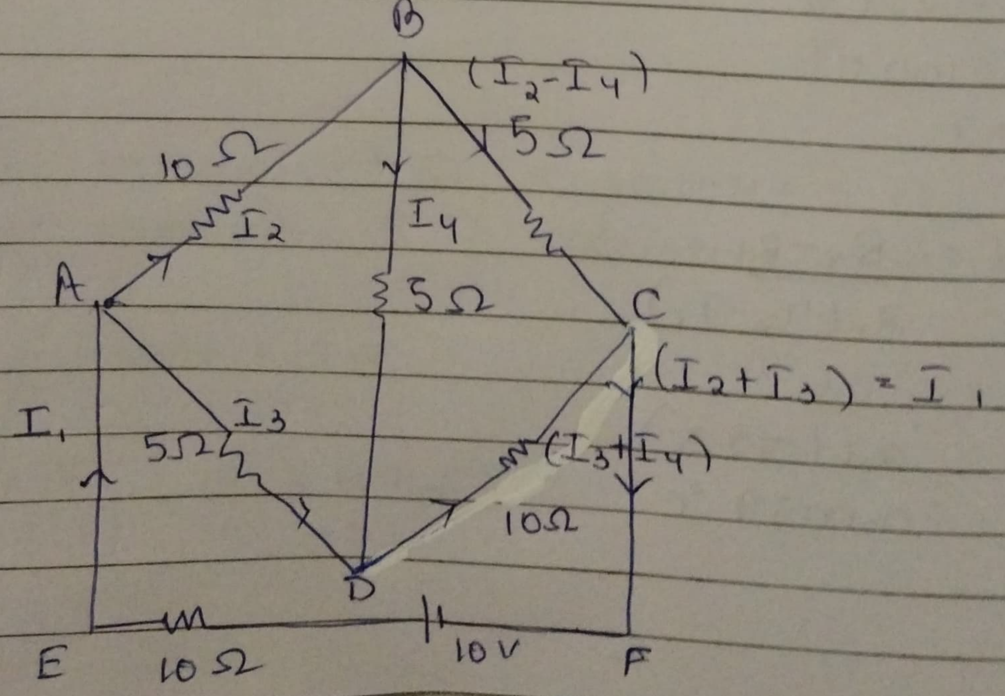
$$\Rightarrow T_2 - 27 = \frac{82.14 - 71.87}{71.87 \times 1.70 \times 10^{-4}}$$

$$\Rightarrow T_2 - 27 = \frac{10.27}{122.17 \times 10^{-4}}$$

$$\Rightarrow T_2 - 27 = 840.5$$

$$\Rightarrow T_2 = 867.5^\circ C$$

3.9)



Date
Page

For the circuit ABDA,

$10I_2 + 5I_4 - 5I_3 = 0$

$\Rightarrow 2I_2 + I_4 = I_3$ — (I)

For the circuit BCDB

$\Rightarrow 5(I_2 - I_4) - 10(I_3 + I_4) - I_4 5 = 0$

$\Rightarrow 5I_2 - 5I_4 - 10I_3 - 10I_4 - 5I_4 = 0$

$\Rightarrow 5I_2 - 10I_3 - 20I_4 = 0$

$\Rightarrow I_2 = 2I_3 + 4I_4$ — (II)

For the circuit ABCFEA,

$\Rightarrow 10I_2 + 5(I_2 - I_4) + 10(I_1) - 10 = 0$

$\Rightarrow 3I_3 + 2I_1 - I_4 - 2$ — (III)

From (I) and (II)

$\Rightarrow I_3 = 2(2I_3 + 4I_4) + I_4$

$\Rightarrow I_3 = 4I_3 + 8I_4 + I_4$

$\Rightarrow 9I_9 = -3I_3$

$\Rightarrow 3I_4 = -I_3$ — (IV)

putting (IV) in (I)

$\Rightarrow 2I_2 + I_4 = -3I_4$

$\Rightarrow I_2 = -2I_4$ — (V)

As $I_1 = I_2 + I_3$ — (VI)

$= -3I_4 - 2I_4 = -5I_4$

Putting (VI) in (I).

$3I_2 - 2(I_3 + I_2) - I_4 = 2$

$\Rightarrow 5I_2 + 2I_3 - I_4 = 2$ — (VII)

putting (IV) and (V) in equ$^n$ (VII)

$\Rightarrow 5(-2I_4) + 2(-3I_4) - I_4 = 2$

$\Rightarrow -10I_4 - 6I_4 - I_4 = 2$

$\Rightarrow I_4 = \frac{-2}{17}$ A

$I_3 = \frac{6}{17}$ A

$I_2 = \frac{4}{17}$ A.

$I_1 = I_2 + I_3$

$= \frac{6}{17} + \frac{4}{17} = \frac{10}{17}$ A

$\therefore$ Total current $= \frac{10}{17}$ A.

3.10) a) $l_1 = 39.5$ cm

$Y = 12.5\ \Omega$.

$\frac{X}{Y} = \frac{100 - l_1}{l_1}$

$X = \frac{100 - 39.5}{39.5} \times 12.5$

$= 8.2\ \Omega$

b) If X and Y are interchanged, $l_1$ becomes 60.5 cm.

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

3.11) $E = 8.0 \text{ V}$.

$r = 0.5\ \Omega$

$V = 120 \text{ V}$.

$R = 15.5\ \Omega$

Effective voltage $= V'$

$V' = V - E$

$= 112 \text{ V}$.

$I = \frac{V'}{R + r}$

$\Rightarrow \frac{112}{15.5 + 0.5} = 7 \text{ A}$.

Voltage across resistor $= IR = 7 \times 15.5 = 108.5 \text{ V}$.

Terminal voltage = DC supply − voltage drop.

$= 120 - 108.5$

$= 11.5 \text{ V}$

3.12) $E_1 = 1.25 \text{ V}$.

$l_1 = 35 \text{ cm}$

$l_2 = 63 \text{ cm}$

$E_2 = ?$

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

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

$\Rightarrow 2.25\ V$.

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

$l = 3\ m$

$A = 2.0 \times 10^{-6}$

$I = 3\ A$

$I = neAV_d$

$V_d = \frac{l}{t}$ — ①

$I = neA\frac{l}{t}$

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

$= \frac{8.5 \times 10^{28} \times 1.6 \times 10^{-19} \times 2 \times 10^{-6}}{3}$

$= 2.7 \times 10^{4}\ s$

Additional Exercises :

3.14) Surface charge density $\sigma = 10^{-9}\ C m^{-2}$

$r = 6.37 \times 10^{6}$

$I = 1800\ A$.

$A = 4\pi r^2$

$= 4\pi(6.37 \times 10^{6})^2$

$= 5.09 \times 10^{14}\ m^2$

charge on earth's surface :

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

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

$t = \frac{q}{I}$
$= \frac{5.09 \times 10^{5}}{1800}$
$= 282.77$ s

3.15 a) $E = 2$ V
$r = 0.015\ \Omega$
$R = 8.5\ \Omega$.
$n = 6$

$I = \frac{nE}{R + nr}$
$= \frac{6 \times 2}{8.5 + (6 \times 0.015)}$
$= 1.39$ A

b) $E = 1.9$ V
$r = 380\ \Omega$

$I = \frac{E}{r} = \frac{1.9}{380} = 0.005$ A.

∴ Since large amount of current is required to start the motor of a car. It is not possible.

3.16) $\rho_{Al} = 2.63 \times 10^{-8}\ \Omega m$

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

$d_{Al} = 2.7$

$d_{cu} = 8.9$

$$R_{Al} = \frac{\rho l}{A_{Al}} \quad \text{— (i)}$$

$$R_{cu} = \rho_{cu}\frac{l}{A_{cu}} \quad \text{— (ii)}$$

As $R_{Al} = R_{cu}$

$$\rho_{Al}\frac{l}{A_{Al}} = \rho_{cu}\frac{l}{A_{cu}}$$

$$\Rightarrow \frac{\rho_{Al}}{\rho_{cu}} = \frac{A_{Al}}{A_{cu}}$$

$$\Rightarrow \frac{2.63 \times 10^{-8}}{1.72 \times 10^{-8}} = \frac{2.63}{1.72}$$

$$\therefore \frac{A_{Al}}{A_{cu}} = \frac{2.63}{1.72}$$

mass of aluminium wire :

$m_1$ = volume x density

$= A_{Al} l_{Al} \times d_{Al}$ — (iii)

mass of copper wire :

$m_2 = A_{cu} l_{cu} \times d_{cu}$ — (iv)

Dividing equ$^n$ (iii) by (iv)

$\Rightarrow \dfrac{m_1}{m_2} = \dfrac{A_{Al} \, d_{Al}}{A_{cu} \, d_{cu}}$

$\Rightarrow \dfrac{m_1}{m_2} = \dfrac{2.63}{1.72} \times \dfrac{2.7}{8.9}$

$= 0.46$

$\therefore$ Aluminium is lighter than copper.
Since it is lighter, it is preferred for overhead power cables.

3.17) It is observed that the ratio of voltage to current is constant. Hence manganin is a ohmic conductor

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

$= 19.7 \, \Omega$

3.18) Current remains constant.

$A = \dfrac{I}{ne v_d}$

as, current density, drift velocity, $\vec{E}$ are inversely proportional to area of cross section.

b) No, ohm's law is not universally applicable.
Ex- Vaccum diode semi-conductor. is a non-ohmic conductor.

c) As $\Rightarrow I = \dfrac{V}{R}$

If V is low, R should be very low, so that high current can be drawn.

d) If there is a very large internal resistance to a 6KV supply, it will not exceed the safety limit otherwise may cause short circuit.

3.19) a) Greater

b) lower

c) independent of

d) $10^{22}$

3.20) a) no. of resistors $= n$

Resistance of each resistor $= R$

i) To obtain maximum ~~current~~ resistance it should be connected in series. $R_{eq_1} = Rn$

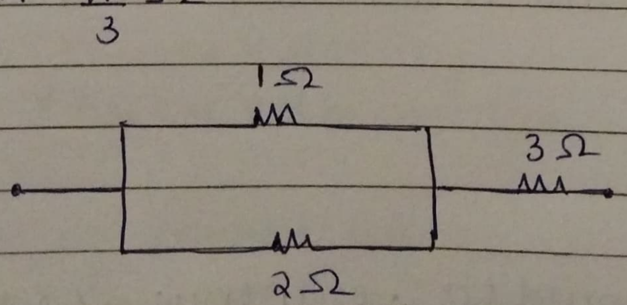
ii) To obtain minimum resistance they should be connected in parallel combination.

$R_{eq_2} = \frac{R}{n}$

iii) $\frac{R_1}{R_2} = \frac{Rn \times n}{R}$

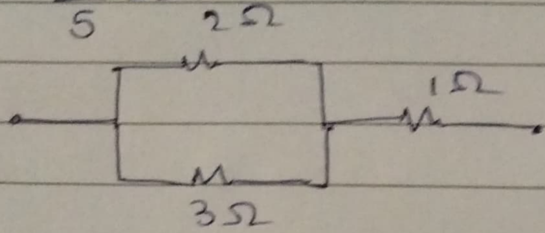
$= n^2$

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




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

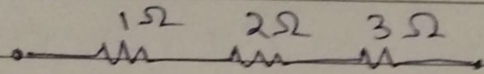
ii) $R' = \frac{11}{5}\ \Omega$




$R' = \frac{2 \times 3}{2+3} + 1$

$= \frac{11}{5}\ \Omega$

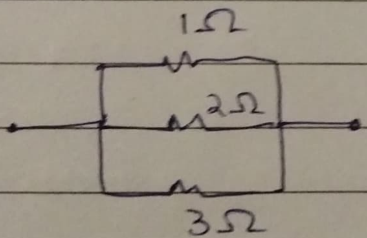
iii) $6\ \Omega$




$R' = 1+2+3$

$= 6\ \Omega$

iv) $\frac{6}{11}\ \Omega$

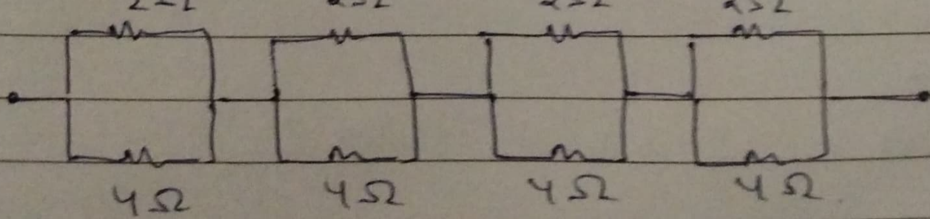



$R' = \frac{1}{1} + \frac{1}{2} + \frac{1}{3}$

$= \frac{11}{6}$

$R_{eq} = \frac{6}{11}\ \Omega$

c)



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

$R' = \frac{4}{3}\ \Omega$

$R_{eq} = 4 \times \frac{4}{3}$

$= \frac{16}{3}\ \Omega$

b) The given circuit is connected in series so,

$R_{eq} = 5R$

3.21) $R = 1\Omega$

Equivalent resistance $= R'$

$R' = 2 + \frac{R'}{(R'+1)}$

$\Rightarrow (R')^2 - 2R' - 2 = 0$

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

$= \frac{2 \pm \sqrt{12}}{2} = 1 \pm \sqrt{3}$

$R' = 1 + 1.73$

$= 2.73\ \Omega$

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

$= \frac{12}{3.23}$

$= 3.72\ A$.

3.22) $E_1 = 1.02\ V$

$l_1 = 67.3\ cm$

$E_2 = ?$

$l_2 = 82.3\ cm$

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

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

$$= \frac{1.02 \times 82.3}{67.3}$$

$$= 1.24\ V$$

b) The use of high resistance is to reduce the current through galvanometer

c) The balance point is not affected by its high resistance.

d) The balance point is not affected by the internal resistance.

e) It will not work as emf of driver cell of potentiometer is less than the emf of other cell.

f) The circuit would be unstable, as the balance point will be closer to point A thus large percentage error so it won't work properly.

To rectify it a series resistance is connected with wire AB.

3.23) $R = 10\,\Omega$

$l_1 =$ ~~68.5 cm~~ 58.3 cm

Current through wire = I

potential drop, $E_1 = IR$ → across R

Unknown resistance = X

$l_2 = 68.5$ cm

potential drop across X, $E_2 = IX$

As we know,

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

$$\Rightarrow \frac{IR}{IX} = \frac{58.3}{68.5}$$

$$\Rightarrow X = \cancel{\frac{58.3}{68.5} \times \frac{1}{10}} \quad \frac{68.5}{58.3} \times 10$$

$$= 11.74\,\Omega$$

If we fail to find a balance point with given cell of emf E, then potential drop across R and X is reduced by putting resistance ~~with~~ in series.

3.24) Internal resistance = r

driver cell emf = 2 V.

$l_1 = 76.3$ cm

$R = 9.5\,\Omega$

$l_2 = 64.8$ cm

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

$$= \left(\frac{76.3 - 64.8}{64.8}\right) \times 9.5 = 1.68\,\Omega$$