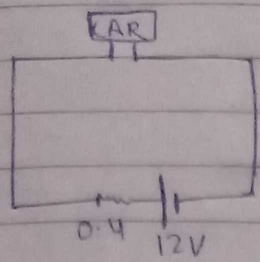
Current electricity - (NCERT)

Q1



Current will be maximum when external resistance will be zero

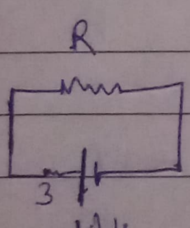
$$I = \frac{E}{r+R}$$

$$= \frac{E}{r} \qquad R = 0$$

$$= \frac{12}{0.4}$$

$$= \underline{30A}$$

3.2)



$I = 0.5A$

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

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

$$1.5 + 0.5R = 10V$$

$$0.5R = 8.5V$$

$$R = \frac{8.5}{0.5} = \underline{17\Omega}$$

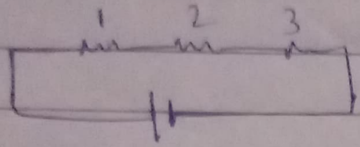
Terminal Voltage = ~~V~~ ~~ε Ir~~ $\varepsilon - Ir$

$= 10 - 0.5 \times 3$

$= 10 - 1.5$

$= 8.5V$

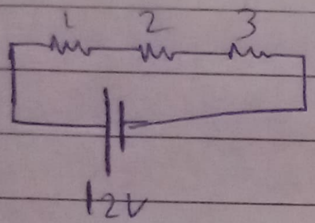
3.3



(a) $R = 1+2+3$

$= 6\Omega$

(b)



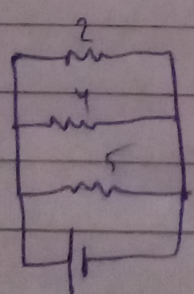
$I = \frac{V}{R} = \frac{12}{6} = 2A$

$V_1 = IR_1$
$= 2 \times 1$
$= 2V$

$V_2 = IR_2$
$= 2 \times 2$
$= 4V$

$V_3 = IR_3$
$= 2 \times 3$
$= 6V$

3.4



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

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

$\frac{1}{R_{eq}} = \frac{10+5+4}{20}$

$$\frac{1}{R_{eq}} = \frac{19}{20}$$

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

(b) Emf ($\mathcal{E}$) = 20 V

$$V = IR$$

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

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

Total current $= \underline{19\ A}$

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

$$= \frac{20}{2}$$

$$= \underline{10\ A}$$

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

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

3.5) $R_2 = R_1[1 + \alpha(T_2 - T_1)]$

$R_1 = \cancel{27°C}\ 100\,\Omega$ $\quad T_1 = \cancel{100\Omega}\ 27.0°C$

$R_2 = 117\,\Omega$ $\quad T_2 = x°C$

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

$R_2 = R_1[1 + \alpha(T_2 - T_1)]$

$\frac{R_2}{R_1} = 1 + 1.70 \times 10^{-4}(\cancel{27 - x})$ $x - 27$

27
17
189
27
459

$\frac{117}{100} = 1 + \cancel{45.9 \times 10^{-4}}\ 1.70x \times 10^{-4} - 45.9 \times 10^{-4}$

$1.17 = \cancel{1.00459 + 1.70x \times 10^{-4}}\ 0.99541 + 1.70x \times 10^{-4}$

-0.00459
1.00459
1.00000

$\cancel{1.70x \times 10^{-4} = 1.00459}$

$1.17 - \cancel{1.00459}\ 0.99541 = 1.70x \times 10^{-4}$

$0.17459 = 1.70x \times 10^{-4}$

$x = \frac{0.17459}{1.7 \times 10^{-4}}$

$= \underline{1027°C}$

3.6) Wire ~~length~~ length = 15 m

Uniform cross - section of $6.0 \times 10^{-7}\,m^2$

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

$R = 5\,\Omega$

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

$5 = \rho \frac{15}{6.0 \times 10^{-7}}$

$\rho = \frac{\cancel{5} \times \cancel{6}\overset{2}{0} \times 10^{-7}}{\cancel{15}\,\cancel{3}}$

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

3.7) $R_1 = 2.1\Omega$ $\quad R_2 = 2.7\Omega$

$T_1 = 27.5°C$ $\quad T_2 = 100°C$

$R_2 = R_1 [1 + \alpha (T_2 - T_1)]$

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

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

$\frac{2.7}{2.1} - 1 = \alpha (100 - 27.5)$

$\frac{27}{21} \frac{9}{7}$

$\frac{2}{7} = \alpha (72.5)$

$\begin{array}{r} 100.0 \\ -27.5 \\ \hline 72.5 \end{array}$

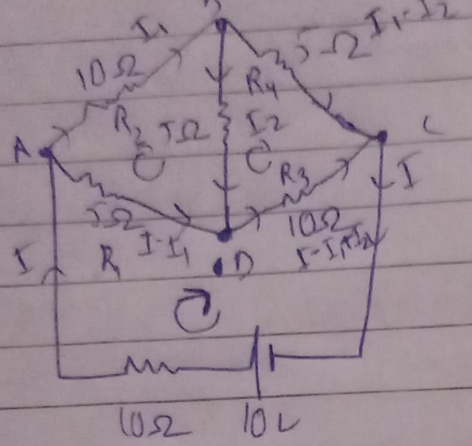
$\alpha = \frac{2}{7 \times 72.5}$

$= 0.0039\ °C^{-1}$

3.8) Use Formula $R = \frac{V}{I}$

Then $R_1 = R_2[1 - \alpha(T_2 - T_1)]$

3.9)



$\frac{10}{5} = 5$

$\frac{R_2}{R_1} = \frac{R_4}{R_3}$ As $\frac{10}{5} \neq \frac{5}{10}$

So it is a not wheat stone bridge

Use Kirchoff's law,

$R_{net\ external} = \frac{15 \times 15}{15 + 15} = 7.5$

$-5(I - I_1) + 10(I_1) + 5I_2 = 0$ — i

$r = 10$

$-10(I - I_1 + I_2) - 5(I_2) + 5(I_1 - I_2) = 0$ — ii

$V = 10V$

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

$10(I) + 5(I - I_1) + 10(I - I_1 + I_2) = 10$ — (iii)

$= \frac{10V}{10 + 7.5}$

Solving i & ii & iii,

Current in branch $AB = \frac{4}{17}A$, $BC = \frac{6}{17}A$, $CD = -\frac{4}{17}A$

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In branch AD = $\frac{6}{17}$ A, In branch BD = $\left(\frac{-2}{17}\right)$A

3.11/ emf = 8 V
r = 0.5 Ω
Volt = 120 V

Series resistor of 15.5 Ω

$V'_{(T.V.)} = V - E$
$= 120 - 8$
$= 112 V$

~~V = 120 - 8~~

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

$= \frac{112}{15.5 + 0.5} = \frac{112}{16} = 7A$

IR = 7×15.5
Voltage drop = 108.5V

DC supply voltage = Terminal voltage of battery + Voltage drop across R

T.V. = 120 - 108.5
= 11.5 V

A series resistor in a charging circuit limits the current drawn from the ext source. The current will be extremely high in its absence.

3.12 $n_e = 8.5 \times 10^{28} m^{-3}$

$D = 3.0 M$

$A = 2.0 \times 10^{-6} M^2$

$I = 3A$

$I = neAV_d$

$V_d = \frac{I}{neA}$ e = charge of e

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

8.5
2

$= \frac{3}{\cancel{17 \times 10^{22}}\ 27 \times 10^{3}}$

$= \cancel{0.17 \times 10^{-22}}$

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

$= \frac{3}{\frac{3}{27 \times 10^{3}}}$

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

$= 7.5 hr$

Additional Exercises :

3.14

Surface charge density, $\sigma = 10^{-9} Cm^{-2}$

Current over the entire globe, $I = 1800 A$

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

Surface area of the earth,

$A = 4\pi r^2$

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

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

Charge on the earth 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) $n = 6$ $E = 2.0V$

$r = 0.015 \Omega$ $R = 8.5 \Omega$

$I = \frac{nE}{R + nr}$

$= \frac{6 \times 2}{8.5 + 6 \times 0.015}$

$= \frac{12}{8.59} = 1.39 A$

Terminal voltage, $V = IR = 1.39 \times 8.5$
$= 11.87 V$ (Ans)

$I = 1.39A$ (Ans)

b) After a long time use, emf of the secondary cell, $E = 1.9V$

Int resistance of the cell, $r = 380\Omega$

$I = \frac{E}{r} = \frac{1.9}{380} = 0.005 A$ (Maxm Current)

No, it cannot start the motor of the car

3. b) $R_1 = R_2$

$\Rightarrow \frac{\rho_1 l_1}{A_1} = \frac{\rho_2 l_2}{A_2}$

$\Rightarrow \frac{\rho_1}{A_1} = \frac{\rho_2}{A_2}$ (Ans)

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$$\frac{A_1}{A_2} = \frac{\rho_1}{\rho_2}$$

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

Mass = Vol × density

$M_1 = A_1 l_1 d_1$

$M_2 = A_2 l_2 d_2$

$$\frac{M_1}{M_2} = \frac{A_1 d_1}{A_2 d_2}$$

$$\frac{M_1}{M_2} = \frac{2.63}{1.72} \times \frac{2.7}{8.9} = 0.46$$

Hence, Aluminium is lighter than cable.

Since, aluminium is lighter, it is preferred for overhead power cables

Q3.17 The ratio of voltage with current is a constant, which is equal to 19.7 & Manganin is a ohmic conductor

3.18

(a) When a steady current flows in a metallic conductor of non-uniform cross-section, the current flowing through the conductor is constant.

Current density, electric field, and drift speed are inversely proportional to the area of cross section.
They aren't constant.

b) No. GaAs (Galenium Arsenide) doesn't follow ohm's law

c) $I = \frac{V}{R}$ (According to ohm's law

If V is low, then R must be very low, so that I can be high

(d) A (HT) supply of 6kV must have a very large resistance because if the internal ~~resi~~ resistance is not large, then the current drawn can exceed the safety limits

3.19

a) Greater

b) alloys have lower temp ~~of~~ co-efficients of resistance than pure metals.

c) Independent

d) 10^{22}

3.20 (a) i) to get max^{m} resistance: connect it in series
ii) to get min^{m} resistance: connect it in parallel

iii) Ratio of max^{m} to min^{m}: $\frac{nR}{R/n} = n^2$

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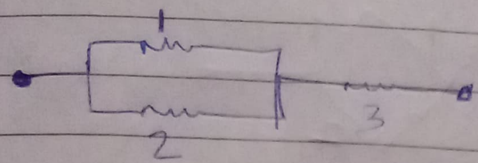
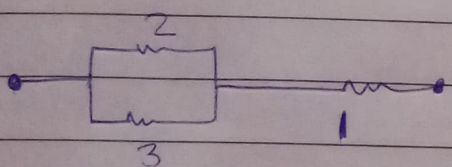
b) i) $1\Omega, 2\Omega, 3\Omega$



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

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

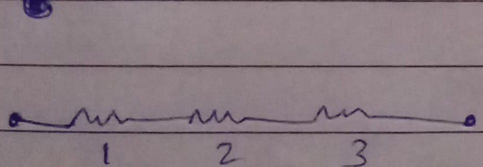
(ii) $11/3\ \Omega$



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

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

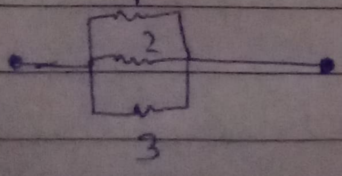
(iii) 6Ω



$R' = 1+2+3$

$= 6\Omega$

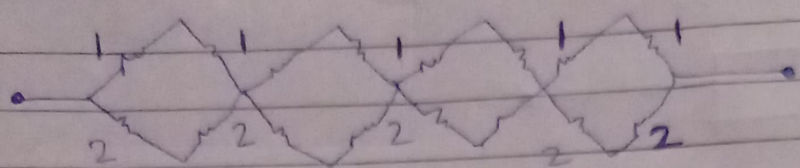
(iv) $6/11\ \Omega$



$\Rightarrow R' = \frac{6}{11}\Omega$

c) Determine the eqv resistance of networks:

ans)



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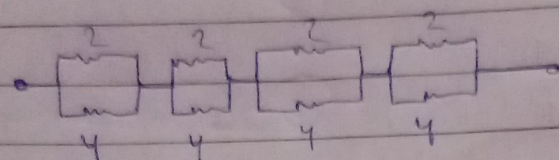


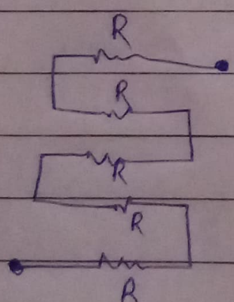
$$R_{eqv} = 4\left(\frac{2\times 4}{2+4}\right)$$

$$= 4\left(\frac{8}{6}\right)$$

$$= \frac{32}{6}$$

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

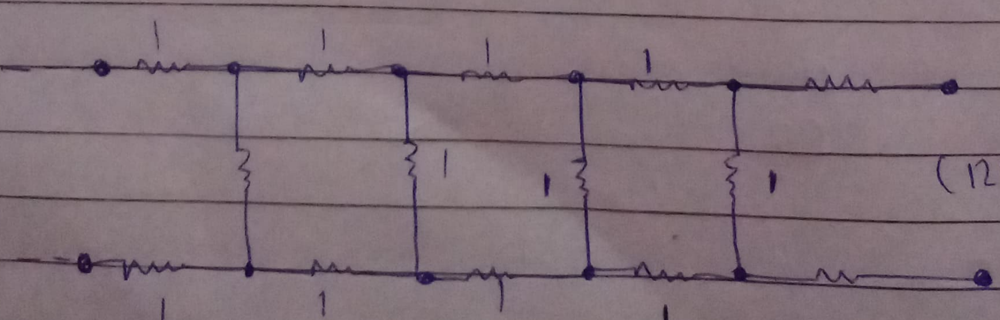
b)



$$R_{net} = R+R+R+R+R$$

$$= \underline{5R}$$

~~Q3.21~~



(12V, 0.5Ω)

Let eqv resistance in the circuit = R'

∴ R

∴ $R' = 2 + \frac{R'}{(R'+1)}$

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

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

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

Negative value of R' cannot be accepted.

Hence, equivalent resistance

$R' = 1 + \sqrt{3}$

$= 1 + 1.73$

$= 2.73\,\Omega$

$r = 0.5\,\Omega$

Total resistance of the given circuit $= 2.73 + 0.5$

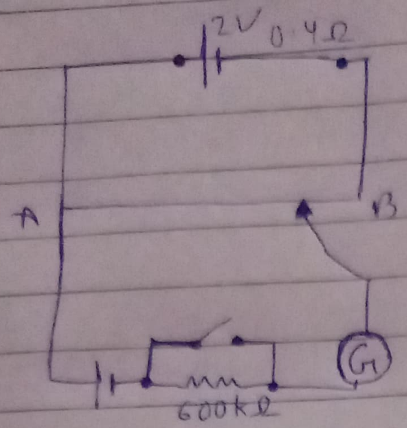
$= 3.23\,\Omega$

$V = 12V$

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

$= \frac{12}{3.23} = 3.72A$

3.22



(a) $E_1 = \cancel{1.02}\ 1.02\ V$

Balance-point $(l_1) = 67.3cm$

~~now~~ replaced by unknown emf (ε)

New balace point $(l_2) = 82.3$

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

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

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

$$= \cancel{1.2}\ 1.247V$$

The value of unknown emf is 1.247V

(b) ans Purpose of using high resistance of 600kΩ to reduce the current through galvanometer.

(c) The balance point is not affected by the int resistance of the driver cell.

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(d) The point is not affected by the int resistance of the driver cell.

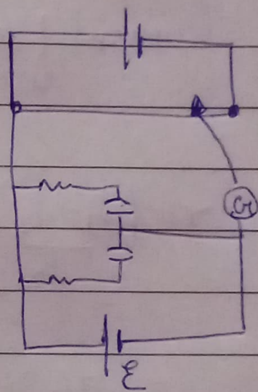
(e) The circuit would not work well for determining an extremely small emf. As the circuit would be unstable, the balance point would be close to end A.

This can be modified if a series resistance is connected with the wire AB

Q3.23 Potentiometer for comparison of 2 resistance.

$R = 10.0\,\Omega$

$l_1 = 58.3$ cm



$E_1 = iR$

Unknown resistor $= X$

$E_2 = iX$

The relation connecting emf and balance point is,

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

$$\frac{iR}{iX} = \frac{l_1}{l_2}$$

$$X = \frac{l_1}{l_2} \times R$$

$$= \frac{68.5}{58.3} \times 10 = 11.749\,\Omega$$

The value of unknown resistance, X, is 11.75 Ω

If balance point is not obtained, we add a series resistance to it.

~~Q3.24~~

Q3.24

Ans Int resistance of the cell = r

$l_1 = 76.3$ cm

$R = 9.5\ \Omega$

$l_2 = 64.8$ cm

Current flowing through the circuit = I

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

$$= \frac{76.3 - 64.8}{64.8} \times 9.5$$

$$= 1.68\ \Omega$$

Int resistance of the cell is 1.68 Ω