Current Electricity
Ncert Solution

3.1

$E = 12V$
$r = 0.4$
Maximum current = I

$E = Ir$

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

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

3.2

$E = 10V$
$r = 3\Omega$
$I = 0.5A$
Resistance of Resistor = R

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

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

$R = 20 - 3 = 17\Omega$

Terminal Voltage of Resistor = V

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

3.3
a) $R_s = 1\Omega + 2\Omega + 3\Omega = 6\Omega$

Current = I

b) Emf of battery = E = 12V

$R = 6\Omega$

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

$V_1 = 2 \times 1 = 2V$

$V_2 = 2 \times 2 = 4V$

$V_3 = 2 \times 3 = 6V$

Potential drop across 1Ω, 2Ω, 3Ω resistors are 2V, 4V and 6V

3.4

a) $R_1 = 2\Omega$

$R_2 = 4\Omega$

$R_3 = 3\Omega$

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

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

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

b) Emf of battery $V = 20V$

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

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

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

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

3.5 $T = 27^\circ C$

Resistance of heating element at T, $R = 100\Omega$

T_1 is increased Temperature

Resistance of heating element at T_1, $R_1 = 117\Omega$

Temperature co-efficient of material of filament

$\alpha = 1.7 \times 10^{-4} \, {}^\circ C^{-1}$

$$\alpha = \frac{R_1 - R}{R(T_1 - T)}$$

$$T_1 - T = \frac{R_1 - R}{R\alpha}$$

$$T_1 - 27 = \frac{117 - 100}{100(1.7 \times 10^{-4})}$$

$$T_1 - 27 = 1000$$

$$T_1 = 1027^\circ$$

3.6 Length of wire = 15m
Area = $6.0 \times 10^{-7} m^2$
$R = 5.0 \Omega$
Resistivity = ρ

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

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

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

3.7 $T_1 = 27.5^\circ C$
Resistance of silver wire at T_1, $R_1 = 2.1 \Omega$

$T_2 = 100^\circ C$
Resistance of silver wire at T_2, $R_2 = 2.7 \Omega$

Temperature coefficient of silver

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

$$= \frac{2.7 - 2.1}{2.1(100 - 27.5)} = 0.0039^\circ C^{-1}$$

3.8

3.5 $V = 230\,V$

$I_1 = 3.2\,A$

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

steady state value of current, $I_2 = 2.8\,A$

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

$\alpha = 1.7 \times 10^{-4}\,°C^{-1}$

$T_1 = 27\,°C$

Study state temperature reached by nichrome $= T_2$.

T_2 can be obtained

$\alpha = \frac{R_2 - R_1}{R_1(T_2 - T_1)} \Rightarrow T_2 - 27°C = \frac{82.14 - 71.87}{71.87 \times 1.7 \times 10^{-4}}$

$= 840.5$

$T_2 = 840.5 + 27 = 867.5\,°C$

3.9

I_1 = current flowing through outer circuit

I_2 = current through branch AB

I_3 = current through branch AD

$I_2 - I_4$ = Current through BC

$I_3 + I_4$ = Current through CD

I_4 = Current through BD

In circuit ABDA

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

$I_3 = 2 I_2 + I_4$ — (1)

For circuit BCDB

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

$I_2 = 2 I_3 + 4 I_4$ — (2)

In circuit ABCFEA

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

$10 = 15I_2 + 10I_1 - 5I_4$

$3I_2 + 2I_1 - I_4 = 2$ —— (3)

from 1 and 2

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

$I_3 = 4I_3 + 8I_4 + I_4$

$-3I_3 = 9I_4$

$-3I_4 = I_3$ —— (4)

$I_3 = 2I_2 + I_4$

$I_2 = -2I_4$

$I_{8_1} = I_3 + I_2$

Current in branch

$AB = \frac{4}{17} A$

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

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

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

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

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

$= \frac{10}{17} A$

(ii)

1. Balance point from end A. Resistance of wire X = [illegible]

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

$X = \frac{100 - 39.5}{39.5}$ [illegible]

2. If X and Y are interchanged / when l_1 and $100 - l$ interchanged, I get

$l_2 = 100 - 39.5 = 60.5$ cm

60.5 cm from end

3. When the 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.

3.11

$E = 8.0 V$

$r = 0.5 \Omega$

$V = 120 V$

$R = 15.5 \Omega$

Effective voltage = V'

$V' = V - E$

$V' = 120 - 8 = 112 V$

$I = \frac{V'}{R + r} = \frac{112}{15.5 + .5} = \frac{112}{16} = 7A$

Voltage, $IR = 7 \times 15.5 = 108.5V$

DC supply Voltage = Terminal Voltage + Voltage drop across

Terminal Voltage = 120 − 108.5

= ~~1~~ V

= 11.5 V

A series resistor in a charging circuit limits the current drawn from External source the current would be extremely high in its absence which is very dangerous

31. $E_1 = 1.25V$

Balance point $= l_1 = 35cm$

The cell is replaced by another cell of emf E_2

New balance point $l_2 = 63cm$

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

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

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

3.13

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

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

$I = nAeV_d$

$I = nA_d e \frac{l}{t}$

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

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

$= 2.7 \times 10^4 s$

3.14

$\sigma = 10^{-9} C m^{-2}$

$I = 1800 A$

$r = 6.37 \times 10^6 m$

$A = 4 \pi r^2$

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

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

$q = \sigma \times A$

$= 10^{-9} \times 5.09 \times 10^{14}$

$= 5.09 \times 10^5 C$

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

$t = \frac{q}{I} = \frac{5.09 \times 10^5}{1800} = 282.78$

(c) Number of secondary cells n = 6

Emf of each secondary cell, E = 2V

$r = 0.015\Omega$

$R = 8.5\Omega$

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

$= \frac{6 \times 2}{8.5 + 6 \times 0.015} = \frac{12}{8.59} = 1.39A$

$V = IR = 1.39 \times 8.5 = 11.87V$

(i) $E = 1.9V$

$r = 380\Omega$

Maximum current $= \frac{E}{r} = \frac{1.9}{380} = 0.005A$

Since a large current is required to start the motor of a car, the cell cannot be used to start a motor.

3.16

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

$d_1 = 2.7$

l_1 be length of aluminium wire and m_1 be its mass

Resistance of aluminium wire R_1

Area of cross-section of aluminium wire $= A_1$

Resistivity of copper, $\rho_{Cu} = 1.72 \times 10^{-8}\ \Omega m$

$d_2 = 8.9$

$R_1 = \rho_1 \frac{l_1}{A_1}$

$R_2 = \rho_2 \frac{l_2}{A_2}$

$R_1 = R_2$

$l_1 = l_2$

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

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

$= \frac{2.63\times10^{-8}}{1.72\times10^{-8}} = \frac{2.63}{1.72}$

m_1 = Volume × Density

$= A_1 l_1 \times d_1 = A_1 l_1 d_1$

m_2 = Volume × Density

$A_2 L_2 \times d_2 = A_2 L_2 d_2$

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

$l_1 = l_2$

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

$\frac{A_1}{A_2} = \frac{2.63}{1.72}$

$\frac{m_1}{m_2} = \frac{2.63}{1.72} \times \frac{27}{89} = 0.4$

It can be inferred from this ratio that m_1 is less than m_2. Hence aluminium is lighter than copper.

Since aluminium is lighter it is preferred for overhead power cables over copper.

3.17 It can be inferred from the given table that the ratio of voltage with current is a constant which is equal to 19.7. Hence manganin is an ohmic conductor i.e. the alloy obeys ohms law. According to ohm's law, the ratio of voltage with ~~resistance~~ current is resistance. Hence the resistance of manganin is 19.7 Ω.

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. Therefore, they are not constant.

b) No, Ohm's law is not universally applicable for all conducting elements. Vacuum diode semiconductor is a non-ohmic conductor. Ohm's law is not valid for it.

c) According to Ohm's law the relation of the potential is $V = IR$

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

d) In order to prohibit the current from exceeding the safety limit, a high tension supply must have a very large internal resistance. If the internal resistance is not large then the current drawn can exceed the safety limits in case of short circuit.

3.19

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

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

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

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

3. a) i) Total number of resistors = n
Resistance of each resistor = R

n resistors in series effective resistance R_1 is the maximum given by nR

$$R_1 = nR$$

ii) When n resistors are connected in parallel effective resistance R_2 is minimum given by $\frac{R}{n}$

iii) The ratio of maximum to minimum resistance is

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

b) i) Equivalent resistance

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

(ii) Equivalent resistance

$R = \frac{2 \times (3+1)}{2+4} = \frac{8}{6} = 1.33\,\Omega$

(iii) Equivalent resistance

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

(iv) Equivalent resistance

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

c) (i) $R = \frac{2 \times 4}{2+4} = \frac{8}{6} = \frac{4}{3}\,\Omega$

(ii) If four resistors are connected in series

$\frac{4}{3} \times 4 = \frac{16}{3}\,\Omega$

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

5.21

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

$R^2 - 2R - 2 = 0$

$R = \frac{2 \pm \sqrt{4+8}}{2} = \frac{2 + \sqrt{12}}{2} = 1 \pm 3$

$R = (1 + \sqrt{3}) = 2.73\Omega$

$r = 0.5\Omega$

Total resistance $= 2.73 + 0.5 = 3.23\Omega$

$V = 12V$

current drawn from source is given by ratio $\frac{12}{3.23} = 3.72A$

323 $\frac{E_1}{E_2} = \frac{l_1}{l_2}$

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

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

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

X is 11.75Ω

324 The relation connecting resistance and emf is

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

$= \frac{76.3 - 64.8}{64.8} \times 9.5 = 1.68\Omega$