Chapter - 3

Current Electricity

1. $E = 12 V$

$r = 0.4 \Omega$

Maximum current drawn from the battery = I

According to Ohm's law,

$$E = Ir$$

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

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

The maximum current drawn from the given battery is 30A.

2. $E = 10 V$

$r = 3 \Omega$

$I = 0.5 A$

Resistance of the resistor = R

The relation for current using Ohm's law is,

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

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

$$= \frac{10}{0.5} = 20 \Omega$$

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

Terminal voltage of the resistor = V

According to Ohm's law,

$$V = IR$$

$$= 0.5 \times 17$$

$$= 8.5 V.$$

3(a) Three resistors of resistances 1Ω, 2Ω and 3Ω are combined in series. Total resistance of the combination is given by the algebraic sum of individual resistances.

Total resistance $1+2+3 = 6\,\Omega$

(b) Current flowing through the circuit $= I$

$E = 12\,V$

$R = 6\,\Omega$

The relation for current using Ohm's law is

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

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

Potential drop accross 1Ω resistor $= V_1$

From Ohm's law, the value of $1V$ can be obtained as $V_1 = 2\times 1 = 2V$ ---- i

Potential drop accross 2Ω resistor $= V_2$

Again, from Ohm's law, the value of V_2 can be obtained as $V_2 = 2\times 2 = 4V$ --- ii

3Ω resistor $= V_3$

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

Therefore, the potential drop access 1Ω, 2Ω and 3Ω resistors are $2V$, $4V$ and $6V$ ~~respe~~ respectively.

4 (a) There are three resistors of resistances,

$R_1 = 2\,\Omega$ $R_2 = 4\,\Omega$ and $R_3 = 5\,\Omega$

They are connected in parallel. Hence, total resistance (R) of the combination is given by,

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

$$= \frac{1}{2} + \frac{1}{4} + \frac{1}{5} = \frac{10+5+4}{20} = \frac{19}{20}$$

$$\therefore R = \frac{20}{19}\,\Omega$$

Therefore, total resistance of the combination is $\frac{20}{19}\,\Omega$.

(b) $V = 20 V$

current (I_1) flowing through resistor R_1 is given by,

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

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

current (I_2) flowing through resistor R_2 is given by,

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

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

current (I_3) flowing through resistor R_3 is given by,

$I_3 = \frac{V}{R_3}$

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

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

Therefore, the current through each resistor is 10 A, 5A and 4 A respectively and the total current is 19 A.

5. $T = 27°C$

$T, R = 100 \Omega$

Let T_1 is the increased temperature of the filament.

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

Temperature co-efficient of the material of the filament,

$a = 1.70 \times 10^{-4}\ °C^{-1}$

a is given by the relation,

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

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

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

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$T_3 - 27 = 1000$

Therefore, at $1027\,^\circ C$, the resistance of the element is $117\,\Omega$.

6. $l = 15\ m$

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

$R = 5.0\,\Omega$

Resistivity of the material of the wire $= \rho$

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

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

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

7. $T_1 = 27.5\ ^\circ C$

$T_1, R_1 = 2.1\,\Omega$

$2\ T_2 = 100\ ^\circ C$

$T_2, R_2 = 2.7\ \Omega$

Temperature coefficient of silver $= \alpha$

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

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

8. $V = 230\ V$

$I_1 = 3.2 A$

R_1, which is given by the relation,

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

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

~~$R_2 = \frac{230}{2.8}$~~ $I_2 = 2.8\ A$

R_2, which is given as,

$$R = \frac{230}{2.8} = 82.14\,\Omega\,3$$

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

$T_1 = 27.0°C$

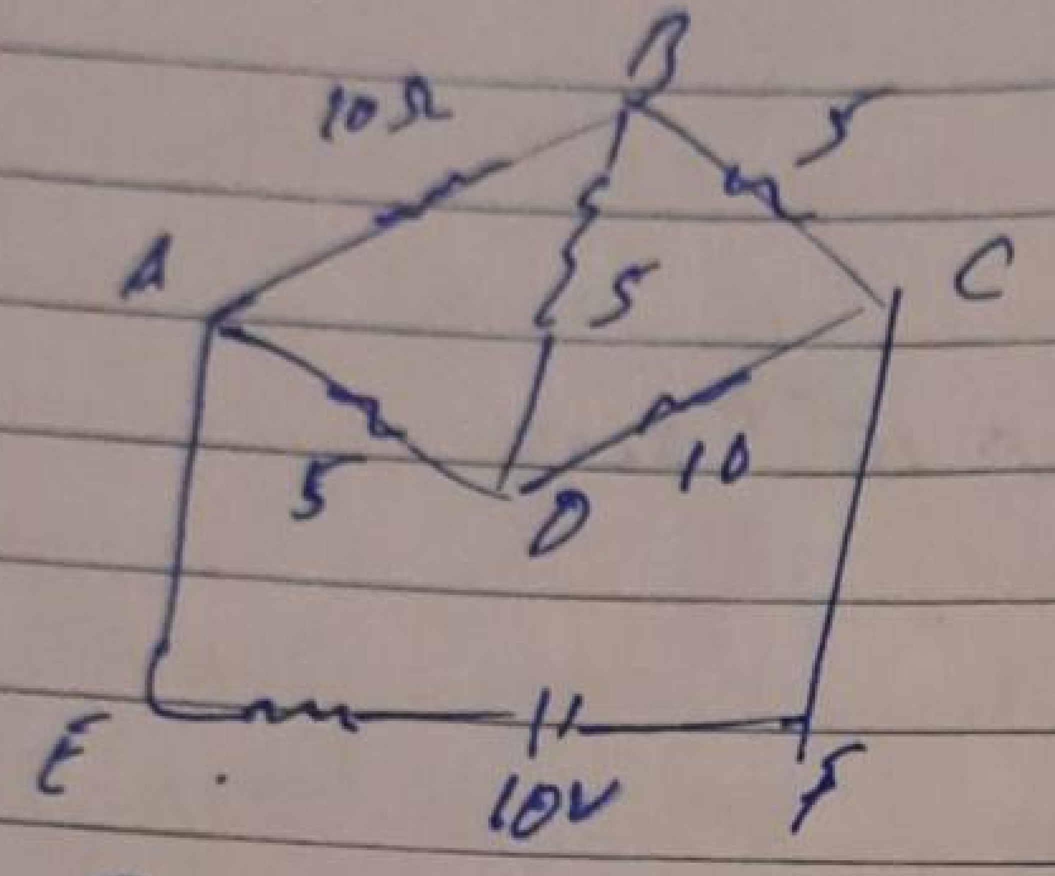
T_2 can be obtained by the relation for α

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

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

$T_2 = 840.5 + 27 = 867.5\ °C$

9.



For the ~~ct~~ closed circuit ABDA, potential is zero

$\cancel{5(I_2 - I_4) - 10(I_3 + I_4)}$

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

$2I_2 + I_4 + I_3 = 0$

$I_3 = 2I_2 + I_4 \quad \text{----} \quad (1)$

For the closed circuit BCDB, potential is zero i,e...,

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

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

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

$I_2 = 2I_3 + 4I_4 \quad \text{----} \quad (2)$

For the closed circuit ABCFEA, Potential is zero i,e..,

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

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

$3I_2 + 2I_1 - I_4 - 2 \quad \text{----} \quad (3)$

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

$I_3 = 4I_3 + 8I_4 + I_4$

$-3I_3 = 9I_4$

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$-3I_4 = +I_3$ . . . . (4)

$I_3 = 2I_2 + I_4$

$-4I_4 = 2I_2$

$I_2 = 2I_4$ . . . . (5)

$I_1 = I_3 + I_2$ . . . . (6)

$3I_2 = 2(I_3 + I_2) - \cancel{I_4}\, I_4 = 2$

$5I_2 + 2I_3 - I_4 = 2$ . . . . (7)

Putting equations (4) and (5) is equation (7), we obtain

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

$-10I_4 - 6I_4 - I_4 = 2$

$17I_4 = 2$

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

Equation (4) reduces to

$I_3 = -3(I_4)$

$= -3\left[\frac{-2}{17}\right] = \frac{6}{17} A$

$I_2 = -2(I_4)$

$= -2\left[\frac{-2}{17}\right] = \frac{4}{17} A$

$I_2 - I_4 = \frac{4}{17} - \left[\frac{-2}{17}\right] = \frac{6}{17} A$

$I_3 + I_4 = \frac{6}{17} + \left[\frac{-2}{17}\right] = \frac{4}{17} A$

$I_1 = I_3 + I_2$

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

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

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

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

In branch BD $= \left[\frac{-2}{17}\right] A$

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

10 (a)

(a) A, $l_1 = 39.5$ cm
$Y = 12.5\ \Omega$
Condition for the balance is given as,
$$\frac{X}{Y} = \frac{100 - l_1}{l_1}$$
$$X = \frac{100 - 39.5}{39.5} \times 10.5 = 8.2\ \Omega$$

(b) If X and Y are interchanged, then l_1 and $100-l_1$ get interchanged. The balance point of the bridge will be $100-l_1$ from A. $100 - l_1 = 100 - 39.5 = 60.5$ cm.

(c) When the galvanometer and cell are interchanged at the balance point of the bridge, the galvanometer will show not deflection. Hence, no current would flow through the galvanometer.

11. $E = 8.0$ V
$r = 0.5\ \Omega$
$V = 120$ V
$R = 15.5\ \Omega$
Effective voltage in the circuit $= V_1$
$V' = V - E$
$V' = 120 - 8 = 112$ V
Current flowing in the circuit $= I$, which is given by the relation,
R is connected to the storage battery in series. Hence, it can be written as
$$I = \frac{V'}{R + r}$$

$$= \frac{122}{15.5 + 0.5} = \frac{112}{16} = 7A$$

$IR = 7 \times 15.5 = 108.5V$

Voltage accross resistor R given by the product, $IR = 7 \times 15.5 = 108.5V$

DC supply voltage = Terminal voltage of battery + voltage drop accross R

Terminal voltage of battery $= 120 - 108.5 = 11.5V$

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

12. $E_1 = 1.25V$

$l_1 = 35$ cm

E_2.

$l_2 = 63$cm

The balance condition is given by the relation,

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

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

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

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

$L = 3.0m$

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

$I = 3.0A$

$I = nAev_d$

where,

e = Electric charge $= 1.6 \times 10^{-19}C$

V_d = Drift velocity = $\frac{\text{Length of the wire } (l)}{\text{Time taken to cover } (t)}$

$I = nAe \cancel{v} \frac{l}{t}$

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

$= \frac{3 \times 8.5 \times 10^{28} \times 2 \times 10^{-6} \times 1.6 \times 10^{-19}}{3.0}$

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