NCERT Exercise Solution

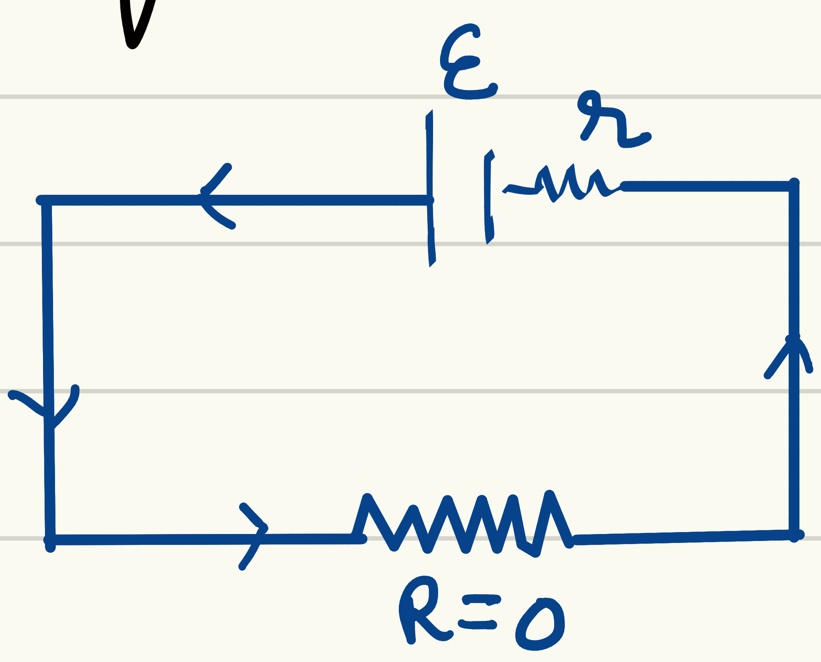
Current Electricity

Sol^n 1.

$\varepsilon = 12V$

$r = 0.4\,\Omega$

$I_{max} = ?$



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

$$I_{max} = \frac{\varepsilon}{r} \qquad [R=0]$$

$$= \frac{120}{0.4} = 30$$

$$I_{max} = 30\,A$$

Ans

Sol^n

$\varepsilon = 10\,V$

$r = 3\,\Omega$

$R = ?$ $\qquad V = ?$

$I = 0.5\,A$

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

$$R+r = \frac{\varepsilon}{I} = \frac{100}{0.5} = 20$$

$$R+r = 20$$

$$R = 20 - r$$

$$= 20 - 3$$

$$R = 17\,\Omega$$ Ans

Now, terminal voltage

$$V = \varepsilon - Ir$$

$$= 10 - (0.5 \times 3)$$

$$= 10 - 1.5$$

$$V = 8.5 \text{ Volt}$$ Ans

Sol^n

$$R_T = R_0(1+\alpha\Delta T) \qquad [\Delta T = T_2 - T_1]$$

$$R_2 = R_1(1+\alpha\Delta T)$$

Given

$T_1 = 27^\circ C$

$T_2 = ?$

$R_1 = 100\,\Omega$

$R_2 = 117\,\Omega$

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

We know

$$\alpha = \frac{R_2 - R_1}{R_1 \Delta T}$$

or $$\Delta T = \frac{R_2 - R_1}{R_1 \alpha}$$

$$= \frac{117 - 100}{100 \times 1.7 \times 10^{-4}}$$

$$= \frac{\cancel{170}^{\,10} \times 10^{2}}{\cancel{1.7}}$$

$$= 10^3 = 1000^\circ C$$

$\Delta T = 1000$

$T_2 - T_1 = 1000$

$T_2 = 1000 + T_1$

$= 1000 + 27$

or $T_2 = 1027^\circ C$

Sol^n Given

$l = 15\,m$

$A = 6 \times 10^{-7}\,m^2$

$R = 5.0\,\Omega$

$\rho = ?$

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

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

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

Sol^n 5

$R_1 = 2.1\,\Omega$

$T_1 = 27.5\,°C$

$R_2 = 2.7\,\Omega$

$T_2 = 100\,°C$

$\alpha = ?$

We have

$$\alpha = \frac{R_2 - R_1}{R_1 \Delta T}$$

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

$$= \frac{0.\cancel{6}\,2}{2\cancel{1}_{3} \times 72.5}$$

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

$$= \frac{2}{507.5}$$

$$\alpha = \frac{\overset{800}{\cancel{20000}} \times 10^{-3}}{\underset{203}{\cancel{5075}}}$$

[Multiply by $10^{3} \times 10^{-3}$ to make calculation easy

$$= \frac{800}{203} \times 10^{-3}$$

$$\alpha = 3.94 \times 10^{-3}$$

$$= 0.00394$$

$$\alpha \simeq 0.0039\ ^{\circ}C^{-1}$$

Sol^n 6 Given

$V = 230$ volt

$I_1 = 3.2\ A$

$I_2 = 2.8\ A$

$T_1 = 27^\circ C$

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

$T_2 = ?$

We have

$$R_2 = R_1 (1 + \alpha \Delta T)$$

here $R_1 = \frac{V}{I_1} = \frac{230}{3.2}\ \Omega$

and $R_2 = \frac{V}{I_2} = \frac{230}{2.8}\ \Omega$

so $$\frac{\cancel{230}}{\cancel{2.8}_{7}} = \frac{\cancel{230}}{\cancel{3.2}_{.8}} (1 + \alpha \Delta T)$$

$$\frac{8}{7} = 1 + \alpha \Delta T$$

$$\frac{8}{7} - 1 = \alpha \Delta T$$

$$\frac{1}{7} = \alpha \Delta T$$

$$\Delta T = \frac{1}{7\alpha} = \frac{1}{7 \times 1.7 \times 10^{-4}}$$

$$\Delta T = \frac{1}{11.9 \times 10^{-4}} = \frac{10^4}{11.9}$$

$$= \frac{1000}{11.9} \times 10^2$$

$$\Delta T = 8.40 \times 10^2$$

$$T_2 - T_1 = 840$$

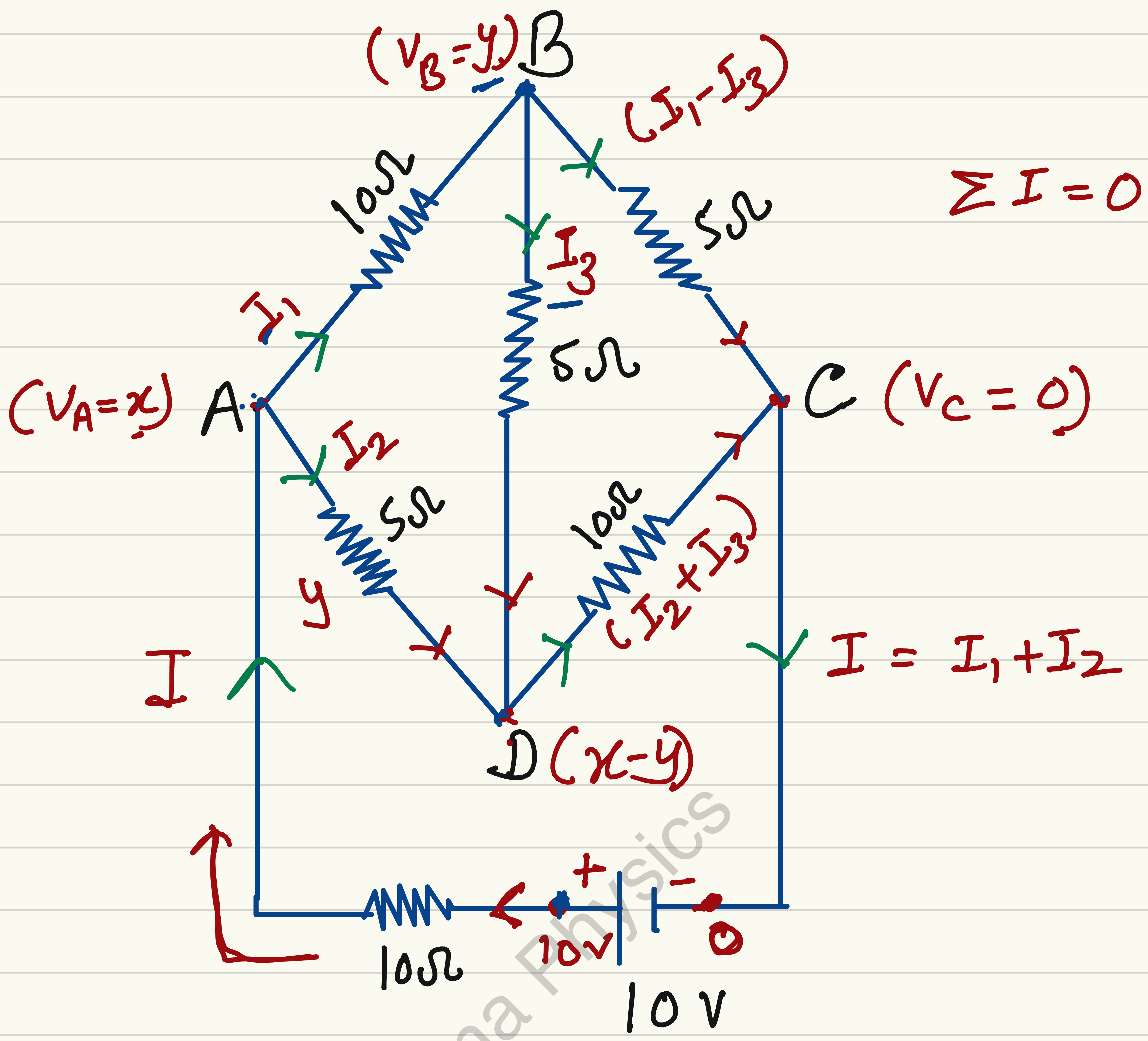
$$T_2 = 840 + T$$

$$= 840 + 27$$

$$T = 867^\circ C \quad \underline{Ans}$$

i.e at $867^\circ c$ the current becomes 2.8 A

Sol^n 7



By KCL, at point 'A'

$$I = I_1 + I_2$$

By Ohm's law

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

put the values

$$\frac{10-x}{10} = \frac{x-y}{10} + \frac{y}{5}$$

or $\quad 10 - x = x - y + 2y$

or $\quad 10 - x = x + y$

or $\quad 2x + y = 10 \quad — (1)$

At point 'B'

$$I_1 = I_3 + (I_1 - I_3)$$

$$\frac{x-y}{10} = \frac{y-(x-y)}{5} + \frac{y}{5}$$

or $$\frac{x-y}{10} = \frac{2y-x}{5} + \frac{y}{5}$$

or $$x-y = 2(2y-x) + 2y$$

or $$x-y = \underline{4y} - 2x + \underline{2y}$$

$$3x = 7y$$

or $$y = \frac{3x}{7}$$

put $y = \frac{3}{7}x$ in eqn (1),

$$2x + y = 10$$

$$2x + \frac{3}{7}x = 10$$

$$14x + 3x = 70$$

$$17x = 70$$

$$x = \frac{70}{17} \text{ volt}$$

so $$y = \frac{3}{7}x = \frac{3}{7} \times \frac{70}{17}$$

$$= \frac{3}{\cancel{7}} \times \frac{\cancel{70}^{10}}{17}$$

$$y = \frac{30}{17}$$

We have,

$$x = \frac{70}{17} \text{ volt} \quad , \quad y = \frac{30}{17} \text{ volt}$$

Therefore by,

$$I_1 = \frac{x-y}{10} = \frac{\frac{70}{17} - \frac{30}{17}}{10}$$

or $$I_1 = \frac{40}{17 \times 10}$$

or $$I_1 = \frac{4}{17} \text{ Amp}$$

Now $$I = \frac{10 - x}{10}$$

$$= \frac{10 - \frac{70}{10}}{10}$$

$$= \frac{100}{17 \times 10} = \frac{10}{17}$$

i.e $$I = \frac{10}{17} \text{ Amp}$$

Now $$I_2 = I - I_1$$

$$= \frac{10}{17} - \frac{4}{17} = \frac{6}{17}$$

i.e $$I_2 = \frac{6}{17} \text{ Amp}$$

Now,

$$I_3 = \frac{y - (x-y)}{5} = \frac{2y - x}{5}$$

$$= \frac{2 \times \frac{30}{17} - \frac{70}{17}}{5}$$

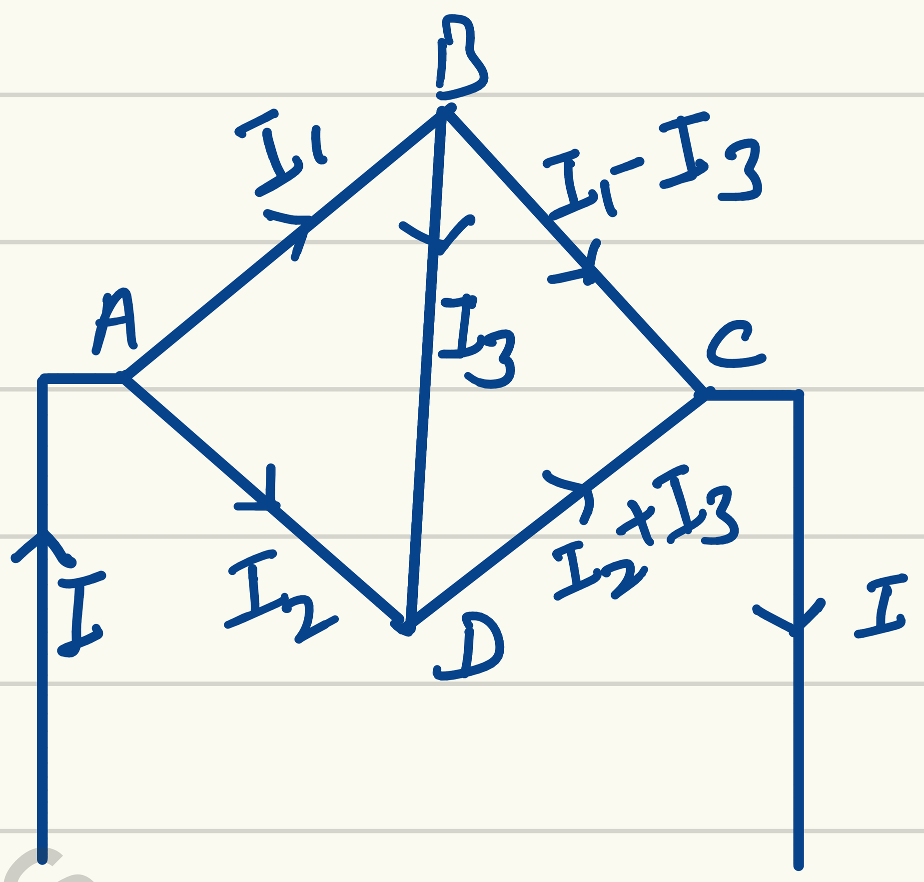
$$I_3 = \frac{10}{17 \times 5} = \frac{-2}{17}$$

i.e $\quad I_3 = -\frac{2}{17}$ Amp

So current in branch

$AB = I_1 = \frac{4}{17}\ A$

$AD = I_2 = \frac{6}{17}\ A$



$BD = I_3 = -\frac{2}{17}\ A$

$BC = I_1 - I_3 = \frac{6}{17}\ A$

$DC = I_2 + I_3 = \frac{4}{17}\ A$

Total current $I = \frac{10}{17}\ A$ Ans

II Method

By KCL
$$I = I_1 + I_2$$

By KVL $(\Sigma V = \Sigma IR = 0)$

In loop (1)

$$-10 I_1 - 5I_3 + 5I_2 = 0$$

or $-2I_1 - I_3 + I_2 = 0$

or $2I_1 - I_2 + I_3$ — (1)

In loop (2)

$$-5I_3 - 10(I_2 + I_3) + 5(I_1 - I_3) = 0$$

or $-5I_3 - 10I_2 - 10I_3 + 5I_1 - 5I_3 = 0$

or $5I_1 - 10I_2 - 20I_3 = 0$

or $-I_1 + 2I_2 + 4I_3 = 0$ — (2)

In loop (3) (ADCA)

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

or $-5I_2 - 10I_2 - 10I_3 + 10 - 10(I_1 + I_2) = 0$

or $-25I_2 - 10I_3 - 10I_1 + 10 = 0$

$$2I_1 + 5I_2 + 2I_3 = 2 \quad \text{— (3)}$$

We have

$$I_1 \begin{cases} 2I_1 - I_2 + I_3 = 0 & \text{--- (1)} \end{cases}$$

$$I_1 \begin{cases} -I_1 + 2I_2 + 4I_3 = 0 & \text{--- (2)} \\ 2I_1 + 5I_2 + 2I_3 = 2 & \text{--- (3)} \end{cases}$$

eqn (1) + 2x eqn (2)

$$\begin{aligned} \cancel{2I_1} - I_2 + I_3 &= 0 \\ -\cancel{2I_1} + 4I_2 + 8I_3 &= 0 \\ \hline 3I_2 + 9I_3 &= 0 \end{aligned}$$

or $$I_2 + 3I_3 = 0$$

or $$\boxed{I_2 = -3I_3}$$

Again

2x eqn (2) + eqn (3)

$$\begin{aligned} -\cancel{2I_1} + 4I_2 + 8I_3 &= 0 \\ \cancel{2I_1} + 5I_2 + 2I_3 &= 2 \\ \hline 9I_2 + 10I_3 &= 2 \end{aligned}$$

here we put $I_2 = -3I_3$, we get

$$9(-3I_3) + 10I_3 = 2$$

or $$-27I_3 + 10I_3 = 2$$

$$-17I_3 = 2$$

So $$\boxed{I_3 = -\frac{2}{17}\ A}$$

$$I_2 = -3I_3$$

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

$$\boxed{I_2 = \frac{6}{17}\ A}$$

From eqⁿ 1

$$2I_1 - I_2 + I_3 = 0$$

$$2I_1 - \frac{6}{17} - \frac{2}{17} = 0$$

$$2I_1 = \frac{8}{17}$$

$$I_1 = \frac{4}{17}\ A$$

$$I_2 = \frac{6}{17}\ A$$

$$I_3 = -\frac{2}{17}\ A$$

Ans

Sol^n 8. Given

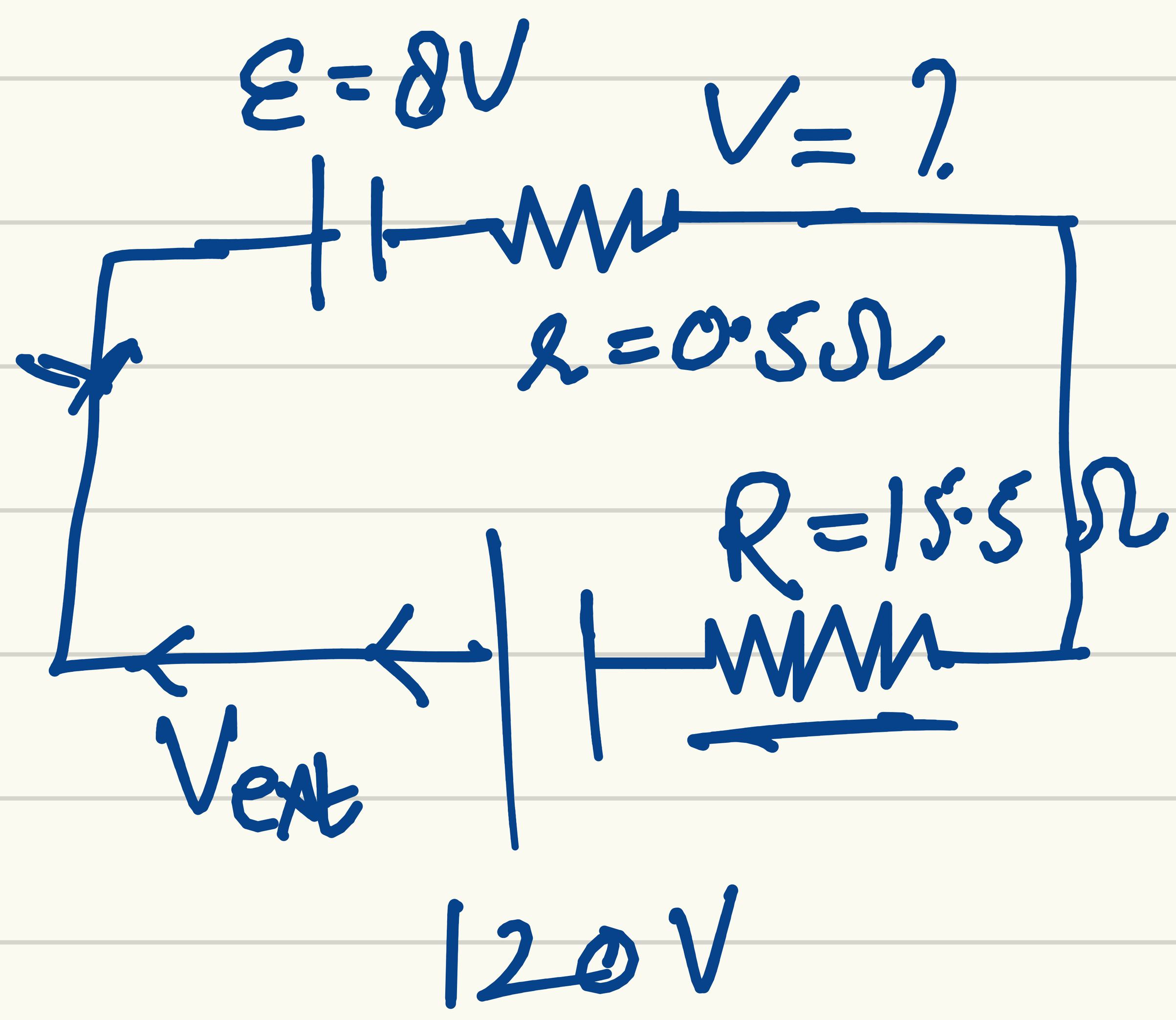
$\mathcal{E} = 8V$

$r = 0.5\Omega$

$R = 15.5\Omega$

$V_{ext} = 120V$

$V = ?$



During charging

$$V = \mathcal{E} + Ir$$

here

$$I = \frac{V_{net}}{R+r} = \frac{120-8}{15.5+0.5}$$

$$I = \frac{112}{16} = 7$$

$$I = 7A$$

Now

$$V = 8 + 7 \times 0.5$$

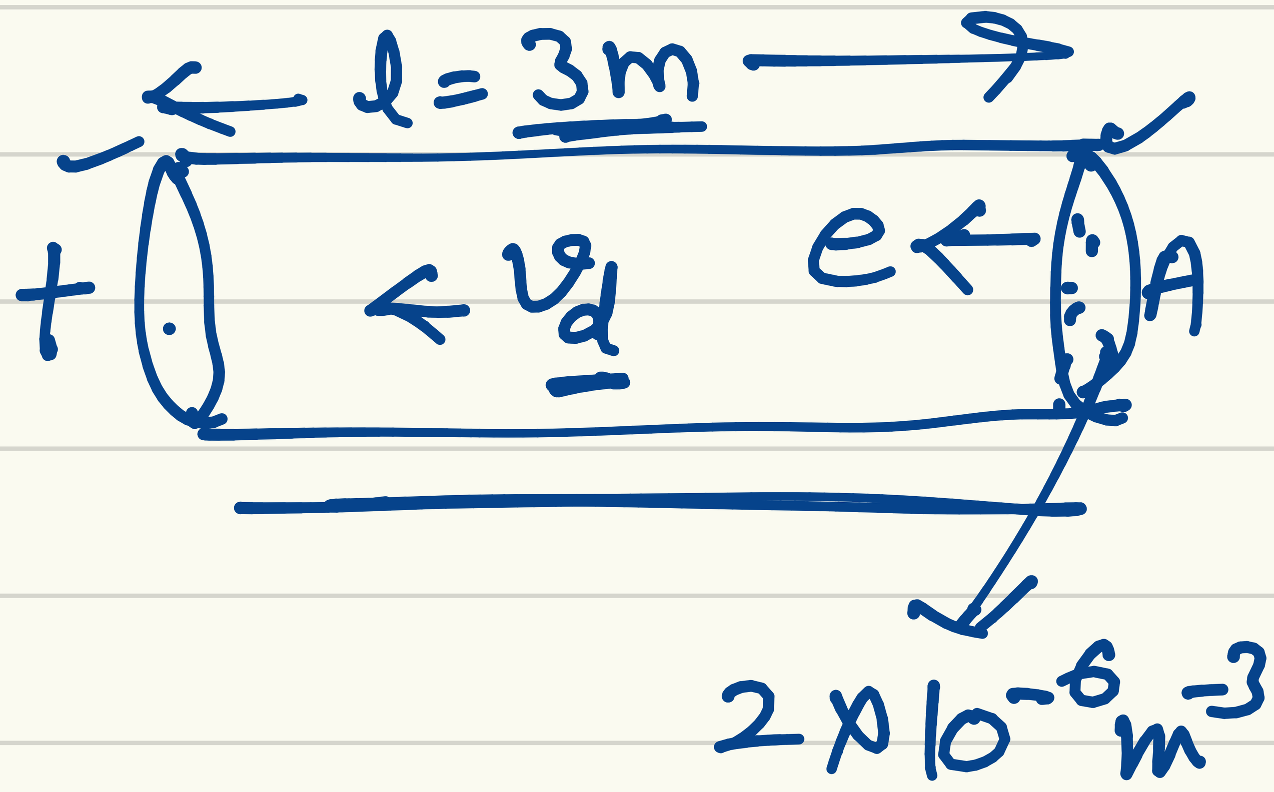
$$V = 8 + 3.5$$

$$V = 11.5 \text{ Volt}$$

Ans

A resistor is connected in series to limit the high current and to protect the circuit.

Sol^n 3.9 Given



$l = 3m$

$A = 2\times10^{-6} m^{-3}$

$I = 3 A$

$n = 8.5\times10^{28} m^{-3}$

$t = ?$

by $t = \dfrac{l}{v_d} = \dfrac{l}{I/neA}$ $\quad [I = neAv_d]$

$$t = \frac{l\,n\,e\,A}{I}$$

$$= \frac{\cancel{3}\times 8.5\times10^{28}\times1.6\times10^{-19}\times2\times10^{-6}}{\cancel{3}}$$

$$= 8.5\times1.6\times2\times10^{3}$$

$$= 17\times1.6\times10^{3}$$

$$= 27.2\times10^{3}$$

$$t = 2.7\times10^{4}\ \text{sec}$$

$$\simeq 7.5\ \text{hrs}$$

$$\frac{2.7\times10^{4}}{60\times60} = 7.5$$