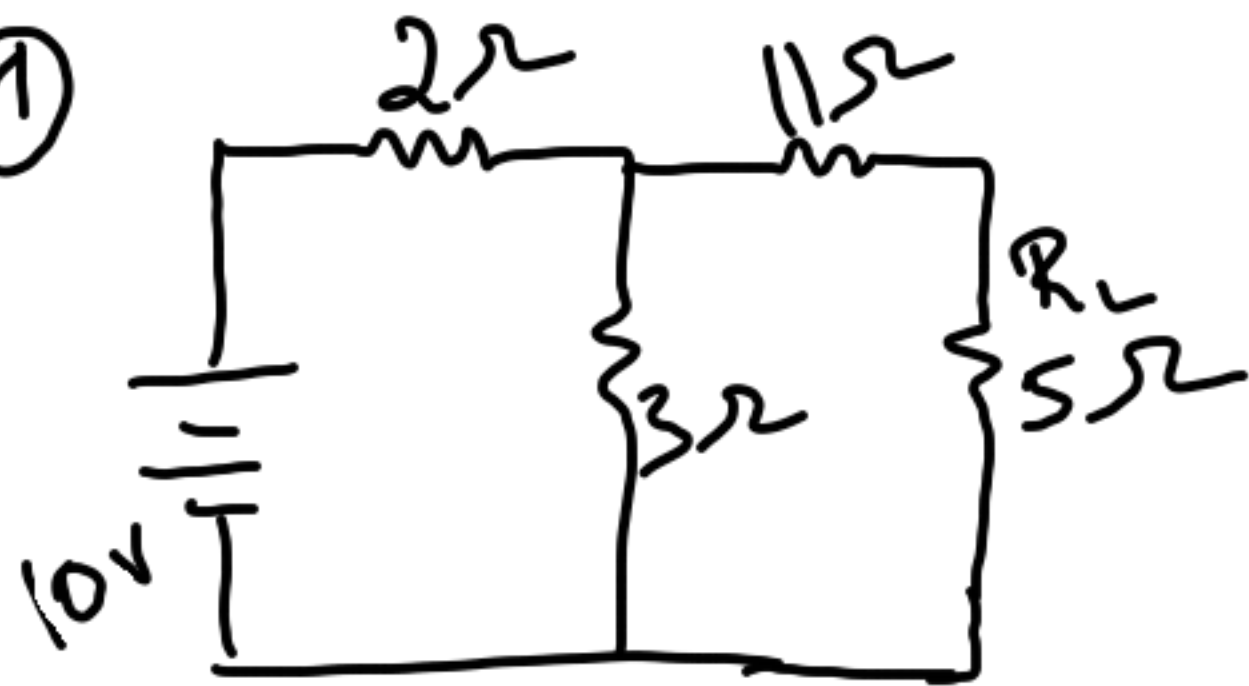
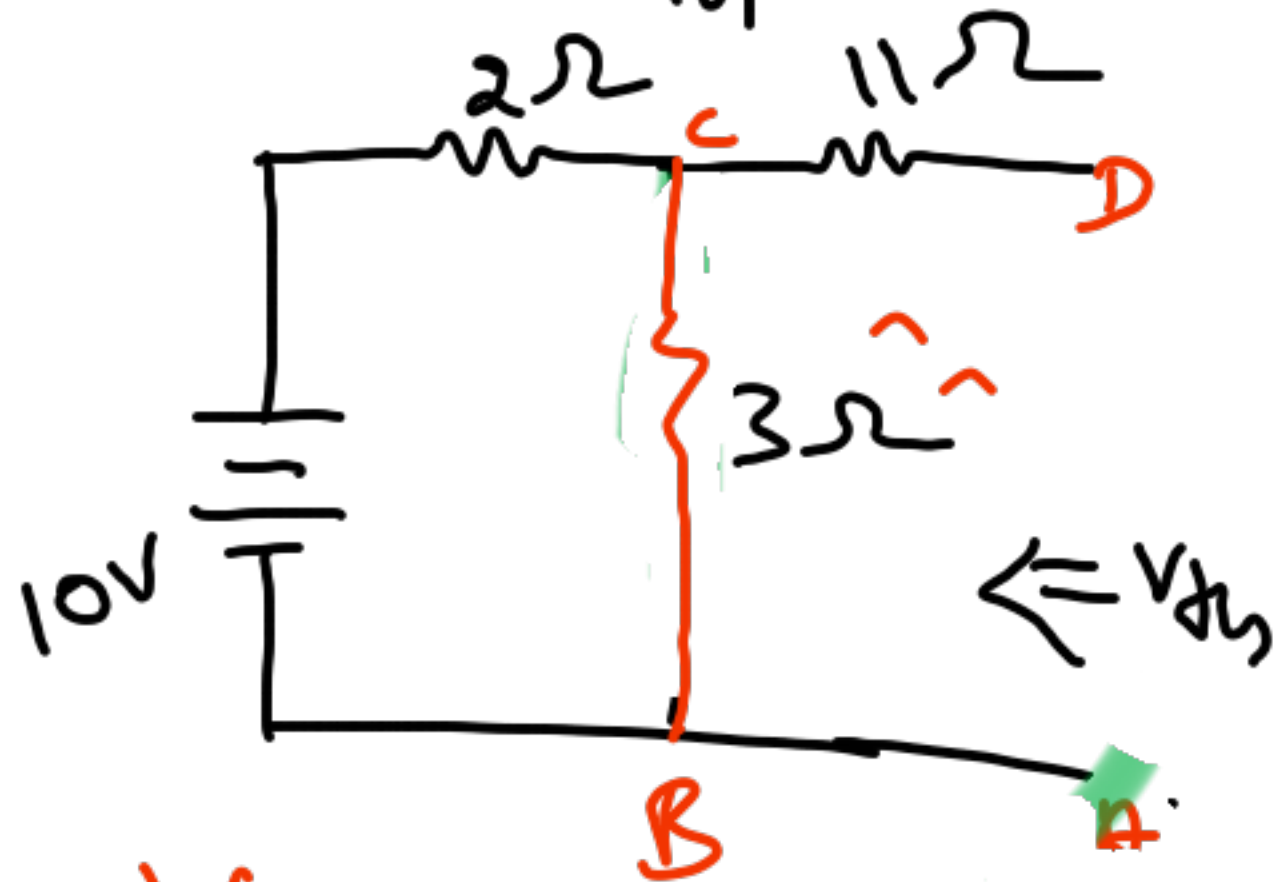


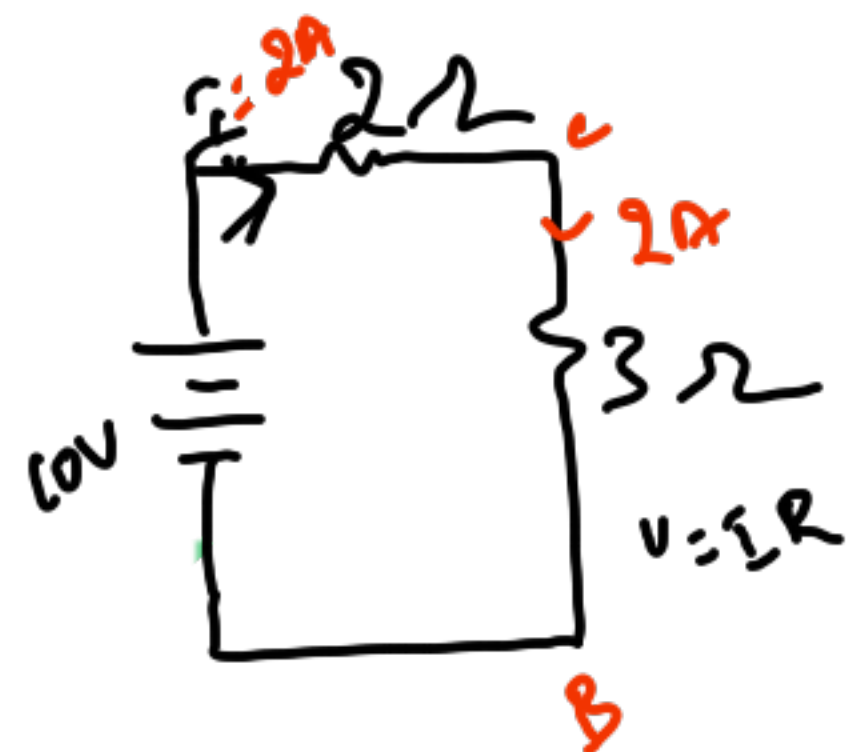
①

To find V_{th} 

$$V_{th} = V_{AB} + V_{BC} + V_{CD}$$

$$= 0 + V_{BC} + 0$$

$$V_{th} = V_{BC}$$



$$I = \frac{V}{R} = \frac{10}{2+3} = \frac{10}{5} = 2A$$

To find current across 3Ω

$$V = I R = 2 \times 3 = 6V$$

$$V_{BC} = 6V$$

$$V_{th} = \underline{6V}$$



$$2 \parallel 3 \Omega$$

$$\frac{1}{R_{eq}} = \frac{1}{2} + \frac{1}{3} = \frac{3+2}{6} = \frac{5}{6}$$

$$R_{eq} = \frac{6}{5} = 1.2 \Omega$$

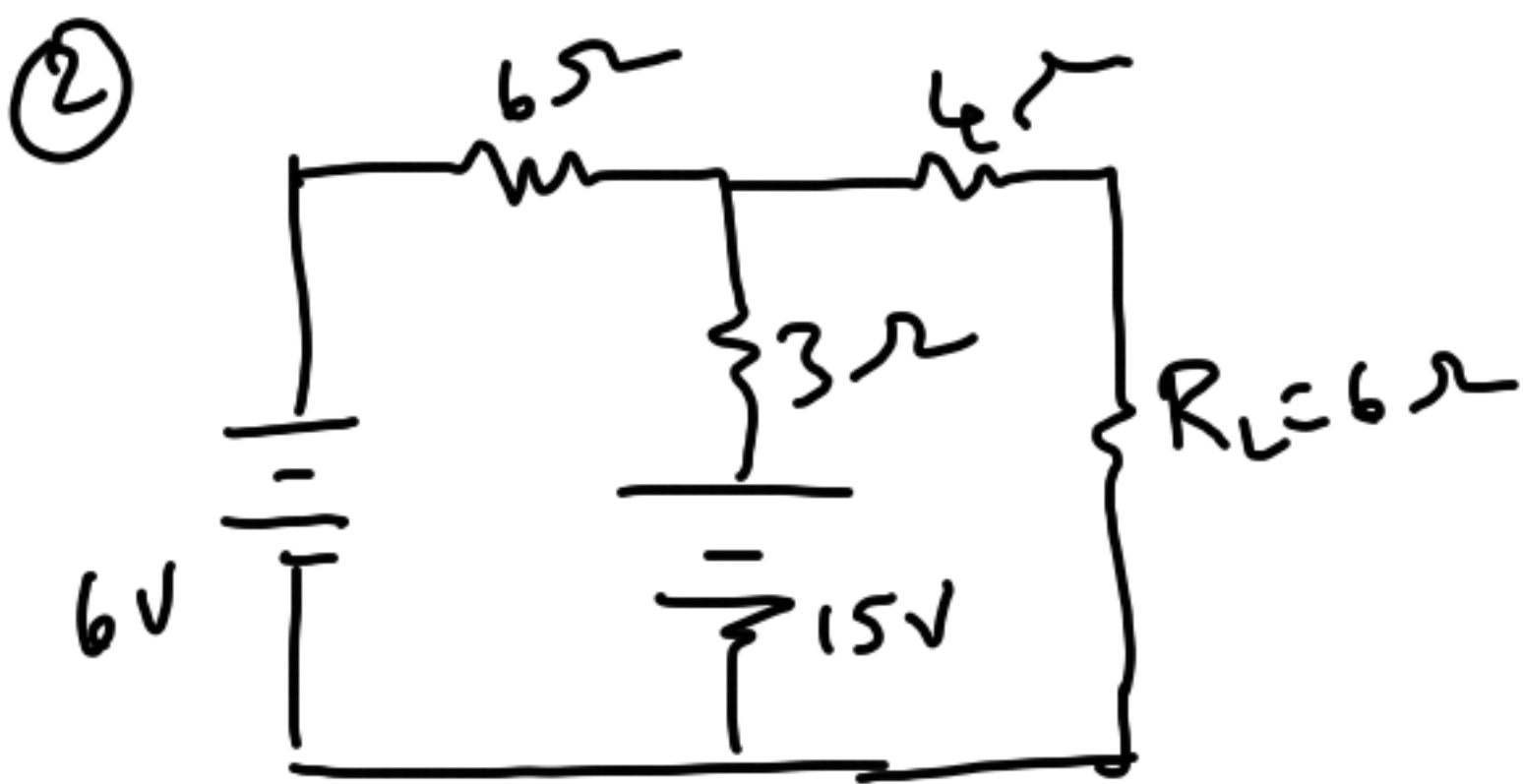
1.2 Ω is series with 11Ω .

$$R_{th} = 1.2 + 11 \Omega = \underline{12.2 \Omega}$$

Thevenin's eq. ckt.

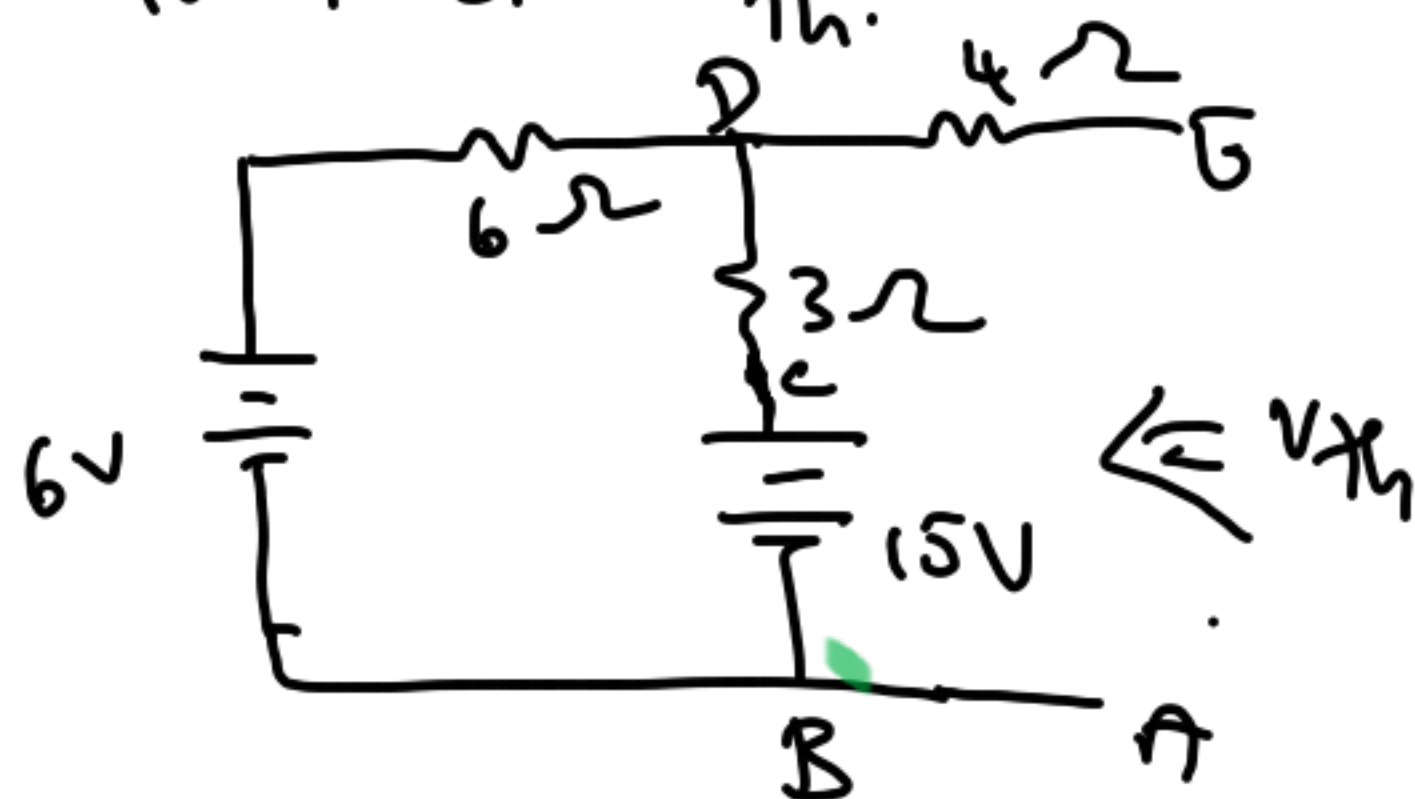


$$I_L = \frac{V_{th}}{R_{th} + R_L} = \frac{6}{12.2 + 5} = \frac{6}{17.2} = 0.35A$$



Soln

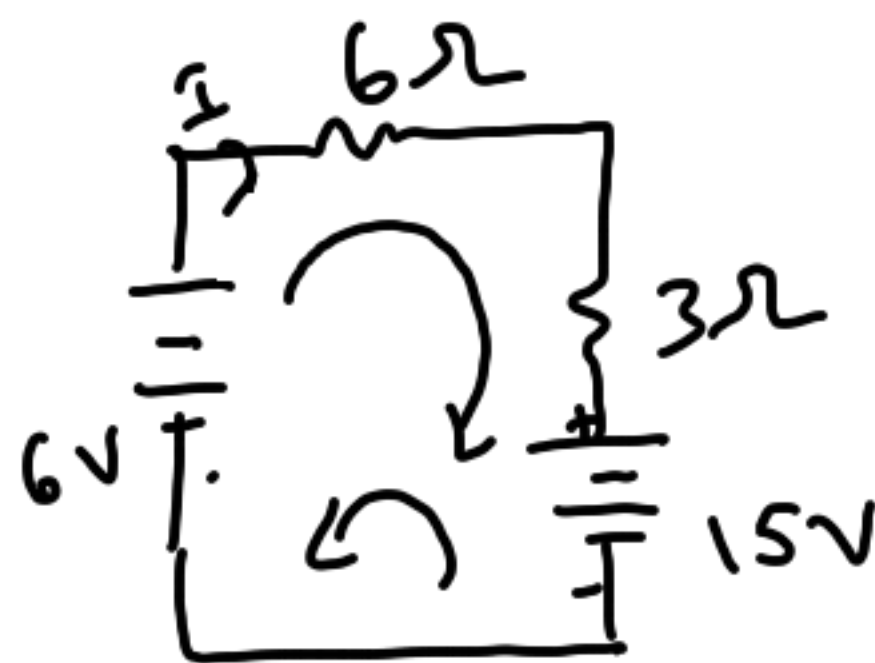
To find V_{th} .



$$V_{th} = V_{AB} + V_{BC} + V_{CD} + V_{DE}$$

$$= 0 + V_{BC} + V_{CD} + 0$$

$$V_{th} = V_{BC} + V_{CD}$$



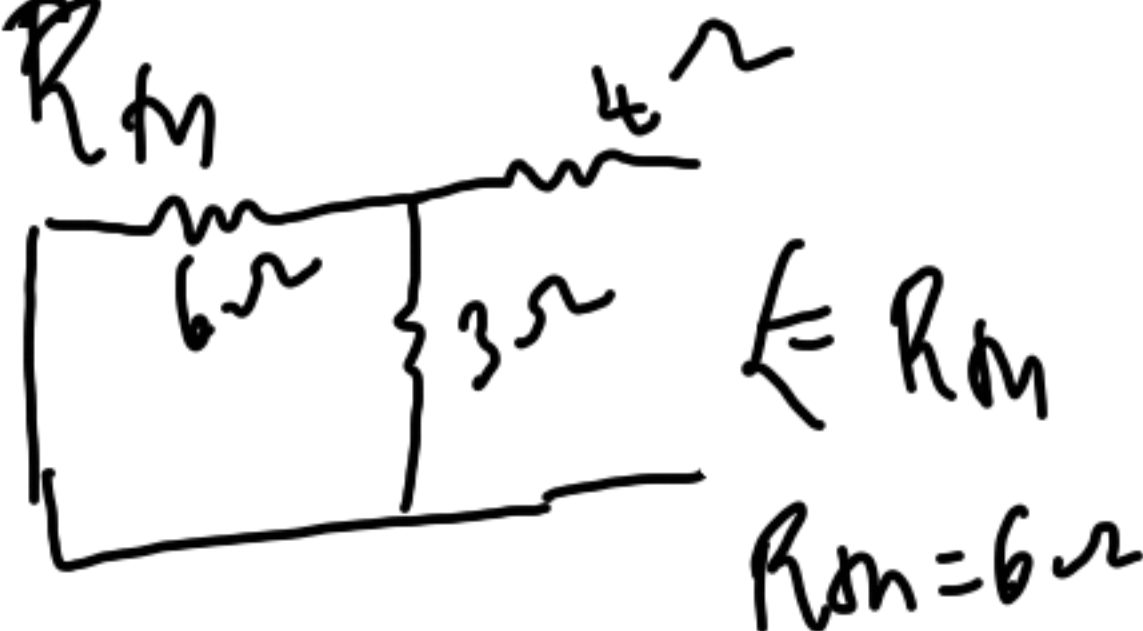
$$I = \frac{V}{R} = \frac{6 - 15}{6 + 3}$$

$$I = \frac{-9}{9} = -1$$

$$V_{CD} = -1 \times 3 = -3V$$

$$V_{th} = 15 - 3 = \underline{\underline{12V}}$$

To find R_{th}



$$I_L = \frac{V_{th}}{R_{th} + R_L}$$

$$= \frac{12}{6 + 6}$$

$$I_L = 1A$$

Norton's Theorem



Soln

To find I_{sc}



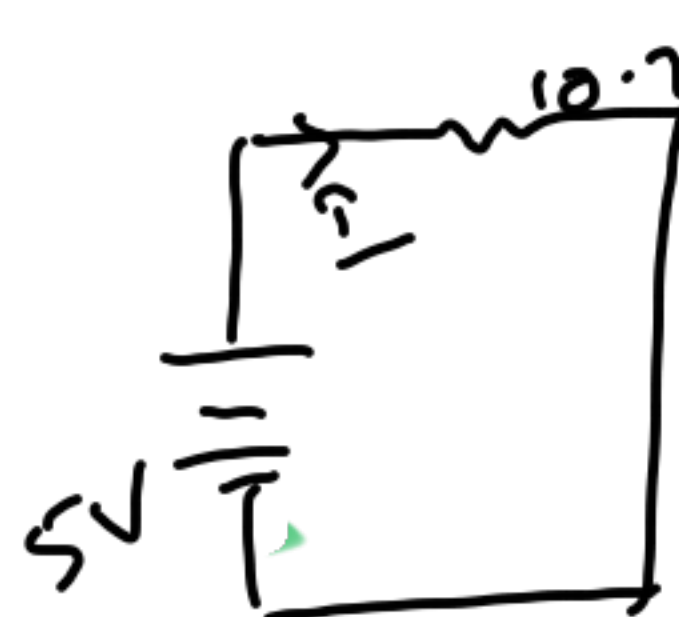
$$10\Omega \parallel 6\Omega$$

$$\frac{1}{R_{eq}} = \frac{1}{10} + \frac{1}{6} = 0.1 + 0.167 = 0.267$$

$$R_{eq} = \frac{1}{0.267} = 3.75\Omega$$

$$R_T = 7 + 3.75$$

$$= 10.75\Omega$$

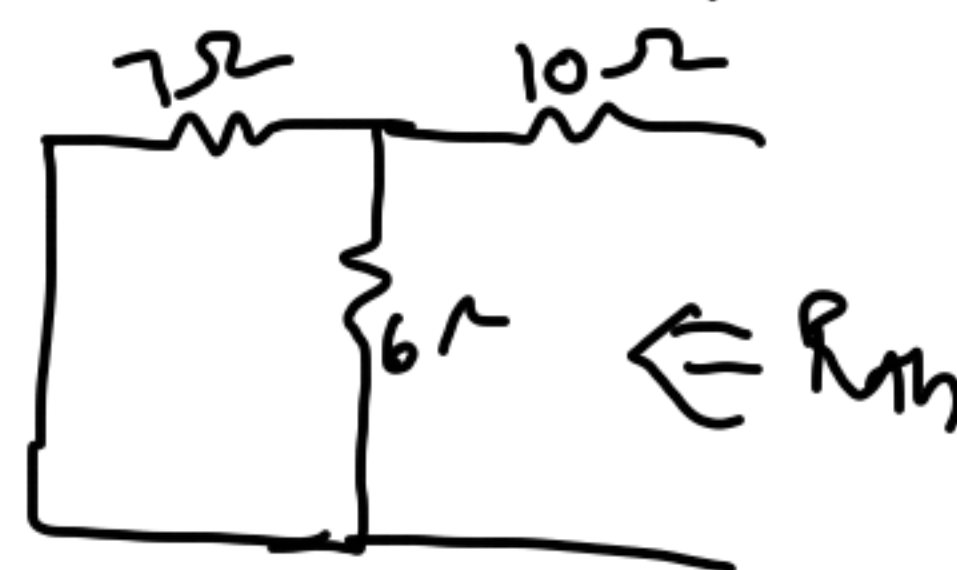


$$I = \frac{V}{R} = \frac{5}{10.75} = 0.465$$

$$I_{sc} = \frac{I \times 6}{6 + 10}$$

$$I_{sc} = \frac{0.465 \times 6}{16} = 0.17A$$

To find R_{th}

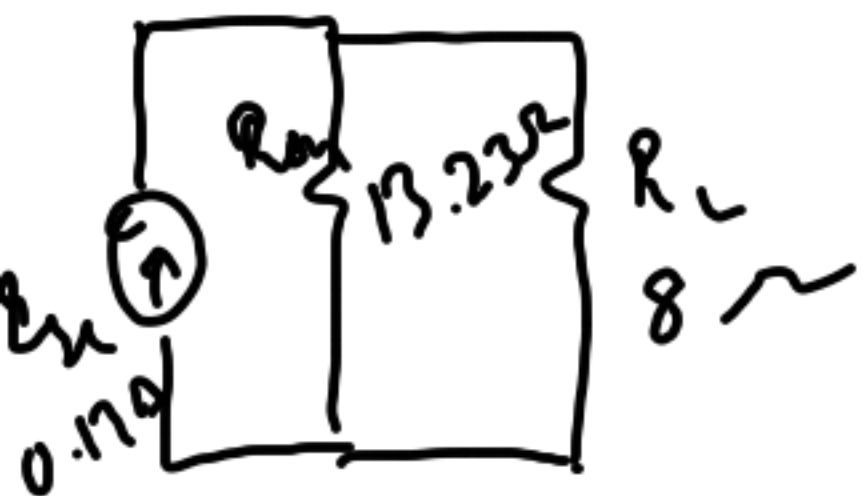


$$7\Omega \parallel 16\Omega = \frac{1}{R_{eq}} = \frac{1}{7} + \frac{1}{6} = 0.3096$$

$$R_{T1} = \frac{1}{0.3096} = 3.23\Omega$$

3.23Ω is series with 10Ω

$$R_{th} = 3.23 + 10 = 13.23\Omega$$

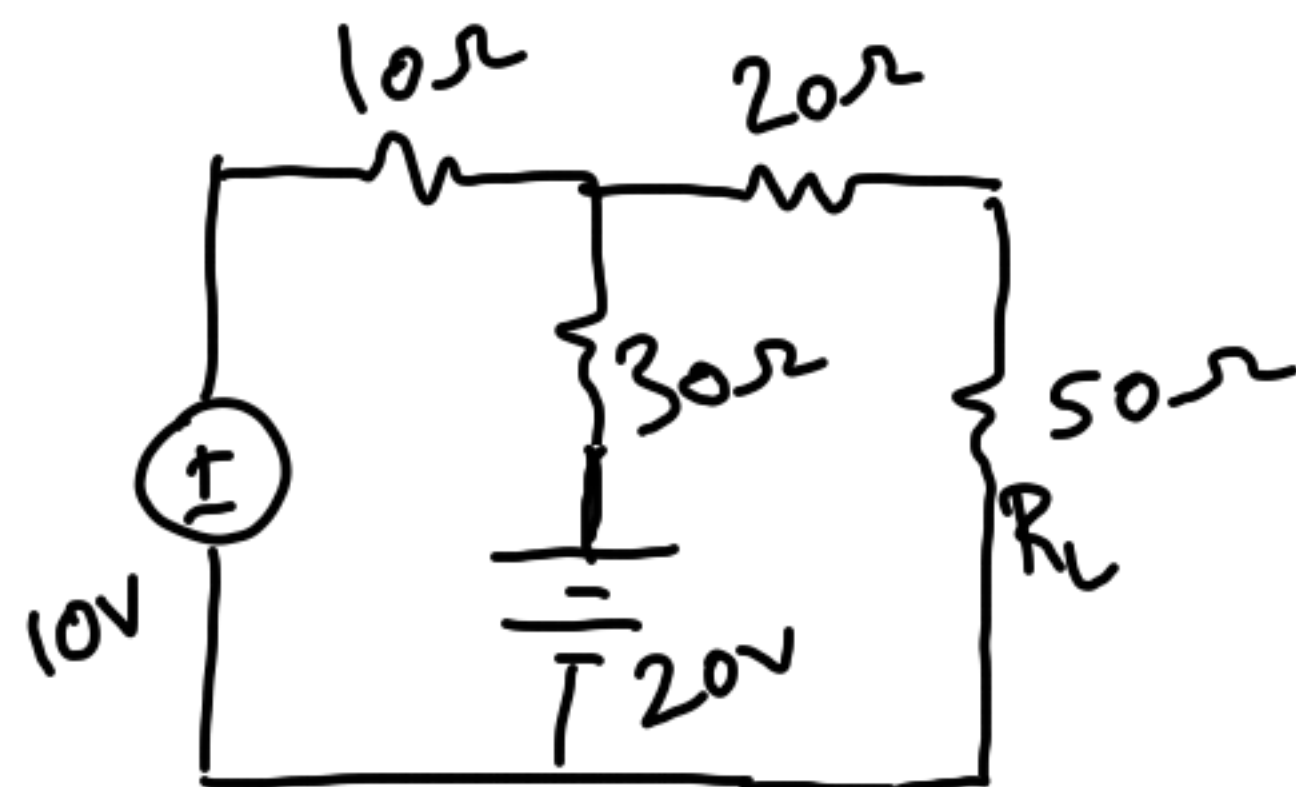


$$I_L = \frac{I_{sc} \times R_{th}}{R_{th} + R_L}$$

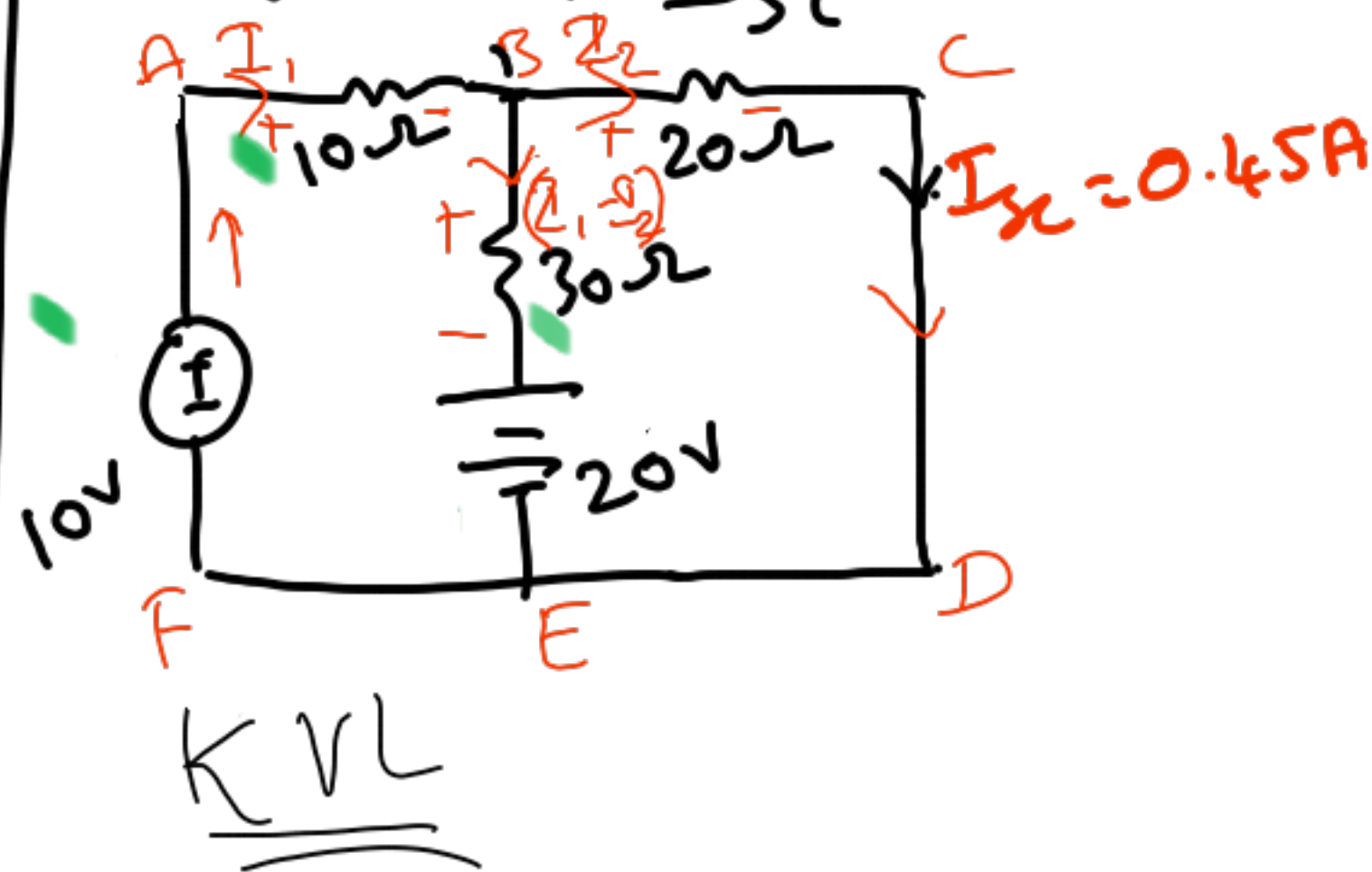
$$= \frac{0.17 \times 13.23}{13.23 + 8}$$

$$I_L = 0.1059$$

$$I_L = 0.11 \text{ A}$$



Soln
To find I_{sc}



KVL

Apply KVL in ABFEA

$$-10I_1 - 30(I_1 - I_2) - 20 + 10 = 0$$

$$-10I_1 - 30I_1 + 30I_2 - 10 = 0$$

$$-40I_1 + 30I_2 = 10$$

$\div$ by 10

$$-4I_1 + 3I_2 = 1 \quad \text{--- (1)}$$

Apply KVL in BCDEB

$$-20I_2 + 20 + 30(I_1 - I_2) = 0$$

$$-20I_2 + 30I_1 - 30I_2 = -20$$

$$30I_1 - 50I_2 = -20$$

$\div$ by 10

$$3I_1 - 5I_2 = -2 \quad \text{--- (2)}$$

Simplify eq ① & ②

$$-4\hat{I}_1 + 3\hat{I}_2 = 1$$

$$3\hat{I}_1 - 5\hat{I}_2 = -2$$

$$\textcircled{1} \times 3 \Rightarrow -12\hat{I}_1 + 9\hat{I}_2 = 3 \quad (+)$$

$$\textcircled{2} \times 4 \quad 12\hat{I}_1 - 20\hat{I}_2 = -8$$

$$-11\hat{I}_2 = -5$$

$$\hat{I}_2 = \frac{5}{11}$$

$$\hat{I}_2 = 0.45 \text{ A}$$

To find R_{th}



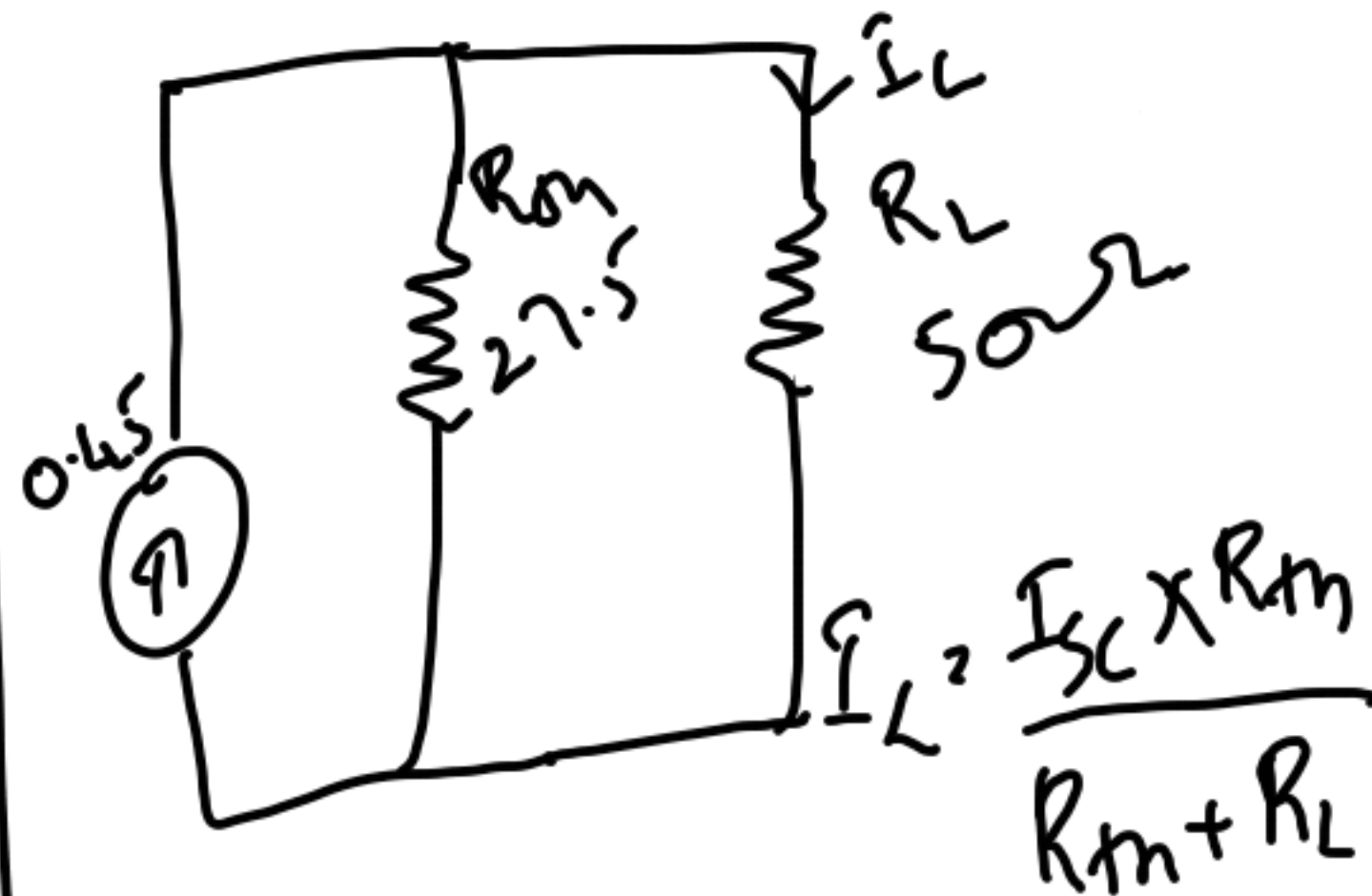
$$10\Omega || 30\Omega = \frac{1}{R_{T1}} = \frac{1}{10} + \frac{1}{30}$$

$$\frac{1}{R_{T1}} = 0.1 + 0.033$$

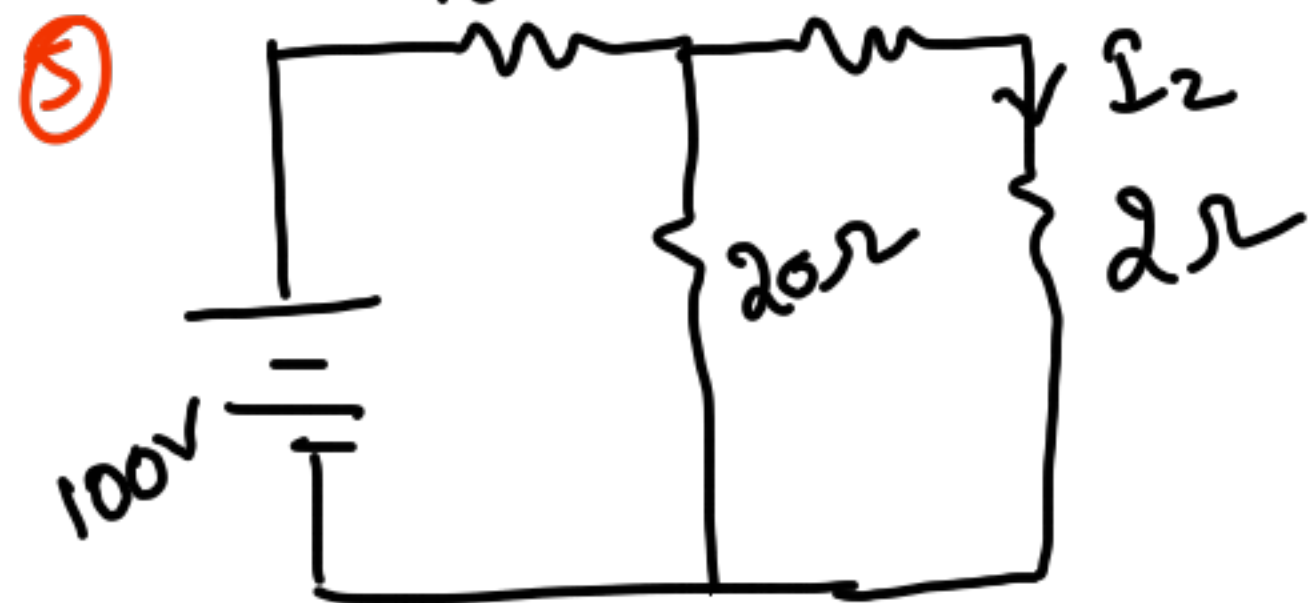
$$= 0.133$$

$$R_{T1} = \frac{1}{0.133} = 7.5\Omega$$

$$R_{th} = 20 \cdot 7.5 = 27.5\Omega$$



=

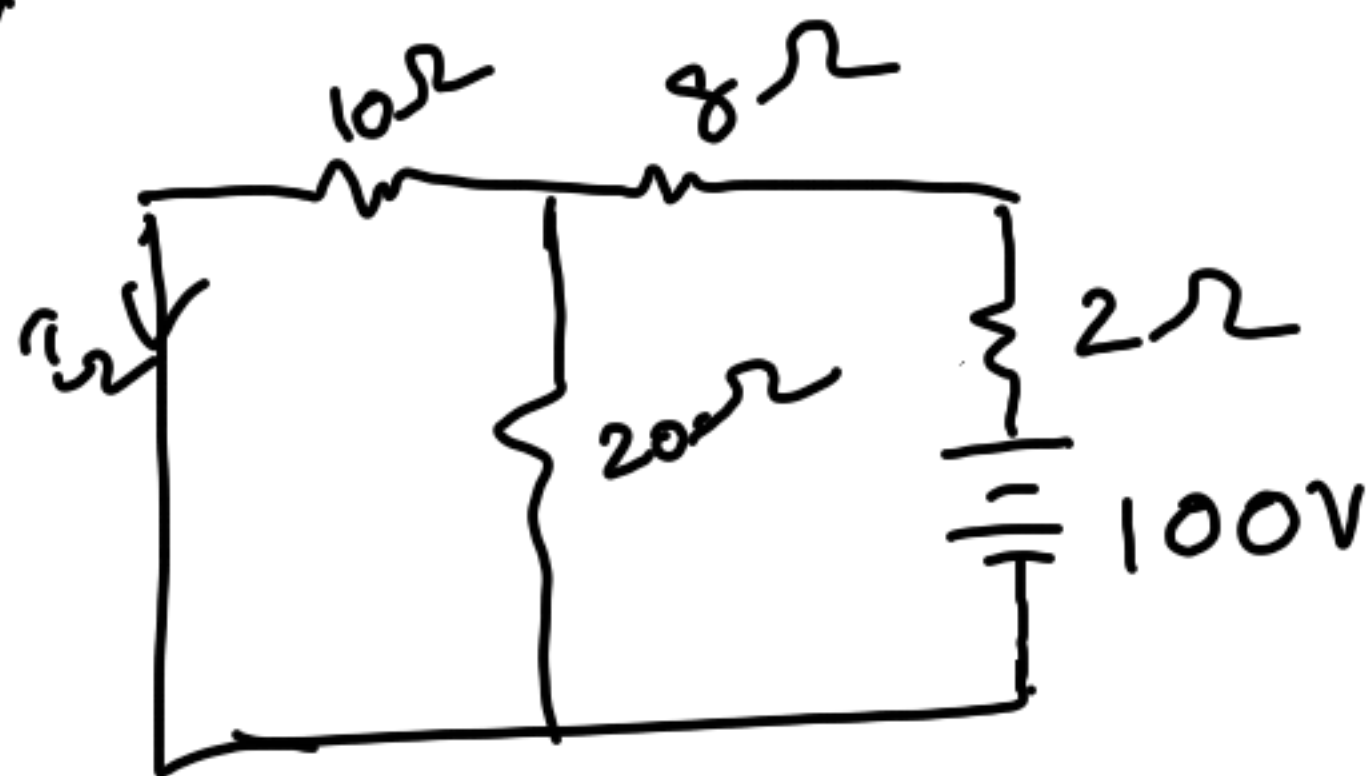


Soln.

$$R_{\text{Total}} = 16.67 \Omega$$

$$\text{Total current} = 6 \text{ A}$$

$$I_2 = 4 \text{ A}$$



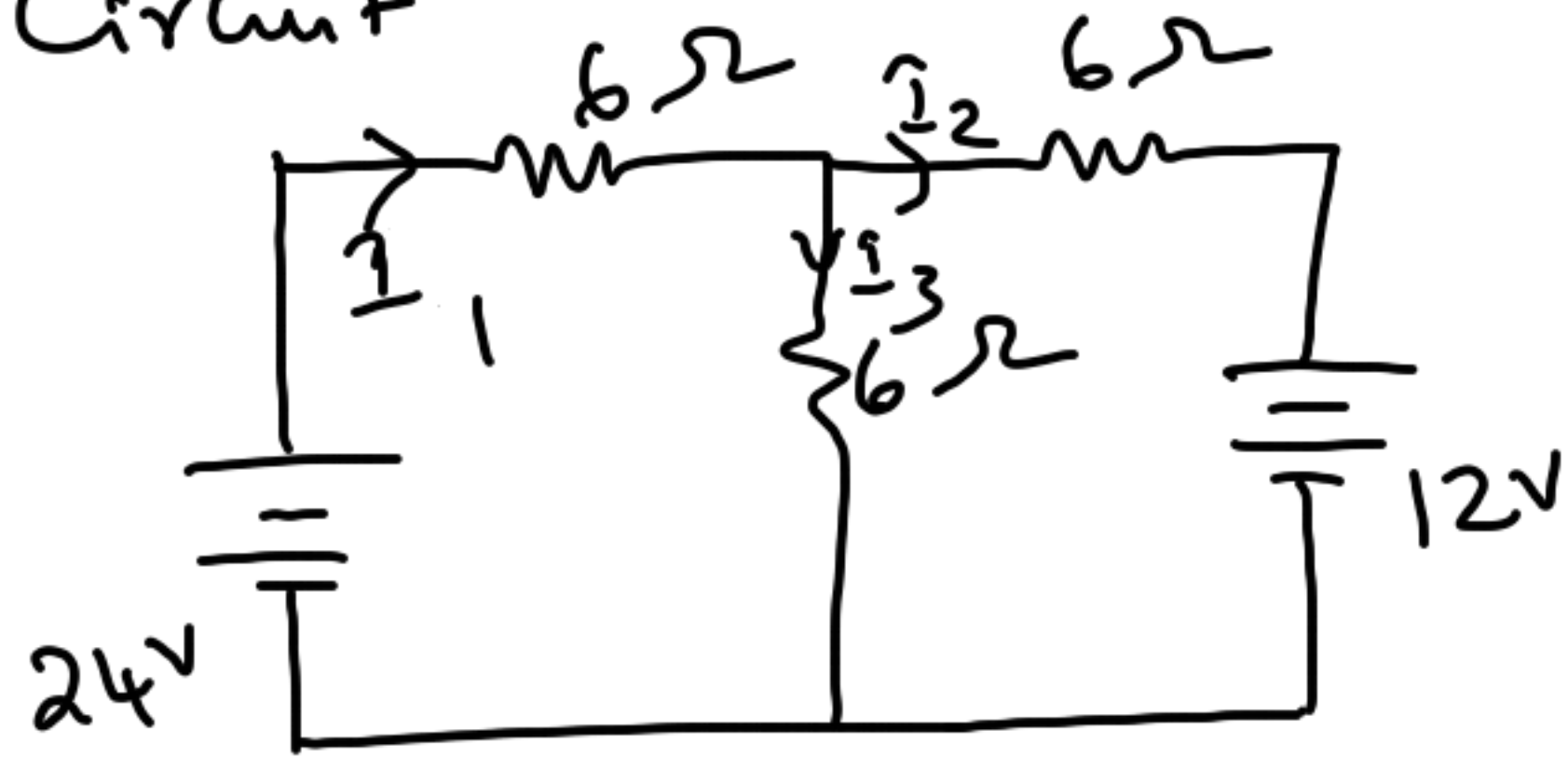
$$R_{\text{Total}} = 16.67 \Omega$$

$$\text{Total current} = 6 \text{ A}$$

$$I_2 = 4 \text{ A}$$

Verify Superposition for the following

Circuit

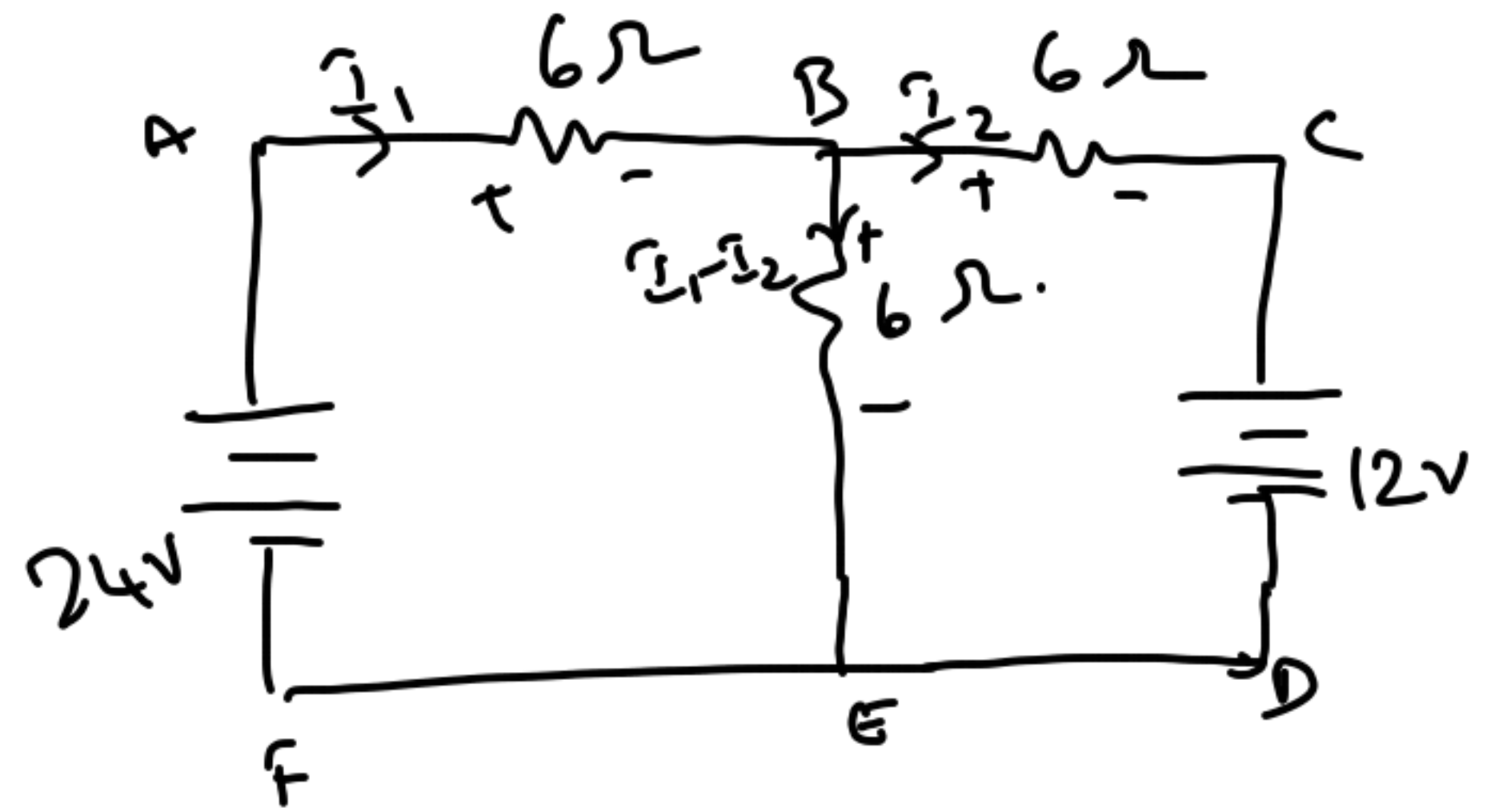


Soln

$$\begin{aligned} I_1 &= 1.33 \\ I_2 &= -1.33 \\ I_3 &= 2.66 \end{aligned}$$

$$\begin{aligned} \underline{I}_{\text{-ckt}} \\ I_1 &= 2.66 \\ I_2 &= 1.33 \\ I_3 &= 1.33 \end{aligned}$$

$$\begin{aligned} \underline{I}_{\text{-ckt}} \\ I_1 &= 1.33 \\ I_2 &= 1.33 \\ I_3 &= 2.66 \end{aligned}$$



Apply KVL in ABEFA

$$-6I_1 - 6(I_1 - I_2) + 24 = 0$$

$$-6I_1 - 6I_1 + 6I_2 = -24$$

$$-12I_1 + 6I_2 = -24$$

div by 6

$$-2I_1 + I_2 = -4 \quad \text{--- (1)}$$

Apply KVL at BCDEB

$$-6I_2 - 12 + 6(I_1 - I_2) = 0$$

$$-6I_2 + 6I_1 - 6I_2 = 12$$

$$+6I_1 - 12I_2 = 12$$

$$\div \text{by } 6$$

$$I_1 - 2I_2 = 2 \quad \text{--- (2)}$$

Solve eq (1) & (2)

$$\text{Eq (1)} \Rightarrow -2I_1 + I_2 = -4$$

$$\text{Eq (2)} \Rightarrow I_1 - 2I_2 = 2$$

$$\text{Eq (1)} \Rightarrow -2I_1 + I_2 = -4 \quad \text{--- (1)}$$

$$\text{Eq (2)} \times 2 \Rightarrow 2I_1 - 4I_2 = 4$$

$$\text{(A B)} \Rightarrow -3I_2 = -0$$

$$I_2 = 0 \text{ A}$$

Sub I_2 in eq (1).

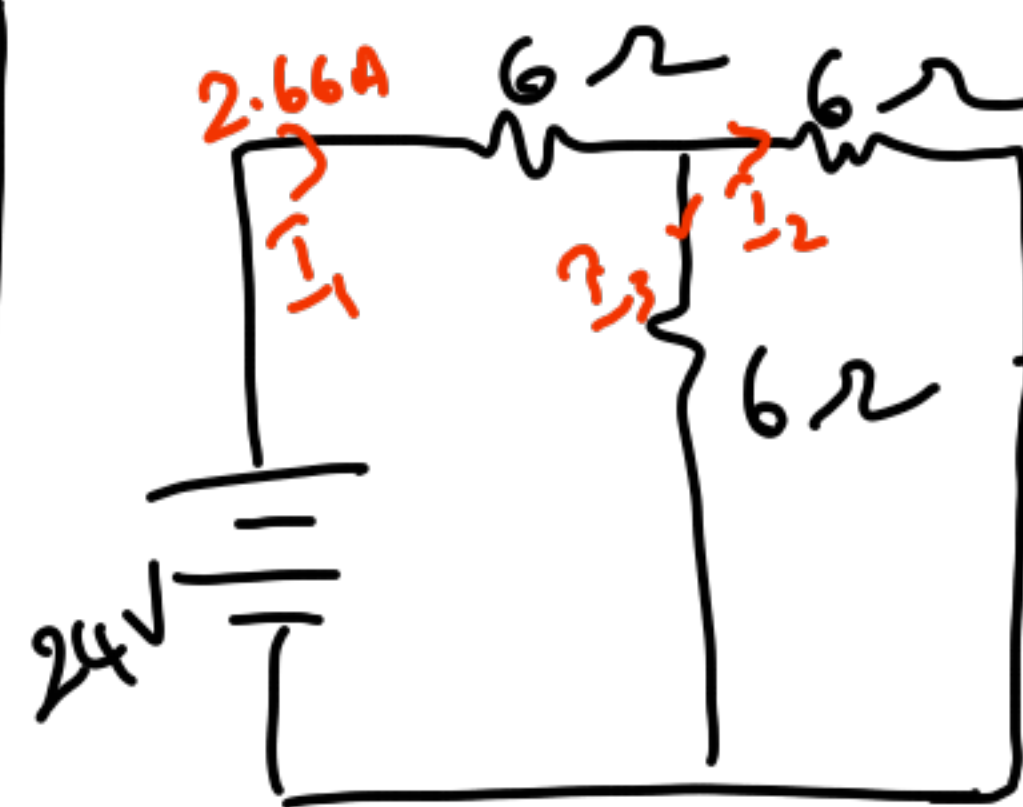
$$\text{(1)} \Rightarrow -2I_1 + 0 = -4$$

$$-2I_1 = -4$$

$$\text{(B)} \Rightarrow I_1 = 2 \text{ A}$$

$$(I_1 - I_2) = 2 - 0$$

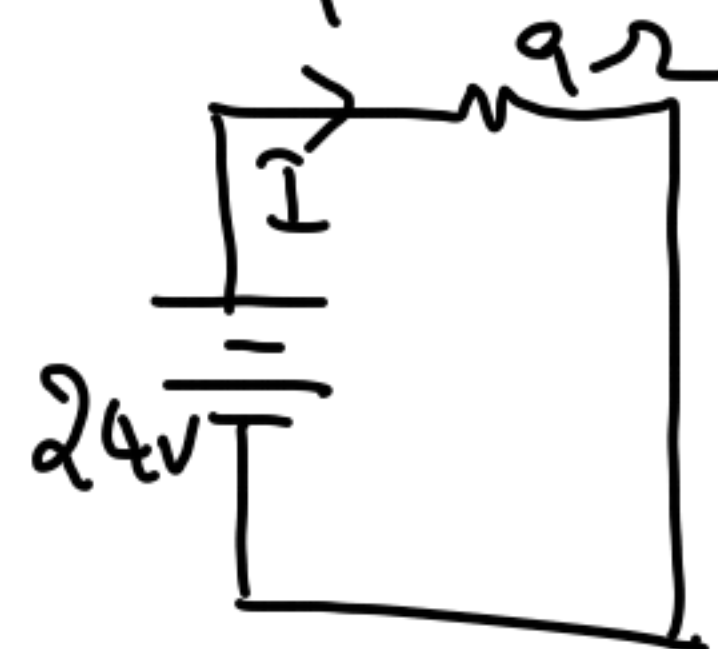
$$\text{(B E)} \Rightarrow = 2 \text{ A}$$



Soln

$$6 \parallel 6 \Rightarrow 3 \Omega$$

$$R_T = 3 + 6 = 9 \Omega$$

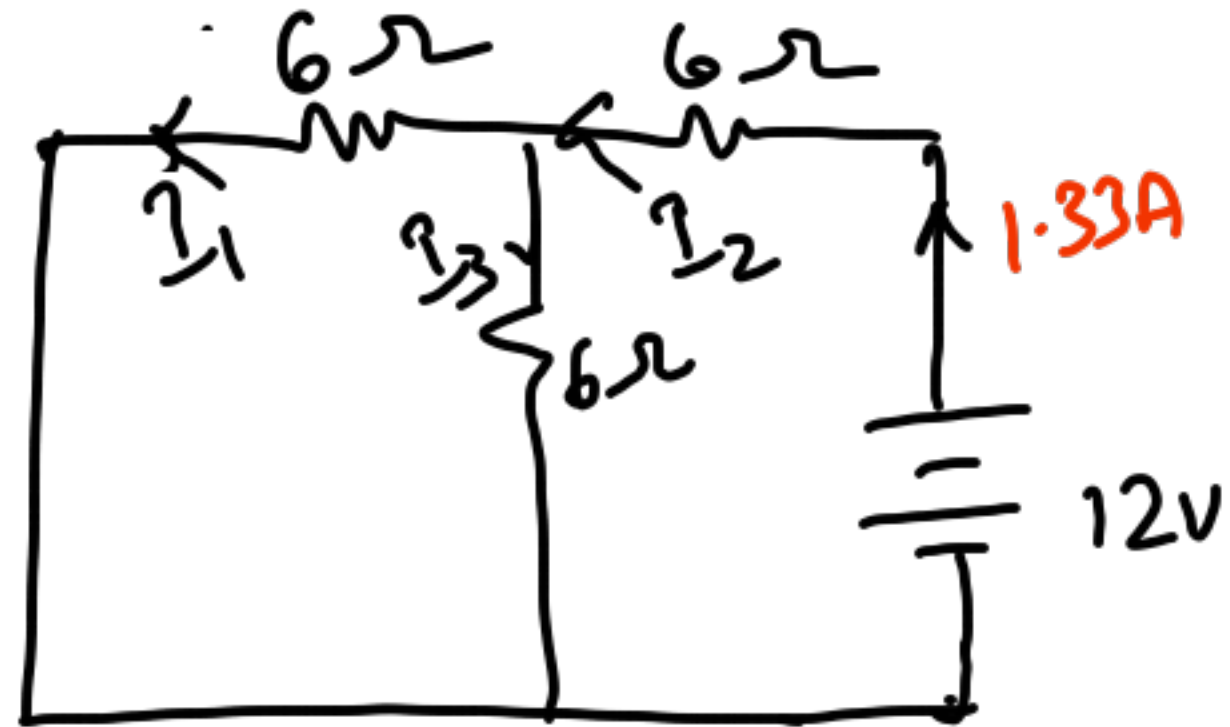


$$I = \frac{V}{R} = \frac{24}{9}$$

$$I_1 = 2.66 \text{ A}$$

$$I_2 = \frac{2.66 \times 6}{12} = 1.33 \text{ A}$$

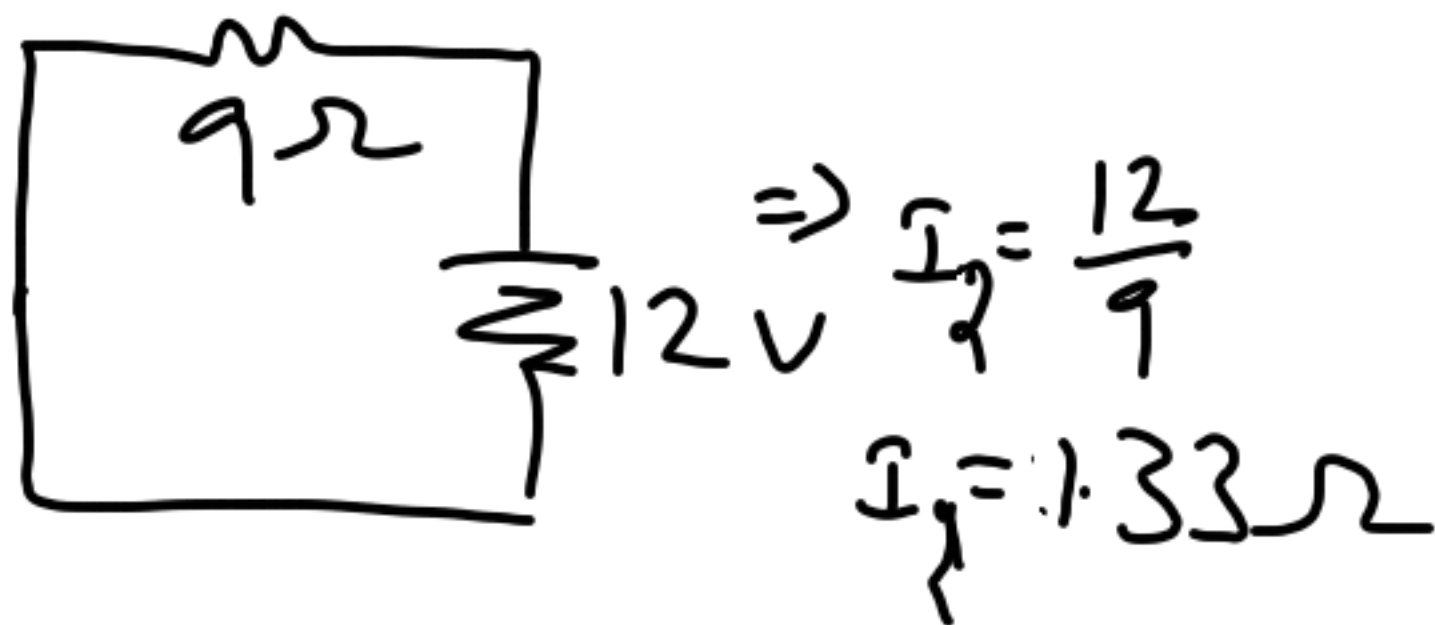
$$I_3 = 1.33 \text{ A}$$



Soln.

$$6 \parallel 6 \Rightarrow 3\Omega$$

$$R_T = 6 + 3 = 9\Omega$$



$$I_1 = \frac{1.33 \times 6}{12} = 0.66A$$

$$I_3 = 0.66A$$

①

$$I_1 = 2A$$

$$I_2 = 0A$$

$$(I_1 - I_2) I_3 = 2A$$

② $I_{a1} = 2.66A$

$I_{a2} = 1.33A$

$I_{a3} = 1.33A$

③

$I_{b1} = 0.66A$

$I_{b2} = 1.33$

$I_{b3} = 0.66$

$$I_1 = I_{a1} + I_{b1} \\ = 2.66 + (-0.66)$$

$$I_2 = I_{a2} + I_{b2} \\ = 1.33 + (-1.33)$$

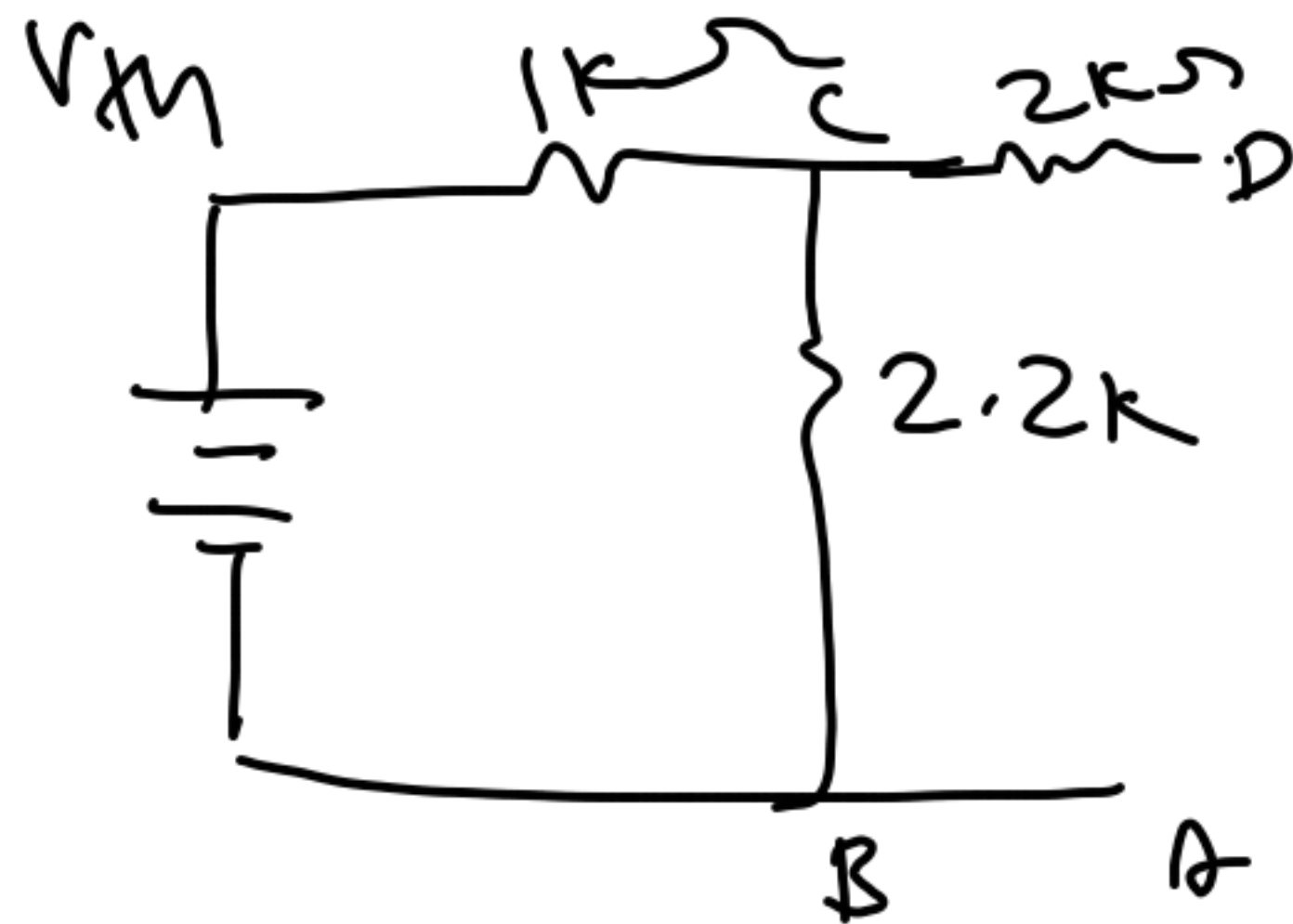
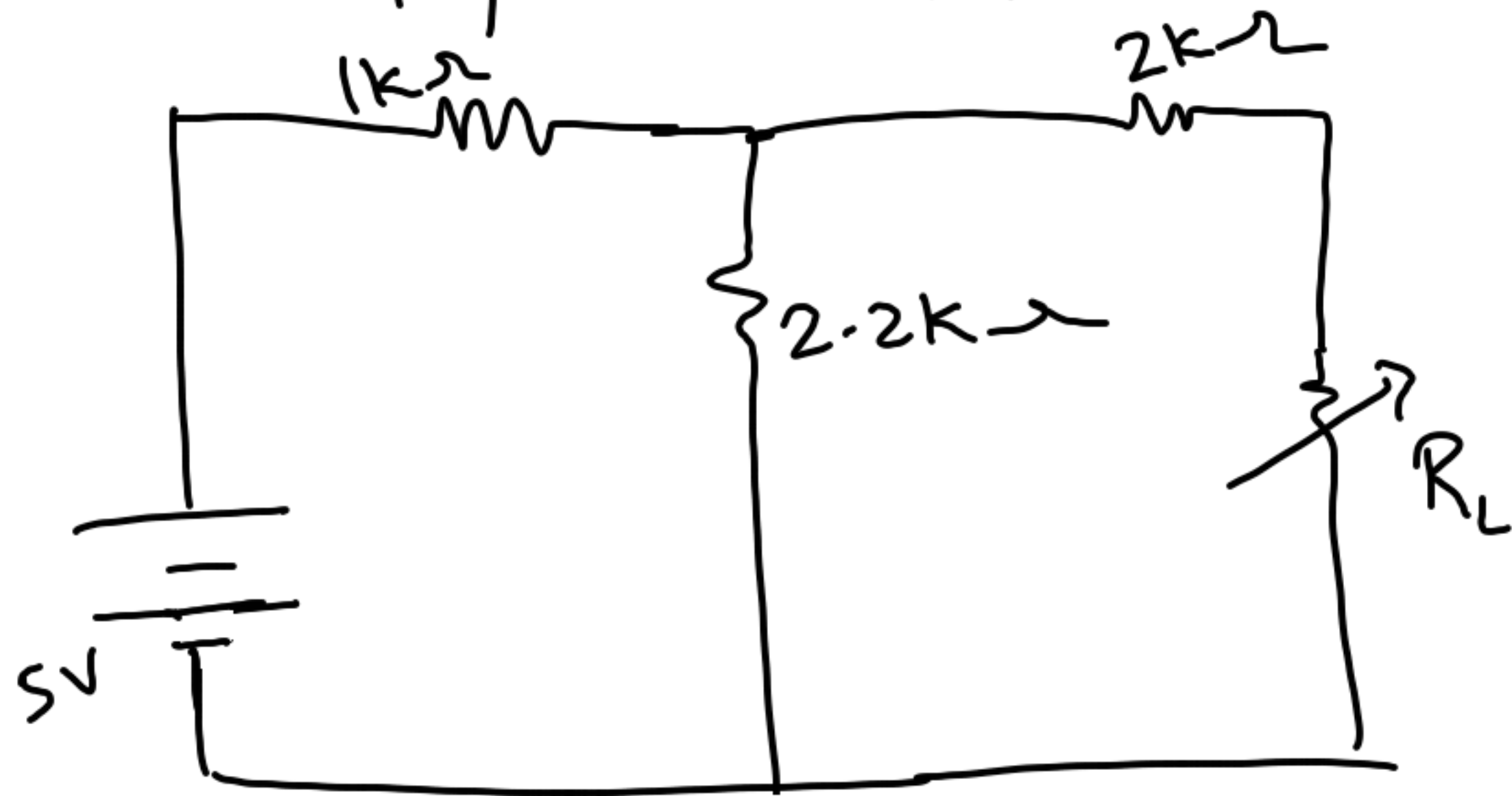
$$I_2 = 0A$$

$$I_3 = I_{a3} + I_{b3} \\ = 1.33 + 0.66$$

$$I_3 = 2A$$

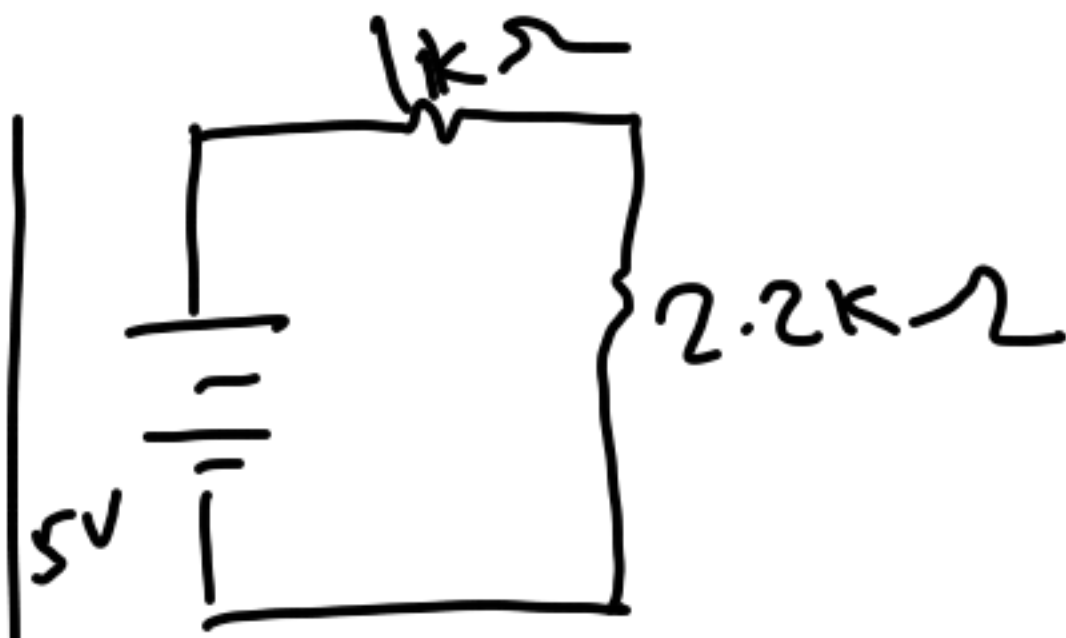
Verified

Maximum Power Transfer.



$$V_{th} = V_{AB} + V_{BC} + V_{CD}$$

$$V_{th} = V_{BC} =$$



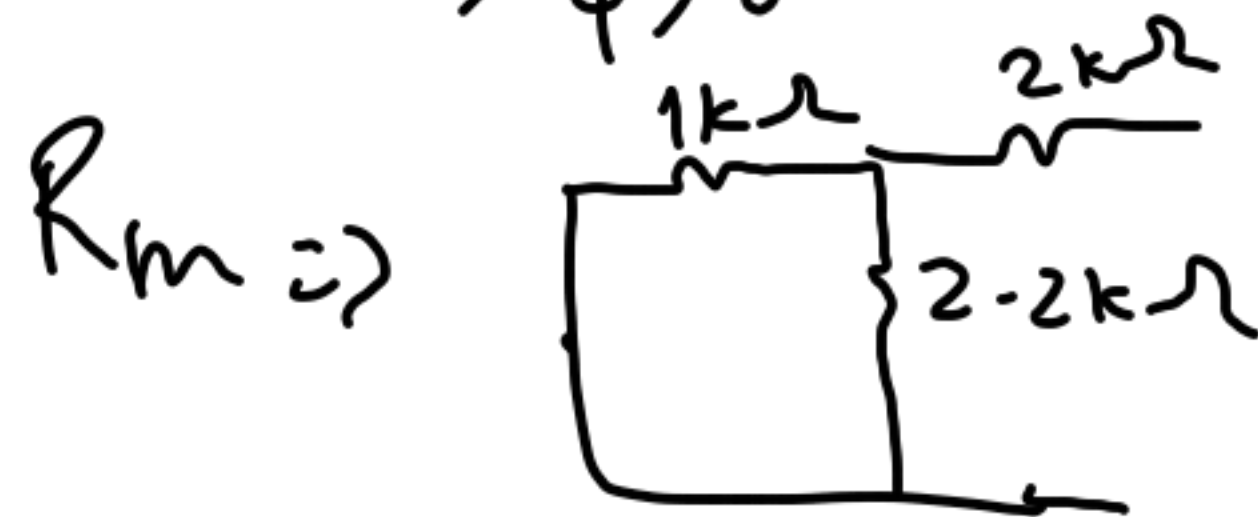
$$I = \frac{V}{R} = \frac{5}{1k + 2.2k}$$

$$I = 1.563 \text{ mA}$$

$$V_{2.2k} = 2.2k \times 1.563 \text{ m}$$

$$V_{2.2k} = 3.4386 \text{ V}$$

$$V_{th} = 3.4386 \text{ V}$$



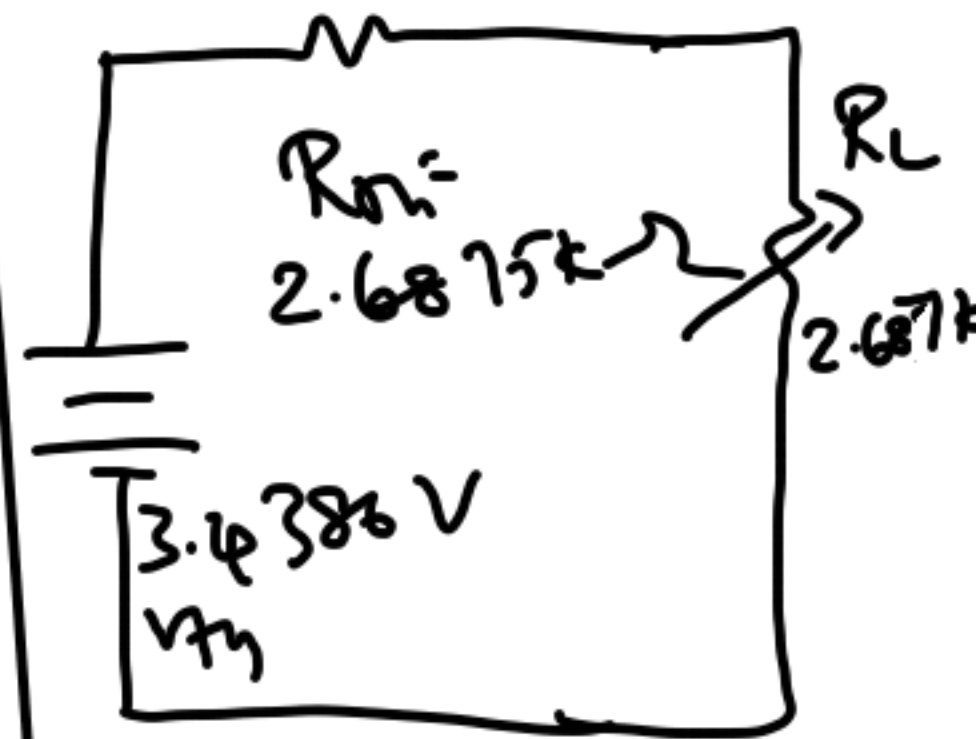
$R_{th} \Rightarrow$

$$1k \parallel 2.2k$$

$$R_{Th} = 0.6875k\Omega$$

$$R_{Th} = 0.6875k + 2k$$

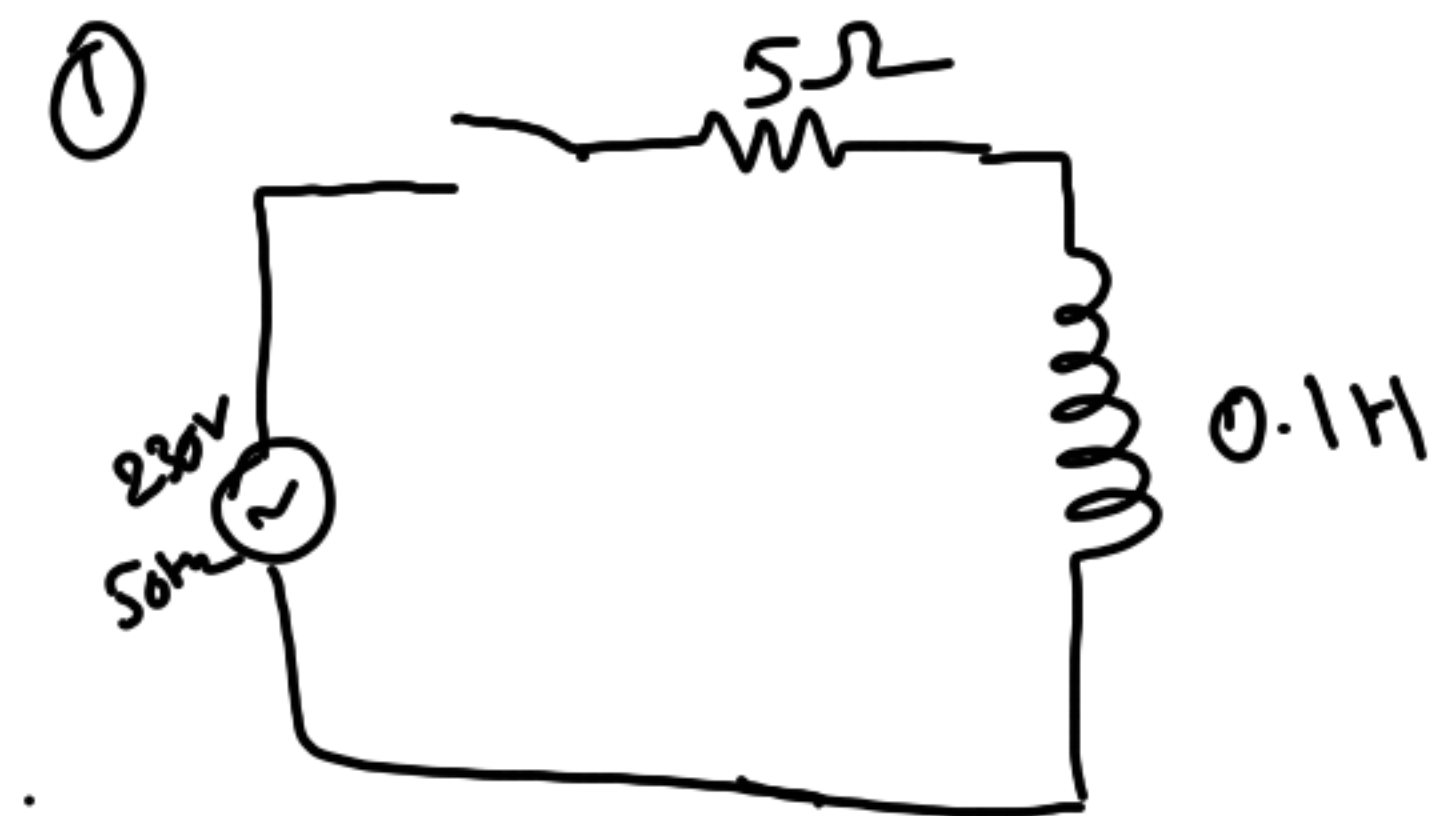
$$R_{Th} = \underline{\underline{2.6875k\Omega}}$$



$$I_L = \frac{3.4386}{2.6875k + 2.6875k}$$

$$I_L = 0.6395 \text{ mA}$$

$$P = I_L^2 R_L$$



$Gm.$
 $R = 5\Omega$
 $L = 0.1H$
 $V = 230V$

Calculate Rate of Rise of current when $t = 0$

$$i = \frac{V}{R} (1 - e^{-Rt/L})$$

$$i = \frac{230}{5} (1 - e^{-5t/0.1})$$

$$i = 46(1 - e^{-50t})$$

$$i = 46 - 46e^{-50t}$$

Diff w.r.t. 't'

$$\frac{di}{dt} = 0 - 46e^{-50t}(-50)$$

$$\frac{di}{dt} = +2300e^{-50t}$$

$$\frac{di}{dt} = 2300e^{-50 \times 0}$$

$$= 2300e^0$$

$$\frac{di}{dt} = 2300 \times 1$$

$$\frac{di}{dt} = 2300 \text{ A/s}$$

when $t = 2\tau$

$$\frac{di}{dt} = 2300e^{-50 \times 2\tau}$$

$$= 2300e^{-50 \times 2 \times \frac{L}{R}}$$

$$= 2300e^{-100 \times \frac{0.1}{5}}$$

$$= 2300e^{-2}$$

$$\frac{di}{dt} = 311.27 \text{ A/s}$$

At $t=0$. Rate of change of Current is 2300 A/s

At $t=2\tau$, Rate of change of Current is 311.27 A/s

Steady State Current

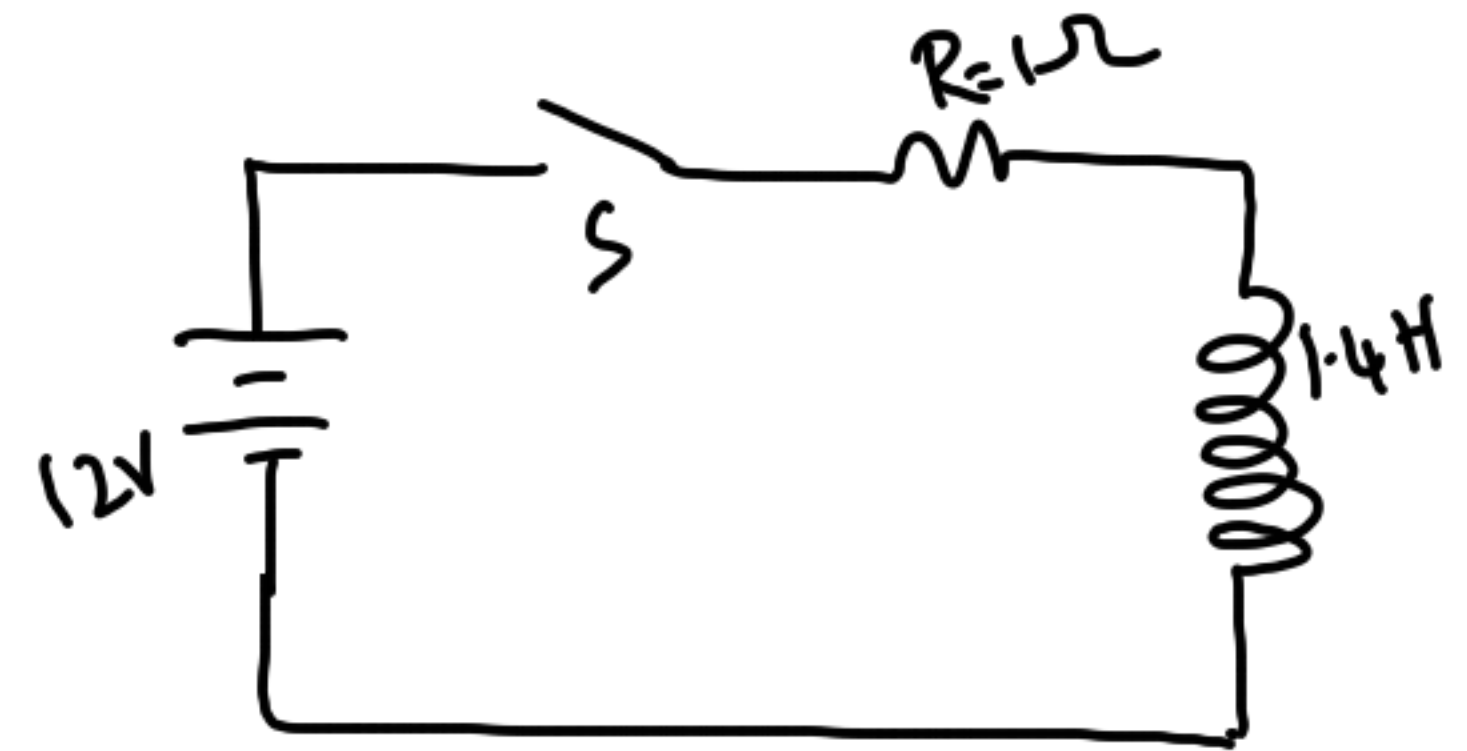
$$I_0 = \frac{V}{R} = \frac{230}{5} = 46 \text{ A}$$

②

$$L = 1.4 \text{ H}$$

$$R = 1 \Omega$$

$$V = 12 \text{ V}$$



$$i = \frac{V}{R} \left(1 - e^{-\frac{Rt}{L}} \right)$$
$$= \frac{12}{1} \left(1 - e^{-1 \times t / 1.4} \right)$$

When $t = 400 \times 10^{-3} \text{ s}$.

$$\begin{aligned}
 i &= 12 \left(1 - e^{-1 \times 400 \times 10^{-3} / 1.4} \right) \\
 &= 12 \left(1 - e^{-0.286} \right) \\
 &= 12 (1 - 0.751) \\
 &= 12 (0.249)
 \end{aligned}$$

$$i = 3 \text{ A}$$

To find the time taken for the Steady State current to drop half of its value.

$$i = \hat{I}_0 e^{-Rt/L}$$

Drop in Steady State current by half

$$\begin{aligned}
 i &= \frac{\hat{I}_0}{2} e^{-Rt/L} \\
 3 &= \frac{12}{2} e^{-t/1.4} \\
 6 &= \frac{12}{1} e^{-t/1.4} \\
 \frac{6}{12} &= e^{-t/1.4}
 \end{aligned}$$

take log on both side

$$\log(0.5) = \log(e^{-t/1.4})$$

$$\log(0.5) = \frac{-t}{1.4}$$

$$-0.301 = \frac{-t}{1.4}$$

$$0.301 \times 1.4 = t$$

$$t = 0.4214 \text{ s}$$

3) As the Capacitor is Charging

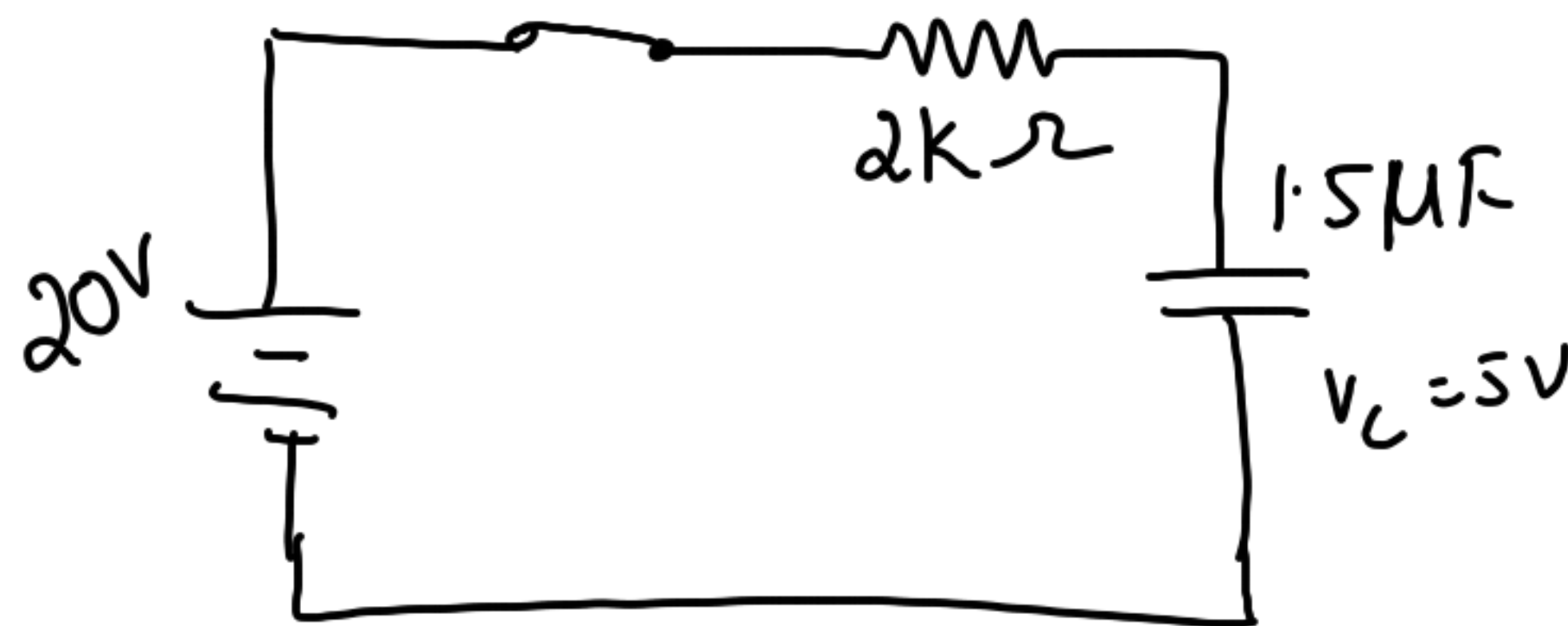
$$V_C = V(1 - e^{-t/\tau})$$

$$\text{Given, } V_C = 5 \text{ V}$$

$$V = 20 \text{ V}$$

$$R = 2 \text{ k}\Omega$$

$$C = 1.5 \mu\text{F}$$



$$5 = 20(1 - e^{-t/\tau})$$

$$5 = 20(1 - e^{-t/RC})$$

$$5 = 20(1 - e^{-t/2 \times 10^3 \times 1.5 \times 10^{-6}})$$

$$\frac{5}{20} = 1 - e^{(-t/3 \times 10^{-3})}$$

$$\frac{1}{4} = 1 - e^{-t/3 \times 10^{-3}}$$

$$e^{-t/3 \times 10^{-3}} = 1 - 0.25$$

$$e^{-t/3 \times 10^{-3}} = 0.75$$

Taking log on both sides

$$i^6) \frac{-t}{3 \times 10^{-3}} = \log(0.75)$$

$$\frac{+t}{3 \times 10^{-3}} = +0.12$$

$$t = 0.12 \times 3 \times 10^{-3}$$

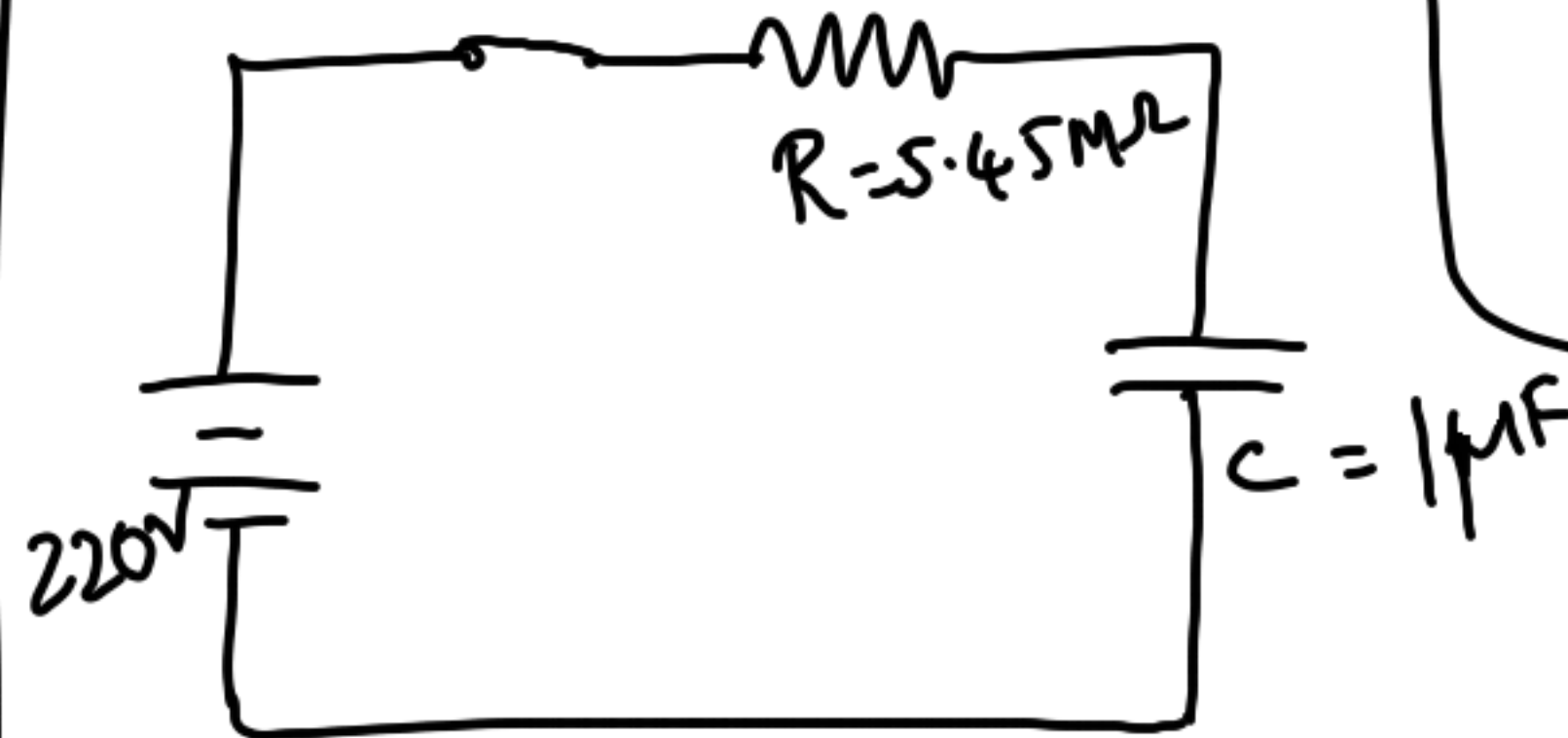
$$t = 0.375 \text{ ms}$$

Ans.

$$C = 1 \mu\text{F}$$

$$R = 5.45 \text{ M}\Omega$$

$$V = 220 \text{ V}$$



As the capacitor is charging

$$V_C = V(1 - e^{-t/RC})$$

$$V_C = 220(1 - e^{-t/5.45 \times 10^6 \times 1 \times 10^{-6}})$$

$$V_C = 220(1 - e^{-t/5.45})$$

V_C is 60% of supply voltage.

$$\frac{220}{100} \times 60 = 220(1 - e^{-t/5.45})$$

$$\frac{22 \times 6}{220} = 1 - e^{-t/5.45}$$

$$0.66 = 1 - e^{-t/5.45}$$

$$e^{-t/5.45} = 1 - 0.66$$

$$e^{-t/5.45} = 0.34$$

Taking log on both sides

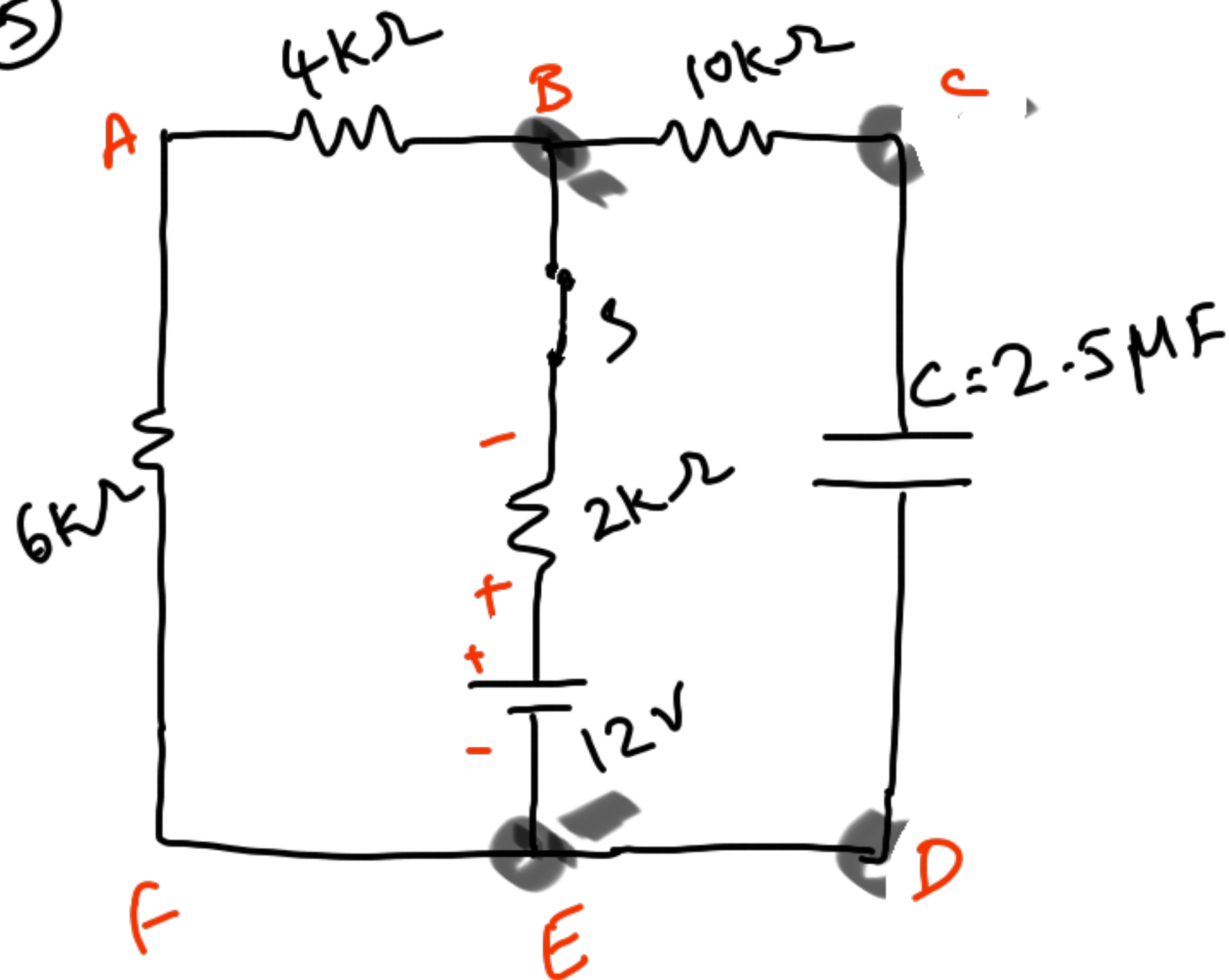
$$\frac{-t}{5.45} = \log(0.34)$$

$$\frac{-t}{5.45} = -0.468$$

$$t = 0.468 \times 5.45$$

$$t = 2.55 \text{ Sec}$$

⑤

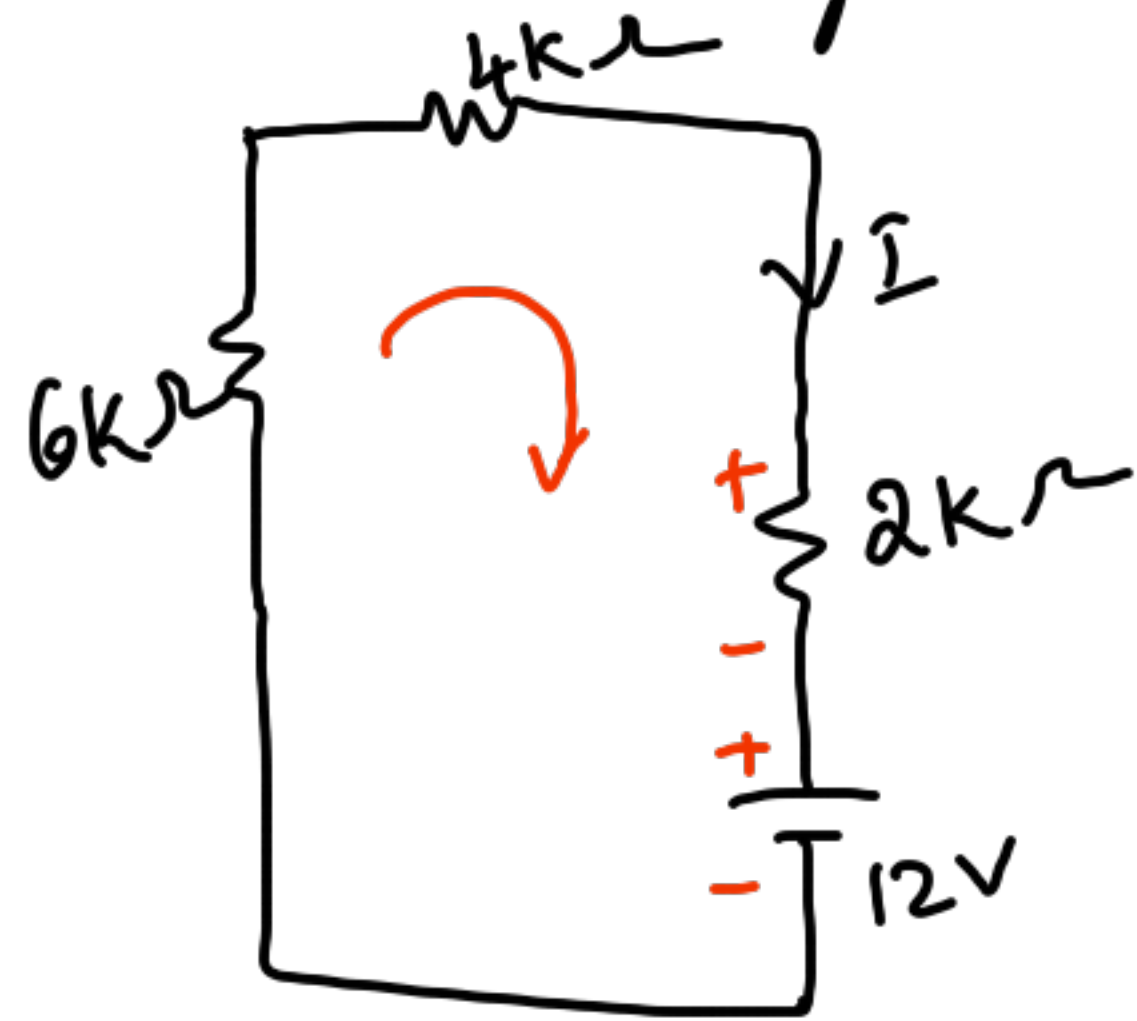


Soln

When the capacitor is fully charged, the capacitor does not allow current to flow through it.

The voltage across capacitor is equal to voltage across **EB**

To find Voltage across E_B



$$I = \frac{V}{R} = \frac{12}{6k + 4k + 2k}$$

$$= \frac{12}{12k}$$

$$= \frac{1}{10^3} = 1 \times 10^{-3}$$

$$I = 1mA$$

Voltage across $2k\Omega$.

$$V_{2k} = I \times R$$

$$= 1 \times 10^{-3} \times 2 \times 10^3$$

$$V_{2k} = 2V$$

Voltage across E_B

$$V_{EB} = 12 - V_{2k}$$

$$= 12 - 2$$

$$V_{EB} = 10V$$

$$V_C = 10V$$

Capacitor discharging after $t = 0.05 \text{ sec}$



$$V_C' = V e^{-t/RC}$$

$$= 10 \times e^{-t/((6k + 4k + 10k) \times 2.5 \times 10^{-6})}$$

$$= 10 \times e^{-t/(20 \times 10^3 \times 2.5 \times 10^{-6})}$$

$$= 10 \times e^{-0.05/(50 \times 10^{-3})}$$

$$V_C' = 3.67V$$

