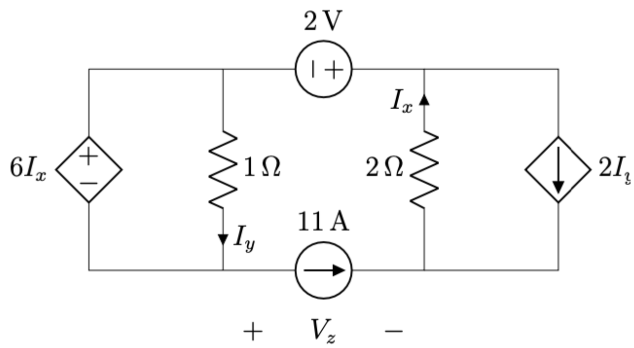
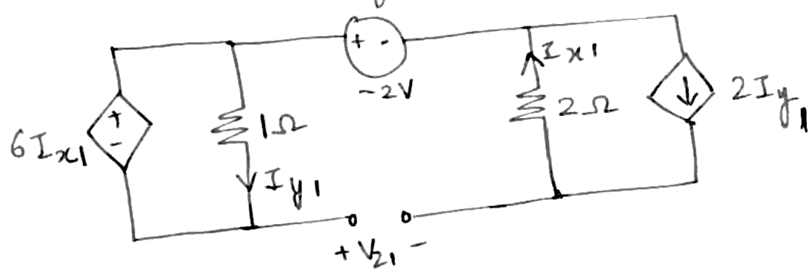
Que 1.

Determine I_x, I_y and V_z using superposition:



Ans 4. (i) Contribution of −2V source:



$$6I_{x1} = 1 \times I_{y1} \quad \text{—(1)}$$

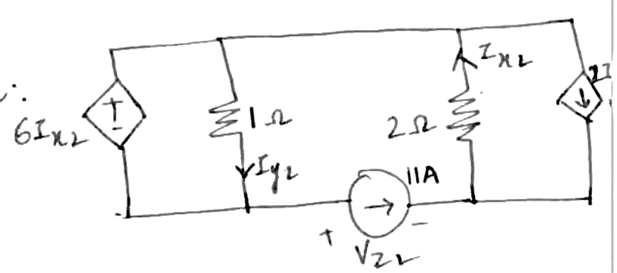
$$2I_{y1} = I_{x1} \quad \text{—(2)}$$

$$\Rightarrow I_{x1} = I_{y1} = 0$$

Also, $-V_{z1} - 1 \times I_{y1} + (-2V) - 2 \times I_{x1} = 0$

$\therefore \quad V_{z1} = -2\text{ V}$

(ii) Contribution of 11A source:



$V_{1\Omega} = 6I_{x2}$

$V_{1\Omega} = 1 \times I_{y2}$

$\Rightarrow 6I_{x2} = I_{y2}$

$11 = I_{x2} - 2I_{y2}$

$\therefore \quad I_{x2} = -1A, \quad I_{y2} = -6A$

Also, $\quad 2I_{x2} + I_{y2} + V_{z2} = 0$

$\Rightarrow V_{z2} = 8V$

$\therefore \; I_x = I_{x1} + I_{x2} = -1A$

$I_y = I_{y1} + I_{y2} = -6A$

$V_z = V_{z1} + V_{z2} = 6V$

Que 2

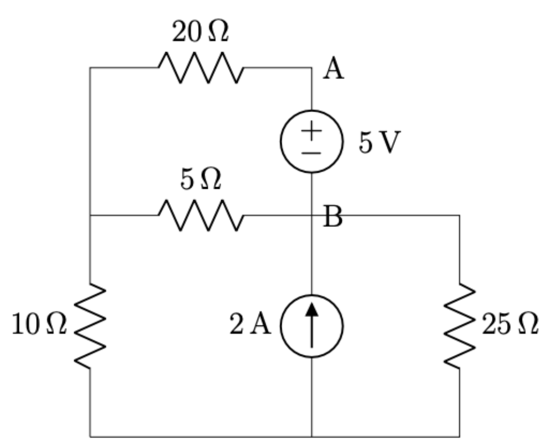
Determine the power supplied by the 5V source using

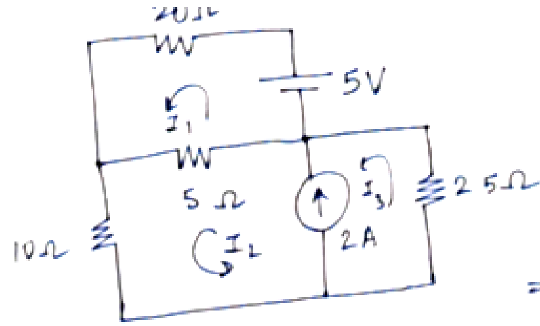
(a) Mesh analysis

(b) Nodal analysis

(c) Superposition principle

(d) Thevenin's equivalent circuit between terminals A and B.





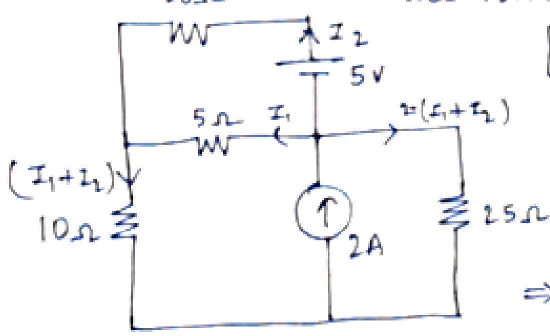
$$20I_1 + 10I_2 + 25I_3 = 5$$
$$I_2 - I_3 = 2$$
$$\therefore 20I_1 + 10I_2 + 25I_2 = 55$$
$$\Rightarrow 20I_1 + 35I_2 = 55$$
$$\Rightarrow 4I_1 + 7I_2 = 11 \quad \text{——} (1)$$

$$20I_1 + 5(I_1 - I_2) = 5$$
$$\Rightarrow 25I_1 - \frac{5}{7}(11 - 4I_1) = 5$$
$$\Rightarrow 25I_1 - \frac{55}{7} + \frac{20}{7}I_1 = 5$$
$$\Rightarrow I_1 = \frac{\left(5 + \frac{55}{7}\right)}{\left(25 + \frac{20}{7}\right)} = 0.46A$$

$$\therefore P_{5V} = -0.46 \times 5 \text{ W} = -2.31\text{W}$$

Shows that power is supplied by the source

(b)



$$[10(I_1 + I_2) + 20I_2] - [25(2 - I_1 - I_2)] = 5$$
$$\Rightarrow 10I_1 + 30I_2 - 50 + 25I_1 + 25I_2 = 5$$
$$\Rightarrow 11I_2 + 7I_1 = 11 \quad \text{——} (1)$$

$$10(I_1 + I_2) + 5I_1 = (2 - I_1 - I_2)25$$
$$\Rightarrow 15I_1 + 10I_2 = 50 - 25I_1 - 25I_2$$
$$\Rightarrow 40I_1 + 35I_2 = 50$$
$$\Rightarrow 8I_1 + 7I_2 = 10 \quad \text{——} (2)$$

From (1) and (2),

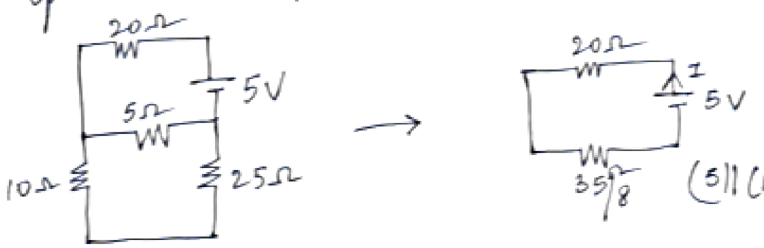
$$11I_2 + \frac{7}{8}(10 - 7I_2) = 11$$

$$\Rightarrow \left(11 - \frac{49}{8}\right) I_2 = 11 - \frac{70}{8}$$

$$\Rightarrow I_2 = 0.46A$$

$$\therefore P_{5V} = -0.46 \times 5W = -2.31W$$

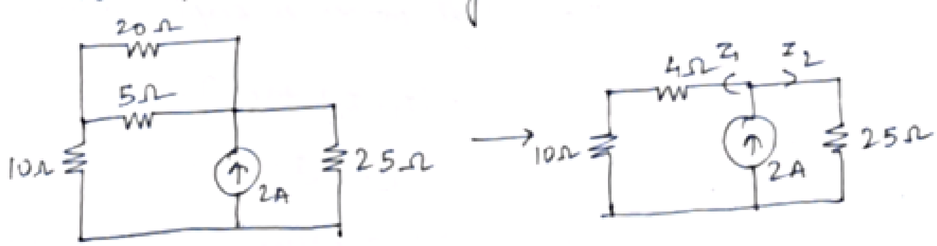
(c) Open circuit current source:



$(5 \| (10+25))$

$$\therefore I = \frac{5}{20 + \frac{35}{8}} A = 0.2A$$

Short circuit voltage source:



$I_2 = 2 - I_1$

$$25(2 - I_1) = I_1(10+4) \Rightarrow I_1 = 1.28A$$

$\cancel{5(1.28)}\ 5i_A = 20(I_1 - i_A)$

$$\Rightarrow i_A(5+20) = 20I_1$$

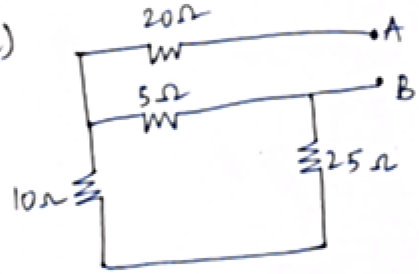
$$\Rightarrow i_A = \frac{4}{5} I_1$$

$$\Rightarrow I_1 - i_A = \frac{I_1}{5} = 0.26A$$

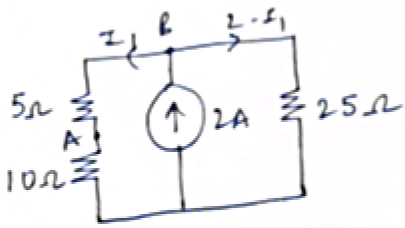
$\therefore I = 0.2A + 0.26A = 0.46A$

$P_{5V} = -0.46A \times 5V = -2.31W$

(d)

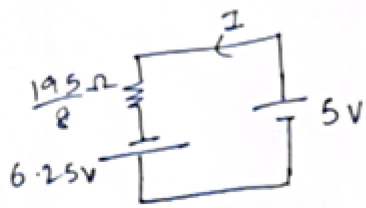


$\rightarrow R_{TH} = 20 + (5 \,||\, (10+25)) = \frac{195}{8}\,\Omega$



$$I_1 = \frac{2 \times 25}{25+10+5}\,A = 1.25\,A$$

$\therefore V_{AB} = -5I_1 = -6.25V = V_{TH}$



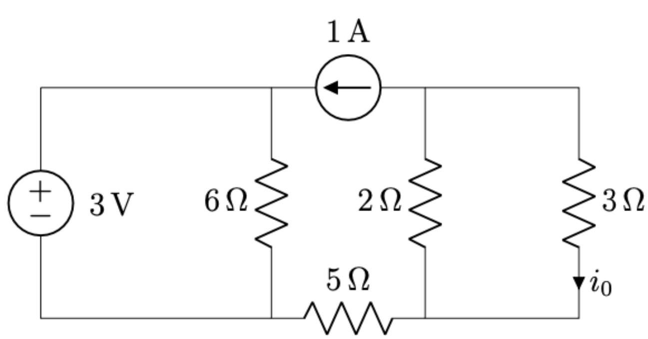
$$(6.25 + 5) = I\left(\frac{195}{8}\right)$$

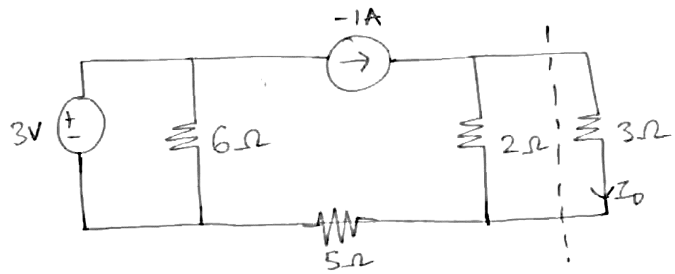
$\Rightarrow I = 0.46\,A$

$\therefore P_{5V} = -0.46 \times 5W = -2.31W$

Que 3

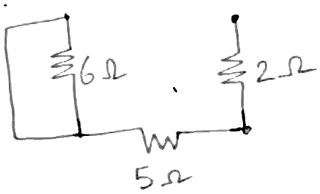
Use Thevenin's theorem to determine i_o.



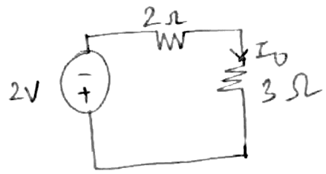


$I_{2\Omega} = -1A \Rightarrow V_{TH} = 2 \times -1V = -2V$

R_{TH}:



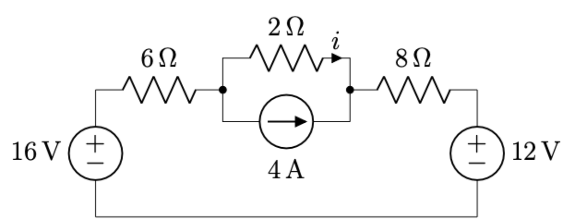
$\Rightarrow R_{TH} = 2\Omega$

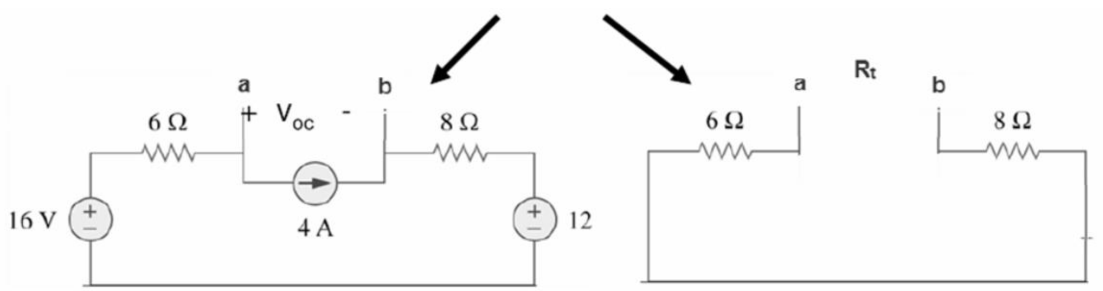


$\therefore I_0 = \frac{-2}{2+3} A = -\frac{2}{5} A$

Que 4

Determine current i through 2Ω resistor by building Thevenin's equivalent for the rest of the circuit.



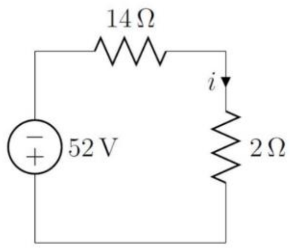


$$-16 + 4 \times 6 + v_{OC} + 4 \times 8 + 12 = 0$$

$$v_{OC} = -52V$$

$$R_t = 14\Omega$$

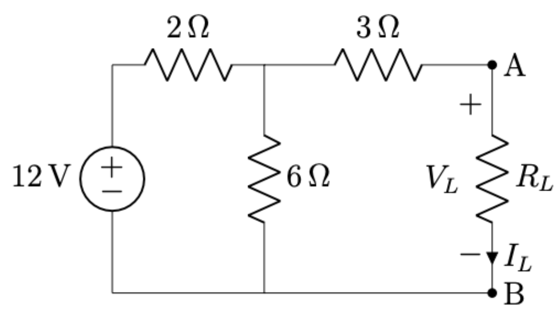
Now, the original circuit can be represented as,



Clearly $i = -3.25A$.

Que 5.

Find Voltage V_L across the load resister R_L, and the current I_L flowing through the load resistor R_L, in the below circuit, by using Norton's Theorem. Where $R_L = 1.5\Omega$.



To compute I_N, we will short circuit terminal AB. Then the current supplied from 12V source is

$$I = \frac{12\text{V}}{2 + 6||3} = 3\text{A}$$

From current division, the current in AB is 2A. Hence, $I_N = 2\text{A}$,

To calculate the R_N, we will short circuit the voltage source. Looking from terminal A-B, the resistance is (2||6 +3)= 4.5 ohm.

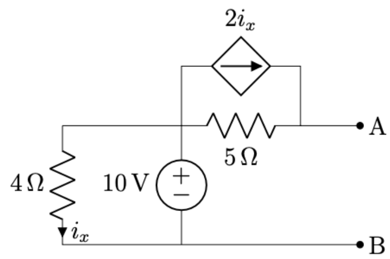
Now, from current division, the current in R_L will be

$$I_l = I_N \frac{4.5}{4.5 + 1.5} = 1.5A$$

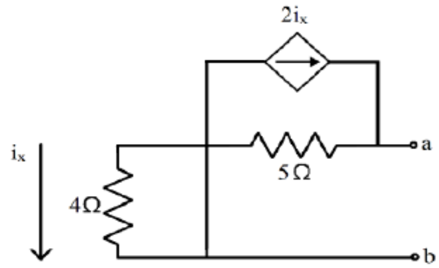
Voltage across R_L is $V_L = I_l R_L = 2.25V$.

Que 6.

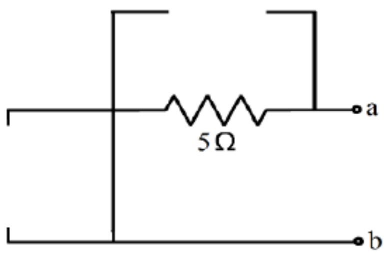
Find the Norton resistance R_N, and the Norton current I_N, at the terminals $A - B$.



Solution: Short the independent voltage source as shown below.

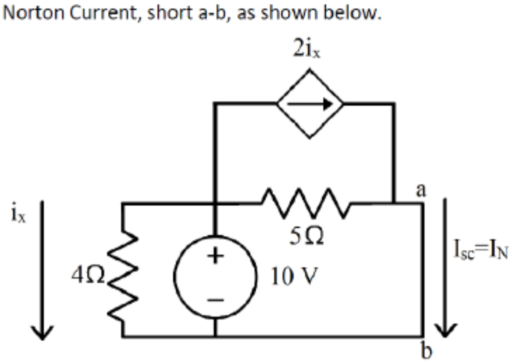


Now, $i_x = 0 \Rightarrow 2i_x = 0$, i.e. the dependent current source is open.



Therefore, $\boldsymbol{R_N = 5\Omega}$

To find the Norton Current, short a-b, as shown below.



All the branches are in parallel. Therefore,

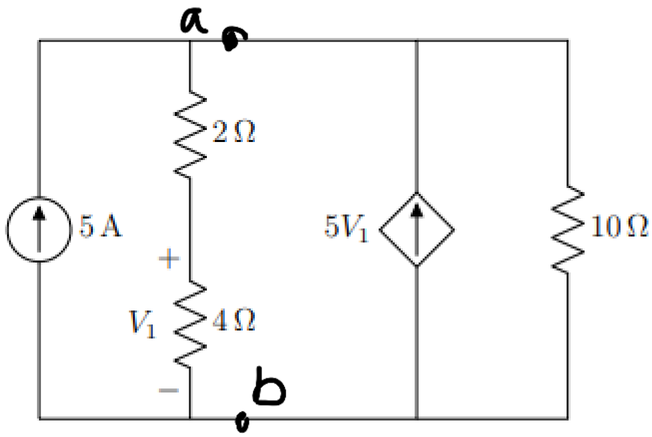
$$i_x = \frac{10}{4} = 2.5A$$

Applying KCL at node a,

$$I_{sc} = I_N = \frac{10}{5} + 2i_x = \boldsymbol{7A}$$

Que 7.

Determine the power dissipated in the 10Ω resistor in the following circuit



tage at node a be V and let b be reference node. Applying KCL at node a,

$$-5 + \frac{V}{6} - 5v_1 + \frac{V}{10} = 0 \quad \text{—— (1)}$$

Also, by voltage division,

$$v_1 = \frac{V \times 4}{2+4} = \frac{4V}{6} = \frac{2V}{3} \quad \text{— (2)}$$

From (1) and (2),

$$-5 + \frac{V}{6} - 5\left(\frac{2V}{3}\right) + \frac{V}{10} = 0$$

$$\Rightarrow \frac{V}{6} - \frac{10V}{3} + \frac{V}{10} = 5$$

$$\Rightarrow \frac{5V - 100V + 3V}{30} = 5$$

$$\Rightarrow -92V = 5 \times 30$$

$$\Rightarrow V = -\frac{5 \times 30}{92} V$$

$$\therefore \text{Power across } 10\Omega = \left(\frac{5 \times 30}{92}\right)^2 \times \frac{1}{10} W$$

$$= \frac{25 \times 900}{920 \times 92} W = 265.83mW$$

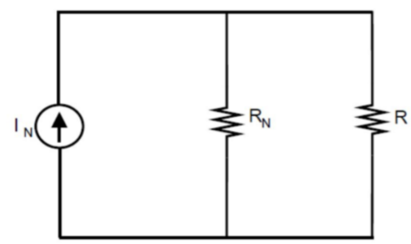
Que 8.

A practical current source provides $10W$ to 250Ω load and, $20W$ to 80Ω load. A resistance R_L with voltage v_L across it, and with current i_L through it, is connected to the source. Find the values of R_L, v_L, and i_L if,

(a) $v_L.i_L$ is maximum.

(b) v_L is maximum.

(c) i_L is maximum.



10 W to 250 Ω corresponds to 200mA. Similarly, 20W to 80 Ω corresponds to 500 mA. By Voltage division, we have

$$I_R = I_N \frac{R_N}{R + R_N}$$

So, we have

$$0.2 = I_N \frac{R_N}{250 + R_N}$$

$$0.5 = I_N \frac{R_N}{80 + R_N}$$

Solving, we get I_N=1.7 A and R_N= 33.33 Ω.

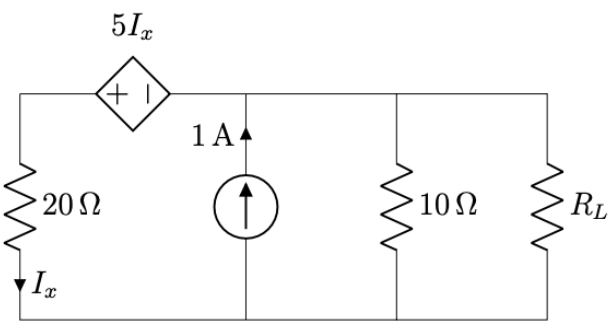
(a) If $v_L i_L$ is a maximum, then we have $R_L = R_N = 33.33\ \Omega, i_L = 1.7 \times \frac{33.33}{33.33+33.33} = 850$ mA, v_L= 33.33 i_L = 28.33 V

(b) If v_L is a maximum, then $v_L = I_N(R_N||R_L)$. Then v_L is a maximum when $R_N||R_L$ is a maximum, which occurs at $R_L = \infty$. Then $i_L = 0$ and $v_L = 1.7 \times R_N = 56.66$ V.

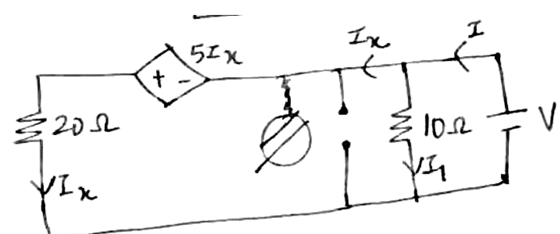
(c) If i_L is a maximum, then $i_L = i_N \frac{R_N}{R_N+R_L}$ is maximum when $R_L = 0\ \Omega$. So, $i_L = 1.7A$, and $v_L = 0\ V$.

Que 9.

Determine the value of R_L in the below circuit, such that maximum power is delivered into R_L. Calculate the value of the maximum power.



For maximum power transfer, $R_L = R_{TH}$.

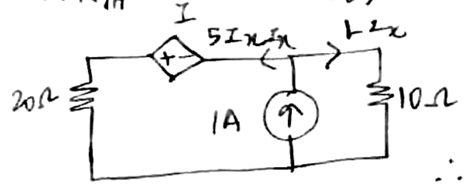


$$\frac{V+5I_x}{20} = I_x$$

$$\Rightarrow V = 15I_x \quad \text{— (1)}$$

$$\frac{V}{10} = I_1 \Rightarrow I = I_1 + I_x = \frac{V}{10} + \frac{V}{15} = \frac{V}{6}$$

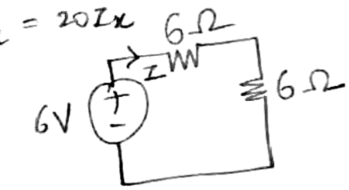
$$\therefore R_{TH} = \frac{V}{I} = V/V\left(\frac{1}{6}\right) = 6\,\Omega$$



KVL: $10(1-I_x) + 5I_x = 20I_x$

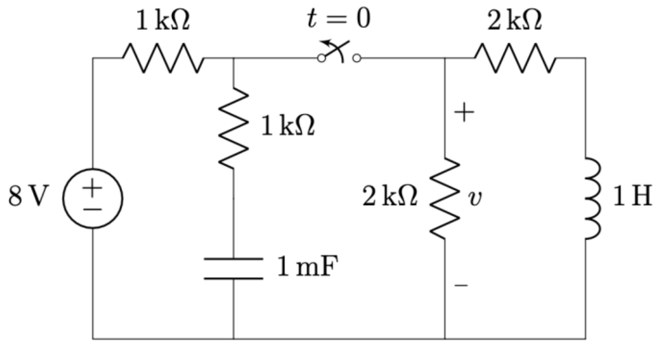
$$\Rightarrow I_x = \frac{2}{5}\,A$$

$$\therefore V_{oc} = \left(1-\frac{2}{5}\right) \times 10 = 6V$$

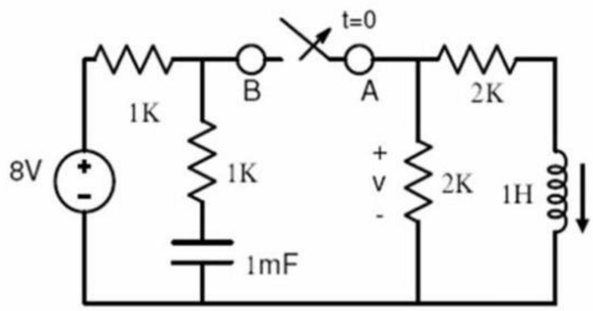


$I = \frac{6A}{12} = 0.5A$ $\therefore P_{max} = (0.5)^2 \times 6\,W = 1.5W$

10. For the circuit shown below, determine the voltage across the 2K resistor (vertical) as a function of time after the switch is opened at $t = 0$.



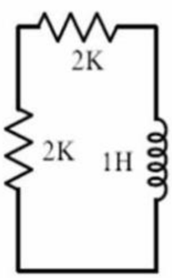
Solution:



Circuit after opening the switch (t > 0)

First find the inductor current

$$i_L(t) = i_L(\infty) + \{i_L(0^+) - i_L(\infty)\} \times e^{-\frac{t}{\tau}}$$



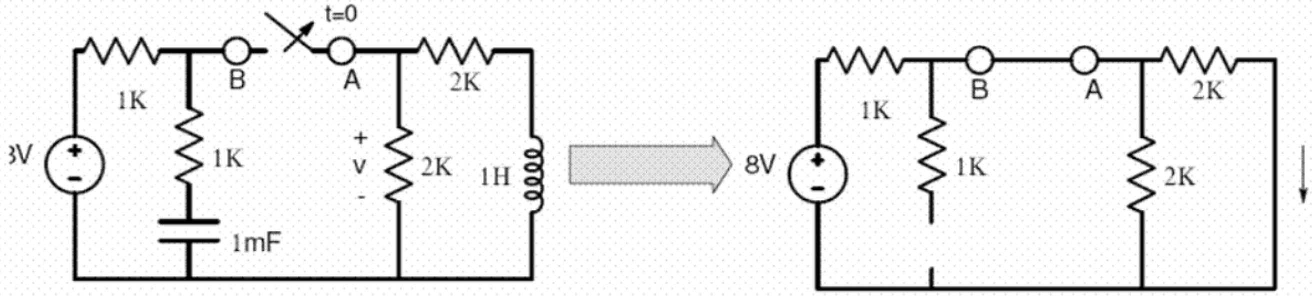
$$R_{eq} = 2K + 2K = 4K$$

$$\tau = \frac{L}{R_{eq}} = 0.25ms$$

One can also see that : $i_L(\infty) = 0$

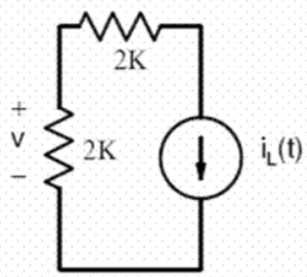
$i_L(0^+) = i_L(0^-)$

Circuit before opening the switch (t < 0) and assuming steady state condition:



$$i_L(0^+) = i_L(0^-) = \frac{8}{(2K \| 2K) + 1K} \times 0.5 = 2mA \quad \Rightarrow i_L(t) = 2 \times e^{-4000t} \, mA$$

Voltage across the 2K resistor:



$$v(t) = -2 \times 10^3 \times i_L(t) = -4 \times e^{-4000t} V$$

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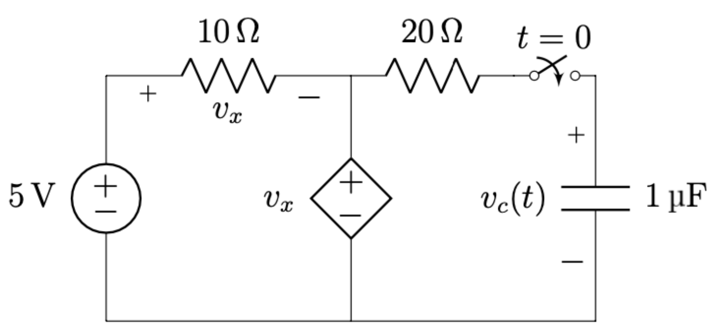
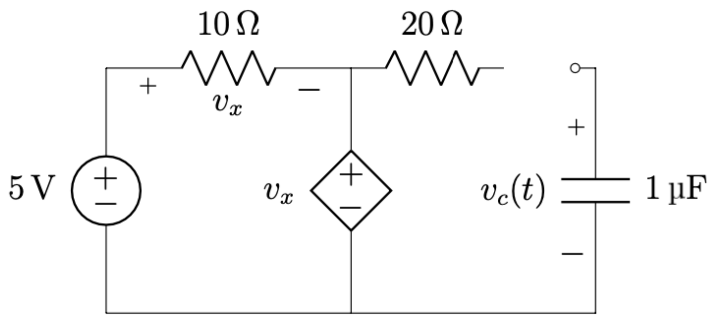
11. Find $v_c(t)$ for $t > 0$ in the following circuit if the capacitor voltage is zero for $t < 0$.



Solution:

Before the circuit is closed:



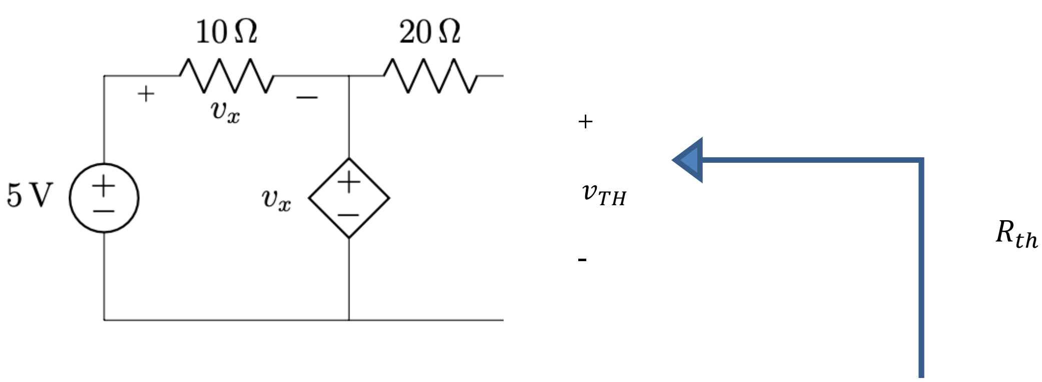
Applying KVL in the first loop

$$5 - V_x - V_x = 0$$

or

$$V_x = 2.5V$$

After the switch is closed



Thevenin voltage
Vth =2.5V

Short circuit current=
$Isc \ = \frac{2.5A}{20} = 125\ mA$

$R_{th} = \dfrac{2.5v}{125mA} = 20\Omega$

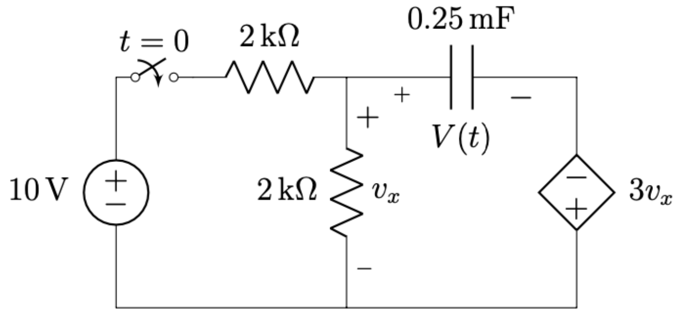
Hence, the time constant is

$$\tau = 20 \times 10^{-6} = 20\mu s$$

The voltage is given as

$$\mathrm{V_c(t) = \ V_c(\infty) + [V_c(0) - \ V_c(\infty)]e^{-\frac{t}{\tau}}}$$
$$= 2.5\ +\ (0 - \ 2.5\ )e^{-\frac{t}{2\times10^{-5}}}\ V$$
$$= 2.5\left(1 - \ e^{-\frac{t}{2\times10^{-5}}}\right)\ V$$

12. Assuming that the capacitor does not have any initial charge, determine the voltage across the capacitor $V(t)$ as a function of time after the switch is closed at $t = 0$.



Solution:

$$v(t) = v(\infty) + \{v(0^+) - v(\infty)\}e^{-t/\tau}$$

$$v(0^+) = 0 \ [\mathbf{1}$$

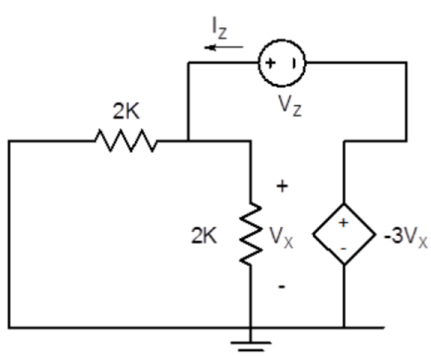
At $t \to \infty$, the capacitor is open circuit. Therefore,

$$v_X = \frac{2K}{2K + 2K} * 10 = 5V$$

$$v(\infty) = V_X - (-3V_X) = 4V_X = 20V \ [\mathbf{1\ m}$$

$$\tau = CR_{eq}$$

R_{eq} can be found from the circuit:



$$R_{eq} = \frac{v_Z}{i_Z}$$

$$v_Z = v_X - -3v_X = 4v_X$$

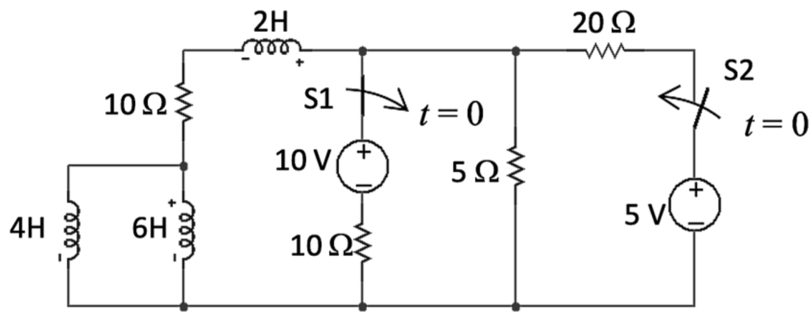
$$i_Z = \frac{v_X}{1K}$$

$$R_{eq} = \frac{v_Z}{i_Z} = 4K \ [\mathbf{1}$$

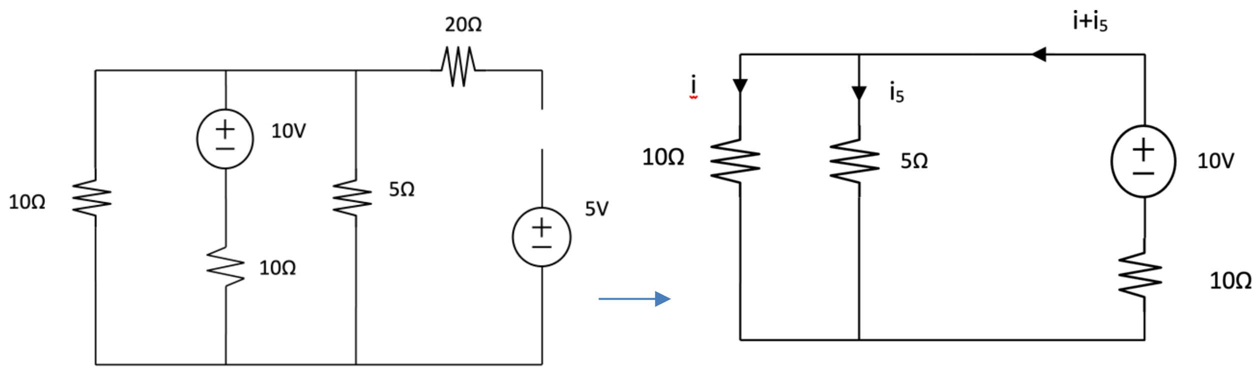
$$\tau = CR_{eq} = 1s \ [\mathbf{1}$$

$$v(t) = 20\{1 - e^{-t}\} \ [\mathbf{1}$$

13. In the following circuit the switch S1 is closed and S2 is left open for a long time. At t=0, S1 is opened and S2 is closed. Determine the current, i_5, through the 5Ω resistor for all time



Solution:
For t = 0^-



$$R_{eq} = 10 + \left(10\, x \frac{5}{15}\right) = \left(10 + \frac{50}{15}\right)\Omega = \left(10 + \frac{10}{3}\right)\Omega$$

$$i_{5\Omega} = \left(\frac{10}{10 + \frac{10}{3}}\right) \times \frac{10}{15} A = 0.5\, A$$

$$10 - 10i - 10i - 10i_5 = 0$$

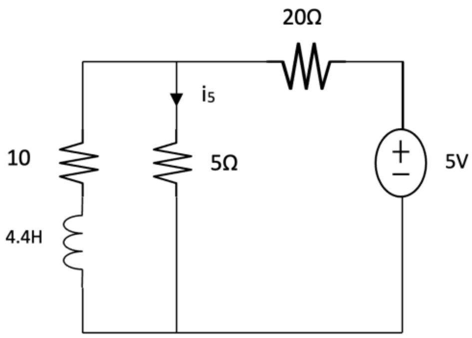
$$1 - i_5 = 2i$$

$$10 - 5i_5 - 10i - 10i_5 = 0$$

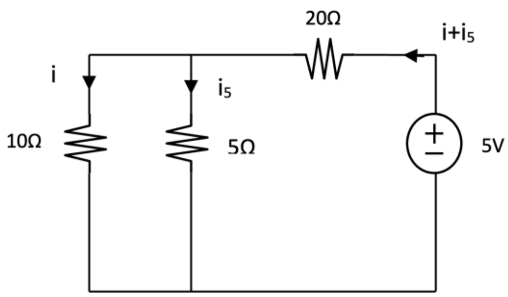
$$i = \left(\frac{1}{4}\right) A$$

$$i(0^-) = (1/4)A = i(0^+)$$

At t > 0



$t \to \infty$



$5 - 20i - 20v_5 - 5i_5 = 0$

$5 - 20i - 20i_5 - 10i = 0$

$i = 5/70$ A , $i_5 = 10/70$ A

$R_{th} = (20||5) + 10 = 14\Omega$

Therefore, $\tau = 4.4/14 = 0.314$ s

t>0

$i(t)=i(\infty)+[i(0^+)-i(\infty)]e^{-t/\tau}$

therefore, $i(t)=(1/14)+((1/4)-(1/14))e^{-3.2t}$ A

$$v_{5\Omega} = 10i + L\left(\frac{di}{dt}\right) = \frac{5}{7} + \left(\frac{5}{2} - \frac{5}{7}\right)e^{-3.2t} + (4.4)\left(\frac{1}{4} - \frac{1}{14}\right)e^{-3.2t}(-8.2)V$$

therefore, $V_{5\Omega} = \left(\frac{10}{14}\right)(1 - e^{-3.2t})\ V$

therefore,

$i_{5\Omega} = \left(\frac{1}{7}\right)(1 - e^{-3.2t})A$