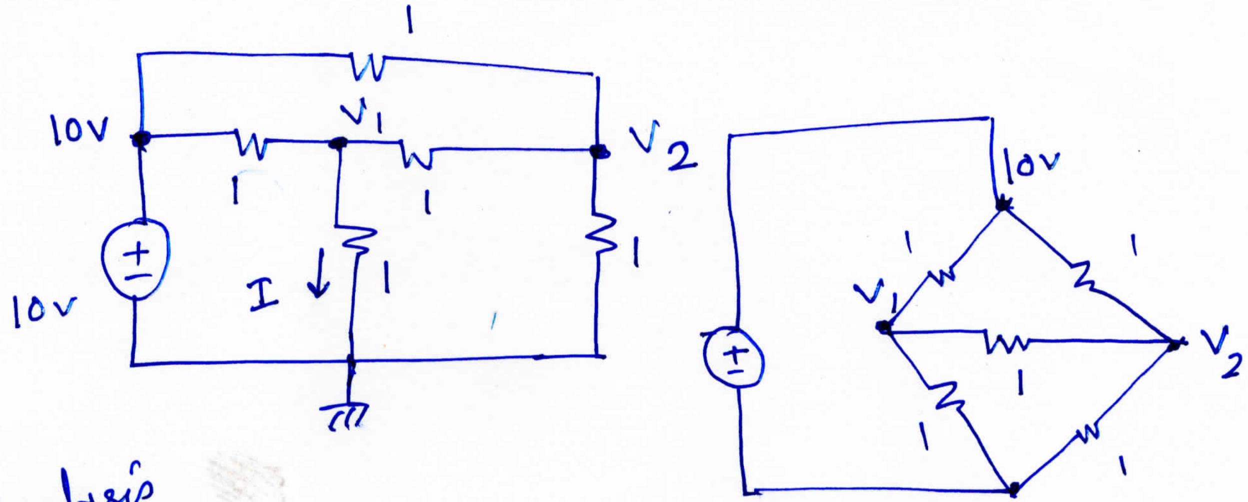
A pure Voltage Source ($R_s = 0$) between two nodes

ex



Node Analysis

Node V_1

$$\frac{V_1 - 10}{1} + \frac{V_1 - 0}{1} + \frac{V_1 - V_2}{1} = 0$$

$$\Rightarrow \quad 3V_1 - V_2 = 10$$

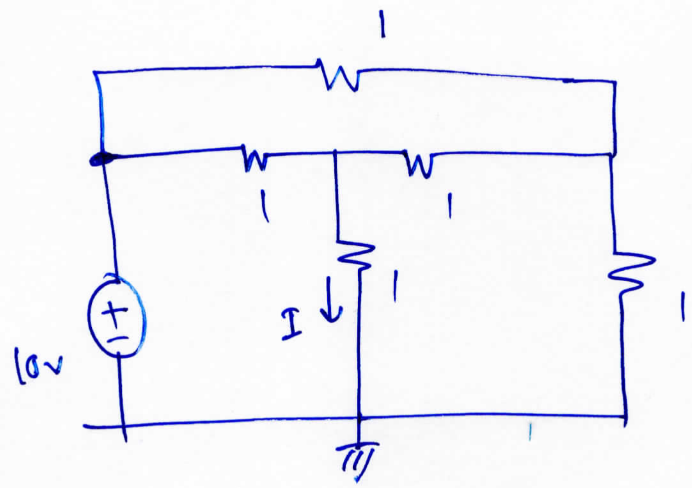
Node V_2

$$\frac{V_2 - 10}{1} + \frac{V_2 - V_1}{1} + \frac{V_2 - 0}{1} = 0$$

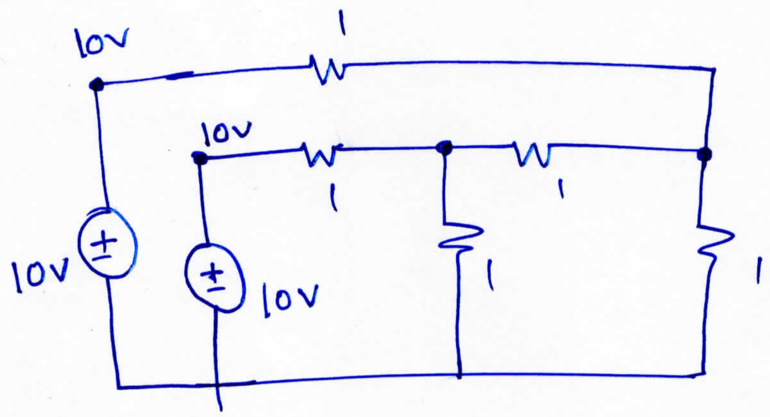
$$\Rightarrow \quad 3V_2 - V_1 = 10$$

Sol^n: $V_1 = V_2 = 5V$

$$\Rightarrow I = \frac{V_1}{1} = \frac{5}{1} = 5A$$

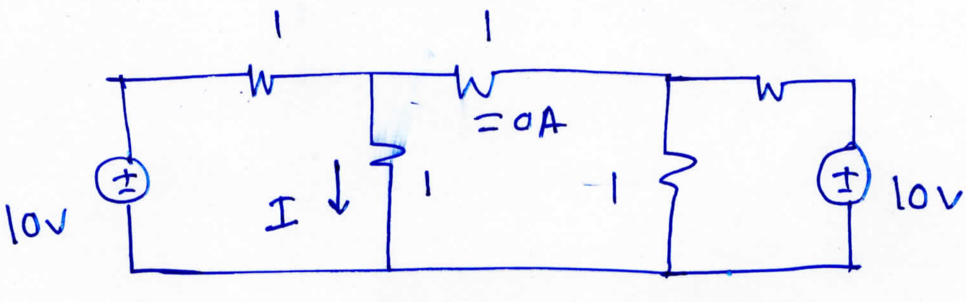


⇒

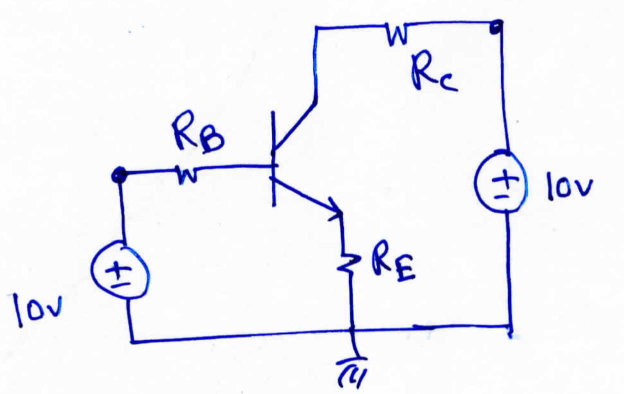


Voltage Source Splitting

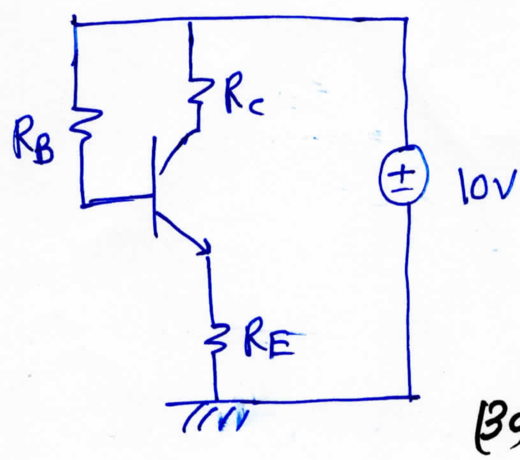
⇒



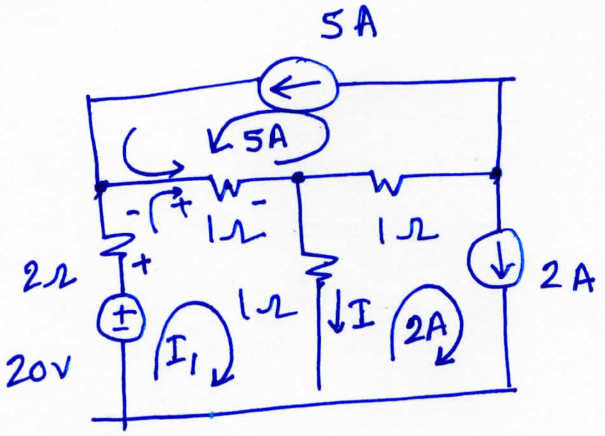
$$I = \frac{10}{2} = 5A$$



$\equiv$



A Current Source between two nodes



KVL

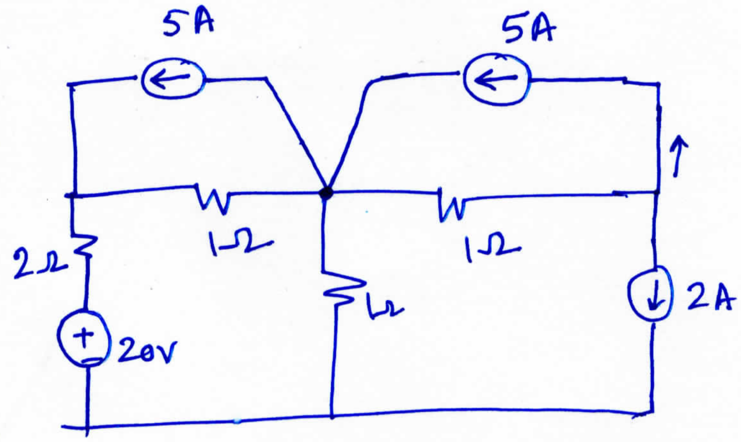
$$20 - 2I_1 - 1(I_1+5) - 1(I_1-2) = 0$$

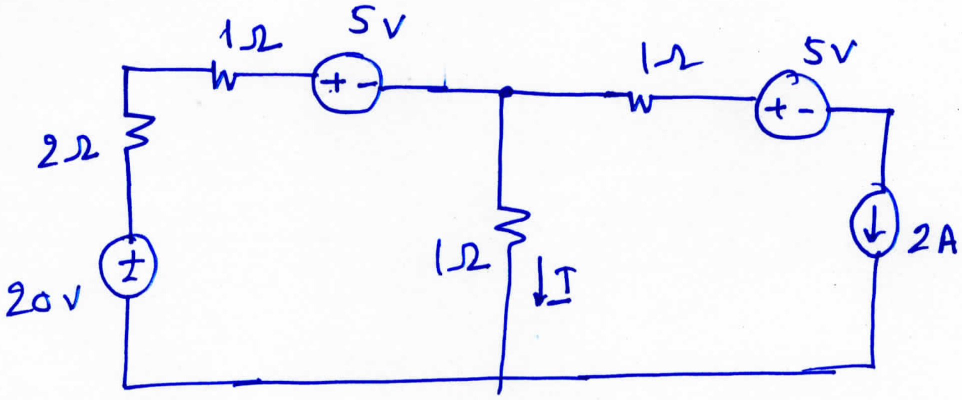
$$\Rightarrow \quad 20 - 4I_1 - 5 + 2 = 0$$

$$\Rightarrow \quad 4I_1 = 17 \quad \Rightarrow I_1 = \frac{17}{4}\,A$$

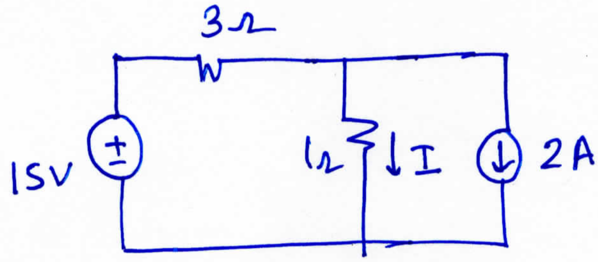
So, $I = I_1 - 2 = \frac{17}{4} - 2 = 9/4\,A$

2nd App.



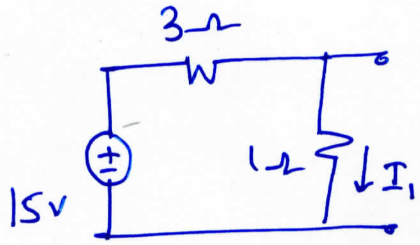


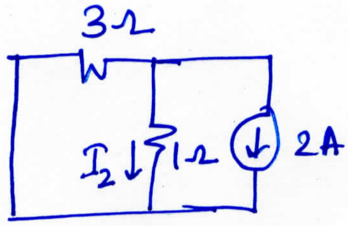
⇒



By Superposition Theorem:

$$I = I_1 + I_2$$





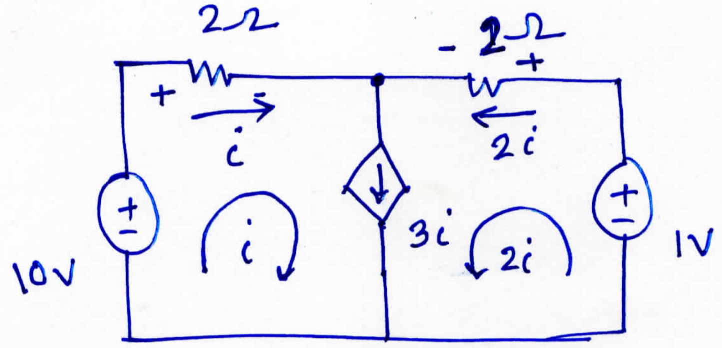
$$I_1 = \frac{15}{4}$$

$$I_2 = \frac{3}{3+1} \times (-2)$$

$$= \frac{3}{4} \times (-2) = -\frac{3}{2}\,A$$

$$I = \frac{15}{4} - \frac{3}{2} = \frac{15-6}{4} = 9/4\,A$$

ex



$i = ?$

Super Mesh

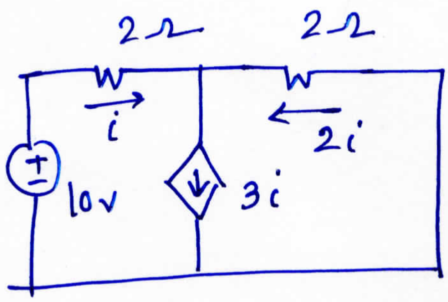
$$10 - 2i + 2 \times 2i - 1 = 0$$

$$\Rightarrow \quad 9 + 2i = 0$$

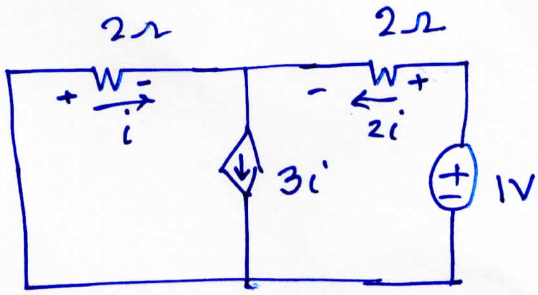
$$\Rightarrow \quad i = -9/2 \text{ A}$$

Superposition theorem

10V



1V



$$10 - 2i + 4i = 0$$

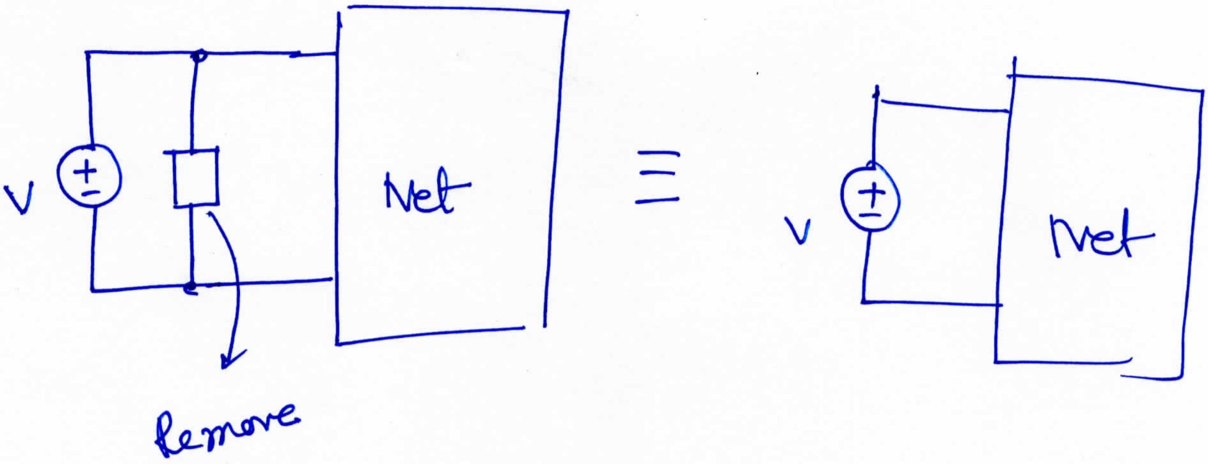
$$\Rightarrow i = -5 \text{ A}$$

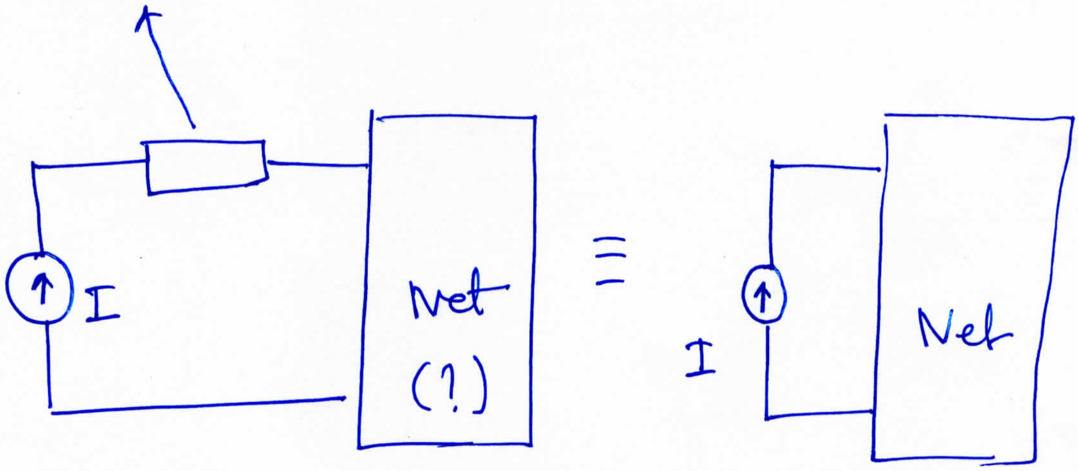
$$1 - 4i + 2i = 0$$

$$\Rightarrow \quad 2i = 1$$

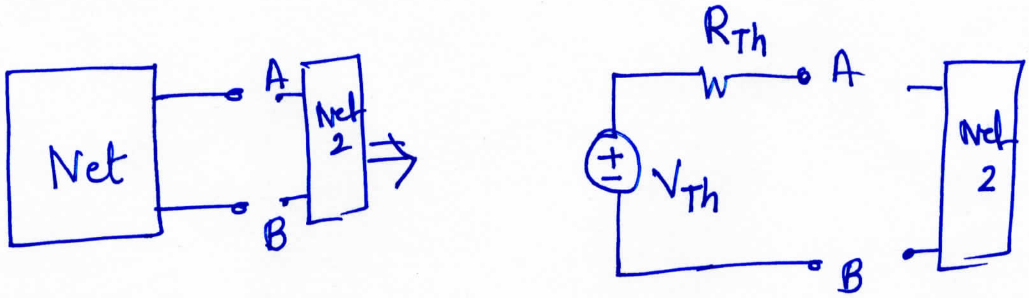
$$\Rightarrow i = 1/2$$

$$\text{So,} \quad i = -5 + \frac{1}{2} = -9/2 \text{ A}$$

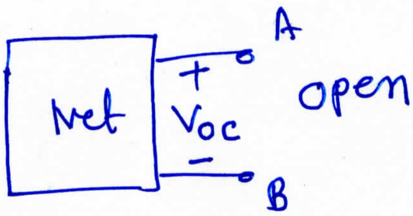




Thevenin Theorem;

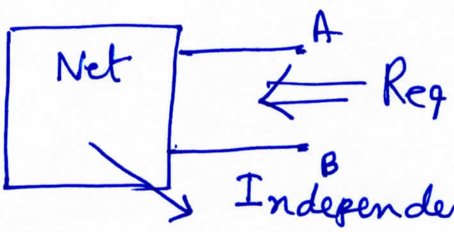


V_{Th}



$V_{Th} = V_{oc}$

R_{Th}

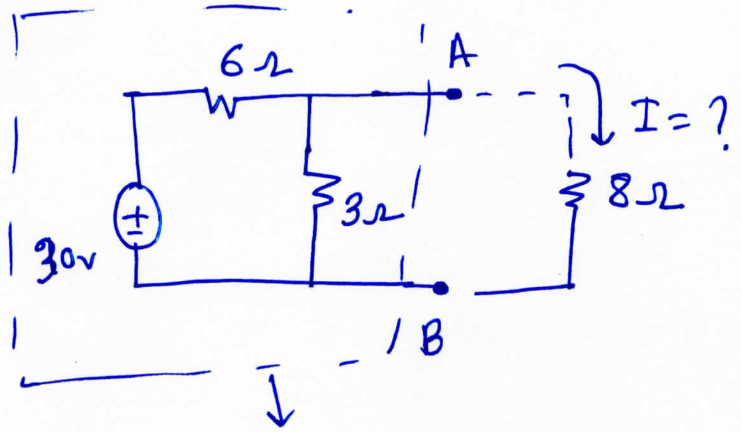


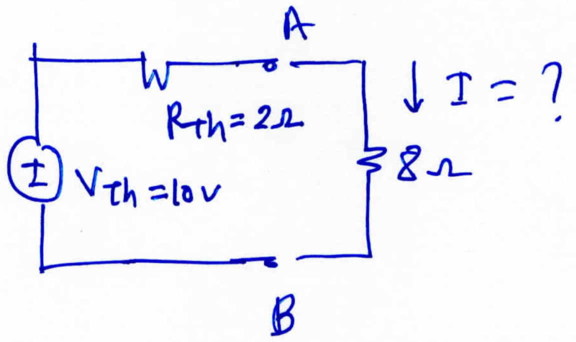
$R_{Th} = R_{eq}$

Independent voltage source → shorted

" current " → opened

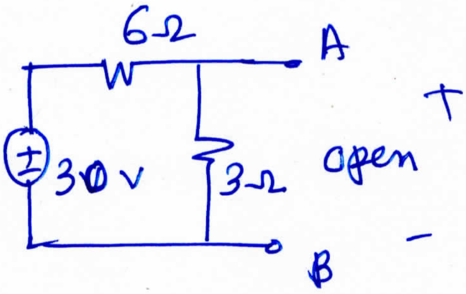
ex





$$I = \frac{V_{Th}}{R_{Th} + 8} = \frac{10}{2+8} = 1A$$

V_Th

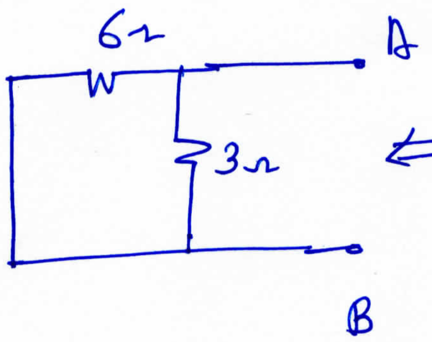


$$V_{oc} = \frac{3}{3+6} \times 30$$

$$= \frac{3}{9} \times 30 = 10V$$

$$= V_{Th}$$

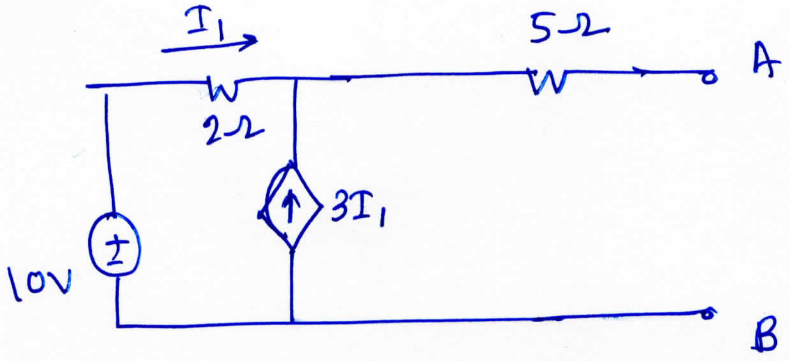
R_Th



$$\Leftarrow R_{eq} = 6 \parallel 3 = \frac{6 \times 3}{6+3} = 2\Omega$$

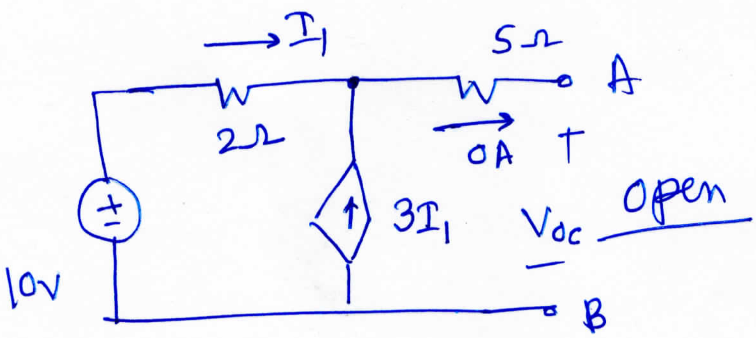
$$= R_{Th}$$

ex



V_{th} & R_{th}

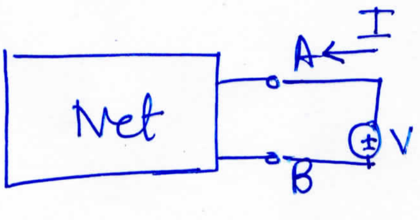
Voc



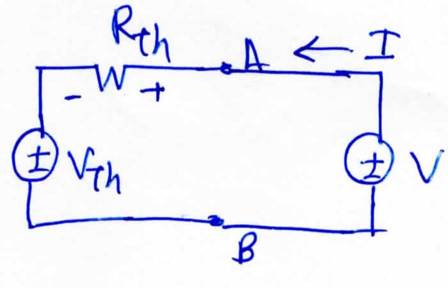
$$I_1 + 3I_1 = 0$$

$$V_{oc} = 10V = V_{th} \qquad \Rightarrow I_1 = 0$$

$R_{th} = ?$



$\Rightarrow$



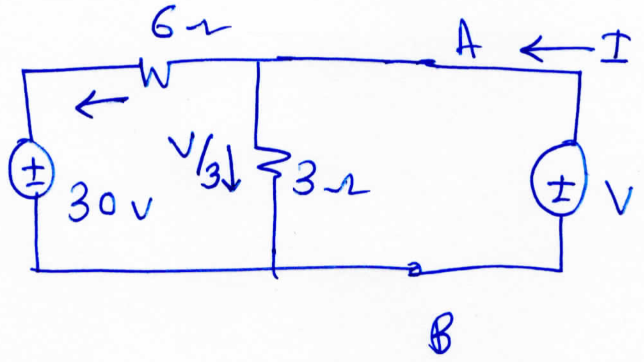
$$V - IR_{th} - V_{th} = 0$$

$$\Rightarrow \boxed{V = IR_{th} + V_{th}}$$

ex $V = 2I + 4$

$V_{th} = 4V$ & $R_{th} = 2\Omega$

ex



$$V - 6\times\left(I - \frac{V}{3}\right) - 30 = 0$$

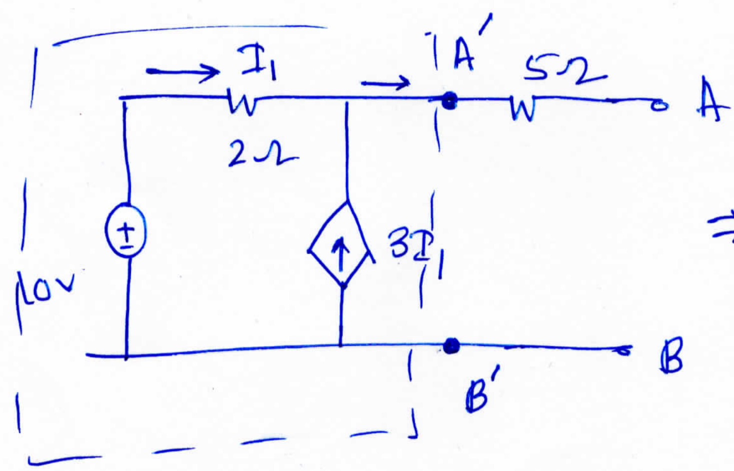
$$\Rightarrow \quad V - 6I + 2V - 30 = 0$$

$$\Rightarrow \quad 3V = 6I + 30$$

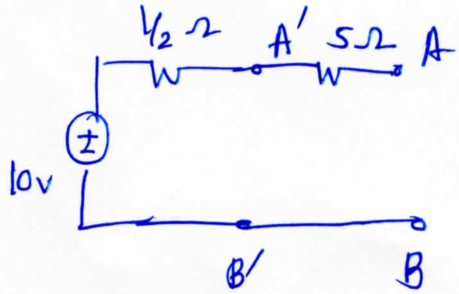
$$\Rightarrow \quad V = \underbrace{2}_{R_{th}} I + \underbrace{10}_{V_{th}}$$

$$\begin{cases} V_{th} = 10\,\text{v} \\ R_{th} = 2\,\Omega \end{cases}$$

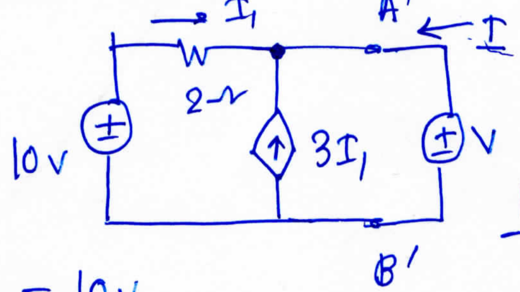
ex



$\Rightarrow$



$$\begin{cases} V_{th} = 10\,\text{v} \\ R_{th} = 5.5\,\Omega \end{cases}$$



$V'_{th} = 10\,\text{v}$

$R'_{th} = 1/2\,\Omega$

$$I_1 + 3I_1 + I = 0$$

$$\Rightarrow I_1 = -I/4$$

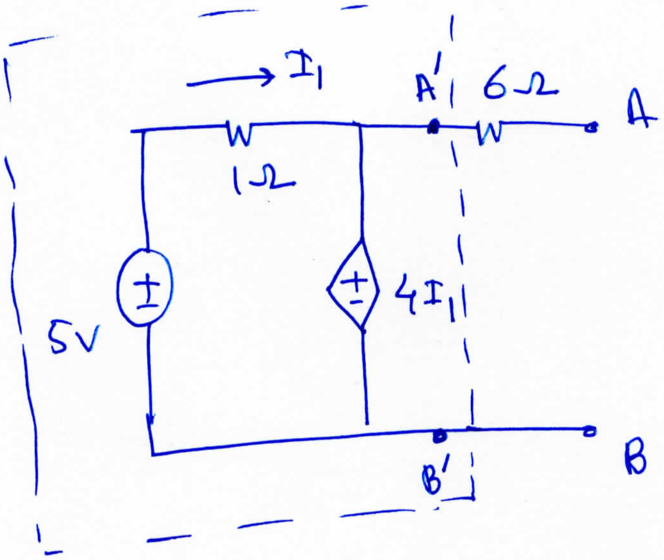
Again

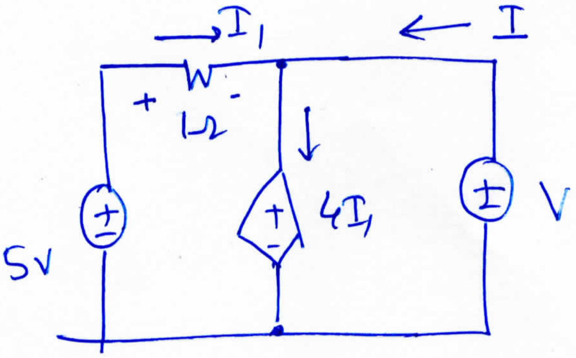
$$10 - 2I_1 - V = 0$$

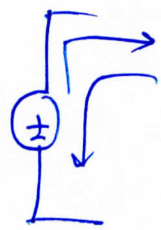
$$\Rightarrow V = -2I_1 + 10 = -2\times(-I/4) + 10$$

$$= I/2 + 10$$

ex







$$5 - 1 \times I_1 - 4I_1 = 0 \quad \& \quad V = 4I_1$$

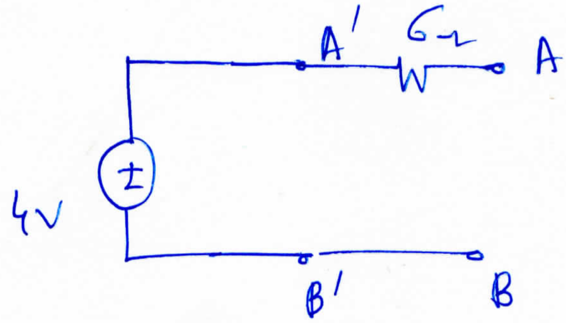
$\Rightarrow 5I_1 = 5$

$\Rightarrow I_1 = 1\,A$

$V = 4I_1 = 4 \times 1 = 4V$

$V = 4 + I \times 0$

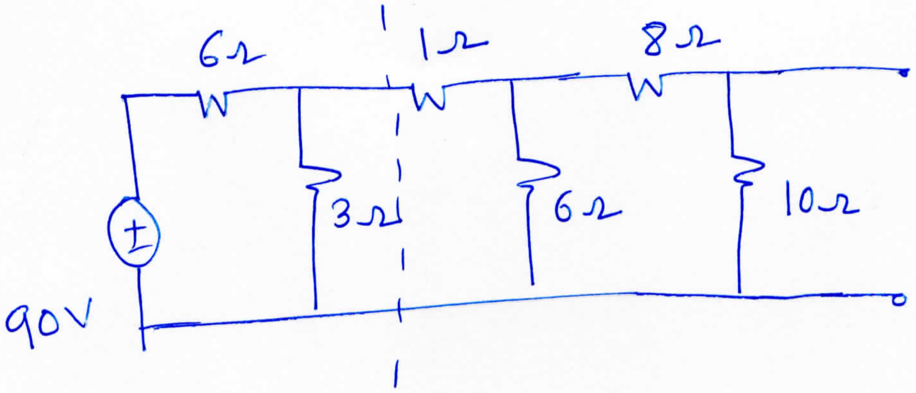
$$\begin{cases} V'_{th} = 4V \\ R'_{th} = 0\,\Omega \end{cases}$$



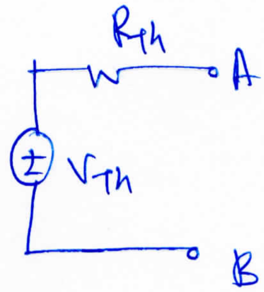
$\Rightarrow V_{th} = 4V$

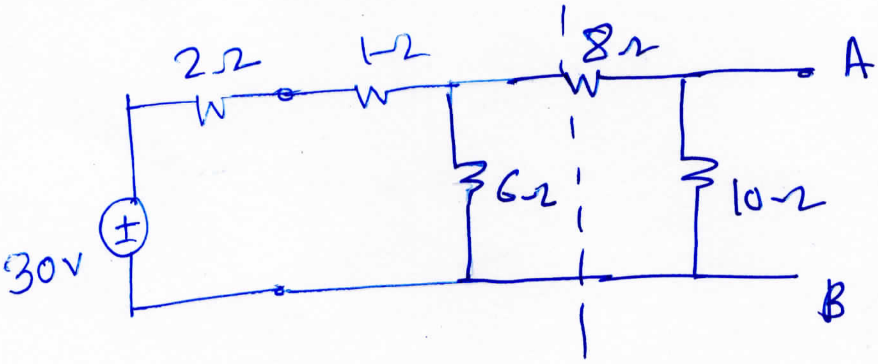
$R_{th} = 6\,\Omega$

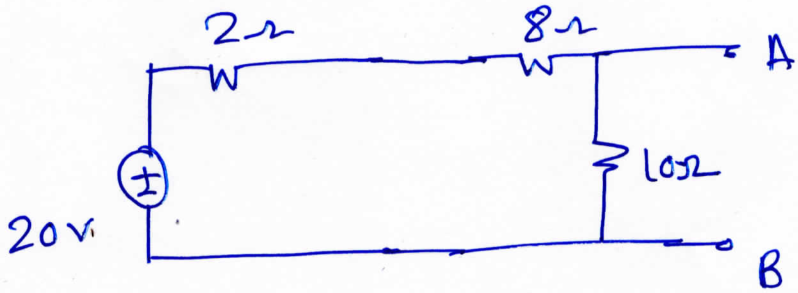
ex

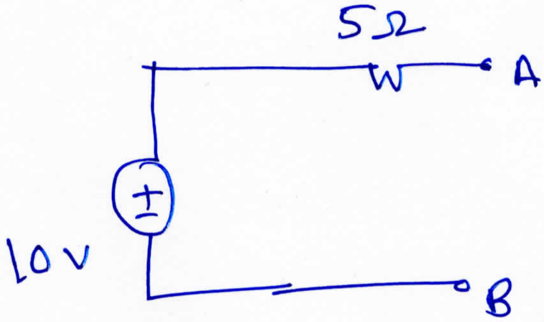


⇒



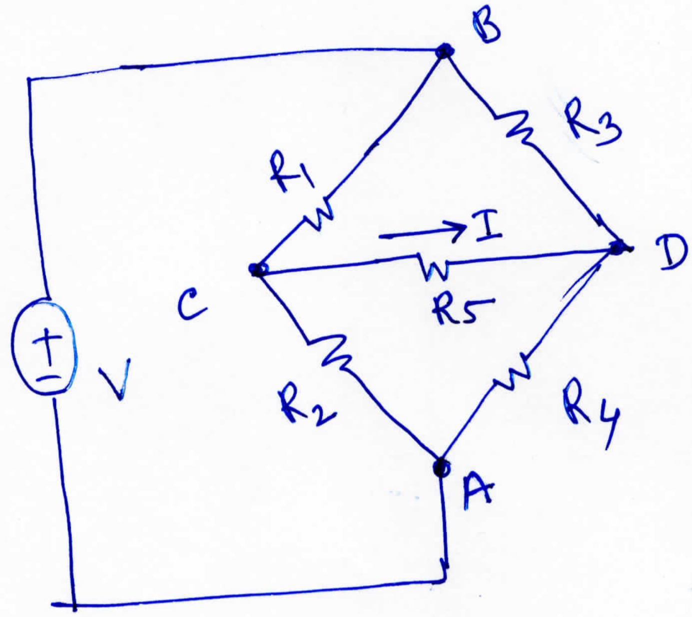


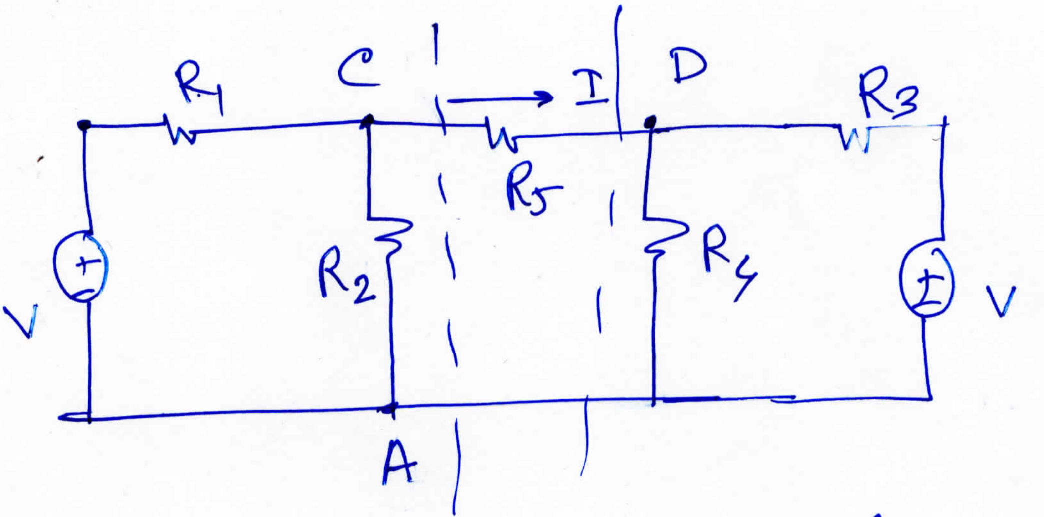


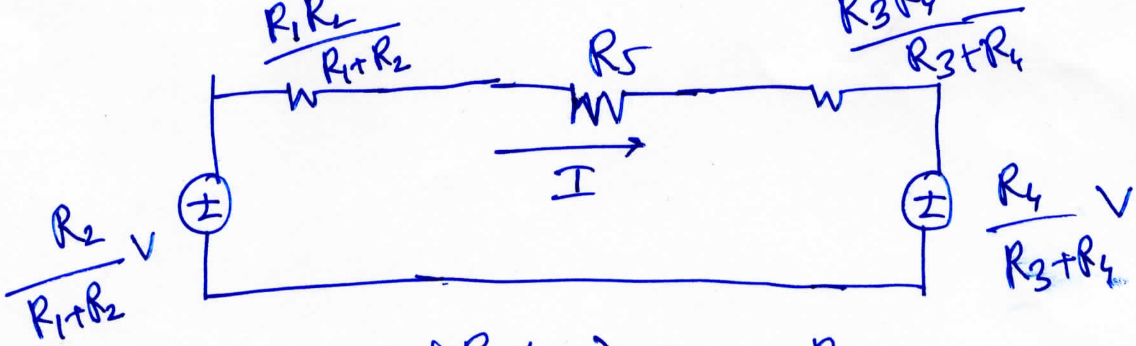


$$\begin{cases} V_{th} = 10V \\ R_{th} = 5\Omega \end{cases}$$

Wheatstone Bridge :

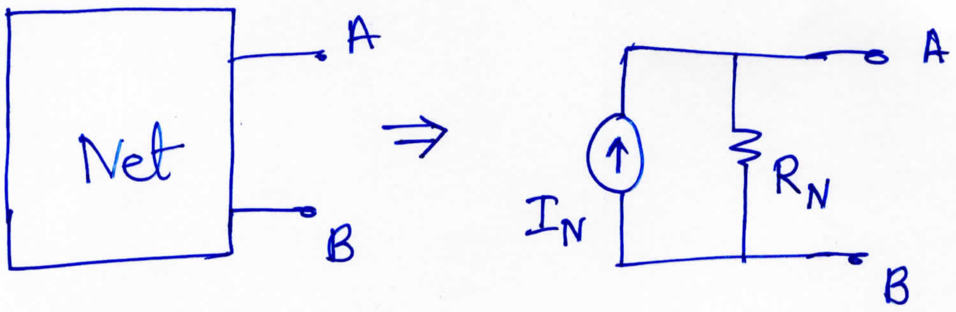




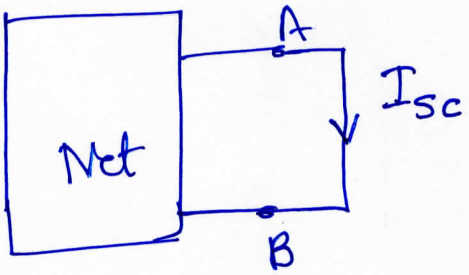


$$I = \frac{\left(R_2/(R_1+R_2)\right)V - R_4/(R_4+R_3)\,V}{(R_1 \parallel R_2) + R_5 + (R_3 \parallel R_4)}$$

Norton's Theorem :

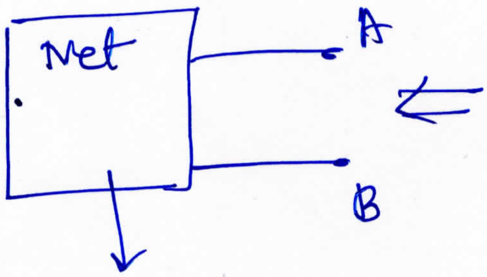


I_N



$I_{sc} = I_N$

R_N

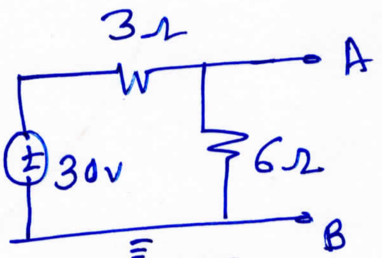


$\Leftarrow$ $R_{eq} = R_N = R_{Th}$

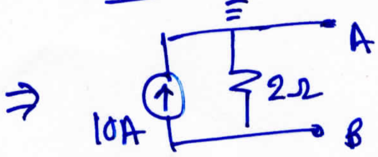
Indep. Voltage Source $\longrightarrow$ Shorted

Indep. Current " $\longrightarrow$ Opened

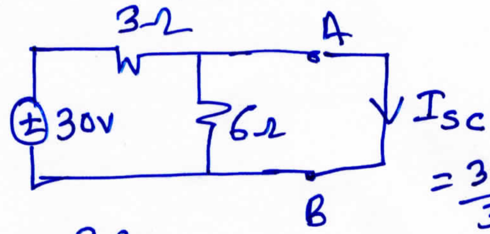
ex



$\equiv$

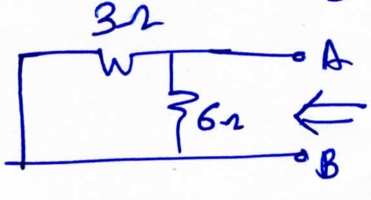


I_N

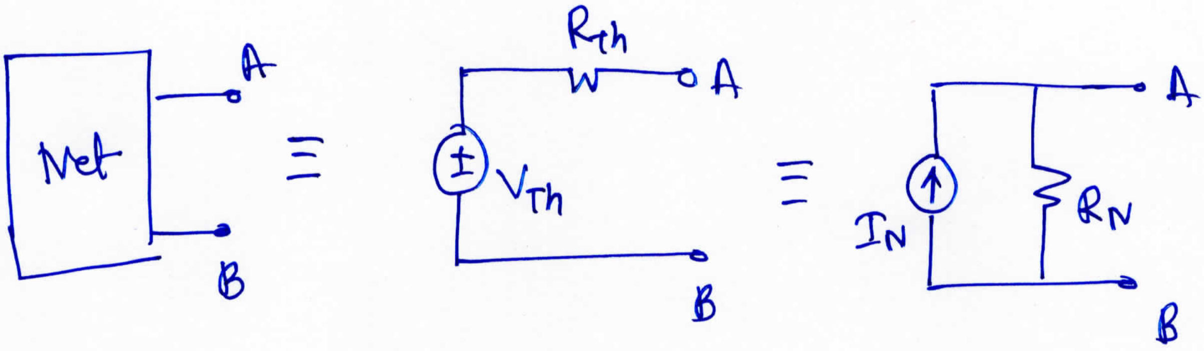


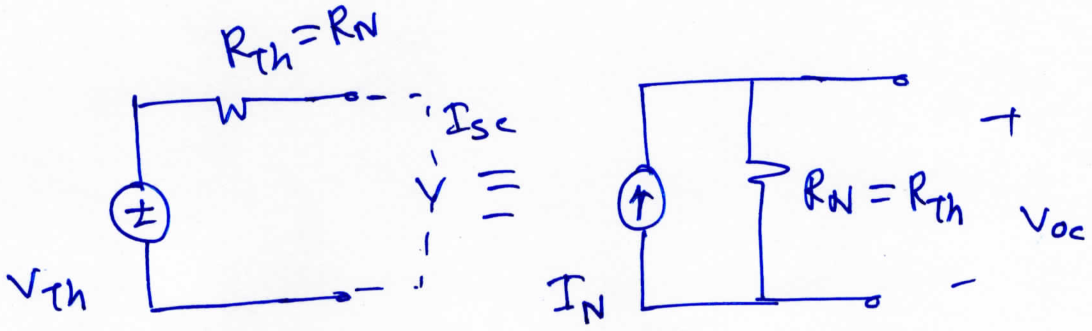
$I_{sc} = \frac{30}{3} = 10A$

R_N



$\Leftarrow$ $R_{eq} = 2\Omega = R_N$





$$I_N = I_{sc} = \frac{V_{Th}}{R_{Th}}$$

$$V_{Th} = V_{oc} = I_N R_N$$

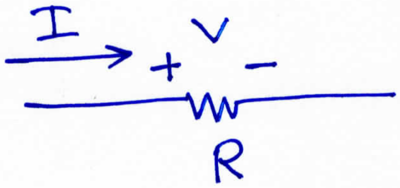
$$\frac{V_{oc}}{I_{sc}} = \frac{I_N R_N}{(V_{Th}/R_{Th})} = \frac{I_N R_N \times R_{Th}}{V_{Th}}$$

$$= \frac{\cancel{I_N R_N} \times R_{Th}}{\cancel{I_N R_N}} = R_{Th} = R_N$$

$$R_{Th} = \frac{V_{oc}}{I_{sc}}$$

Power delivered / Consumed
(P_D) (P_C)

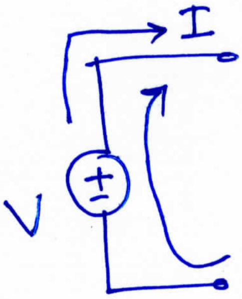
1)



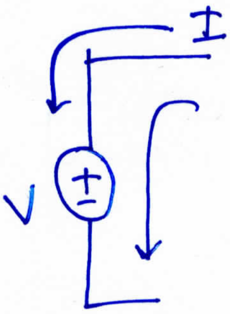
$V = IR$

$$P_C = VI = I^2R = \frac{V^2}{R}$$

2)

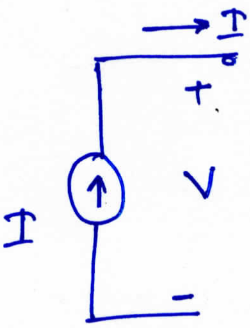


$\Rightarrow \quad P_D = VI$

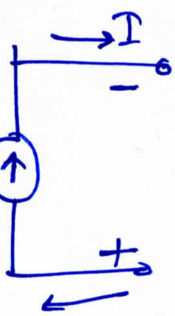


$\Rightarrow \quad P_C = VI$

3)

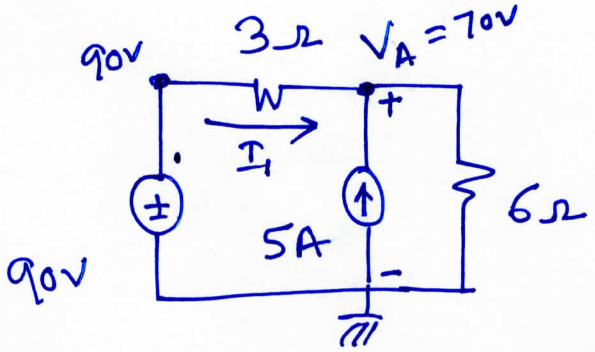


$\Rightarrow \quad P_D = VI$



$\Rightarrow \quad P_C = VI$

ex



$$\frac{V_A - 90}{3} + \frac{V_A - 0}{6} = 5$$

$$\Rightarrow \frac{2V_A - 180 + V_A}{\cancel{6}} = 5$$

$$\Rightarrow 3V_A = 30 + 180 = 210$$

$$V_A = 70\text{ V}$$

3Ω

$$I_1 = \frac{90 - 70}{3} = \frac{20}{3}\text{ A}$$

$$P_{c_1} = I_1^2 \times 3 = \frac{400}{9} \times 3 = \frac{400}{3}\text{ watt}$$

6Ω

$$P_{c_2} = \frac{V^2}{R} = \frac{70^2}{6}$$

90V

$$P_{D_1} = VI = 90 \times I_1 = \cancel{90}^{30} \times \frac{20}{\cancel{3}} = 600\text{ watt}$$

5A

$$P_{D_2} = V \times I = 70 \times 5 = 350\text{ watt.}$$

$$P_{c_1} + P_{c_2} = P_{D_1} + P_{D_2}$$