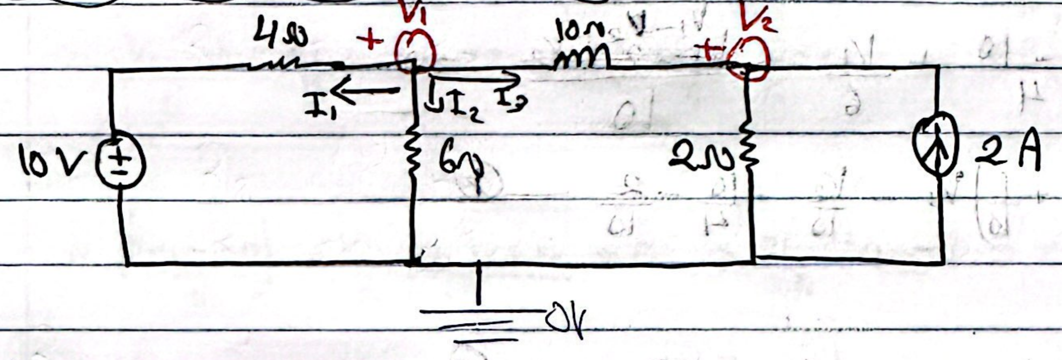
Chapter 4:

- Nodal Method
- Node Voltage Methode.



steps

① refrence node, ground

② node voltages $V_1, V_2, \dots, V_n$ essential nodes only

③ at each node, write KCL eq's in term of node voltages $V_1, V_2, \dots$

$\sum I_{in} = 0$ $\quad$ $\boxed{\sum I_{out} = 0}$

at V_1: $I_1 + I_2 + I_3 = 0$

$$\frac{V_1 - 10}{4} + \frac{V_1}{6} + \frac{V_1 - V_2}{10} = 0$$

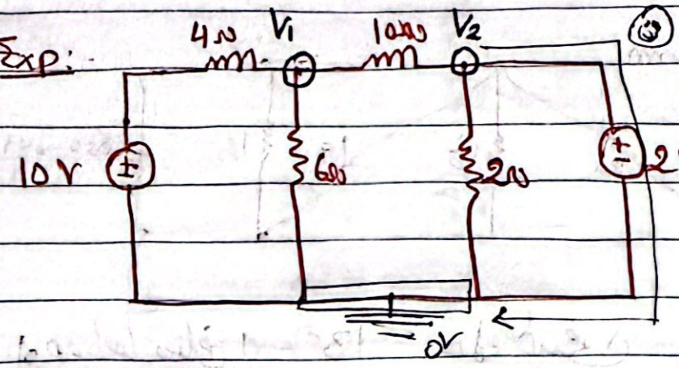
$$\Rightarrow \left(\frac{1}{4} + \frac{1}{6} + \frac{1}{10}\right)V_1 - \frac{1}{10}V_2 = \frac{10}{4} \quad -①$$

at V_2: $\frac{V_2 - V_1}{10} + \frac{V_2}{2} + -2 = 0 \quad -②$

V_1

V_2

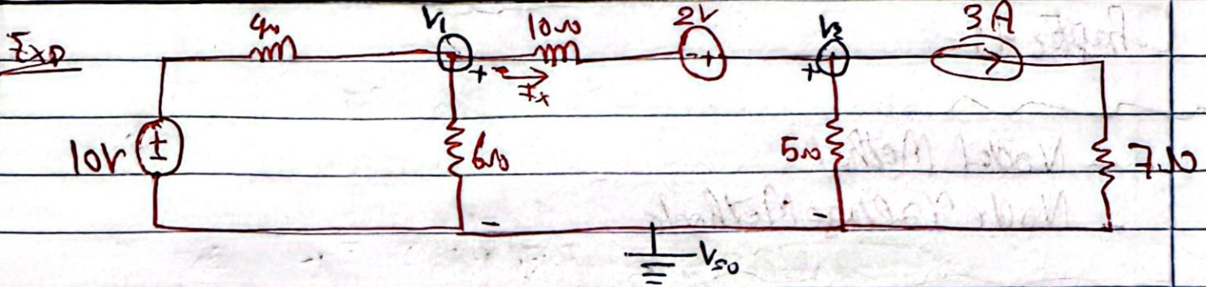
Exp:



Sol: $V_2 = 2V$

@ V_1: $\frac{V_1 - 10}{4} + \frac{V_1}{6} + \frac{V_1 - 2}{10} = 0 \rightarrow V_1 =$

Exp



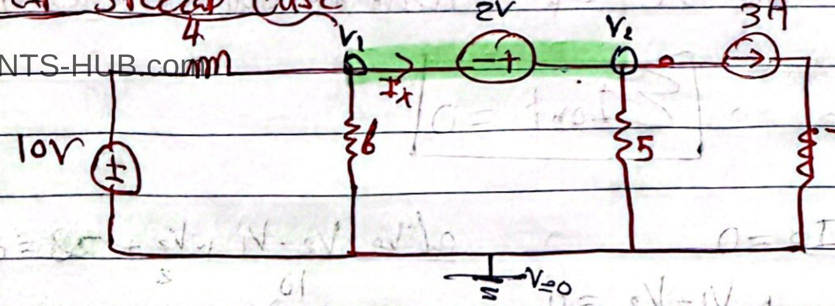
@ V_1: $\frac{V_1 - 10}{4} + \frac{V_1}{6} + \frac{V_1 - V_2 + 2}{10} = 0$

$\left(\frac{1}{4} + \frac{1}{6} + \frac{1}{10}\right)V_1 - \frac{V_2}{10} = \frac{10}{4} - \frac{2}{10}$ — ①

@ V_2: $\frac{V_2 - V_1 - 2}{10} + \frac{V_2}{5} + 3 = 0$ — ②

V_1, V_2

Ex Special case



$\boxed{V_2 - V_1 = 2V}$

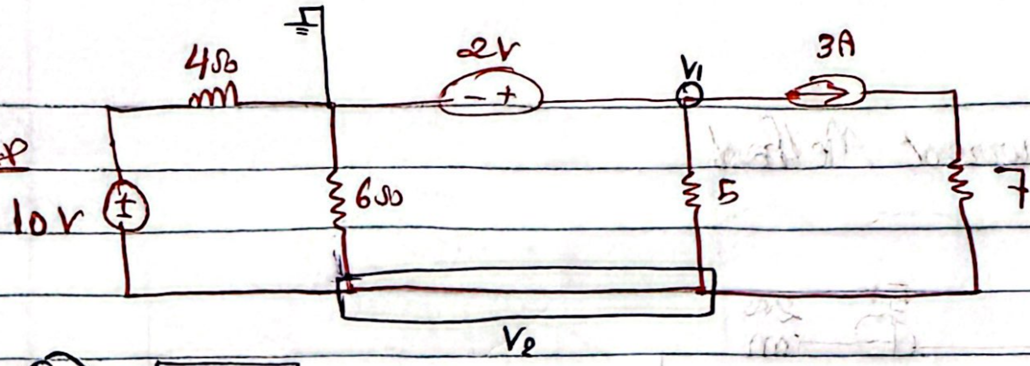
~~Special case~~

super Node

@ V_1: $\underbrace{\frac{V_1 - 10}{4}}_{A} + \underbrace{\frac{V_1}{6}}_{A} + \underbrace{\frac{V_1 - V_2 + 2}{}}_{V} = 0$ ✗

$\hookrightarrow \frac{V_1 - 10}{4} + \frac{V_1}{6} + I_x = 0 \rightarrow \frac{V_1 - 10}{4} + \frac{V_1}{6} + \left(\frac{V_2}{5} + 3\right) = 0$

Exp

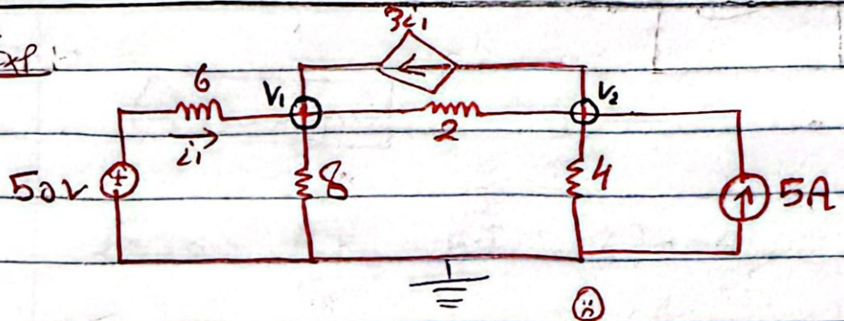


$\boxed{V_1 = 2V}$

@ V_2 : $\frac{V_2+10}{4} + \frac{V_2}{6} + \frac{V_2-2}{5} - 3 = 0$

V_2

Exp :



@ $\frac{V_1-50}{6} + \frac{V_1}{8} + \frac{V_1-V_2}{2} - 3i_1 = 0$, But $i_1 = \frac{50-V_1}{6}$

$\rightsquigarrow \frac{V_1-50}{6} + \frac{V_1}{8} + \frac{V_1-V_2}{2} - 3\left(\frac{50-V_1}{6}\right) = 0$, $+3\left(\frac{V_1-50}{6}\right)$

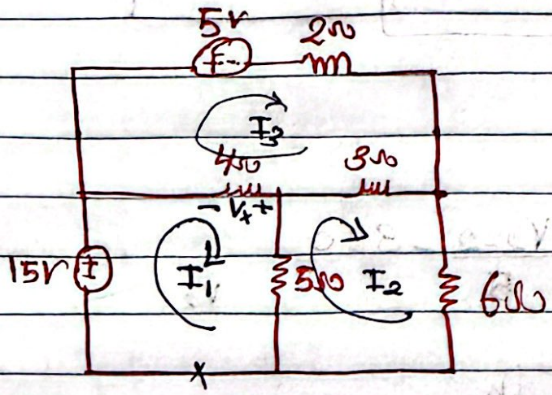
$4\left(\frac{V_1-50}{6}\right) + \frac{V_1}{8} + \frac{V_1-V_2}{2} = 0 \rightarrow \frac{31}{24}V_1 - 0.5V_2 = \frac{100}{3}$ — ①

@ V_2 : $-5 + \frac{V_2}{4} + \frac{V_2-V_1}{2} + 3\left(\frac{50-V_1}{6}\right) = 0$

$-V_1 + \frac{3}{4}V_2 = -20$ — ②

$V_1 = \checkmark$, $V_2 = \checkmark$

* Mesh current Method



mesh current
↳ all CW / CCW.
↳ write KVL eq's.

@ I_1

↳ $-15 + 4(I_1 - I_3) + 5(I_1 - I_2) = 0$

→ $\boxed{9I_1 - 5I_2 - 4I_3 = 15}$ — (1)

@ I_2

↳ $\boxed{-5I_1 + (5+6+3)I_2 - 3I_3 = 0}$ (2)

@ I_3

↳ $\boxed{-4I_1 - 3I_2 + (2+3+4)I_3 = -5}$ — (3)

or

↳ $5 + 2I_3 + 3(I_3 - I_2) + 4(I_3 - I_1) = 0$ بترجعها ل(3) بعد التبسيط

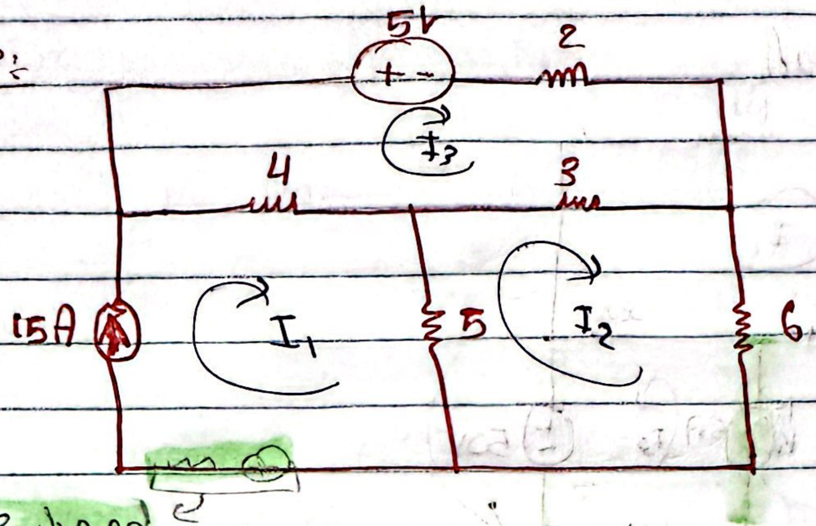
I_1 ↘ I_2 ↘ I_3 ↘.

→ $V_x = 4(I_3 - I_1) = \boxed{}$

$I_1 = 3.359$ A
$I_2 = 1.589$ A
$I_3 = 1.820$ A

$V_x = 6.156$ V

Exp:



[illegible]

[illegible]

$\boxed{I_1 = 15A}$

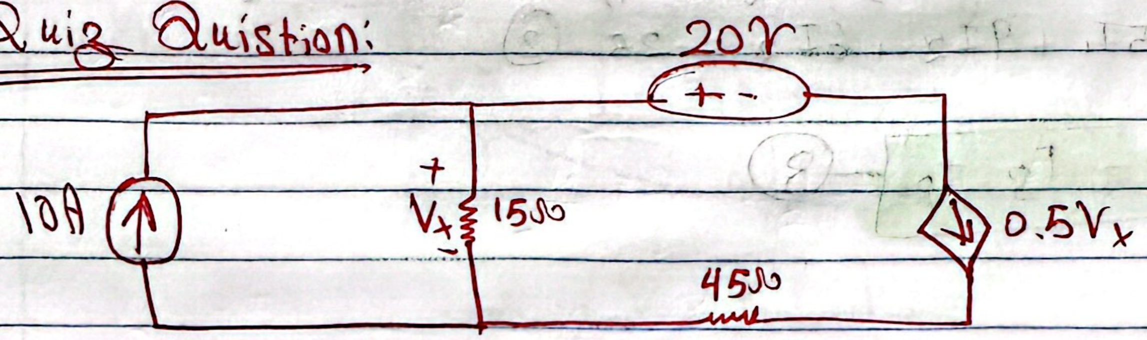
$$@I_2 = 14I_2 - 5\underset{15}{I_1} - 3I_3 = 0 \quad (1)$$

$$@I_3 : 9I_3 - 4\underset{15}{I_1} - 3I_2 = -5 \quad (2)$$

$I_3 =$

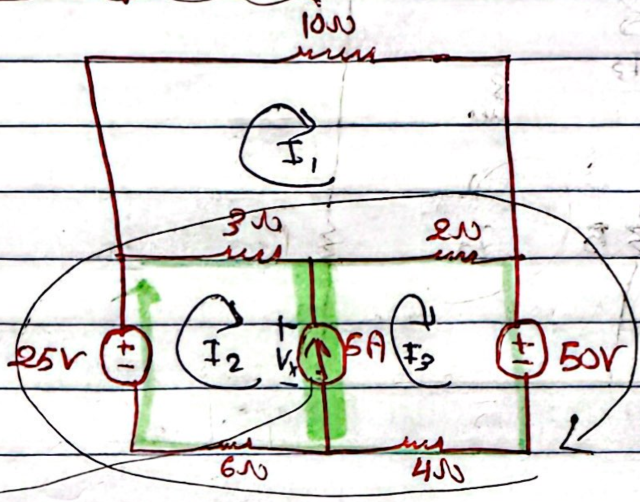
$I_2 =$

Quiz Quistion:



find: P_{10A}, P_{20V}, $P_{15\Omega}$

Ex Page 125 Super mesh



@I_1 $\quad 15I_1 - 3I_2 - 2I_3 = 0$ — (1)

@I_2 $\quad -25 + 3(I_2 - I_1) - 5 + 6I_2 = 0$ X

$\quad V + V - \cancel{A} + V$ $+V_x$

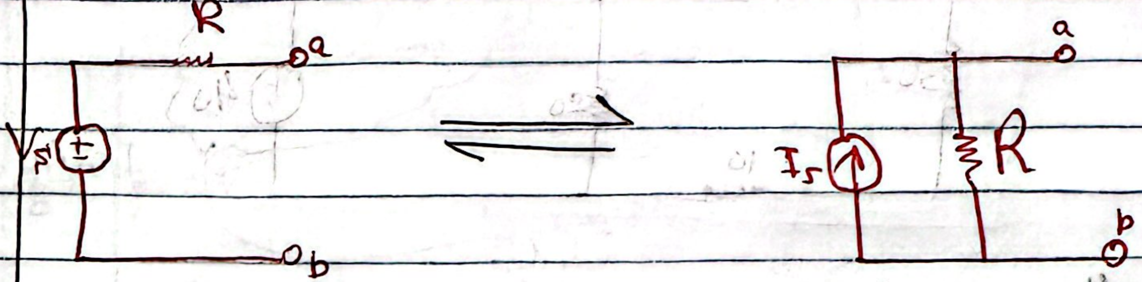
@I_3 $\quad 50 + 4I_3 - V_x + 2(I_3 - I_1) = 0$ X

$\rightarrow -25 + 3(I_2 - I_1) + 2(I_3 - I_1) + 50 + 4I_3 + 6I_2 = 0$

$\rightarrow -5I_1 + 9I_2 + 6I_3 = -25$ — (2)

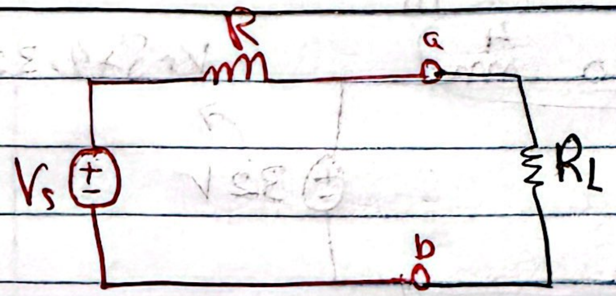
$\rightarrow \boxed{5 = I_3 - I_2}$ — (3)

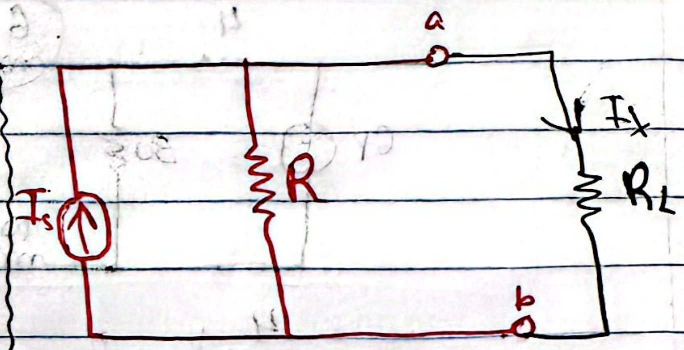
Sourse Transformation



$V_{o.c} = V_{ab} = V_s$ $\qquad$ $V_{ab} = R I_s$

$$\boxed{V_s = R I_s}$$





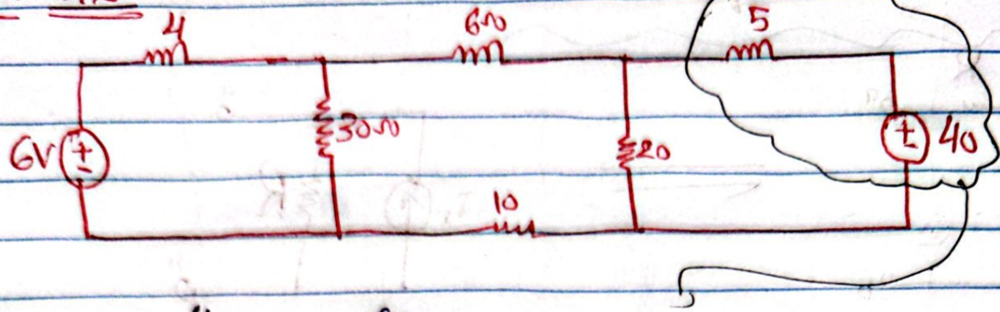
$V_{RL} = V_{ab} = \boxed{\frac{R_L}{R_L+R} \cdot V_s}$

$V_{RL} = V_{ab} = R_L I_x$

$= \boxed{R_L\left(\frac{R}{R+R_L} \cdot I_s\right)}$

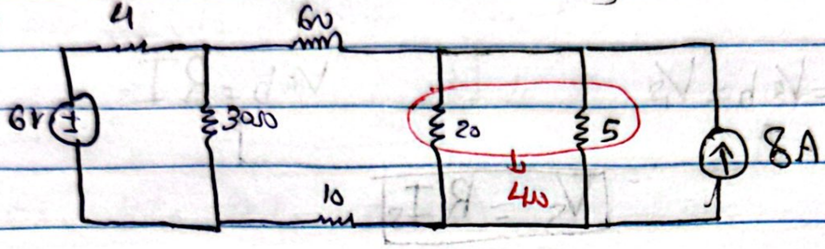
$$\boxed{V_s = R I_s}$$

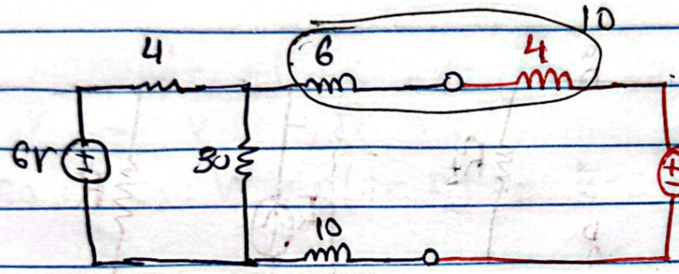
Expr 4.8



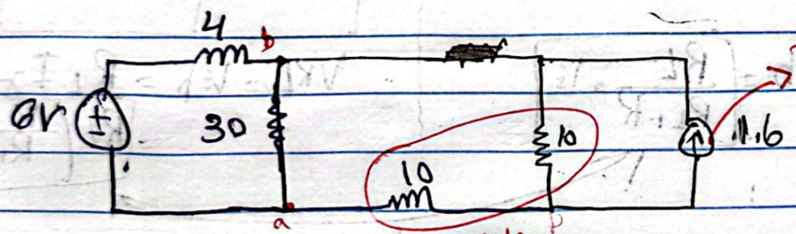
$I = \frac{40}{5} = \boxed{8A}$

$P_{6V} = ?$

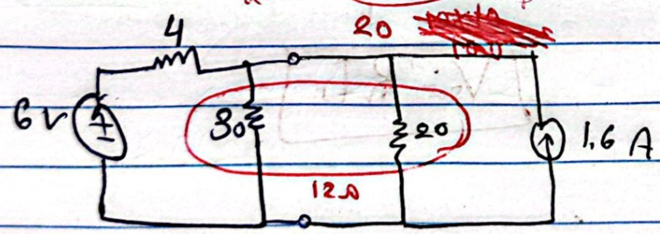


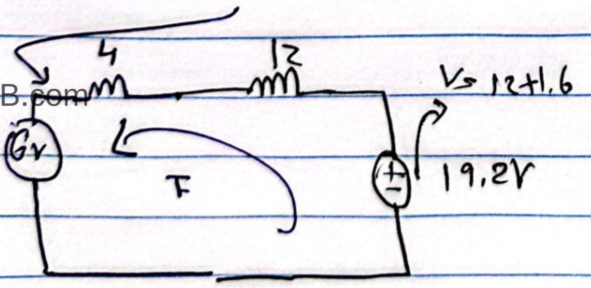


$V_s = 8 \times 4 = 32V$



$I = \frac{32}{20} = 1.6A$





$V_s = 12 \times 1.6 = 19.2V$

$\therefore I = \frac{19.2 - 6}{4 + 12}$

$= \boxed{0.825A}$

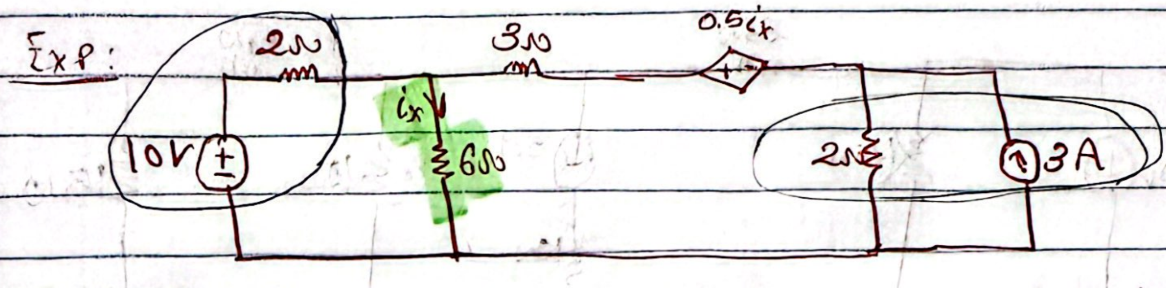
$\rightarrow P = IV$

$= 6 \times 0.825$

$= \boxed{4.95\,W}$ (abs.)

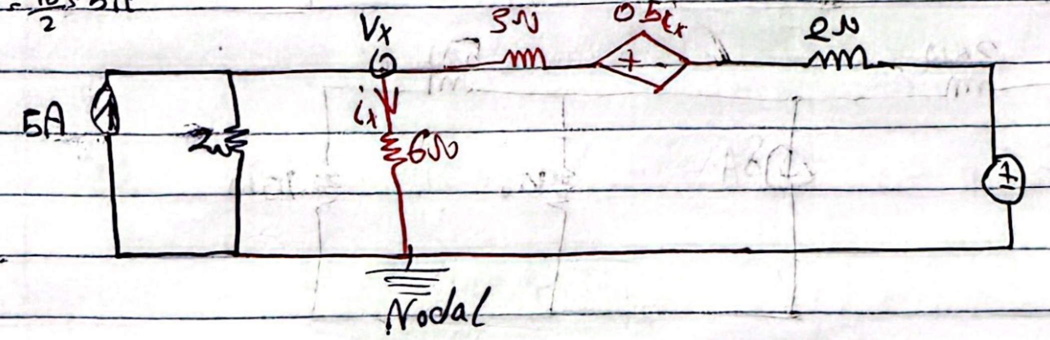
مصنوع لغيرها + حل

Exp:

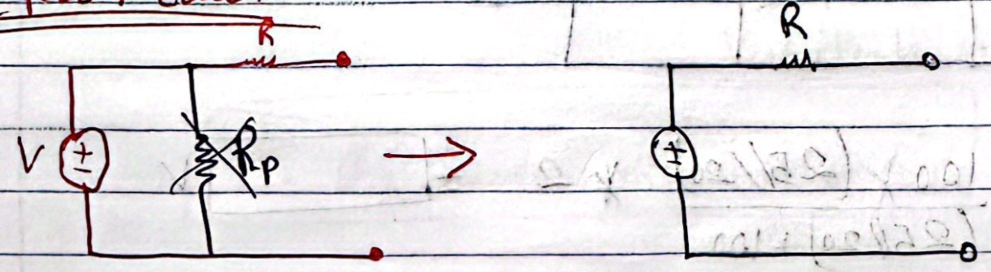


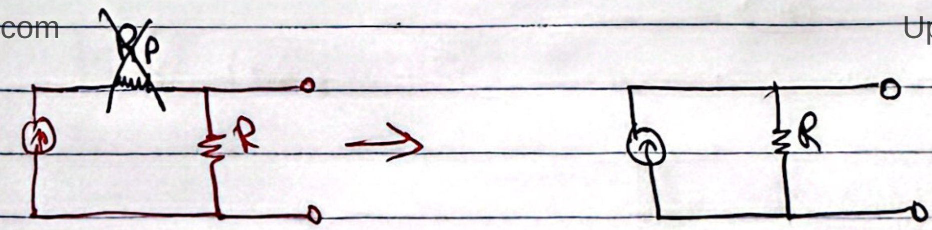
$I = \frac{10}{2} = 5A$

$V = 3 \times 2 = 6V$

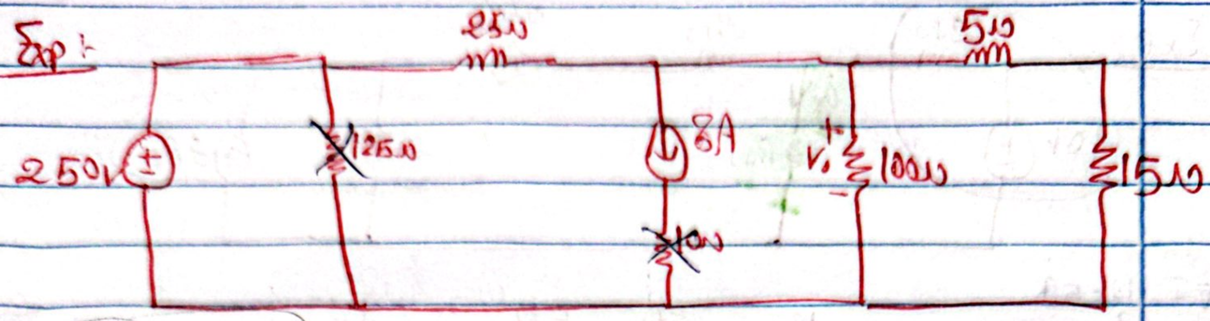


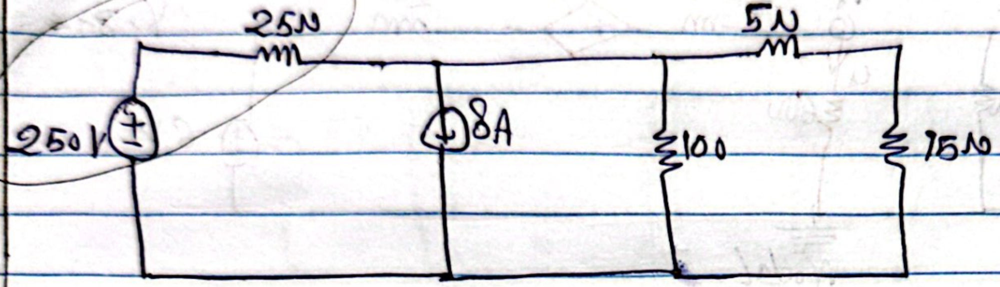
Special case:



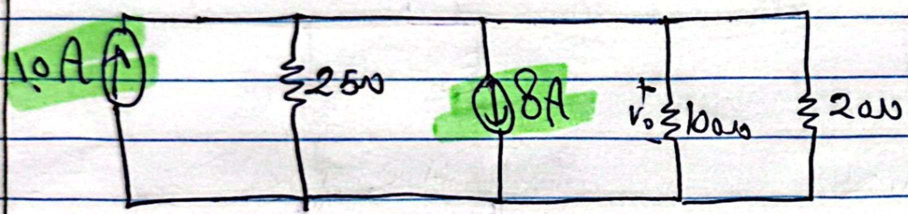


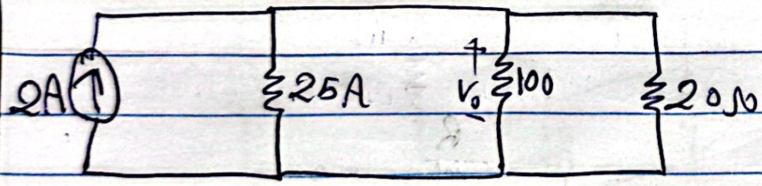
Exp :





$A = \frac{250}{25} = 10A$





$$V_o = \frac{100 \times (25//20)}{(25//20)+100} * 2 = \boxed{\quad} V$$

* superposition theorem :-

Linear circuit

↳ you can calculate the voltage or current by finding the contribution of each individual indep. source acting alone.

↳ dep. source → are left intact

Steps :- Page 101 / Notes

1. ~~kill all~~ kill all indep. sources except one indep. source find the output v_1 i_1

2. Repeat step one for each other indep sources v_2 i_2 v_3 i_3

3. find the total contribution by adding :

$$i_{tot} = i_1 + i_2 + i_3 + \dots$$

$$V_{tot} = V_1 + V_2 + V_3 + \dots$$

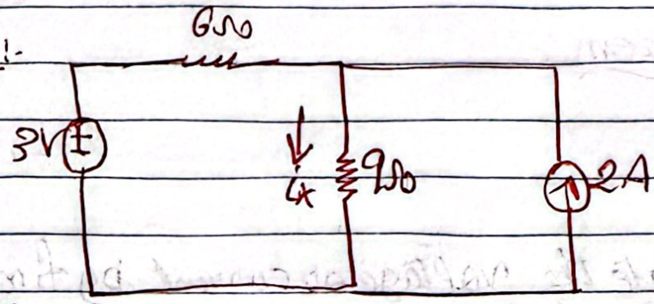
⚠ dep. sources are left intact

Kill indep sources

 S.C.

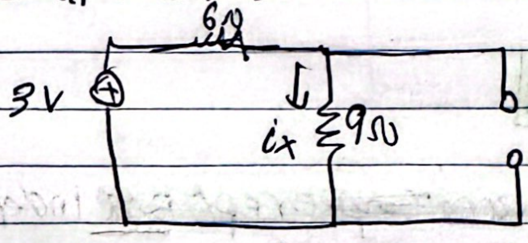
 O.C.

Exp :-



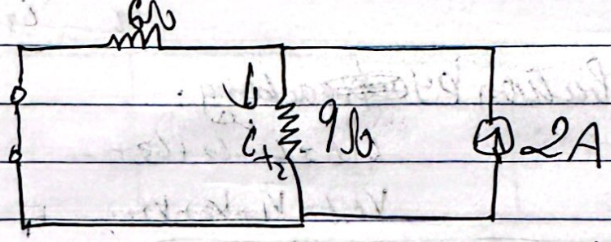
Find i_x

① i_{x_1} due to 3V — kill 2A



$$i_{x_1} = \frac{3}{15} \text{ A}$$

② i_{x_2} due to 2A — kill 3V

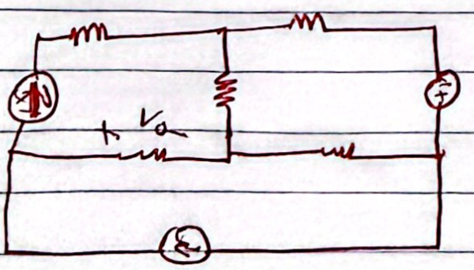


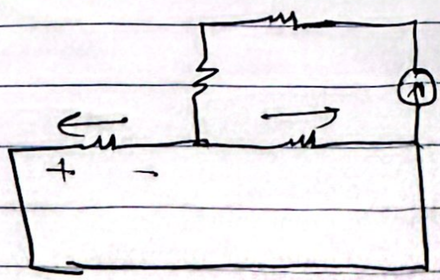
$$i_{x_2} = \frac{6}{6+9} \times 2 = \frac{12}{15} \text{ A}$$

$$\therefore i_x = i_{x_1} + i_{x_2} = \frac{3}{15} + \frac{12}{15} = 1\text{A}$$

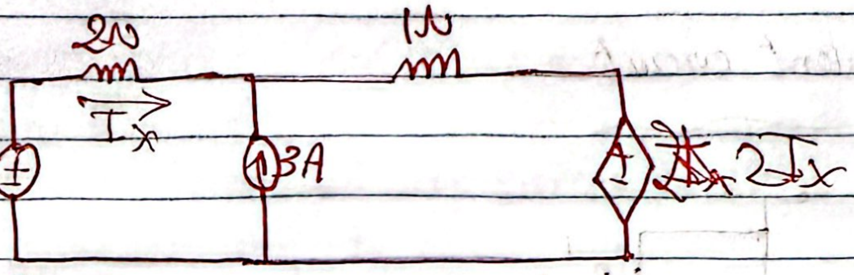
Problem 9.6

Sol



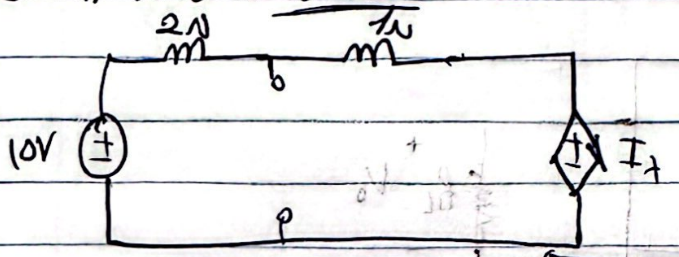


Ex:



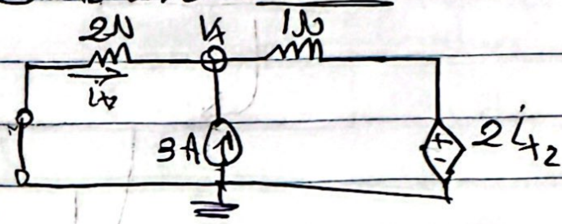
$I_x = ??$

① i_{x_1} due to 10V



$i_{x_1} = \frac{10 - 2I_{x_1}}{3}$ $\boxed{i_{x_1} = 2A}$

② i_{x_2} due to 3A



$\frac{V_x}{2} - 3 + \frac{V_x - 2i_{x_2}}{1} = 0$

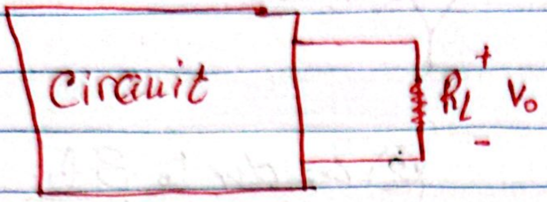
But $i_{x_2} = \frac{V_x}{2}$

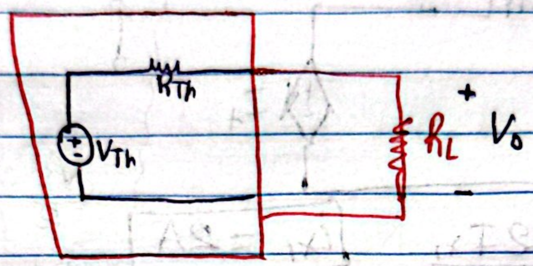
$\rightarrow \frac{5}{2} V_x = 3 \rightarrow \boxed{V_x = \frac{6}{5} V}$

$\therefore i_{x_2} = \frac{-V_x}{2} = -\frac{6}{10} = -\frac{6}{\frac{5}{2}} = \boxed{\frac{-6}{10}}$

$\therefore i_x = i_{x_1} + i_{x_2}$
$= 2 - 0.6 = \boxed{1.4A}$

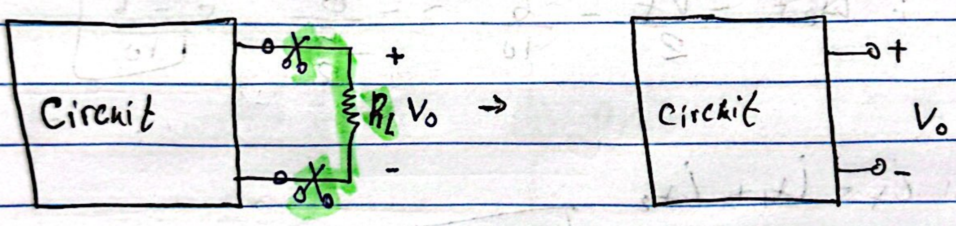
Thevenin equivalent circuit





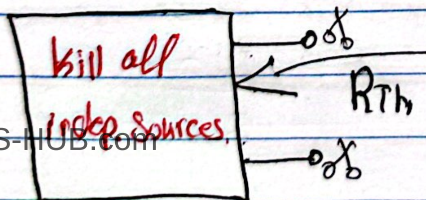
How to find V_{Th} and R_{Th}??

1. $V_{Th} = V_{o.c.}$



2. R_{Th}?

→ Case 1 No dep. Sourses:

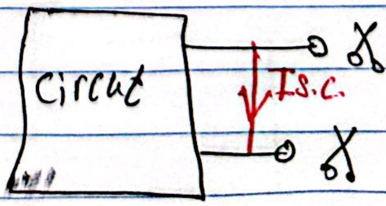


R_{Th} → series / parallel in the circuit

→ Case 2: with dep. Sources:

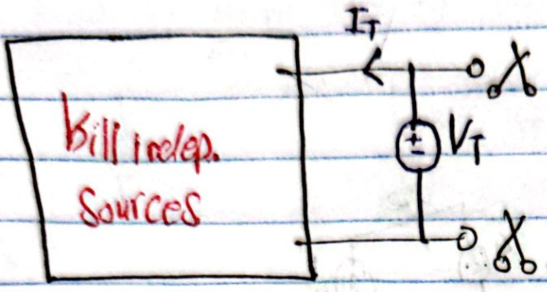
↳ method A

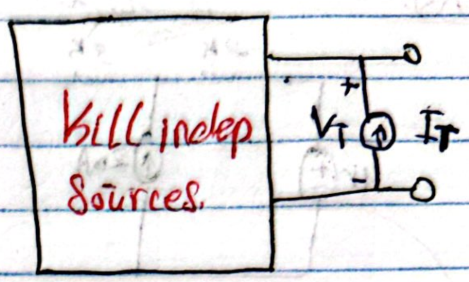
$$R_{Th} = \frac{V_{o.c.}}{I_{s.c.}}$$



↳ method B: Test source method

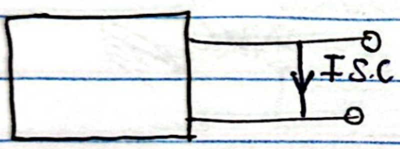
$R_{Th} = \frac{V_T}{I_T}$ | all indep. sources set to zero.



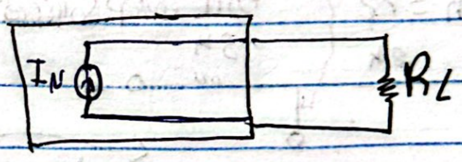


Norton eq. circuit

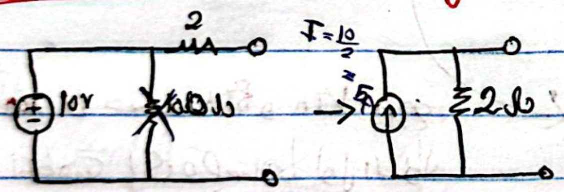
$I_{S.C.} = I_N$



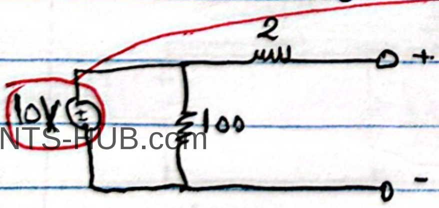
$R_N = R_{Th}$



* Note: Source Transformation



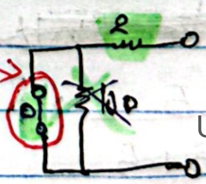
$V_{Th} = V_{o.c}$



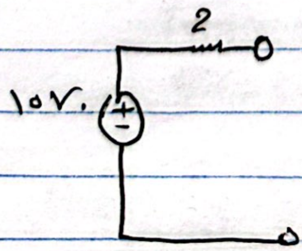
$V_{o.c} = V_{Th} = 10V.$

$R_{Th} = 2Ω$

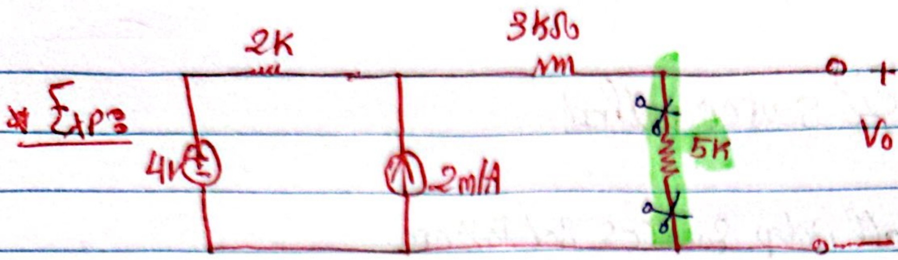
series/Parallel in the circuit



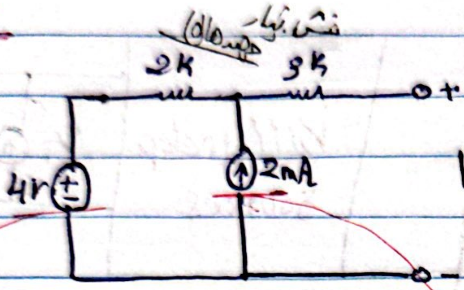
10/10 = 0



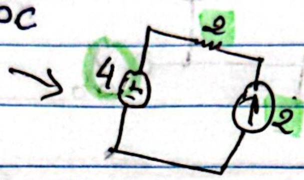
* Exp3



Sol:



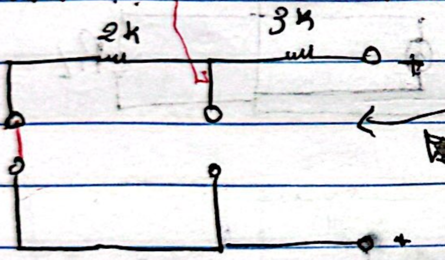
V_{oc} →



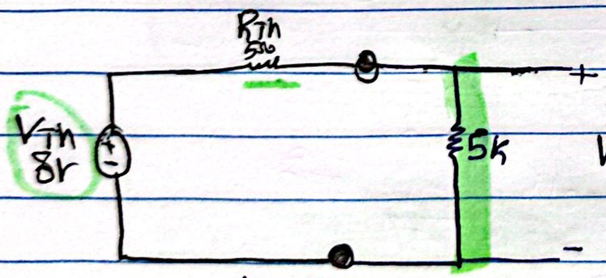
$V_{Th} = V_{o.c}$

$= (2k \times 2mA) + 4 = \boxed{8\ Volt}$

$R_{Th} = ??$ Kill indep. sources



$R_{Th} = 2+3 = 5\,k\Omega$

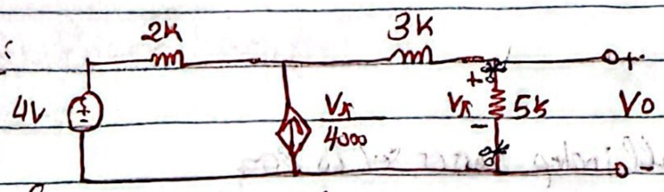


بعد ما حسبنا R_{Th} و V_{Th} بنرجع
الحلقة إلي قطعناها لول السؤال
عشان نحسب V_o

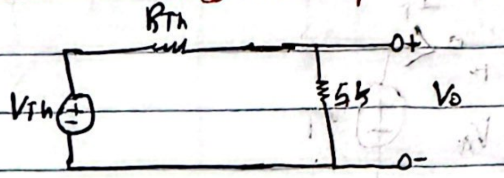
~~$V_o = 4\ Volt$~~

$\rightarrow \frac{5}{5+5} \times 8 = \frac{1}{2} \times 8 = \boxed{4V}$

Exp:

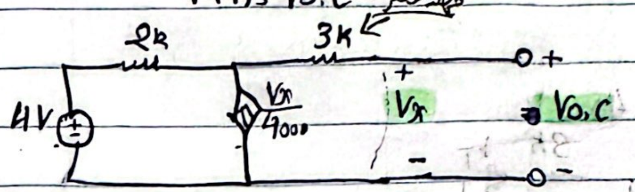


find V_o using thev. eq. circuit.

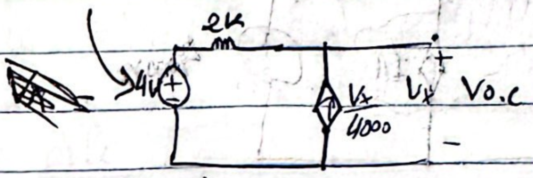


→ V_{Th}

$V_{Th} = V_{o.c}$



$V_{Th} = V_{o.c} = V_x$



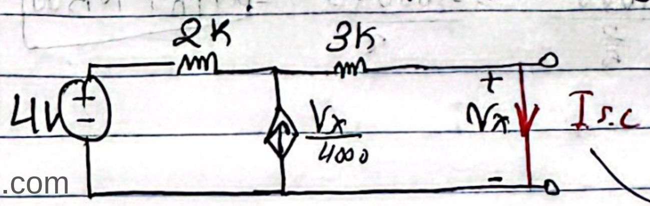
$$V_x = 4 + 2k\left(\frac{V_x}{4000}\right)$$

$$V_x = \frac{4}{1} + \frac{2V_x}{4000} \rightarrow V_x = 4 + \frac{V_x}{2}\left(1 - \frac{1}{2}\right)V_x = 4 \rightarrow V_x = \frac{4}{\frac{1}{2}} = \boxed{8\ \text{Volt}}$$

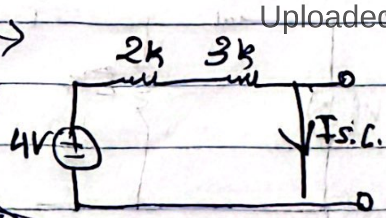
→ R_{Th}

method A

$$R_{Th} = \frac{V_{o.c}}{I_{S.C}} = \frac{8}{I_{S.C}}$$



$V_x = 0$, open circuit



So $\frac{V_x}{4000} = 0$

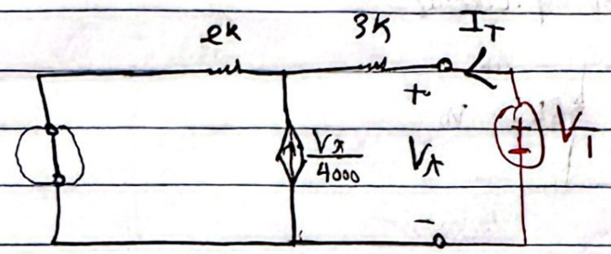
$$I_N = \frac{4}{3+2} = \frac{4}{5} = \boxed{0.8\ mA}$$

$$R_{Th} = \frac{8}{0.8}k = \boxed{10\ k\Omega}$$

OR

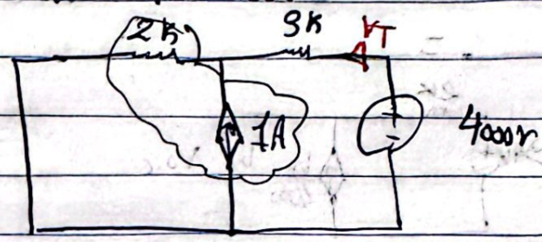
method B :-

$R_{Th} = \frac{V_T}{I_T}\Big|$ all indep. sources set to Zero.



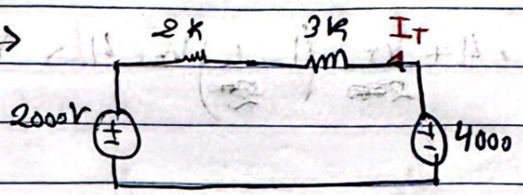
Let $V_T = 4000\,V$

$V_x = V_T = 4000\,V$



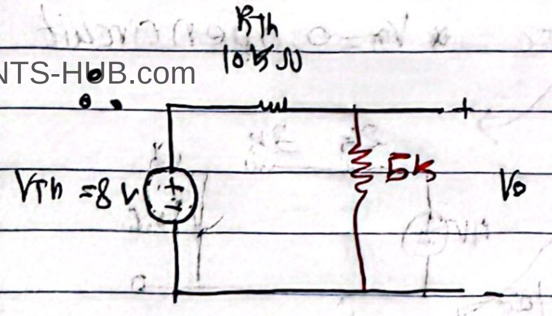
Source Trans.

$V = 2000 \times 1$
$= 2000\,V$



$I_T = \frac{4000 - 2000}{5k} = \frac{2}{5}\,A$

$R_{Th} = \frac{V_T}{I_T} = \frac{4000}{\frac{2}{5}} = \frac{4000 \times 5}{2} \Rightarrow \boxed{R_{Th} = 10k\Omega}$

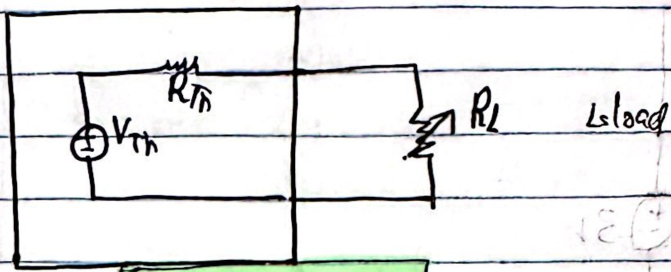


$V_o = \frac{5}{5+10} \times 8$

$V_o = \frac{8}{3}$ Volt

$\boxed{V_o = 2.666\ \text{Volt}}$

Max. Power Transfer:



$\hookrightarrow$ $V_L = \dfrac{R_L}{R_L + R_{Th}} V_{Th}$

$\hookrightarrow$ $P_L = \dfrac{V_L^2}{R_L} = \dfrac{R_L}{(R_L+R_{Th})^2} \cdot V_{Th}^2$

$$\frac{\partial P_L}{\partial R_L} = V_{Th}^2 \frac{(R_L+R_{Th})^2 - 2R_L(R_L+R_{th})}{(R_L+R_{th})^2}$$

for $\dfrac{\partial P_L}{\partial R_L} = 0$

$\rightarrow$ $(R_L + R_{th})^2 = 2R_L(R_L+R_{th})$

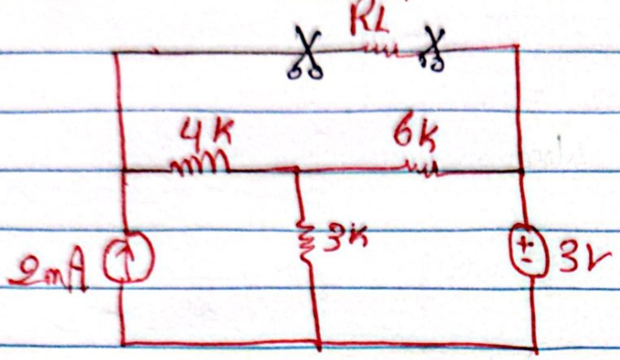
$\rightarrow$ $\boxed{R_L = R_{th}}$

$\therefore$ for max power Transfer

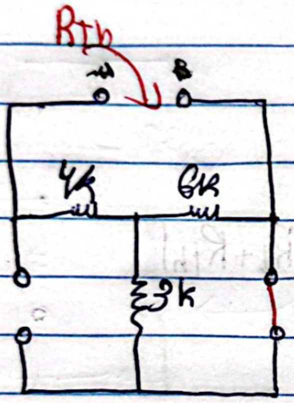
$\boxed{R_L = R_{Th}}$ & $\boxed{P_{max} = \dfrac{V_{th}^2}{4R_{th}}}$

Exp: $R_L = ??$ for P_{max}

find P_{max}:

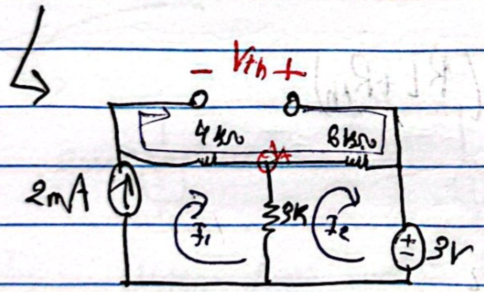


Sol:



$R_{Th} = 4 + (6 \| 3)$

$= \boxed{6\Omega}$



Nodal

$\frac{V_x - 3}{6} + \frac{V_x}{3} = 2$

$V_x - 3 + 2V_x = 12$

$3V_x = 15$

$\boxed{V_x = 5V}$

@ $I_1 = 2mA$

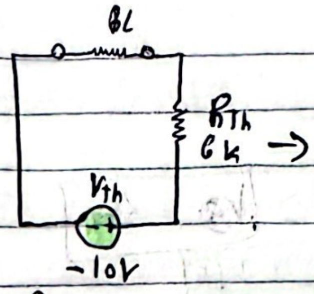
@ $I_2 \to 3 + 3(I_2 - 2mA) + 6kI_2 = 0$

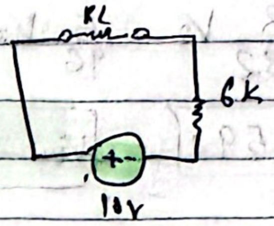
$\cancel{3I_2 - 2mA + 6kI_2 = 3}$

$3 + 3I_2 - 6 + 6I_2 = 0$

$9I_2 = \cancel{2}\ 6\ 3 \to \boxed{I_2 = \frac{3}{9} A}$

$V_{Th} = -(6k \times \frac{3}{9}) - 4k \times 2m = \boxed{-10 \text{Volt}}$





For max Power

$R_L = R_{Th} = 6\,k\Omega$

$$P_{max} = \frac{V_{Th}^2}{4R_{Th}} = \frac{10^2}{4(6)} = \boxed{\frac{25}{6}\,mW}$$

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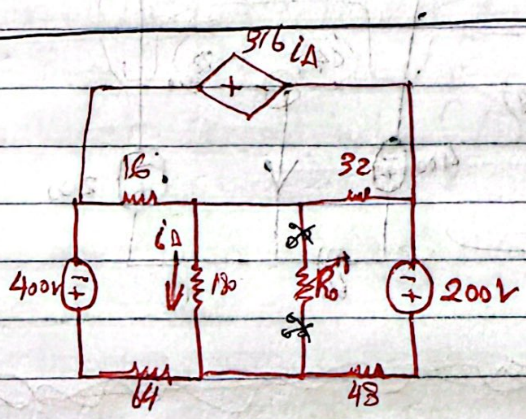
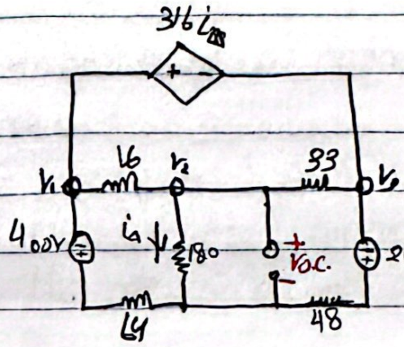


$P_{max} = ??$

$R_O = R_{Th}$ for max Power

$$R_{Th} = \frac{V_{O.C}}{I_{S.C}}$$



$\boxed{V_2 = V_{O.C}}$

$\boxed{i_\Delta = \frac{V_2}{180}}$

Super Node.

$V_1 - V_3 = 316 i_\Delta$

$\rightarrow V_1 - V_3 = \frac{316}{180} V_2$

$\boxed{V_1 - \frac{79}{45} V_2 - V_3 = 0}$ — (1)

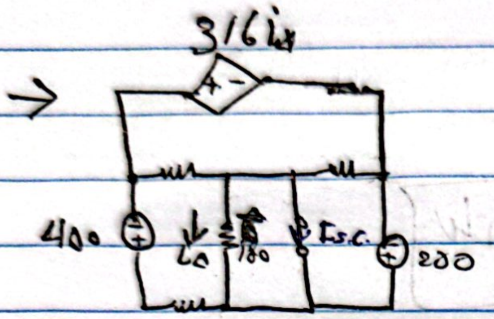
@ $V_2 \rightarrow \frac{V_2 - V_1}{16} + \frac{V_2}{180} + \frac{V_2 - V_3}{32} = 0 \Rightarrow \boxed{-\frac{1}{16} V_1 + \frac{143}{1440} V_2 - \frac{1}{32} V_3 = 0}$ — (2)

@ $V_1 \rightarrow \frac{V_1 + 400}{64} + \frac{V_1 - V_2}{16} + \frac{V_3 - V_2}{32} + \frac{V_3 + 200}{48} = 0$

$\longrightarrow$

$$\frac{5}{64}V_1 - \frac{3}{32}V_2 + \frac{5}{96}V_3 = \frac{-125}{12}$$

$\boxed{V_1 = -592}$, $\boxed{V_2 = -360} = \boxed{V_{o.c} = V_{th}}$, $\boxed{V_3 = 40}$



$i_\Delta = 0$