Toppersnotes
Unleash the topper in you

CSIR-NET

Council of Scientific & Industrial Research

PHYSICAL SCIENCE

VOLUME - IV

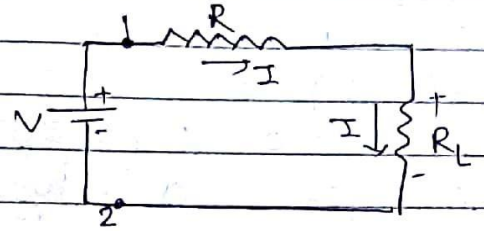
ELECTRONICS

SIERRA INNOVATIONS

ELECTRONICS

NETWORK ANALYSIS

i) Kirchoff Voltage Law:-



$$V - IR - IR_L = 0$$

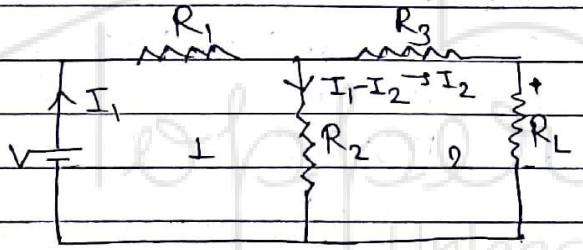
$$I = \frac{V}{R+R_L} = \frac{V}{Req_{12}} \quad (Req = R+R_L)$$

→ Sum of the voltage in any closed loop must be zero. Considering same sign convention.

Voltage drop across R $V_R = IR = \frac{VR}{R+R_L}$

$V_{R_L} = IR_L = \frac{VR_L}{R+R_L}$ } Voltage division Rule.

Ex-



loop 1 $V - I_1R_1 - (I_1-I_2).R_2 = 0$

loop 2 $(R_3+R_L)I_2 - (I_1-I_2)R_2 = 0$

$V = I_1(R_1+R_2) - I_2R_2$

$0 = -R_2I_1 + (R_3+R_L+R_2)I_2$

$$I_2 = \frac{R_2 I_1}{R_3+R_L+R_2}$$

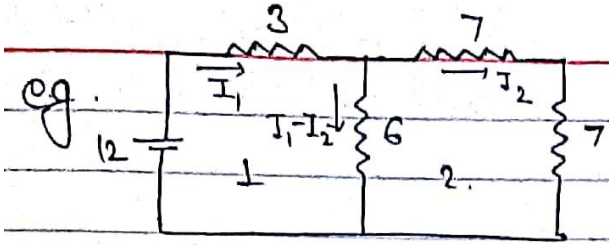
$$V = I_1(R_1+R_2) - \frac{I_1R_2^2}{R_3+R_L+R_2}$$

$$= \left[\frac{(R_1+R_2)(R_3+R_L+R_2) - R_2^2}{(R_3+R_L+R_2)}\right] I_1$$

$$I_1 = \frac{V(R_2+R_3+R_L)}{R_1R_3+R_1R_2+R_2R_3+R_1R_L+R_2R_L}$$

$$I_2 = \frac{VR_2}{R_1(R_3+R_2+R_L)+R_2(R_3+R_L)}$$

eg.



$12-3I_1-6(I_1-I_2)=0$

$9I_1-6I_2=12$

$3I_1-2I_2=4$

(ii) $14I_2-6(I_1-I_2)=0$

$8I_1+6I_2=0 \quad 6I_1=20I_2$

$I_1=-3/4\,I_2 \quad I_1=10/3\,I_2$

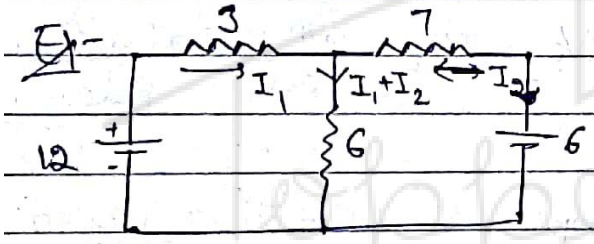
$3(-3/4\,I_2)-2I_2=4 \Rightarrow -9I_2-8I_2=16$

$I_2=-16/17 \quad 10I_2-2I_2=4$

$8I_2=4$

$I_1=5/3$ amp $\quad I_2=1/2$ Amp

Ex-



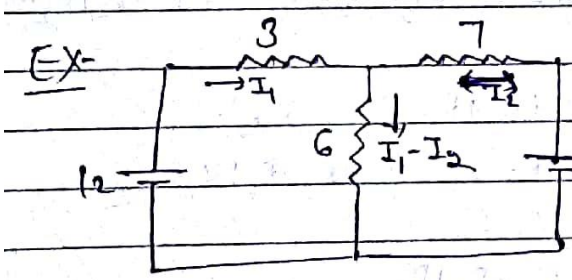
$12-3I_1-6(I_1+I_2)=0$

$6-7I_2-6(I_1+I_2)=0$

$9I_1+6I_2=12$

$6I_1+13I_2=6$

Ex-

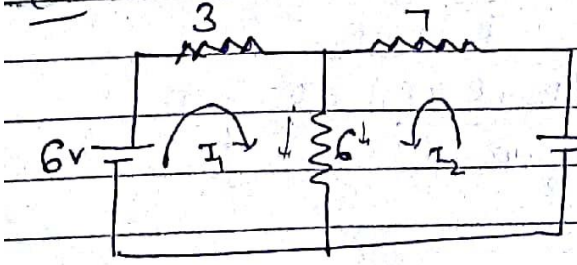


$12-3I_1-6(I_1-I_2)=0$

$6+7I_2-6(I_1-I_2)=0$

$9I_1+6I_2=12$

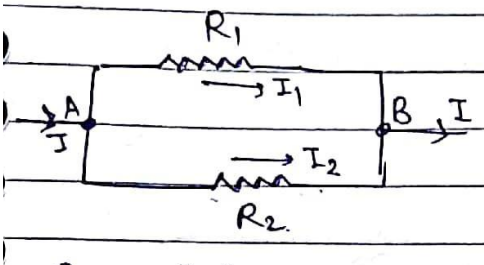
Ex-



$6-9I_1-6I_2=0$

$12-13I_2-6I_1=0$

Current division Rule :



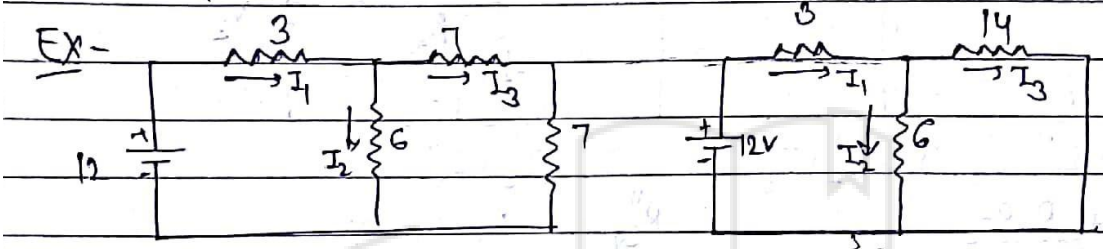
$V_{AB} = I_1R_1 = I_2R_2$

$I = I_1 + I_2 = IR$

$I_2 = \frac{IR_1}{R_1+R_2}$ $\quad I_1 = \frac{IR_2}{R_1+R_2}$

$Req = \frac{R_1R_2}{R_1+R_2}$

EX-

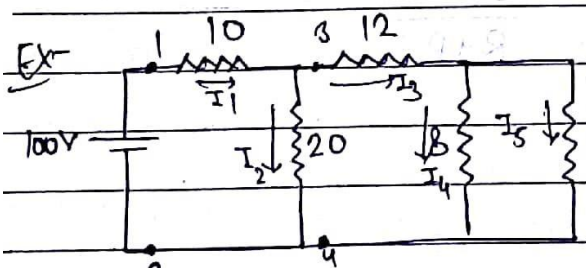


$Req = 3 + \frac{6\times14}{6+14} = 3 + 4.2 = 7.2\Omega$

$I_1 = \frac{12}{7.2} = \frac{10}{6} = 5/3$ amp.

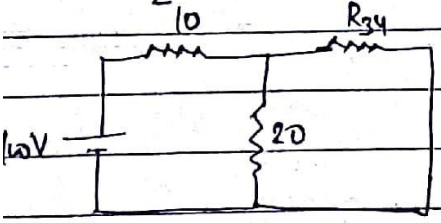
$I_2 = \frac{14\times5/3}{6+14} = \frac{7}{6}$ amp $\quad I_3 = \frac{6\times5/3}{6+14} = \frac{1}{2}$ amp

EX



$R_{34} = 12 + \frac{8\times1\Omega}{8+1\Omega} = 12 + \frac{8}{9}$ (100/240, 800/108, 2.6/13)

$= 12 + 7.5 = 19.5$



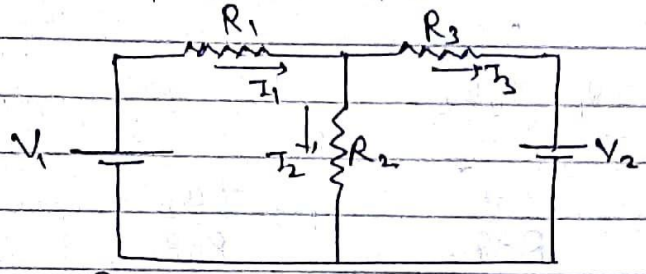
$Req = 10 + \frac{20\times19.5}{20+19.5} = 9\Omega$

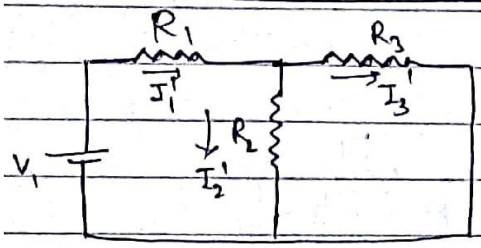
$I_1 = \frac{1\omega}{9} = 5\Omega$

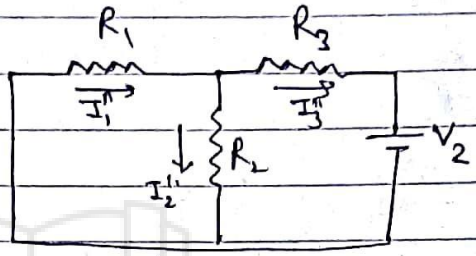
$I_2 = \frac{10\cdot5\times19.5}{20+19.5}$ $\quad I_3 = \frac{20\times I_1}{20+19.5}$

$I_4 = \frac{I_3\times1\omega}{8+1\omega}$ $\quad I_5 = \frac{8\times I_3}{108}$

Superposition Theorem :-







$I_1 = I_1' + I_1''$ $\quad I_2 = I_2' + I_2''$ $\quad I_3 = I_3' + I_3''$

$$R'_{eq} = R_1 + \frac{R_2 R_3}{R_2 + R_3}$$

$$I_1' = \frac{V_1}{R'_{eq}}$$

$$I_2' = \frac{R_3 I_1'}{R_2 + R_3}$$

$$I_3' = \frac{R_2 I_1'}{R_2 + R_3}$$

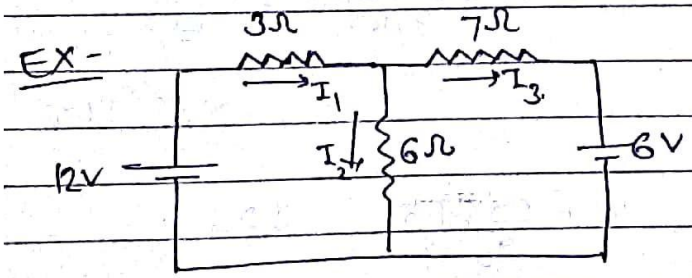
$$R''_{eq} = R_3 + \frac{R_1 R_2}{R_1 + R_2}$$

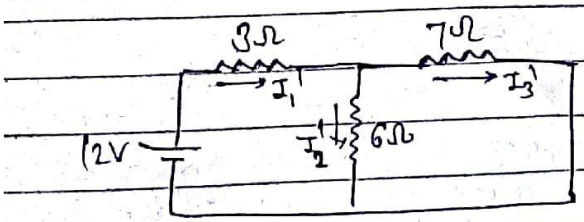
$$I_3'' = \frac{V_2}{R''_{eq}}$$

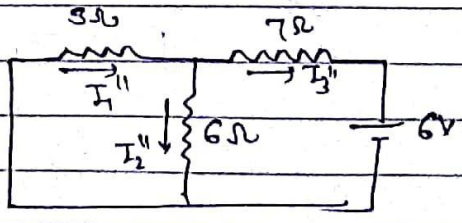
$$I_2'' = \frac{I_3'' R_1}{R_1 + R_2}$$

$$I_1' = \frac{I_3'' R_2}{R_1 + R_2}$$

EX-







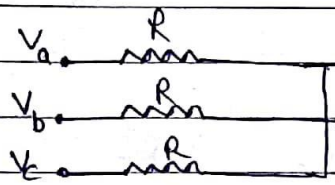
$I_1 = I_1' + I_1'' \quad I_2 = I_2' + I_2'' \quad I_3 = I_3' + I_3''$

$$R'_{eq} = 7 + \frac{3 \times 6}{9} = 9$$

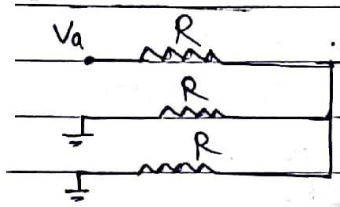
$$R''_{eq} = 3 + \frac{6 \times 7}{6+7} = 3 + \frac{42}{13} = 6.2$$

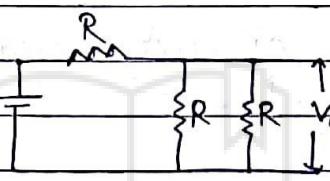
$I_1' = \frac{12}{9/3} = 1.33$ $\quad I_2' = \frac{7 \times 1.33}{13} =$ $\quad I_3' = \frac{6 \times 1.33}{13}$

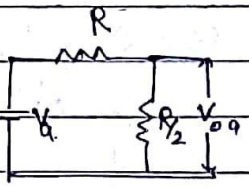
$I_3'' = \frac{6}{6.2} = .9$ $\quad I_1'' = \frac{6 \times .9}{9} = .6$ $\quad I_2'' = \frac{3 \times .9}{9} = .3$

Q. 

$V_0 = V_{0a} + V_{0b} + V_{0c}$

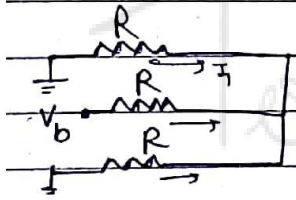


$\equiv$ 

$\equiv$ 

$I = \frac{V_a}{R + R/2}$ $\quad V_{0a} = \frac{V_a \cdot R/2}{3R/2}$

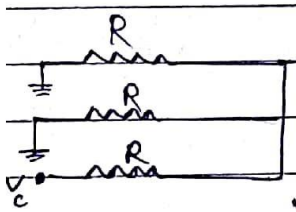
$V_{0a} = V_a/3$



V_{0b}

$\frac{0 - V_{0b}}{R} + \frac{V_b - V_{0b}}{R} + \frac{0 - V_{0b}}{R} = 0$

$V_{0b} = V_b/3$

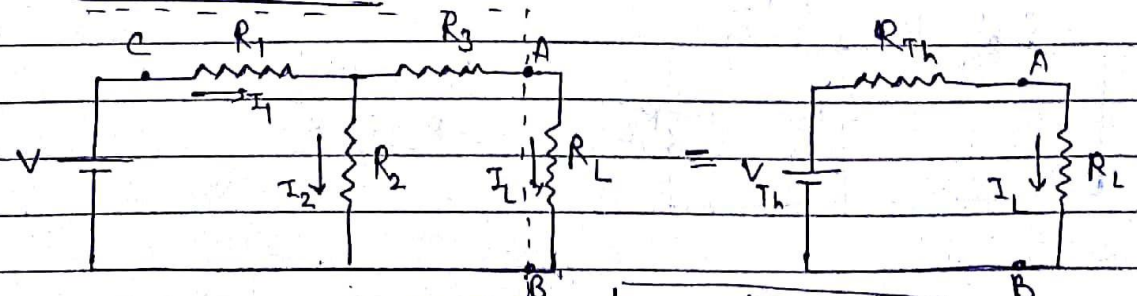


V_{0c}

$V_{0c} = V_c/3$

$V_0 = \frac{V_a}{3} + \frac{V_b}{3} + \frac{V_c}{3}$

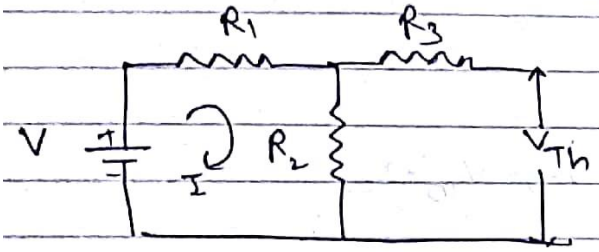
Thevenin Theorem :-



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

Superposition Theorem :-

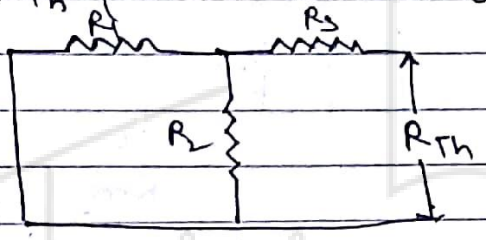
V_{Th} (open circuit Voltage) - $R_1 \to \infty$



$$I = \frac{V}{R_1+R_2}$$

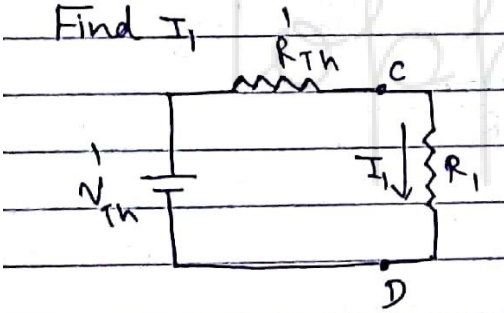
$$V_{Th} = IR_2 = \frac{VR_2}{R_1+R_2}$$

Req R_{Th} (short circuit resistance)

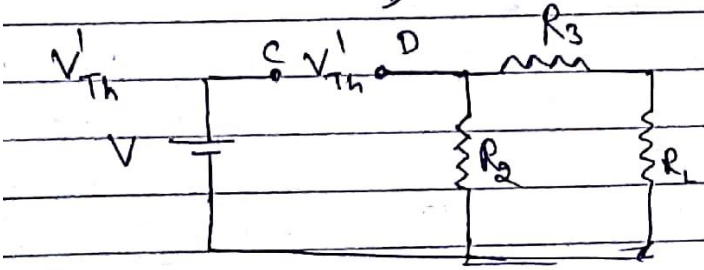


$$R_{Th} = R_3 + \frac{R_1R_2}{R_1+R_2}$$

Find I_1

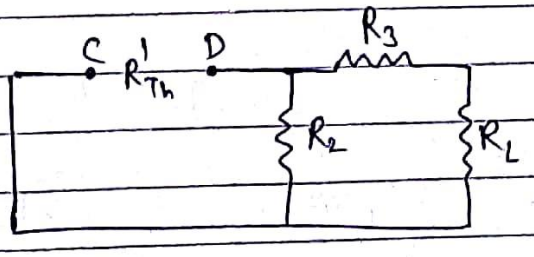


$$I_1 = \frac{V'_{Th}}{R'_{Th}+R_1}$$



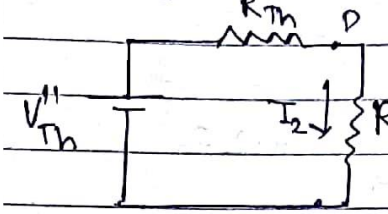
$$V'_{Th} = V$$

R_{Th}

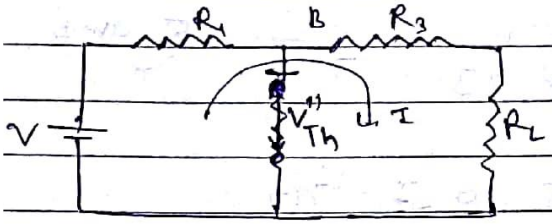


$$\frac{R_2(R_3+R_L)}{R_2+R_3+R_L}$$

Find I_2 - R''_{Th}



$$I_2 = \frac{V''_{Th}}{R''_{Th} + R_2}$$

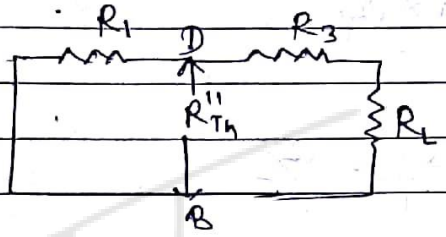


$$V - (R_1 + R_3 + R_L)I = 0$$

$$I = V / R_1 + R_3 + R_L$$

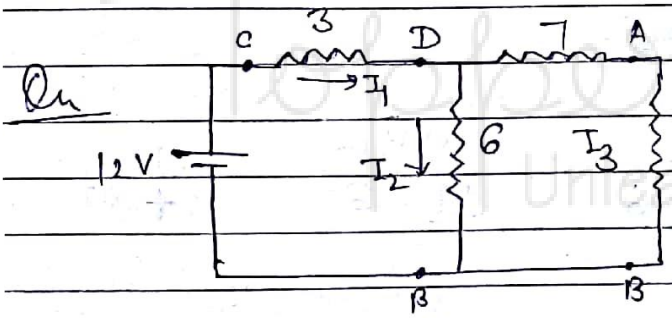
$$V''_{Th} = V - I R_1$$

$$V''_{Th} = I(R_L + R_3)$$

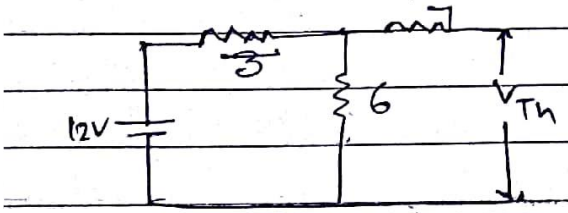


$$R''_{Th} = \frac{R_1(R_3 + R_L)}{R_1 + R_3 + R_L}$$

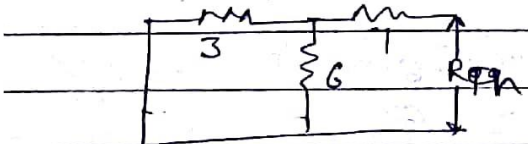
Qn



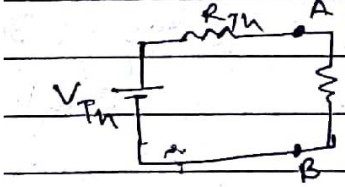
Find I_1, I_2, I_3



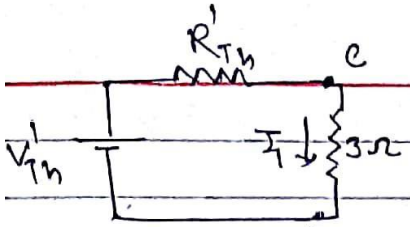
$$V_{Th} = \frac{12 \times 6}{9} = 8\ V$$

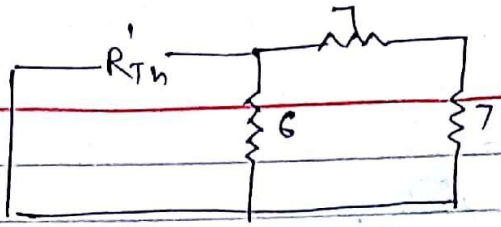


$$R_{Th} = 3 + 7 + \frac{3 \times 6}{9} = 9\ \Omega$$



$$\therefore I_3 = \frac{V_{Th}}{R_{Th} + R_L} = \frac{8}{16} = \frac{1}{2}$$

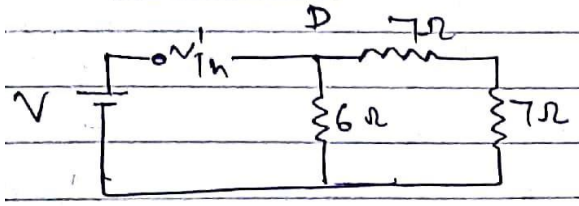


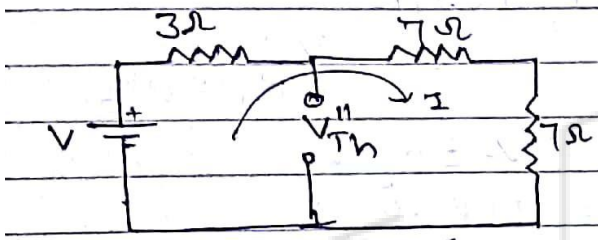


$V'_{Th} = V = 12V$

$R'_{Th} = \frac{6 \times 14}{6+14} = 4.2\,\Omega$

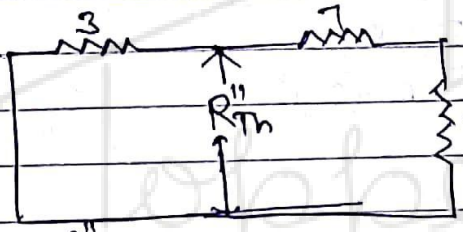
$I_1 = \frac{V'_{Th}}{R'_{Th}+3} = \frac{120}{7 \times \frac{2}{6}} = 5/3$ amp





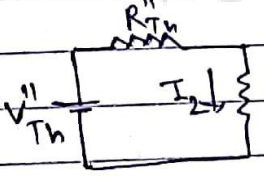
$12 - 17I = 0 \quad I = 12/17$

$V''_{Th} = 14 \times 12/17$



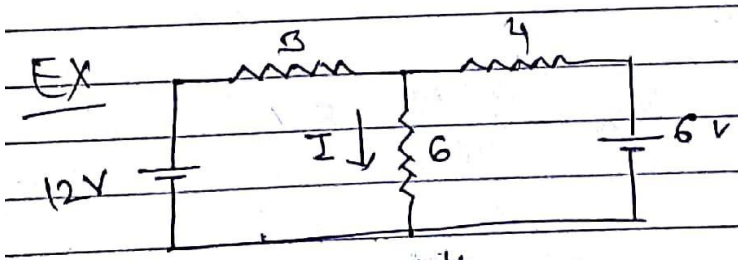
$R''_{Th} = \frac{3 \times 14}{17} = 42/17$

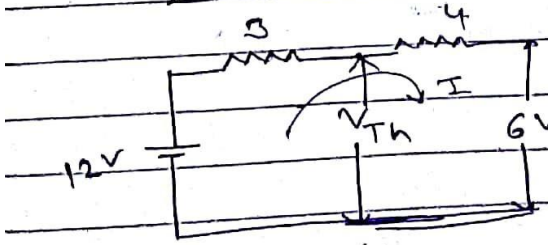
$I_2 =$



$I_2 = \frac{V''_{Th}}{R''_{Th}+6} = \frac{14 \times 12/17}{\frac{42}{17}+6} = \frac{14 \times 12}{42+6 \times 17}$

EX



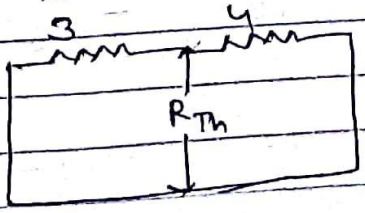


$12 - 7I - 6 = 0$

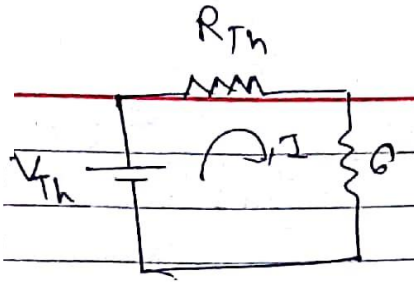
$I = 6/7$

$V_{Th} = 6 - 4 \times 6/7 = 6 - 24/7 = 6 - 3.4$

$= 2.6V$



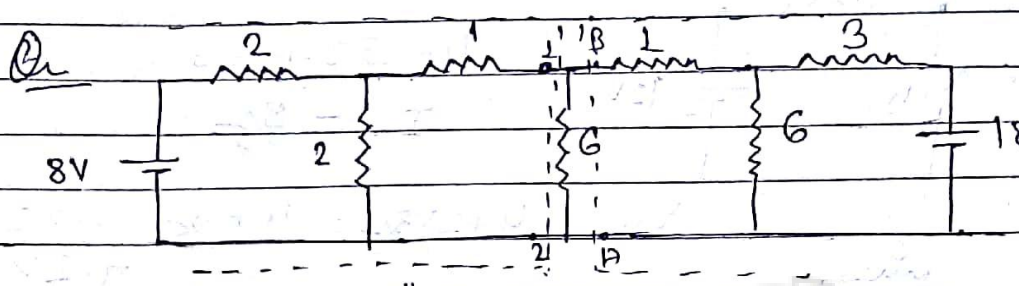
$R_{Th} = \frac{4 \times 3}{4+3} = \frac{12}{7}$

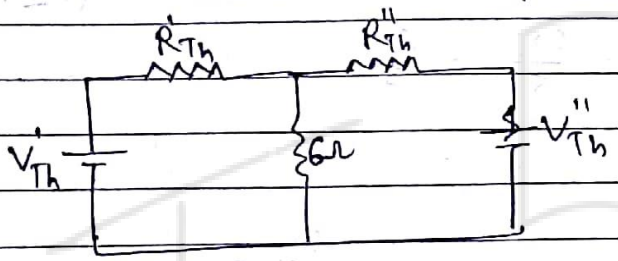


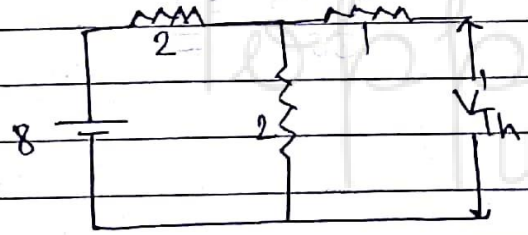
$$26 = \left(6 + \frac{12}{I}\right) I$$

$$I = \frac{2.6 \times 7}{54} = \frac{9.1}{27} \text{ amp.}$$

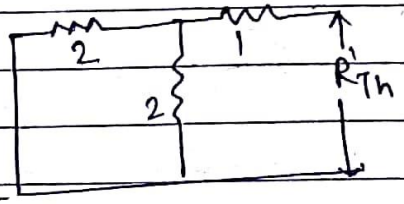
Q.



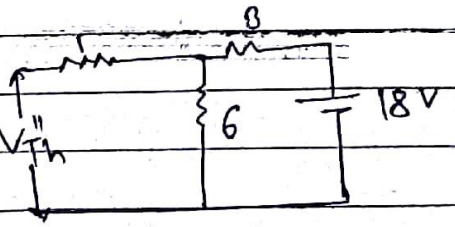




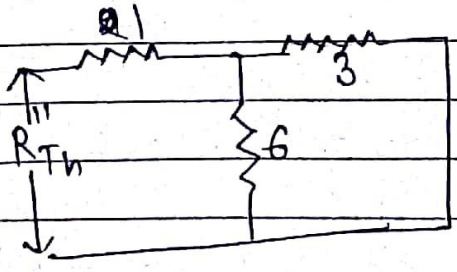
$$V_{Th} = \frac{8 \times 2}{4} = 4$$



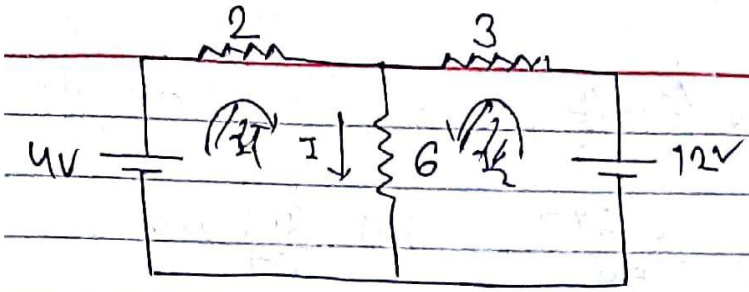
$$R'_{Th} = 3$$



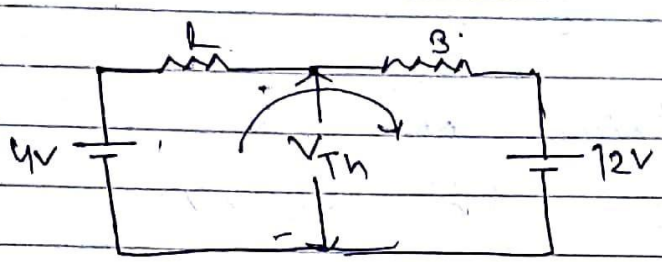
$$V''_{Th} = \frac{2}{9} \times 6 = 12$$



$$R''_{Th} = 1 + \frac{2 \times 3}{5} = 3$$



$I = I_1 + I_2$

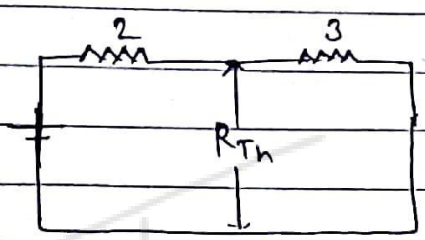


$4 - 5I + 12 = 0$

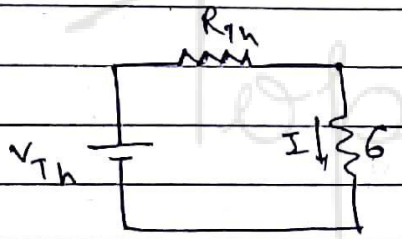
$I = -8/5$

$V_{Th} = 4 + 2 \times 8/5 = 4 + 16/5 = 4 + 3.2$

$7.2V$

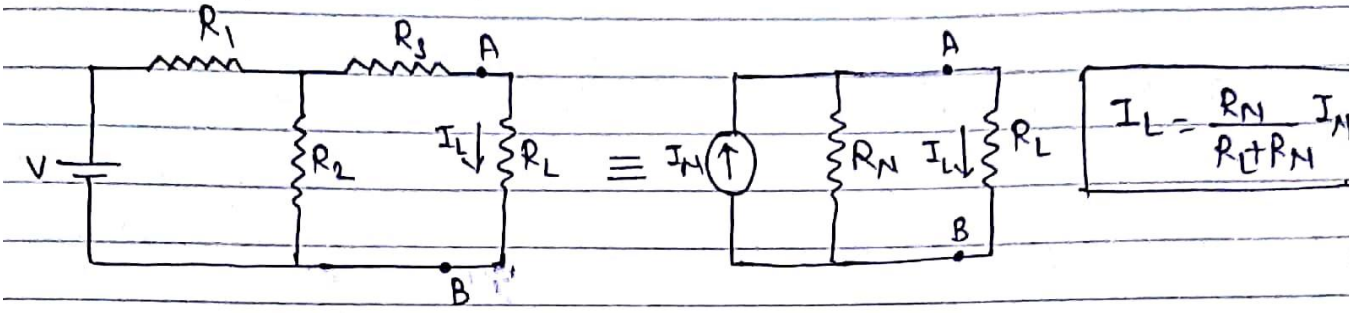


$R_{Th} = \frac{2 \times 3}{5} = 6/5$



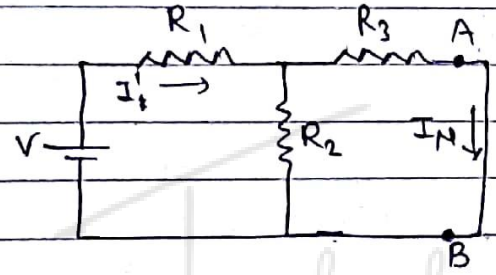
$\frac{7.2}{6/5 + 6} = I = \frac{7.2 \times 5}{36} = 1$

Norton's Theorem :-



$$I_L = \frac{R_N}{R_L + R_N} I_N$$

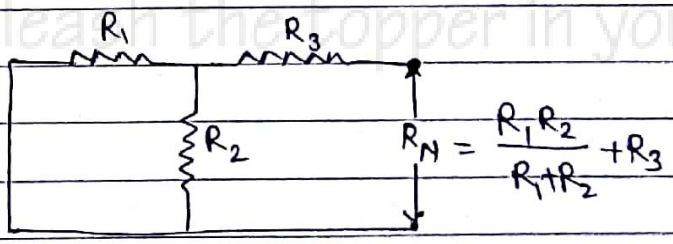
I_N = Short circuit current



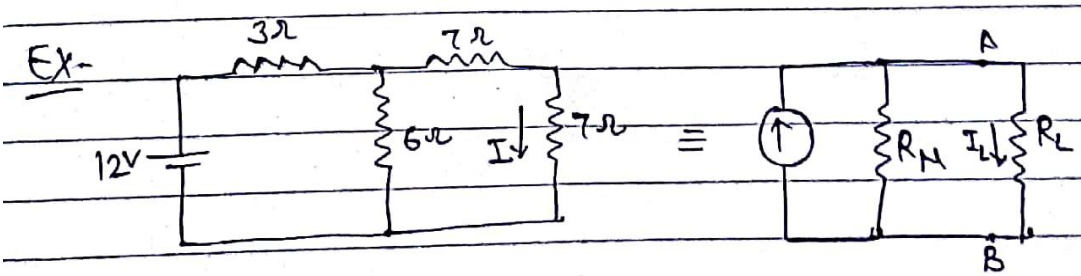
$$I' = \frac{V}{R_1 + \frac{R_2 R_3}{R_2 + R_3}}$$

$$I_N = \frac{R_2}{R_2 + R_3} I'$$

R_N (similar to R_{Th})



Ex-



$$R_N = \frac{3 \times 6}{9} + 7 = 9\Omega$$

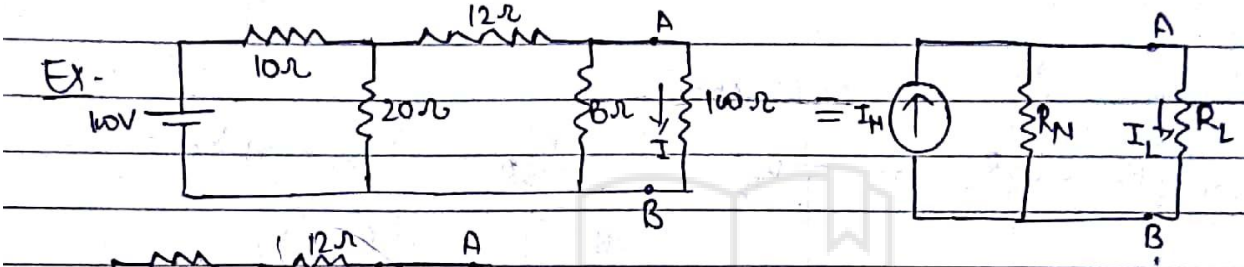
$$I_N = \frac{6}{13} I'$$

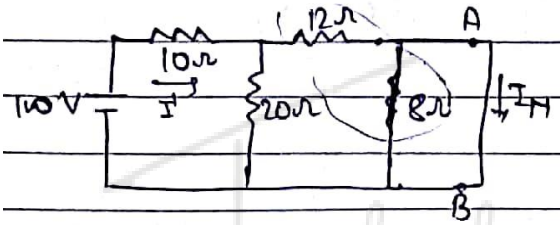
$$I' = \frac{12}{3+\frac{42}{13}} = \frac{12\times13}{81} = \frac{52}{9}\text{ amp.}$$

$$I_N = \frac{6}{13}\times\frac{12\times13}{81} = \frac{72}{81} = \frac{8}{9}\text{ amp}$$

$$I_L = \frac{9}{7+9}\times\frac{72}{81} = \frac{9}{16}\times\frac{8}{9} = \frac{1}{2}\text{ amp.}$$

Ex-





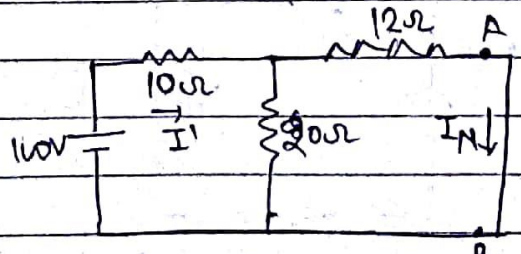
$$I' = \frac{140}{10+\frac{20\times20}{20+20}} = \frac{140}{10+10} = \frac{140}{20} = 7\text{ amp.}$$

$$I_N = \frac{20}{40}I' = \frac{7}{2}\text{ amp.}$$

$$R_N = 10 + \frac{20\times20}{40} = 10+10 = 20\,\Omega$$

$$I_L = \frac{R_N}{R_L+R_N}I_N = \frac{20}{20+140}\times\frac{7}{2} = \frac{10\times7}{120} = \frac{7}{12}\text{ amp.}$$

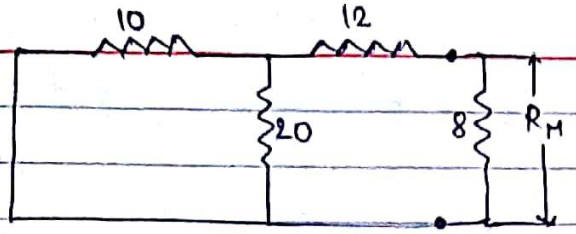
=



$$I_1 = \frac{140}{10+\frac{20\times12}{20+12}} = \frac{40}{7}$$

$$I_N = \frac{20}{32}I' = \frac{20}{32}\times\frac{40}{7} = \frac{25}{7}$$

$$R_N = 10 + \frac{20\times12}{32} =$$

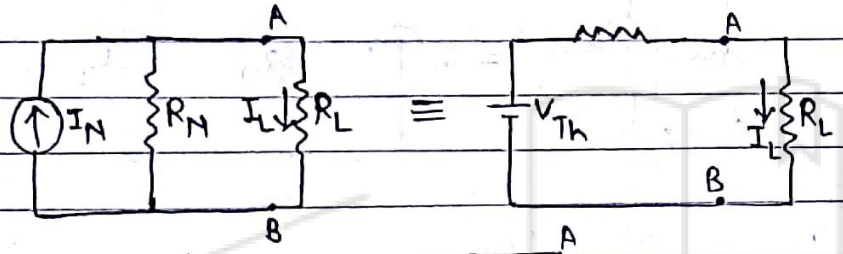


$R_{N_1} = R_1 = \frac{10 \times 20}{30} = \frac{20}{3} = 6.6$

$R_N = \frac{18.6 \times 8}{18.6 + 8} = \frac{18.6 \times 8}{26.6}$

$= 5.6\Omega$

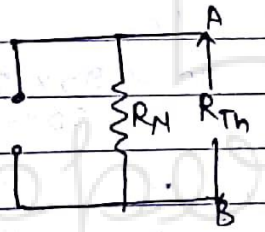
$I_L = \frac{R_N}{R_N + R_L} I_N = \frac{5.6}{5.6 + 100} \times \frac{25}{7} = \frac{5.6 \times 25}{105.6 \times 7} = 0.19$ amp.



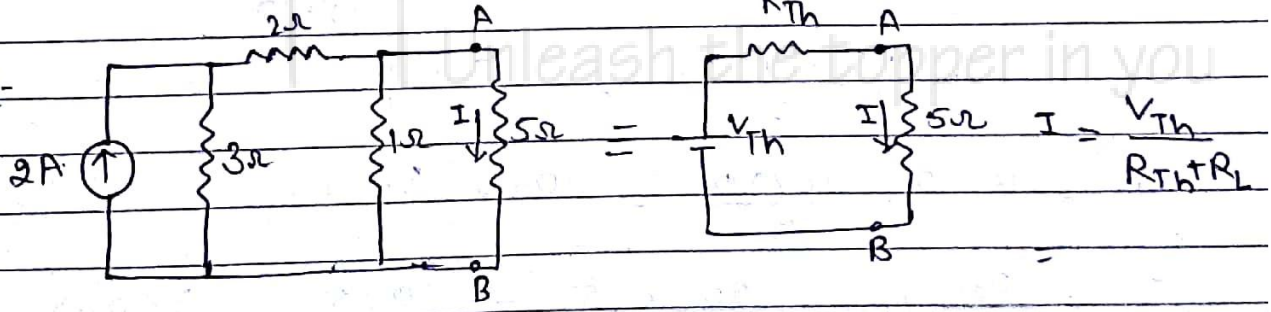
$V_{Th} = I_N R_N$

$R_{Th} = R_N$

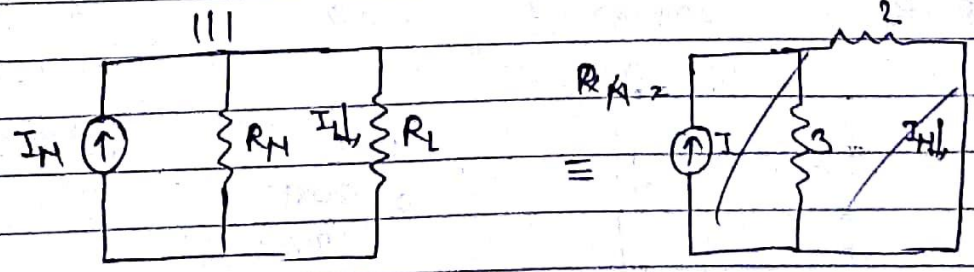
Ex-



Ex-

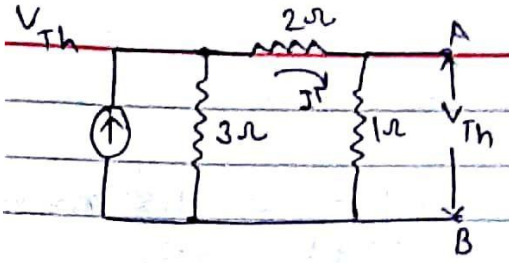


$I = \frac{V_{Th}}{R_{Th} + R_L}$ =



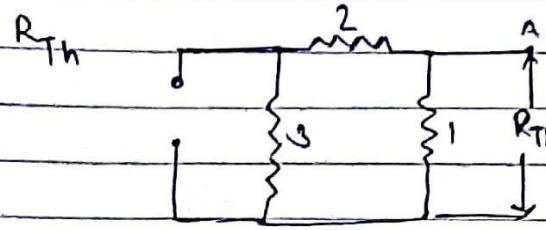
$I_N = 3/5 \times I = 3/5 \times 2 = 6/5$ amp. $I_N = \frac{3}{5} \times I = 3/5 \times 2 = 6/5$

$R_N =$



$$I' = \frac{3}{3+3} I = \frac{3}{6} \times 2 = 1 \text{ amp.}$$

$$V_{Th} = 1 \times 1 = 1 \text{ V}$$



$$R_{Th} = \frac{5 \times 1}{6} = \frac{5}{6}\Omega$$

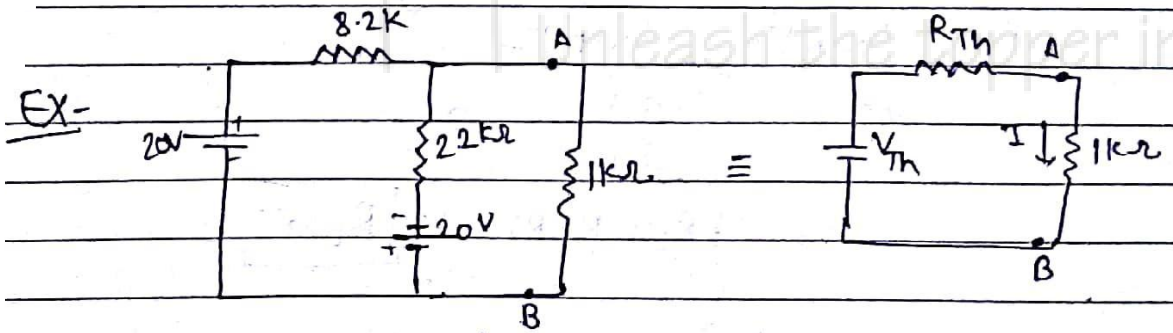
$$I = \frac{V_{Th}}{R_{Th}+R_L} = \frac{1}{5/6+5} = \frac{6}{35} \text{ amp.}$$

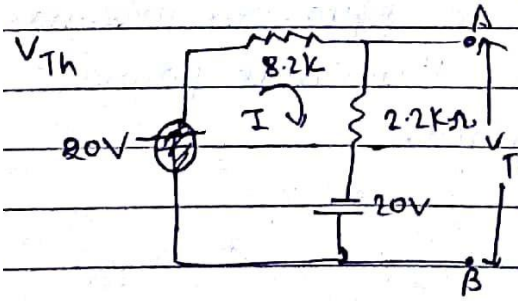
$$V_{Th} = I_N R_N \Rightarrow I_N = \frac{V_{Th}}{R_{Th}} = \frac{1}{5/6} = \frac{6}{5} \text{ amp.}$$

$$I_L = \frac{R_N}{R_L+R_N} I_N = \frac{5/6}{5+5/6} \times \frac{6}{5} = \frac{6}{35} \text{ amp.}$$

V_{Th} - open circuit voltage

EX-





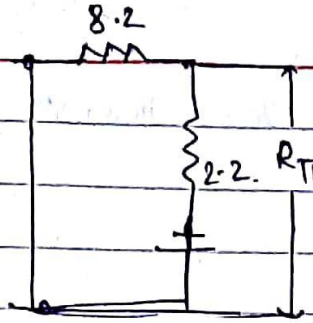
$$-20 + 8.2I + 2.2I - 20 = 0$$

$$I = \frac{40}{10.4} \text{ mamp.}$$

$$V_{Th} = V_{Th} - 2.2 \times \frac{40}{10.4} + 20 = 0$$

$$V_{Th} = -20 + \frac{2.2 \times 40}{10.4}$$

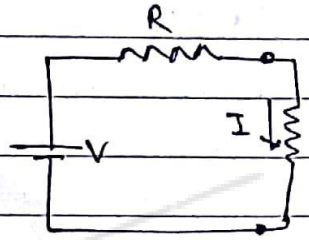
$$= -20 + \frac{88}{52} \approx -11.5 \text{ V}$$



$$R_{Th} = \frac{8.2 \times 2.2}{8.2+2.2} = 1.73\ K\Omega$$

$$I = \frac{V_{Th}}{R_L + R_{Th}} = \frac{-11.5}{1.73+1} = \frac{-11.5}{2.73}\ mamp$$

Maximum Power Transfer Theorem :-



Max power transfer to the load when load resistance is equal to the internal resistance to the source

Power transfer to the load-

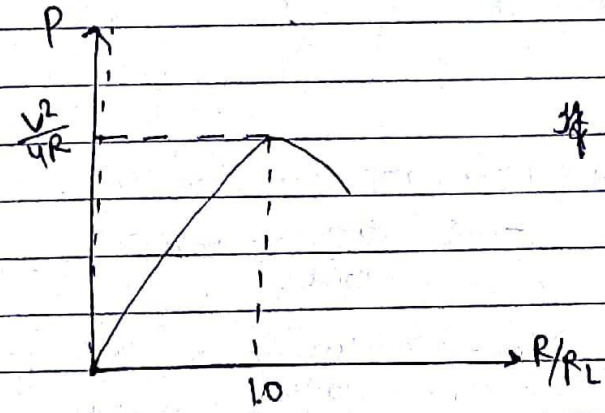
$$P = I^2 R_L = \frac{V^2}{(R+R_L)^2} R_L$$

$$\boxed{\frac{dP}{dR_L} = 0} \Rightarrow$$

$$\frac{dP}{dR_L} = \frac{V^2}{(R+R_L)^2} - \frac{2V^2 R_L}{(R+R_L)^3} = 0$$

$$V^2 - \frac{1 - 2R_L}{R+R_L} = 0$$

$$2R_L = R + R_L \Rightarrow \boxed{R_L = R}$$



If R_L should be equal to internal resistance then max. power will transfer.