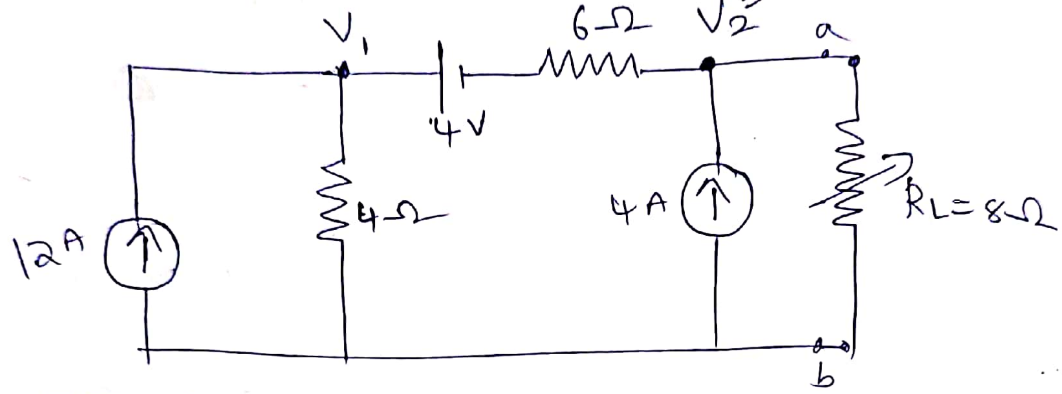
ALM-3 Solutions

① Thevenin's theorem. Calculate current across 8Ω resistor.



To find V_{th} — open circuit R_L. Apply nodal Analysis

At V_1

$$\frac{V_1}{4} + \frac{V_1 - 4 - V_{th}}{6} = 12$$

$$3V_1 + 2V_1 - 8 - 2V_{th} = 144$$

$$5V_1 - 2V_{th} = 152 \longrightarrow (1)$$

At V_2

$$\frac{V_{th} + 4 - V_1}{6} = 4$$

$$-V_1 + V_{th} = 20 \longrightarrow (2)$$

$$\boxed{\begin{array}{c} V_1 = 64V \\ V_{th} = V_2 = 84V \end{array}}$$

To find R_{th}

Voltage source — Short circuit

Current source — open circuit

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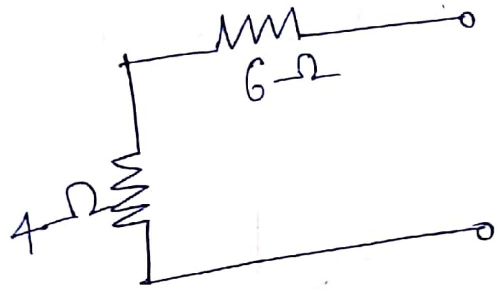
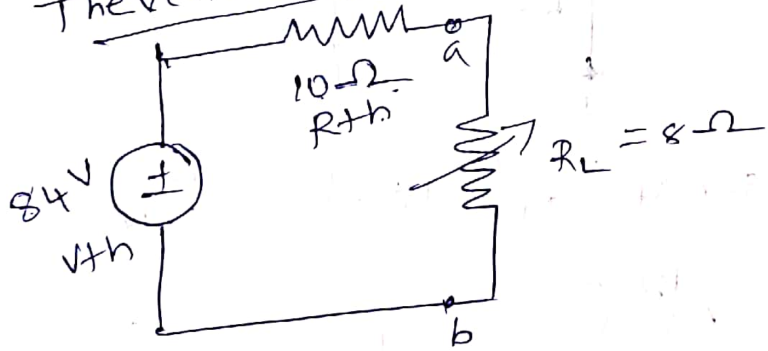


$R_{th} = 6+4 = 10\Omega$

Thevenin's equivalent Circuit



Current across R_L

$$\therefore I_L = \frac{V_{th}}{R_{th}+R_L} = \frac{84}{10+8} = 4.67A$$

$$\boxed{\therefore I_L = 4.67A}$$

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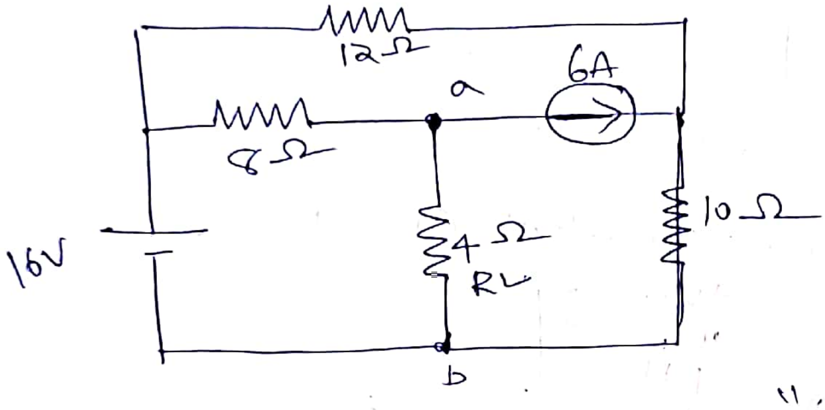
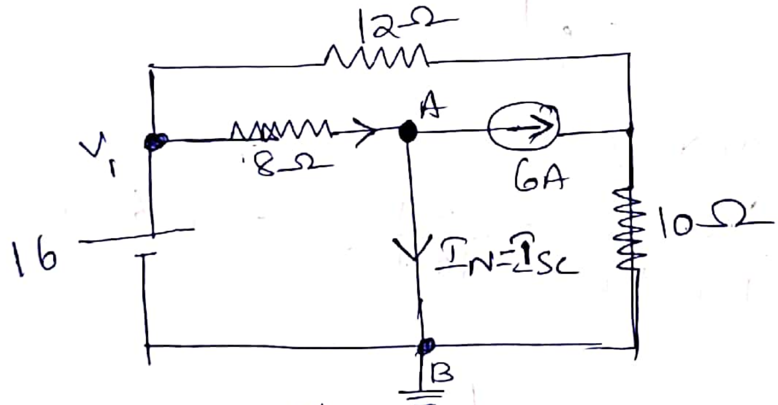
(2) Norton's theorem. find current across 4Ω



Sol:- Short circuit "R_L" to find "I_N"



From the 1^{st} mesh we can directly write.

$\boxed{V_1 = 16V}$

current through 8Ω resistor $= \frac{V_1}{8}$

$$I_{8\Omega} = \frac{16}{8} = 2A$$

$$\boxed{I_{8\Omega} = 2A}$$

Apply. KCL at node A. $\Rightarrow I_{8\Omega} = I_N + 6$

Sum of the currents entering a node = Sum of the currents leaving a node.

$$I_{sc} = I_N = I_{8\Omega} - 6 = 2 - 6 = -4A$$

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$$I_{8\Omega} = I_N + 6$$

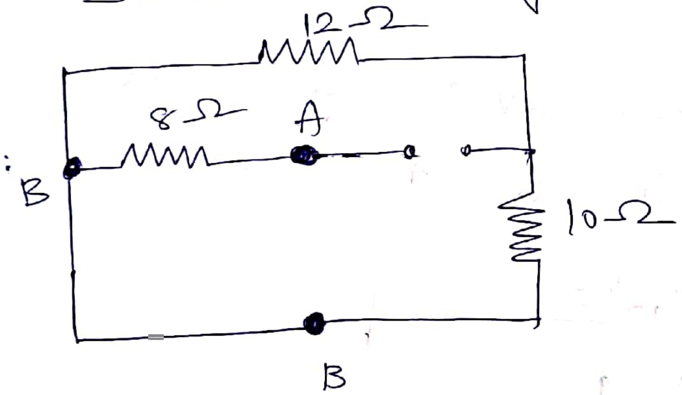
$$I_N = I_{8\Omega} - 6 = 2 - 6 = -4A$$

$$\boxed{I_N = -4A}$$

To find R_N

open circuit current source.

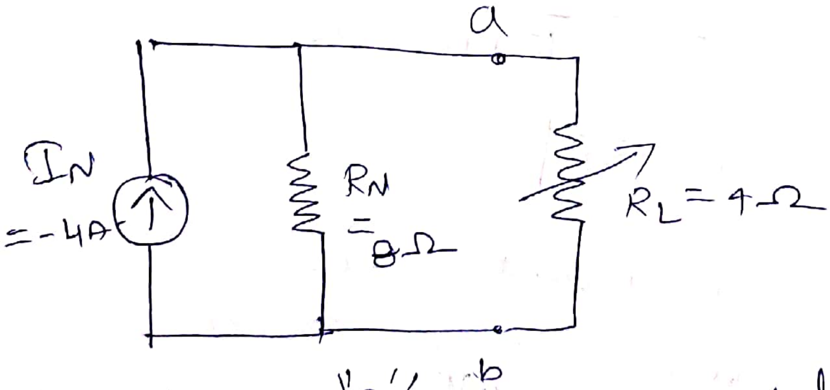
Short circuit voltage source.



R_N = Resistance between node A and B

$$\boxed{R_N = 8\Omega}$$

Norton's equivalent circuit



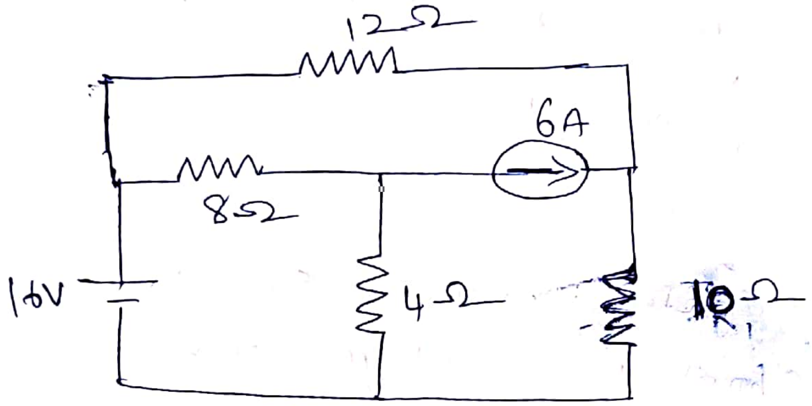
Current across "R_L" ⇒ Apply current division rule.

$$I_L = -4 \times \frac{8}{8+4}$$

$$\boxed{I_L = -2.67A}$$

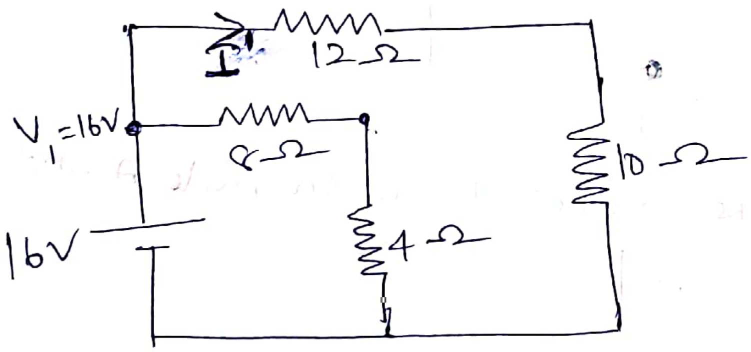
$$= \frac{-8}{3} = -2.67A$$

③ Superposition theorem find current across 12Ω



Sol:-

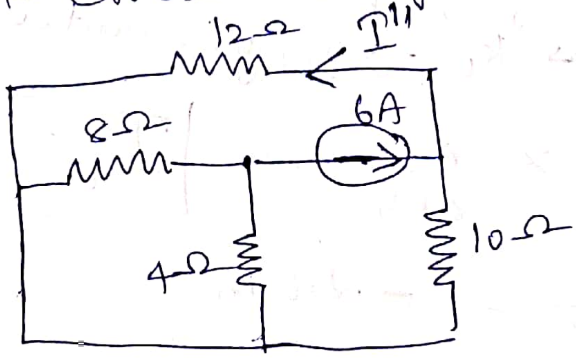
Consider 16V voltage source. open circuit current source.

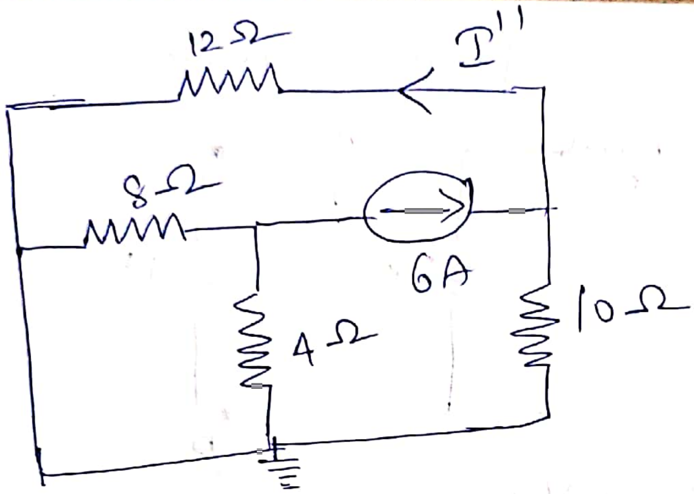


$$I' = \frac{V}{R} = \frac{16}{12+10} = \frac{16}{22}$$

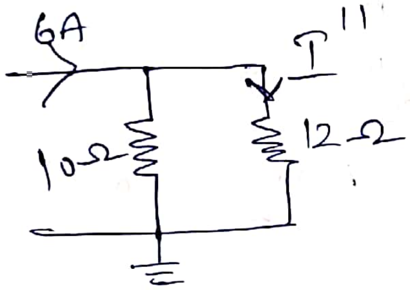
$$\boxed{I' = 0.73A}$$

Consider 6A current source. Short circuit voltage source.





Here $10\Omega \| 12\Omega$ we can re-draw it as



Apply current division rule.

$$I'' = 6 \times \frac{10}{10+12}$$

$$I'' = \frac{60}{22}$$

$$\boxed{I'' = 2.73A}$$

By superposition $I_{12\Omega} = I' - I''$

$$= 0.73 - 2.73$$

$$\boxed{I_{12\Omega} = -2A}$$

∴ Current across 12Ω resistor is

$$\boxed{I_{12\Omega} = -2A}$$

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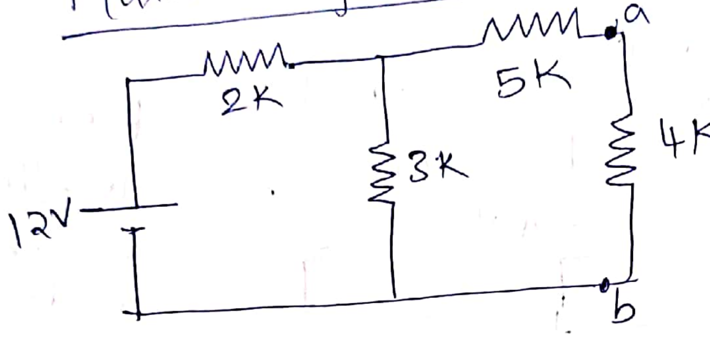
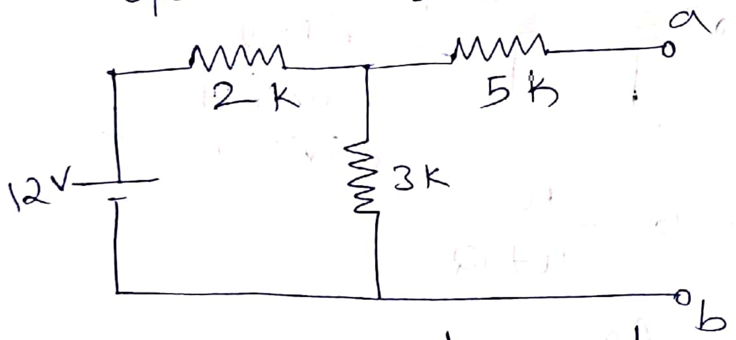
(7) Maximum power transfer theorem



Sol:- <u>To find V_{th}</u>

open circuit "R"



Apply voltage division rule.

$$V_{th} = \text{Total voltage} \times \frac{\text{across that resistor}}{\text{Sum of resistor}}$$

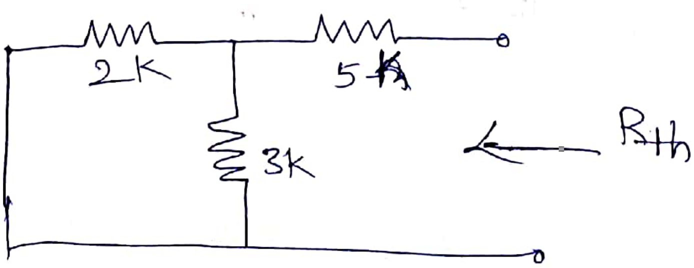
$$= 12 \times \frac{3}{2+3}$$

$$= 36/5 = 7.2V$$

$$\boxed{V_{th} = 7.2V}$$

<u>To find R_{th}</u>

~~open~~ Short circuit Voltage Source



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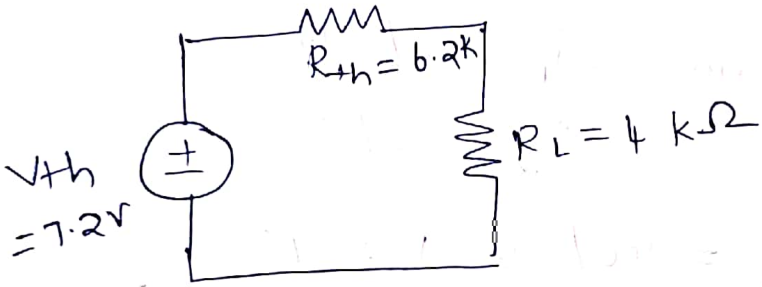
$$R_{th} = \left(\frac{2\times3}{2+3}\right) + 5$$

$$= 5 + \frac{6}{5}$$

$$R_{th} = \frac{31}{5} = 6.2\,k\Omega \quad \therefore \boxed{R_{th} = 6.2\,k\Omega}$$

Thevenin's equivalent Circuit.



Current across R_L

$$I_L = \frac{V_{th}}{R_{th}+R_L} = \frac{7.2}{(6.2+4)k} = 0.71\,mA.$$

$$\boxed{I_L = 0.71\,mA}$$

power across 4Ω resistor.

$$P_{4\Omega} = I_L^2 R_L$$

$$= (0.71 \times 10^{-3})^2 \times 4000$$

$$\boxed{P_{4\Omega} = 2.02\,mW}$$

(ii) To acheive higher power $\boxed{R_L = R_{th}}$ we will get higher power

At $R_L = 6.2k\Omega$

$$P_{Lmax} = \frac{V_{th}^2}{4\times R_{th}} = \frac{(7.2)^2}{4\times 6.2\times 10^{3}} = 2.1\,mW$$

$$\boxed{P_{Lmax} = 2.1\,mW}$$