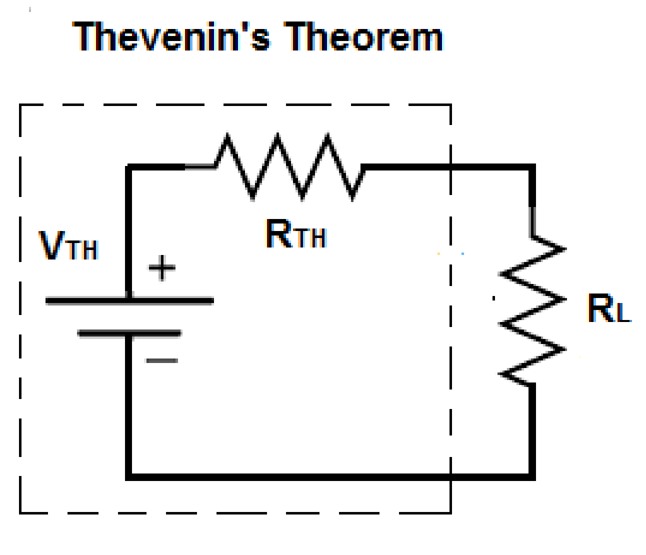
THEVENIN’S THEOREM

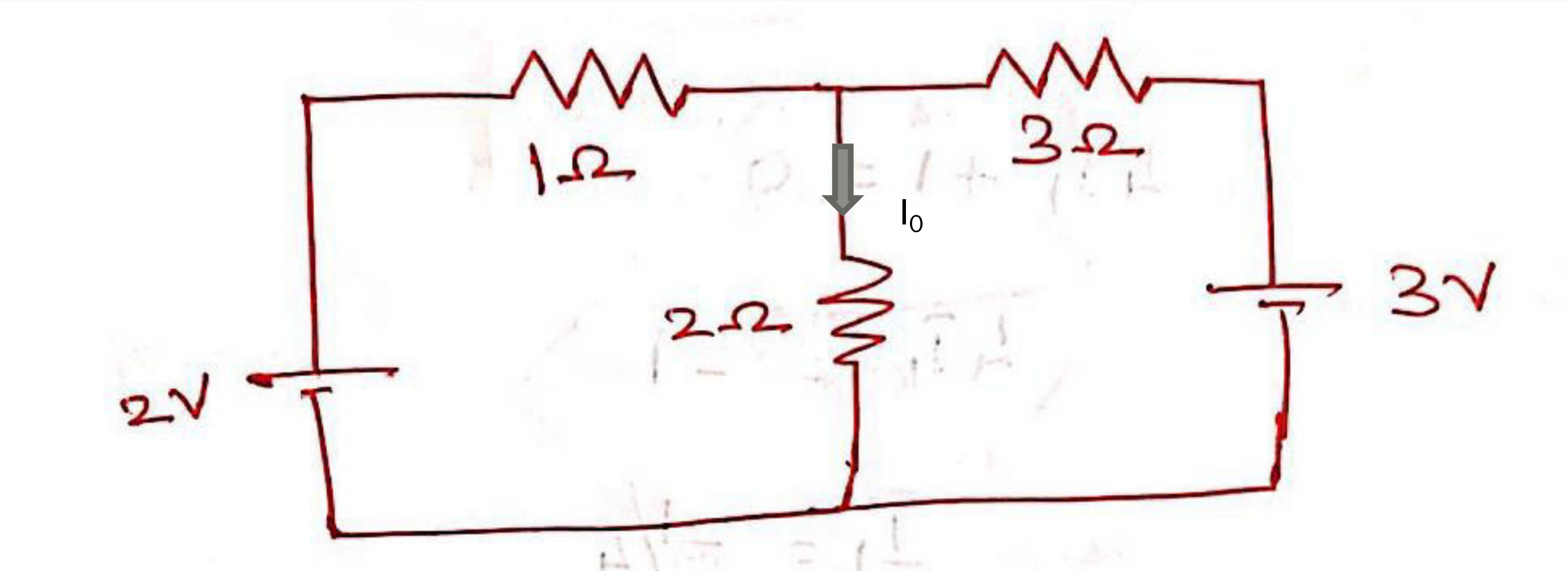
Mr. S.balaji

THEVENIN’S THEOREM

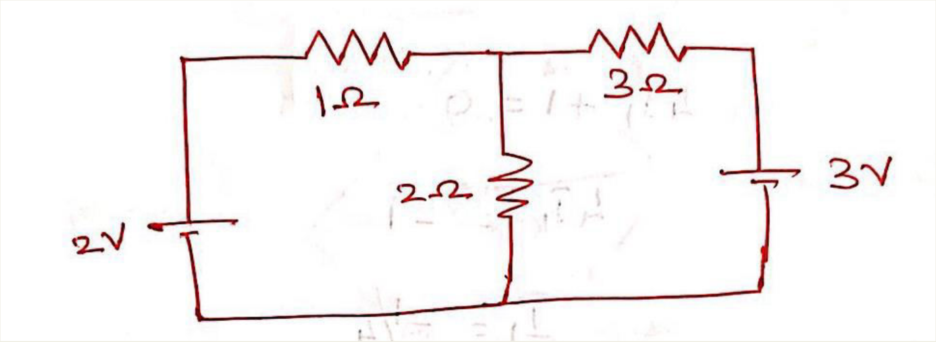
- **Thevenin's Theorem** states that “Any linear circuit containing several voltages and resistances can be replaced by just one single voltage in series with a single resistance connected across the load
- STEP 1: **Find the value of R_{TH}** by removing the load (Resistor through which we have to calculate current) by open circuiting any current source present and short circuit any voltage source present
- STEP 2: Find the value of V_{TH} by removing the load and finding the voltage across the open circuited terminals
- STEP 3: Draw its equivalent circuit
- STEP 4: Use ohms law to find the current through Load
- (i.e) $I_{TH} = \frac{V_{TH}}{R_{TH} + R_L}$



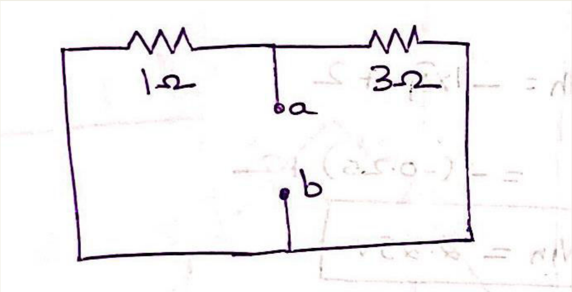
Using Thevenin's equivalent circuit calculate the current I_o, through 2Ω resistor



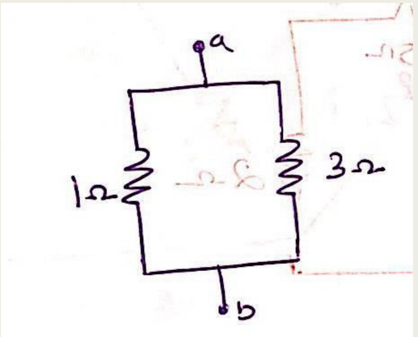
Using Thevenin's equivalent circuit calculate the current I_o, through 2Ω resistor



- STEP 1: Determine Rth by removing load, short circuiting voltage source and open circuiting current source

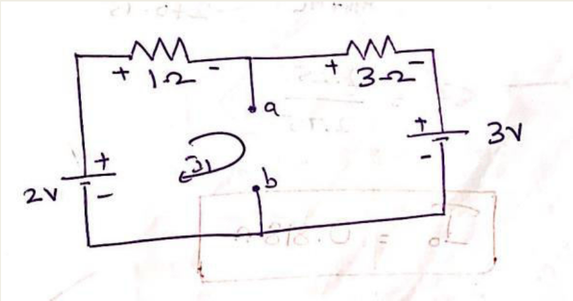


- Redraw the Circuit



$$R_{TH} = \frac{1X3}{1+3}$$
$$= {}^{3}/_{4}$$
$$= 0.75\Omega$$

- STEP 2: Find Vth by removing the load



- By KVL

$$I_1 + 3I_1 + 3 - 2 = 0$$
$$4I_1 + 1 = 0$$
$$4I_1 = -1$$
$$I_1 = -0.25A$$

- Assume a terminal a and b at the opened load.
- Assume an imaginary current which starts from a and end at b.
- it can take any direction to reach b
- By using both directions also the magnitude has to be the same

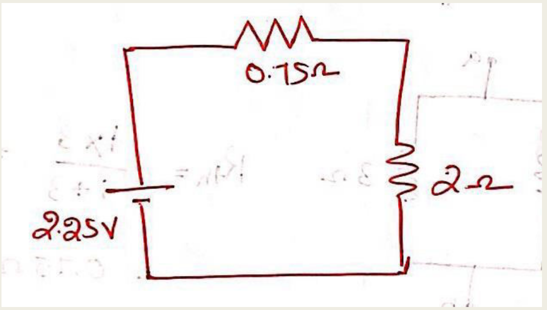
a) Choose the left path first

$$V_{th} = -I_1 + 2$$
$$V_{th} = -(-0.25) + 2$$
$$V_{th} = 2.25V$$

a) Choose the right path

$$V_{th} = 3I_1 + 3$$
$$V_{th} = 3(-0.25) + 3$$
$$V_{th} = -0.75 + 3$$
$$V_{th} = 2.25V$$

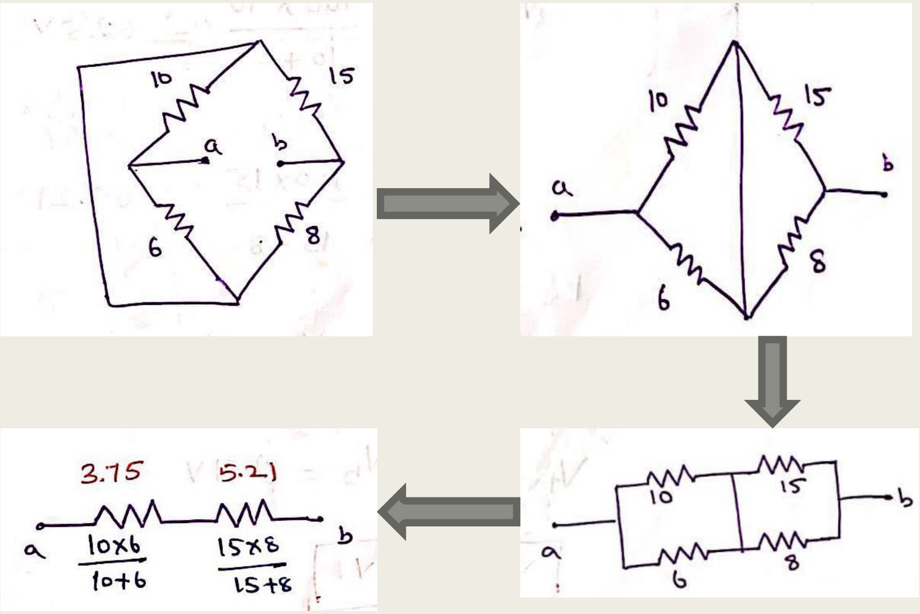
STEP 3: Draw the equivalent Circuit

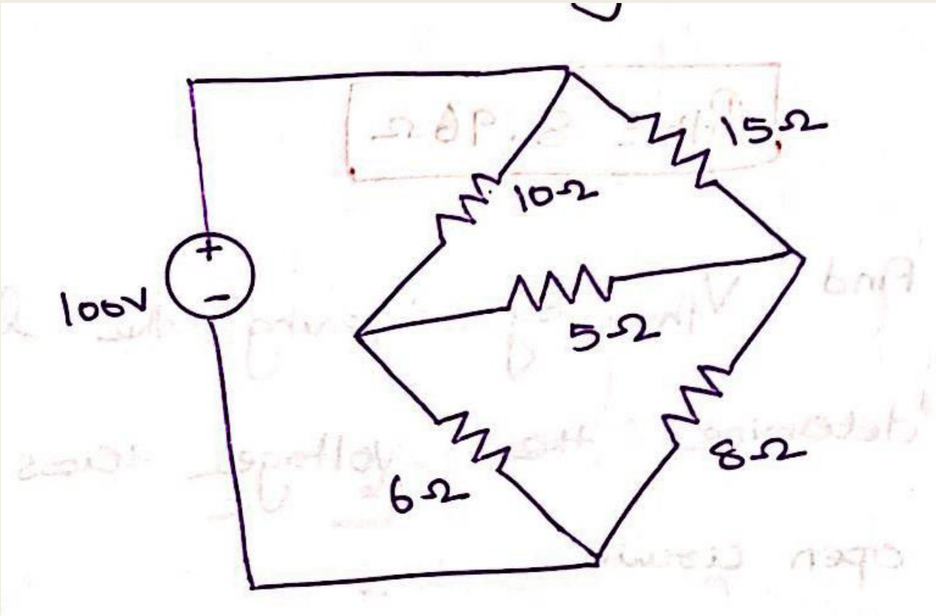


$$I_{2\Omega} = \frac{V_{th}}{R_{th} + R_L}$$
$$I_{2\Omega} = \frac{2.25}{2 + 0.75}$$
$$I_{2\Omega} = 0.818A$$

Using Thevnin's Theorem Find The Current Through 2Ω Resistor

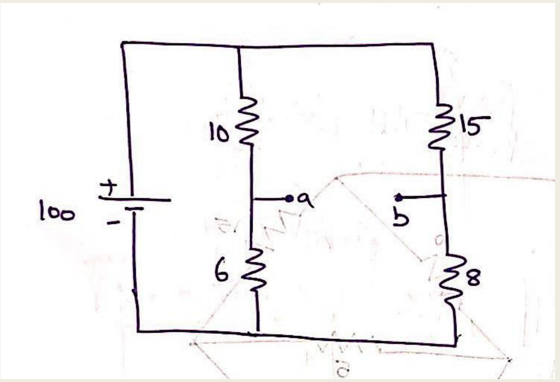
- STEP 1: Determine Rth by removing load, short circuiting voltage source and open circuiting current source





- $R_{TH} = 3.75 + 5.21 = 8.96\Omega$

- STEP 2: Find Vth by removing the load



- By using voltage division rule

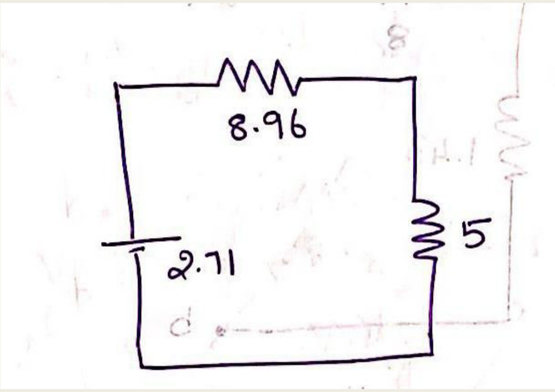
$$V_a = \frac{100 * 10}{10 + 6} = 62.5V$$

$$V_b = \frac{100 * 15}{15 + 8} = 65.21V$$

$$V_{th} = V_a - V_b = 62.5 - 65.21$$

$$\boldsymbol{V_{th} = -2.71V}$$

- STEP 3: Draw the equivalent Circuit

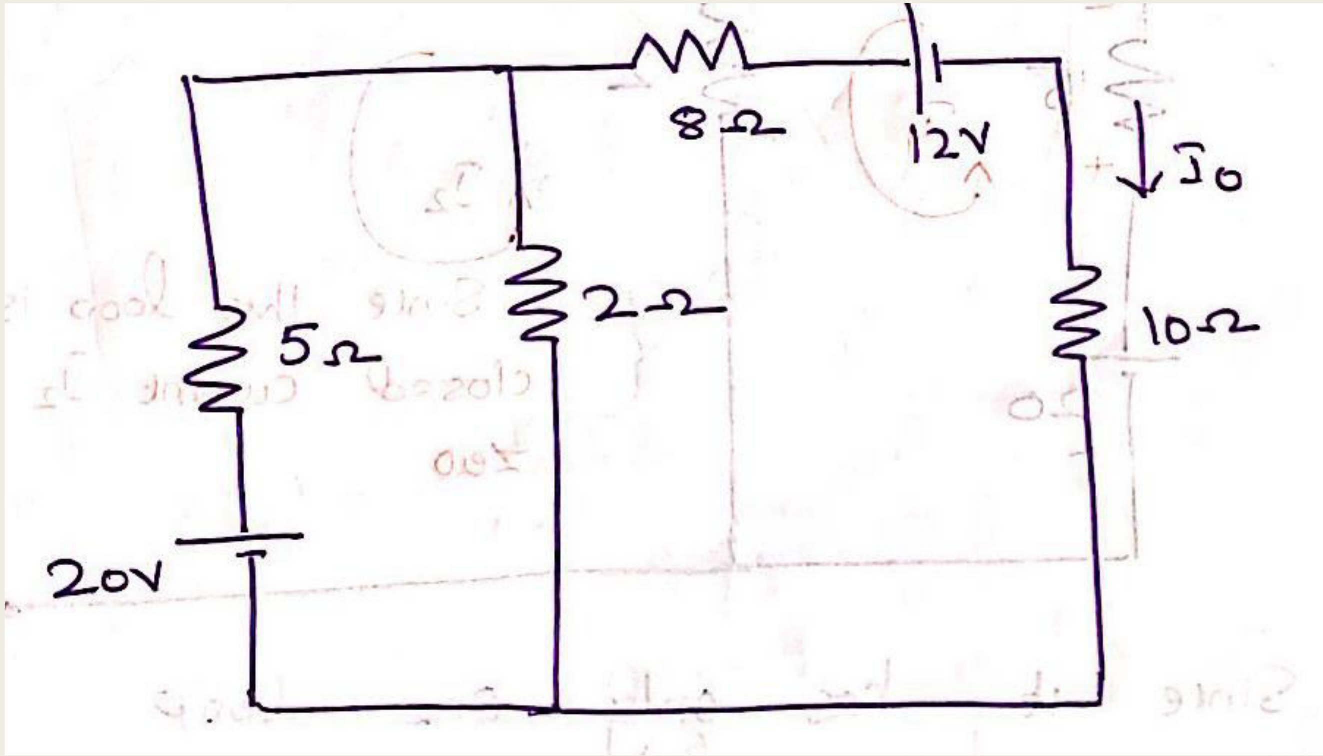


$$I_{5\Omega} = \frac{V_{th}}{R_{th} + R_L}$$

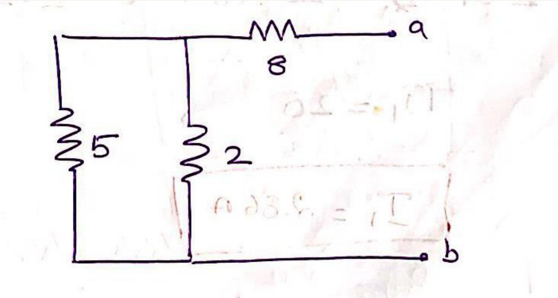
$$I_{5\Omega} = \frac{2.71}{8.96 + 5}$$

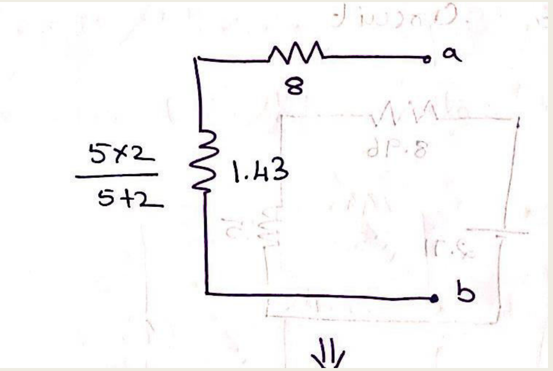
$$\boldsymbol{I_{5\Omega} = 0.19A}$$

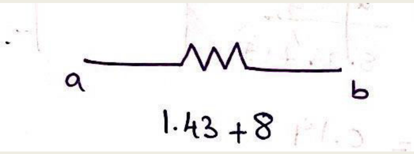
Using thevenin's theorem find the current I_0 in the circuit shown below



- STEP 1: Determine Rth by removing load, short circuiting voltage source and open circuiting current source

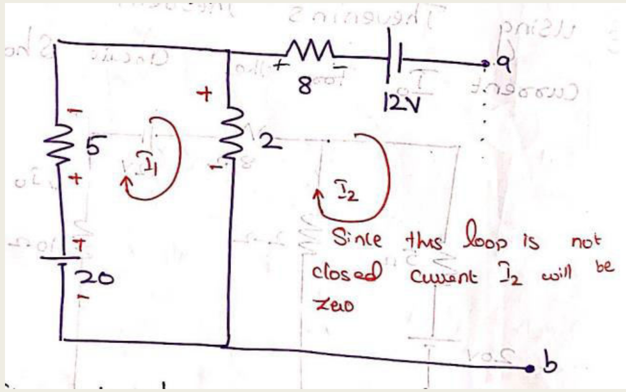






$$\boldsymbol{R_{TH} = 1.43 + 8 = 9.43\Omega}$$

- STEP 2: Find Vth by removing the load



$$2(I_1 - I_2) - 20 + 5I_1 = 0$$

As loop 2 is open circuited $I_2 = 0$

$$7I_1 = 20$$

$$I_1 = 2.86A$$

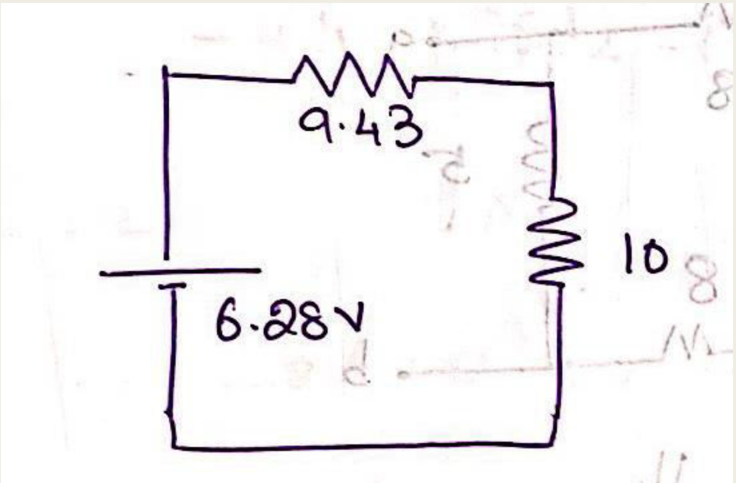
$$V_{th} = -12 - 8I_2 + 2(I_1 - I_2)$$

$$V_{th} = -12 + 2I_1$$

$$V_{th} = -12 + 2 * 2.86$$

$$\boldsymbol{V_{th} = -6.28V}$$

- STEP 3: Draw the equivalent Circuit



$$I_{10\Omega} = \frac{V_{th}}{R_{th} + R_L}$$

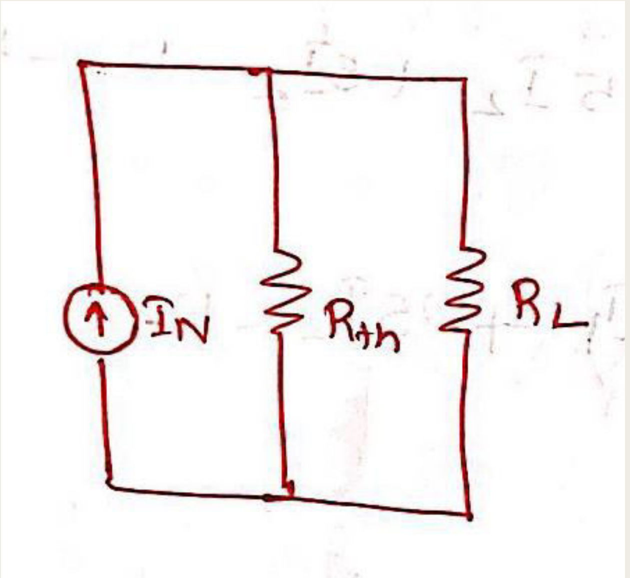
$$I_{10\Omega} = \frac{6.28}{9.43 + 10}$$

$$\boldsymbol{I_{10\Omega} = 0.32A}$$

NORTON’S THEOREM

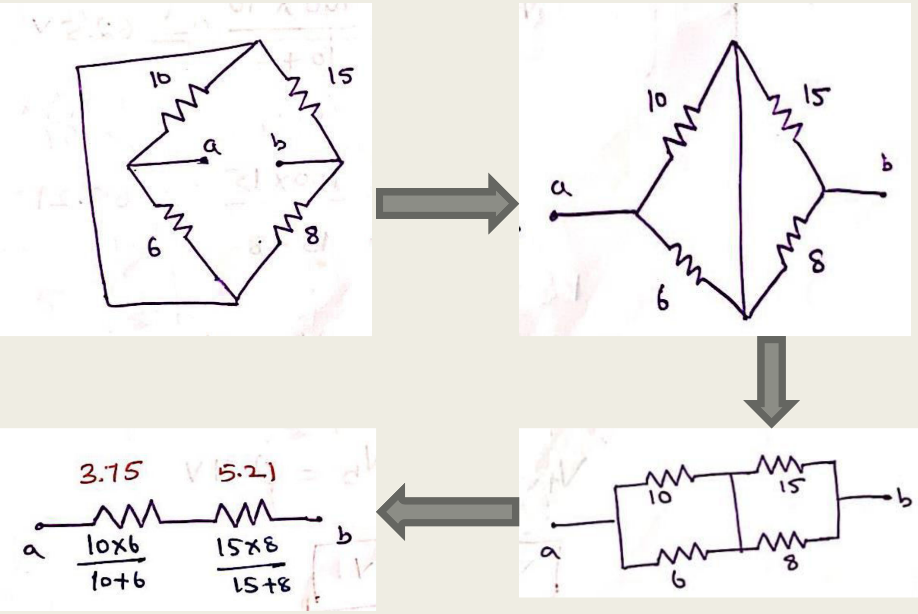
NORTON'S THEOREM

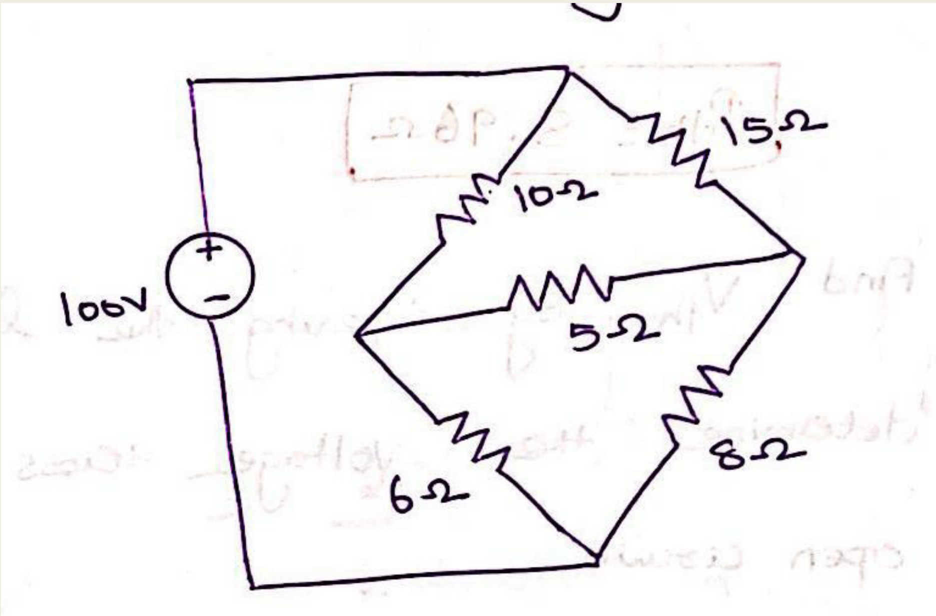
- **Nortons Theorem** states that "Any linear circuit containing several energy sources and resistances can be replaced by a single Constant Current generator in parallel with a Single Resistor
- STEP 1: **Find the value of R_{TH}** by removing the load (Resistor through which we have to calculate current) by open circuiting any current source present and short circuit any voltage source present
- STEP 2: Find the value of I_N by Shorting the load and finding the current through the short circuited branch.
- STEP 3: Draw its equivalent circuit
- STEP 4: Use current division rule to find the current through Load
- (i.e) $I_L = \frac{I_N \text{ X } R_{TH}}{R_{TH} + R_L}$



Using Norton's Theorem Find The Current Through 5Ω Resistor

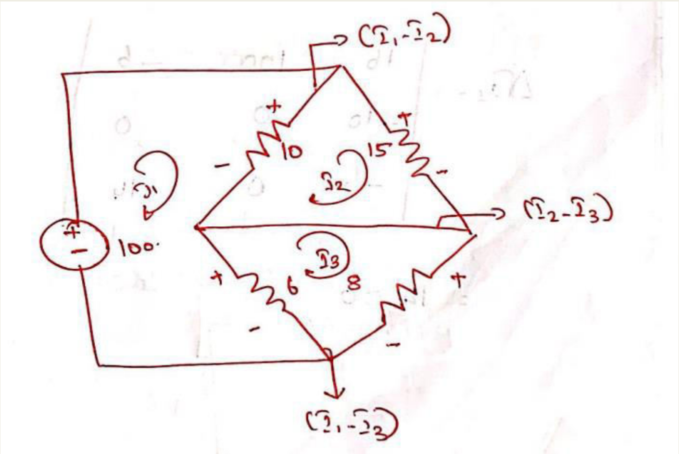
- STEP 1: Determine Rth by removing load, short circuiting voltage source and open circuiting current source





- $\boldsymbol{R_{TH} = 3.75 + 5.21 = 8.96\Omega}$

- Find the value of I_N by Shorting the load and finding the current through the short circuited branch.



- Loop 1

$$16I_1 - 10I_2 - 6I_3 = 100$$

Loop 2

$$-10I_1 + 25I_2 = 0$$

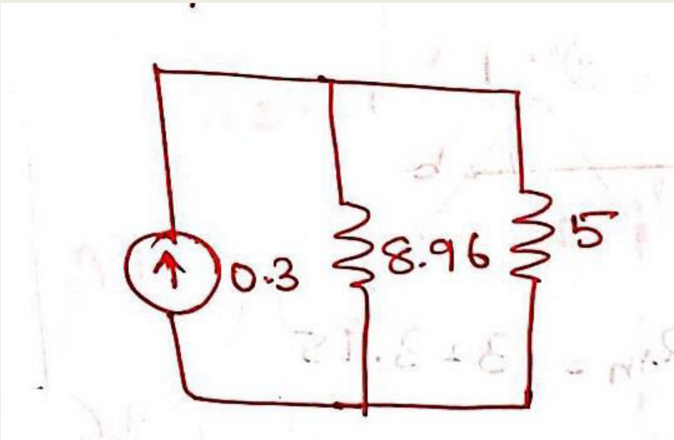
Loop 3

$$-6I_1 + 14I_3 = 0$$

$$I_2 = 4.24A$$

$$I_3 = 4.54\ A$$

- $I_N = I_2 - I_3$
- $I_N = 4.24 - 4.54$
- $I_N = -0.3A$
- Step 33: Draw Norton's Equivalent Circuit



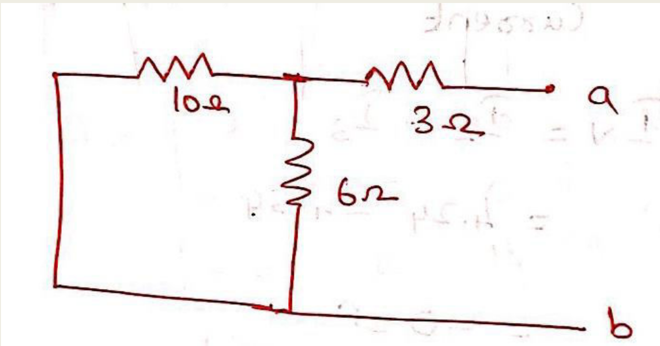
- $I_L = \frac{I_N\ X\ R_{TH}}{R_{TH} + R_L}$

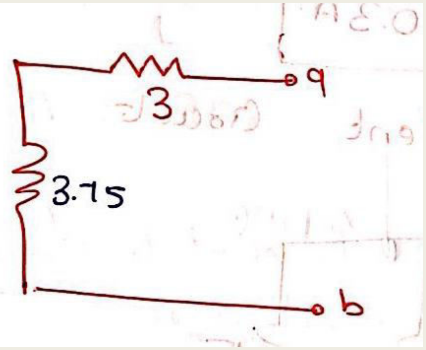
$$I_{5\Omega} = \frac{0.3\ X\ 8.96}{8.96 + 5}$$

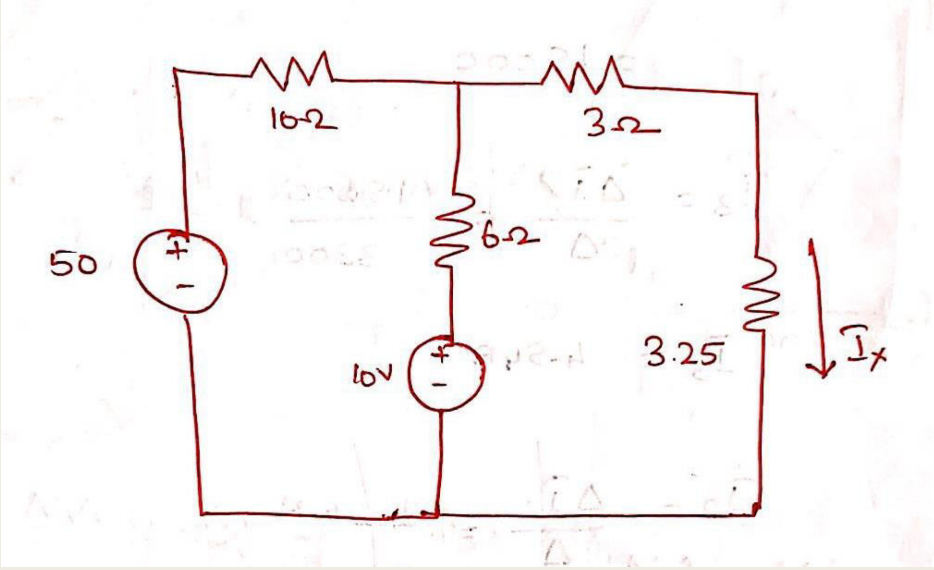
$$I_{5\Omega} = 0.19A$$

Applying Norton's Theorem, Determine the current I_X Marked in the circuit shown Below

- Step 1: Find R_{TH}



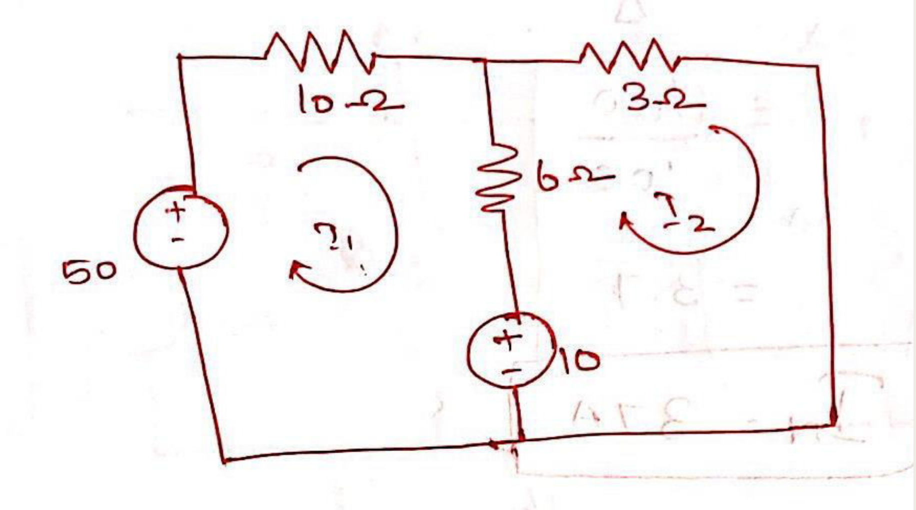




$$\frac{10 \times 6}{10+6}$$

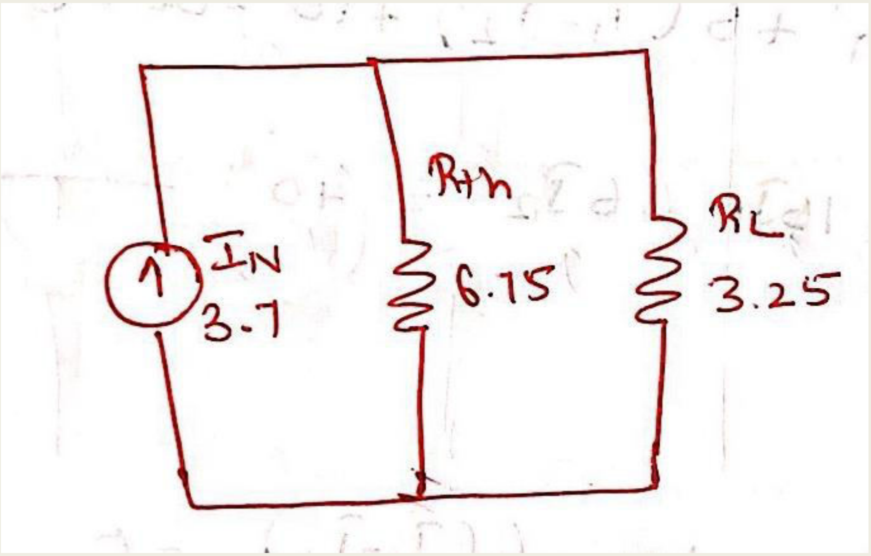
- $R_{TH} = 3.75 + 3 = 6.75\ \Omega$

- Find the value of I_N by Shorting the load and finding the current through the short circuited branch.



- Loop 1
- $16I_1 - 6I_2 = 50$
- Loop 2
- $-6I_1 + 9I_2 = 50$
- $\boldsymbol{I_2 = 3.7\ A}$

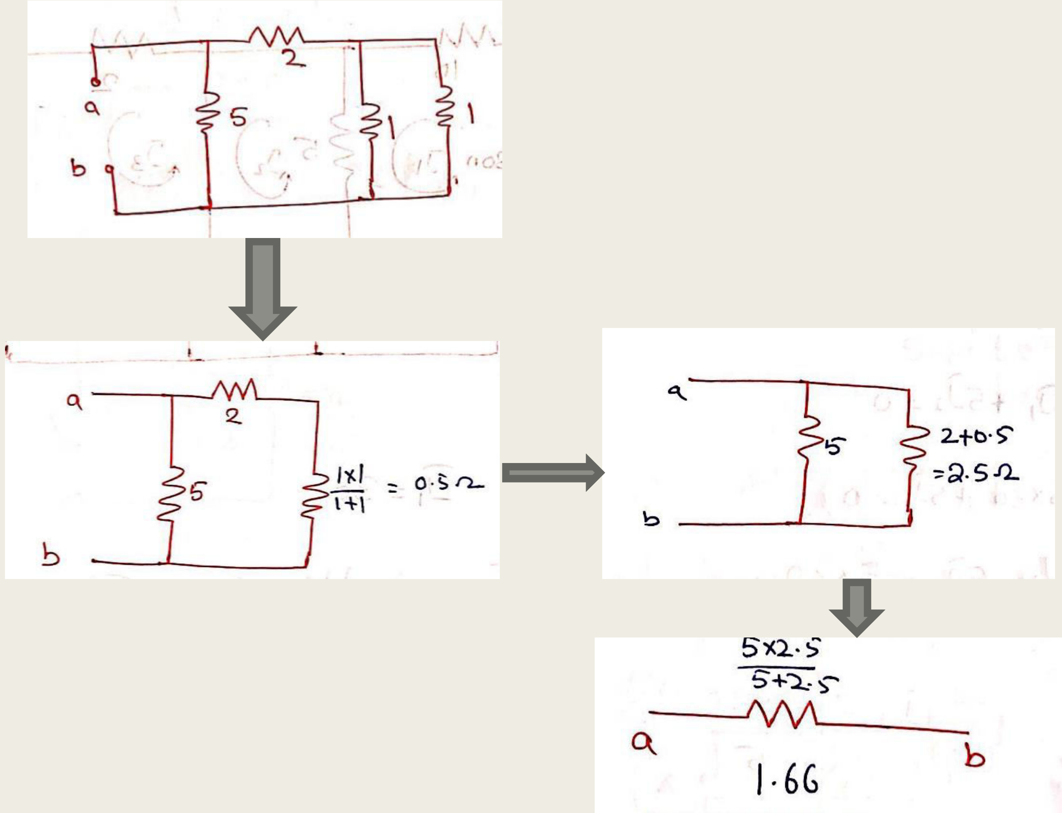
- Step 3: Draw Norton's Equivalent Circuit

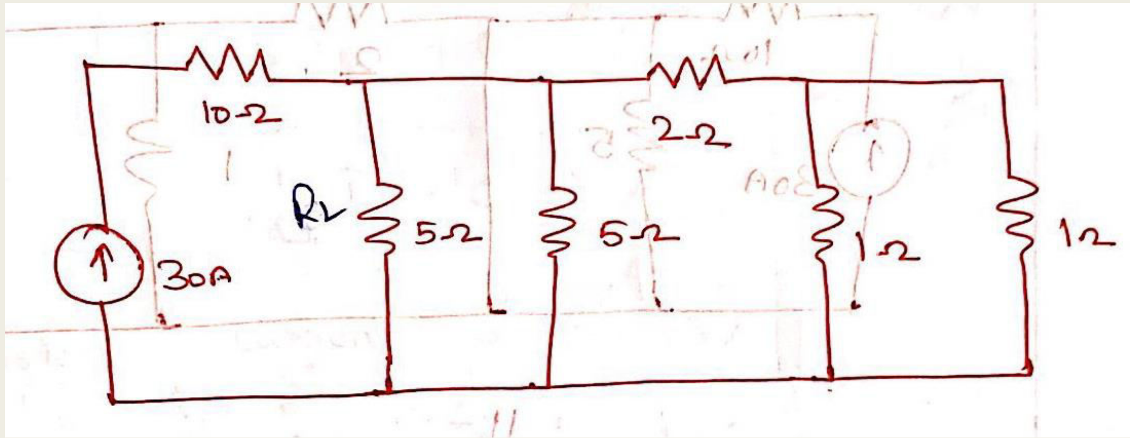


- $I_L = \frac{I_N\ X\ R_{TH}}{R_{TH} + R_L}$
- $I_{3.25\Omega} = \frac{3.7\ X\ 6.75}{6.75 + 3.25}$
- $\boldsymbol{I_{3.25\Omega} = 2.49\ A}$

Determine the current flowing through 5Ω resistor

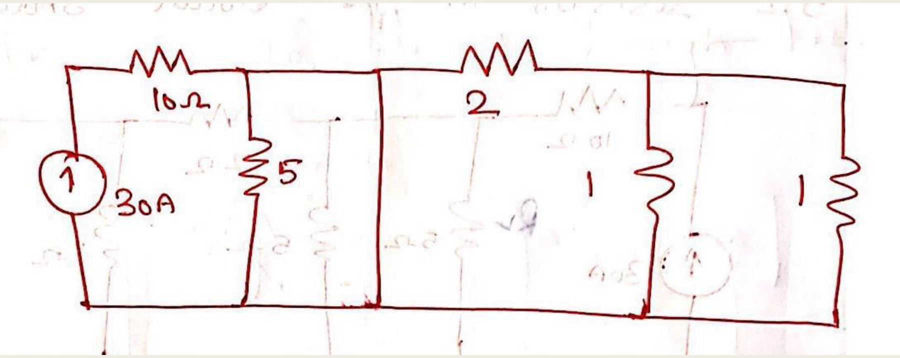
- Step 1: Find R_{TH}





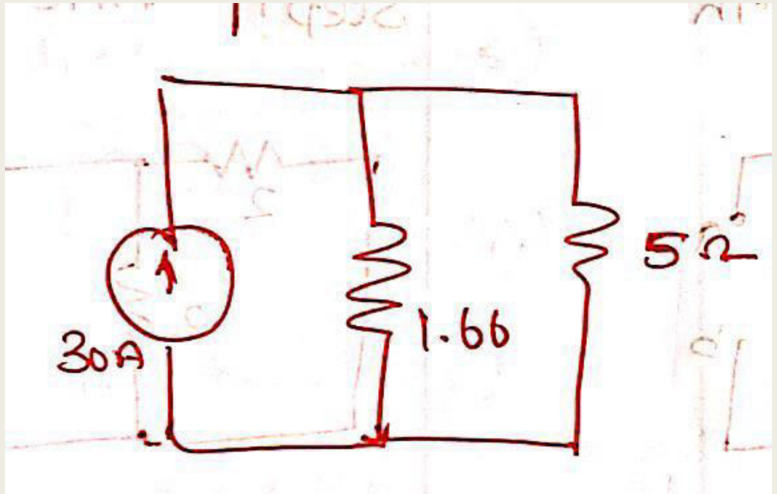
$$R_{TH} = 1.66\Omega$$

- Find the value of I_N by Shorting the load and finding the current through the short circuited branch.



- $\boldsymbol{I_N = 30\ A}$

- Step 3: Draw Norton's Equivalent Circuit



- $I_L = \frac{I_N\ X\ R_{TH}}{R_{TH} + R_L}$
- $I_{5\Omega} = \frac{30\ X\ 1.66}{5 + 1.66}$
- $I_{5\Omega} = 7.48\ A$

MAXIMUM POWER TRANSFER THEOREM

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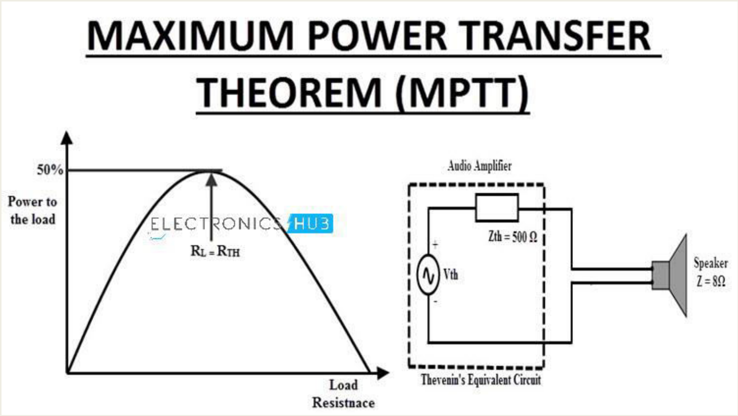
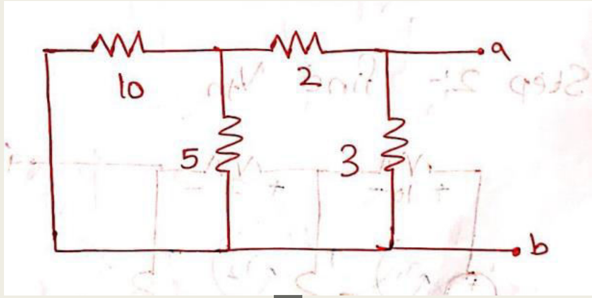


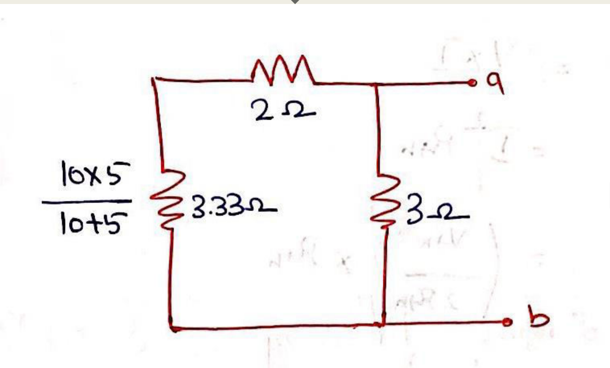
- **Maximum power transfer theorem** states that, to obtain **maximum** external **power** from a source with a finite internal resistance, the resistance of the load must equal the resistance of the source as viewed from its output terminals.
- STEP 1: **Find the value of R_{TH}** by removing the load (Resistor through which we have to calculate current) by open circuiting any current source present and short circuit any voltage source present
- STEP 2: Find the value of V_{TH} by removing the load and finding the voltage across the open circuited terminals
- STEP 3: Draw its equivalent circuit with R_{th} equal to Load Resistance
- STEP 4: Use ohms law to find the current through Load
- (i.e) $I_{TH} = \frac{V_{TH}}{R_{TH} + R_{TH}} = \frac{V_{TH}}{2R_{TH}}$

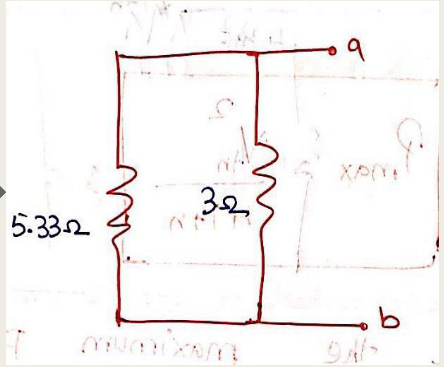
$$P_{Max} = VxI = I^2 R_{TH}$$
$$= \left(\frac{V_{TH}}{2R_{TH}}\right)^2 R_{TH}$$
$$P_{Max} = \frac{{V_{th}}^2}{4R_{th}}$$

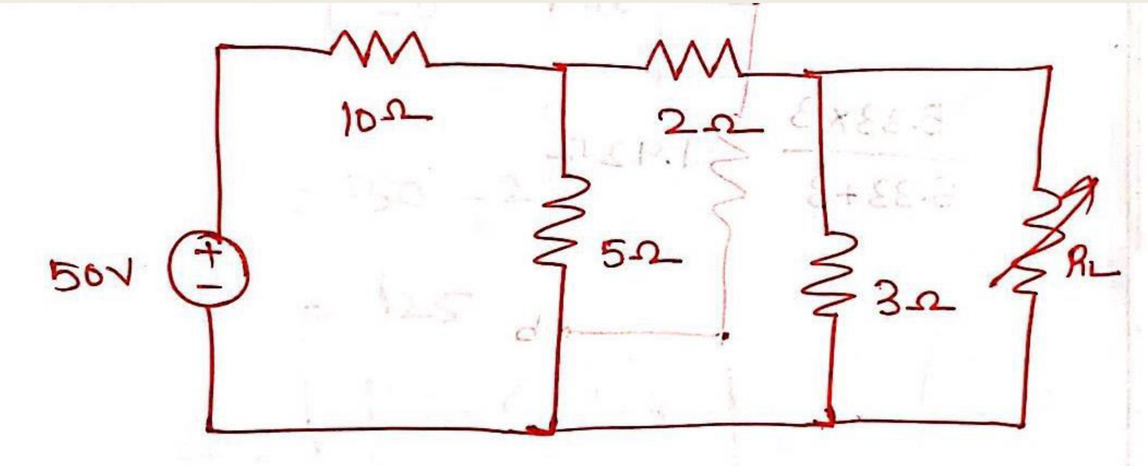
Determine the Maximum Power Delivered to the Load

- Step 1: Find R_{TH}





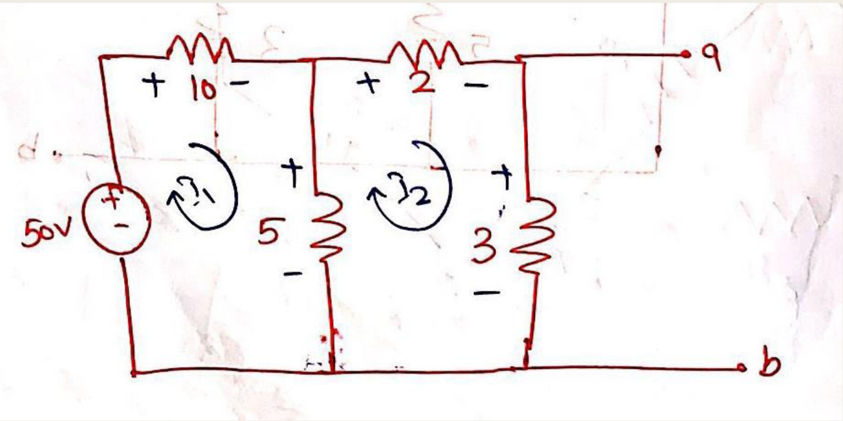




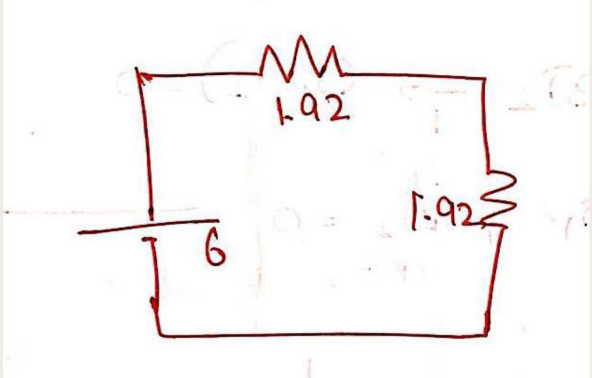
$$R_{TH} = \frac{5.33x3}{5.33 + 3}$$

$$R_{TH} = 1.92\Omega$$

- STEP 2: Find Vth by removing the load



- Loop 1
- $15I_1 - 5I_2 = 50$
- Loop 2
- $-5I_1 + 10I_2 = 0$
- $I_2 = 2A$
- $V_{TH} = 3I_2$
- $V_{TH} = 3 * 2$
- $V_{TH} = 6$
- Step 3: Draw Equivalent Circuit



- $P_{Max} = \frac{{V_{th}}^2}{4R_{th}}$
- $P_{Max} = \frac{6^2}{4 * 1.92}$
- $\boldsymbol{P_{Max} = 4.68\ watts}$

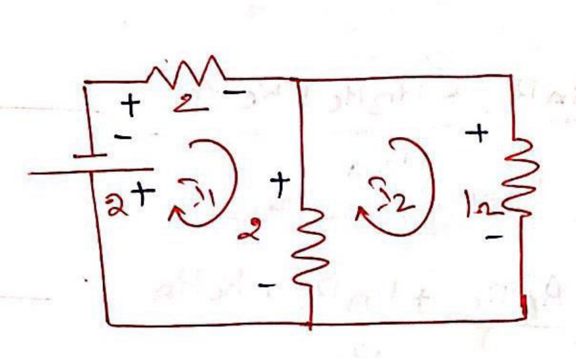
SUPER POSITION THEOREM

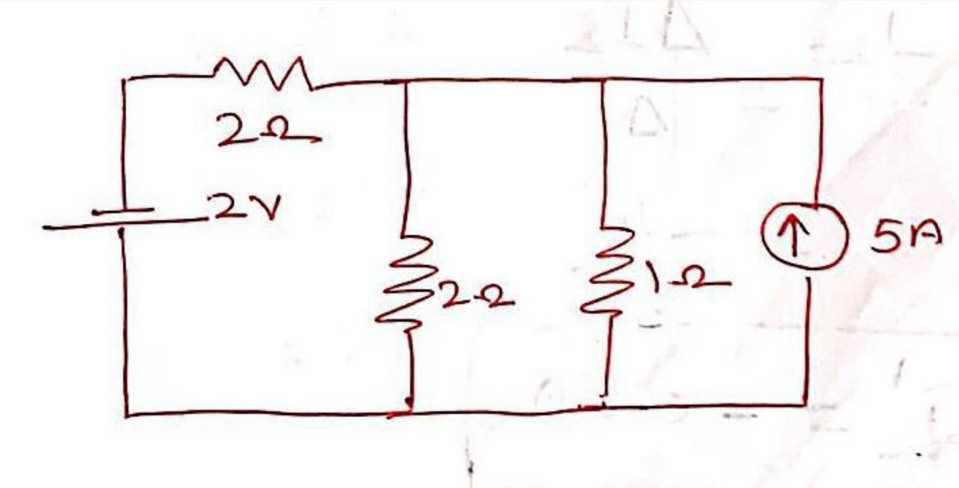
SUPER POSITION THEOREM

- **Superposition theorem** states that in any linear, active, bilateral network having more than one source, the response across any element is the sum of the responses obtained from each source considered separately and all other sources are replaced by their internal resistance.

Calculate the current through 1Ω resistor in the circuit shown below using super position theorem

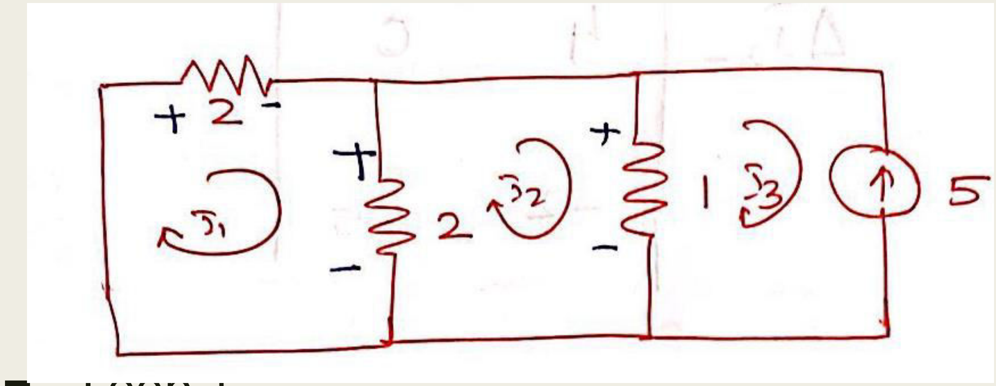
- Case (i): Considering 2V source





- Loop 1
- $4I_1 - 2I_2 = -2$
- Loop 2
- $-2I_1 + 3I_2 = 0$
- $I_2 = -0.5A$

- Case (ii) Considering 5A Source

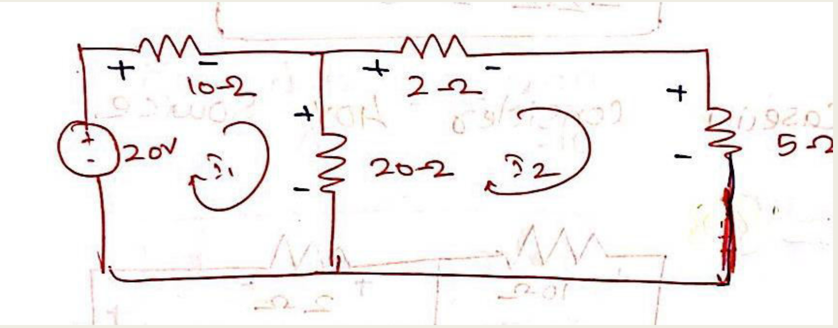


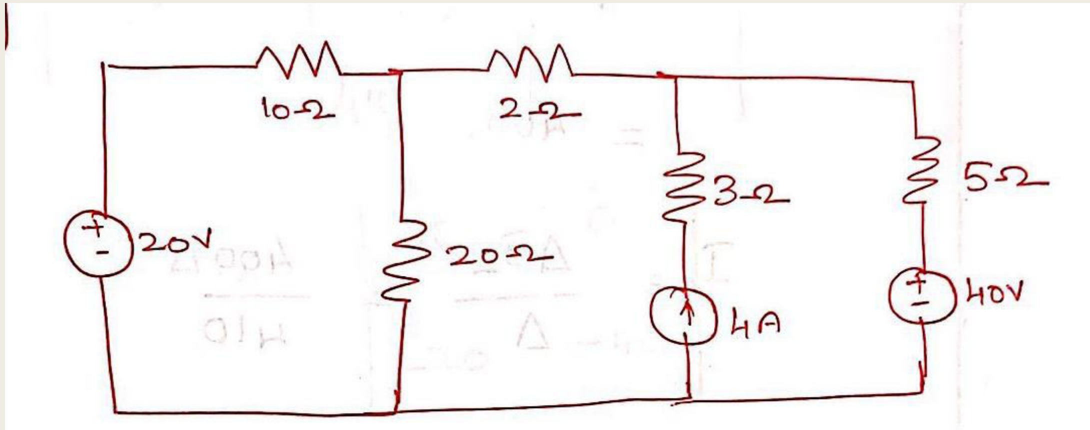
- Loop 1
- $4I_1 - 2I_2 = 0$
- Loop 2
- $-2I_1 + 3I_2 - 1I_3 = 0$
- Loop 3
- $I_3 = -5$
- By solving we get $I_2 = -2.5$
- $I_2 - I_3 = 2.5A$

- Total Current through 1Ω resistor is
- $I_{1\Omega} = case\ (i) + case\ (ii)$
- $I_{1\Omega} = -0.5 + 2.5$
- $I_{1\Omega} = 2A$

In the circuit shown below find the voltage drop across 2Ω resistor using super position theorem

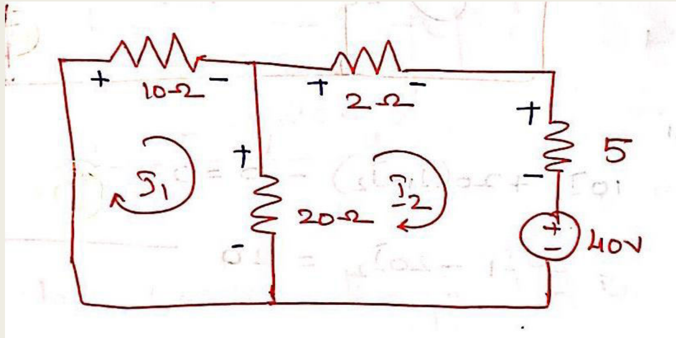
- Case (i): Considering 20V



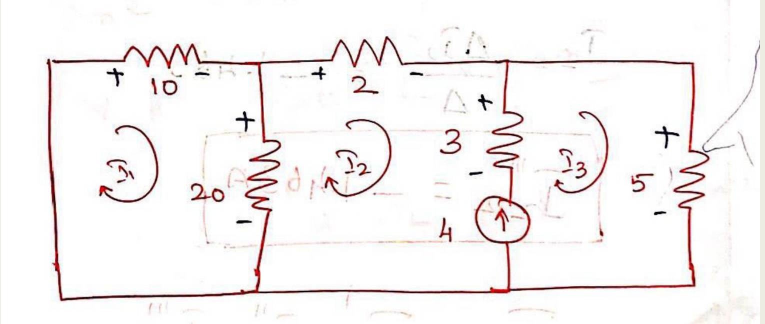


- $30I_1 - 20I_2 = 20$
- Loop 2
- $-20I_1 + 27I_2 = 0$
- $I_2 = 0.975$

- Case (ii): Considering 40V



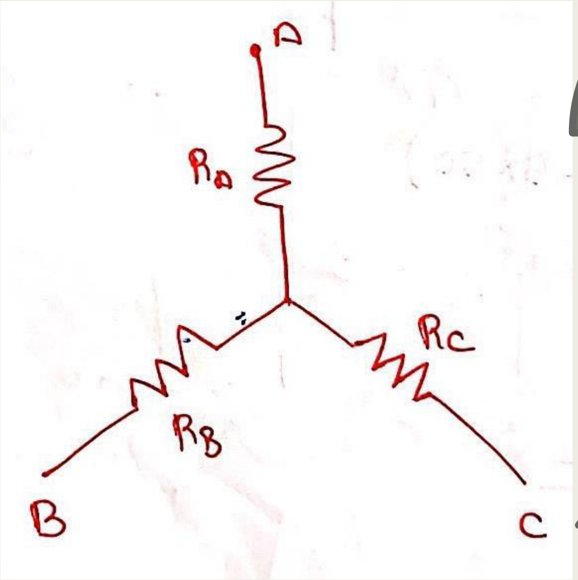
- Loop 1
- $30I_1 - 20I_2 = 0$
- Loop 2
- $-20I_1 + 27I_2 = -40$
- $I_2 = -2.92A$
- Case (iii) Considering 4A Source

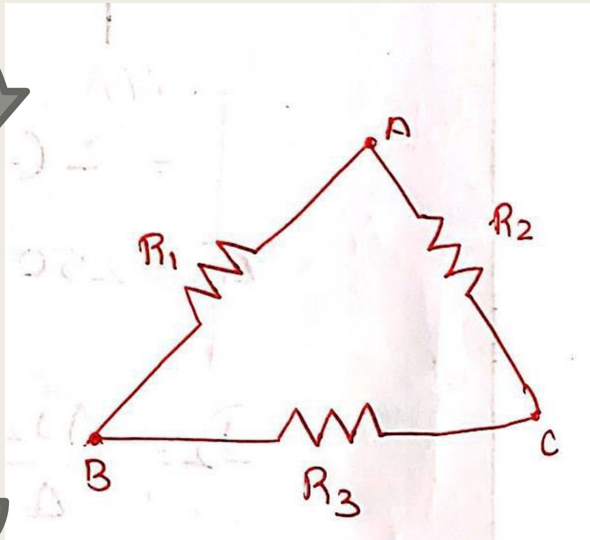


- Between Loop 2 and 3 there is a current source
- $I_2 - I_3 = -4$
- Loop 1
- $30I_1 - 20I_2 = 0$
- Loop 2 and 3 are combined because already for the common branch we got an equation
- $-20I_1 + 22I_2 + 5I_3 = 0$
- $I_2 = -1.463A$
- Total Current through 1Ω resistor is
- $I_{2\Omega} = case\ (i) + case\ (ii)$+case (iii)
- $I_{2\Omega} = 0.957 + (-2.92) + (-1.463)$
- $I_{2\Omega} = -3.426$
- Voltage drop across 2Ω is 2X3.426
- $V_{2\Omega} = 2 * 3.426 = 6.846V$

STAR – DELTA TRANSFORMATION

STAR – DELTA TRANSFORMATION



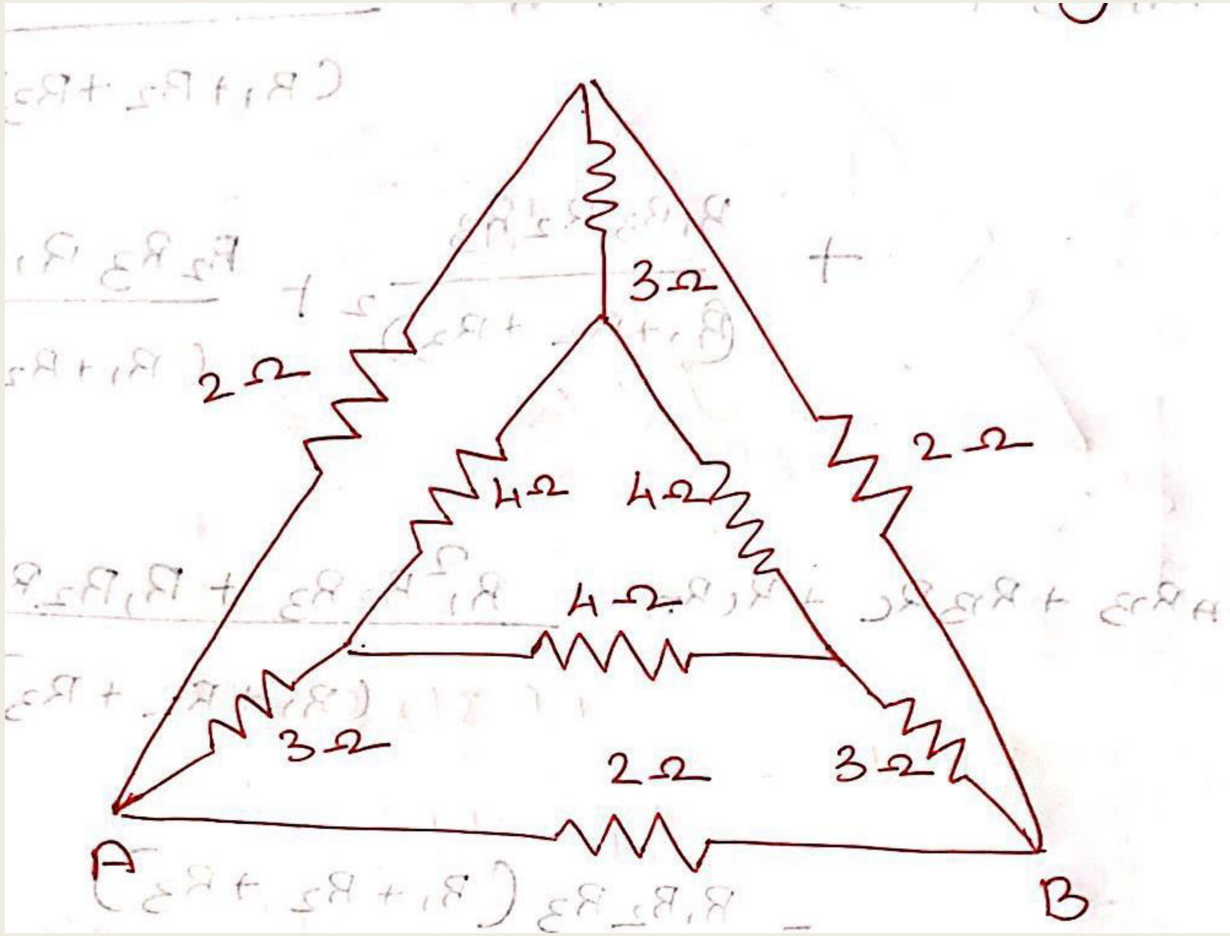


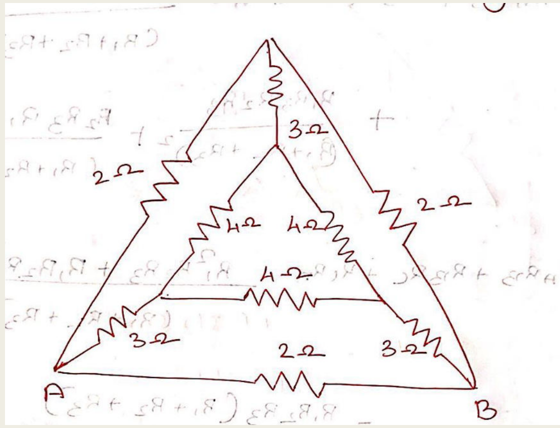
- With respect to Star
- $R_{AB} = R_A + R_B$
- $R_{BC} = R_B + R_C$
- $R_{CA} = R_C + R_A$

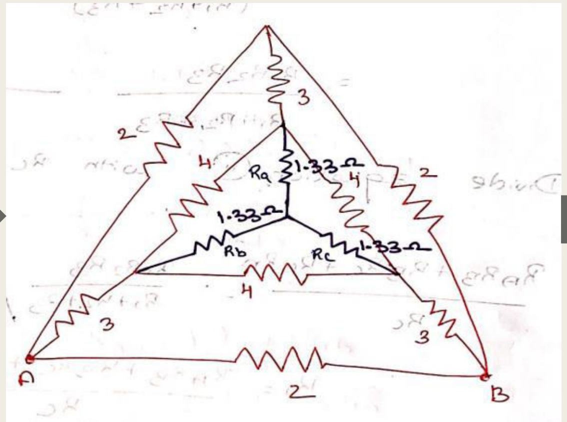
- With respect to Delta
- $R_{AB} = \frac{R_1 R_2 + R_1 R_3}{R_1 + R_2 + R_3}$
- $R_{BC} = \frac{R_1 R_3 + R_2 R_3}{R_1 + R_2 + R_3}$
- $R_{CA} = \frac{R_2 R_1 + R_2 R_3}{R_1 + R_2 + R_3}$

- COMPARING ALL THE ABOVE EQUATIONS
- $R_A + R_B = \frac{R_1R_2+R_1R_3}{R_1+R_2+R_3}$
- $R_B + R_C = \frac{R_1R_3+R_2R_3}{R_1+R_2+R_3}$
- $R_C + R_A = \frac{R_2R_1+R_2R_3}{R_1+R_2+R_3}$
- SIMILARLY
- $R_A + R_C = \frac{R_1R_2-R_2R_3}{R_1+R_2+R_3}$
- ADDING
- $2R_A = \frac{2R_1R_2}{R_1+R_2+R_3}$
- $R_A = \frac{R_1R_2}{R_1+R_2+R_3}$
- $R_B = \frac{R_1R_3}{R_1+R_2+R_3}$
- $R_C = \frac{R_2R_3}{R_1+R_2+R_3}$
- ADDING THE PRODUCTS OF THE RESULTS
- $R_AR_B + R_BR_C + R_CR_A = \frac{R_1R_2R_3}{R_1+R_2+R_3}$
- DIVIDE ABOVE EQUATION BY R_A GIVES R_3
- $R_3 = \frac{R_AR_B+R_BR_C+R_CR_A}{R_A}$
- $R_2 = \frac{R_AR_B+R_BR_C+R_CR_A}{R_B}$
- $R_1 = \frac{R_AR_B+R_BR_C+R_CR_A}{R_C}$

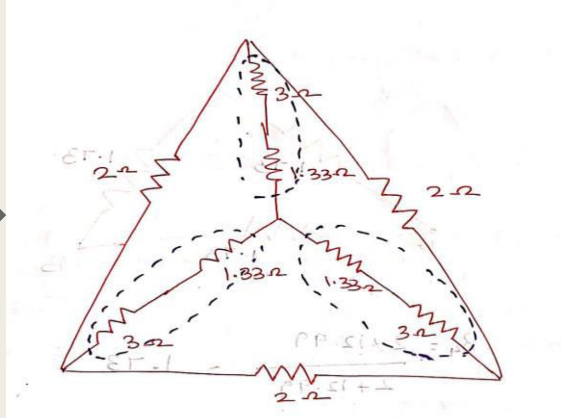
Find the equivalent resistance across A and B in the following circuit



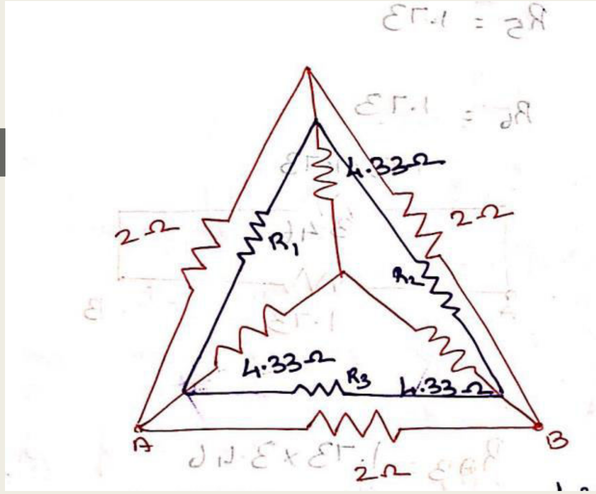




$$R_a = \frac{4 * 4}{4 + 4 + 4} = 1.33\Omega$$
$$R_b = \frac{4 * 4}{4 + 4 + 4} = 1.33\Omega$$
$$R_c = \frac{4 * 4}{4 + 4 + 4} = 1.33\Omega$$

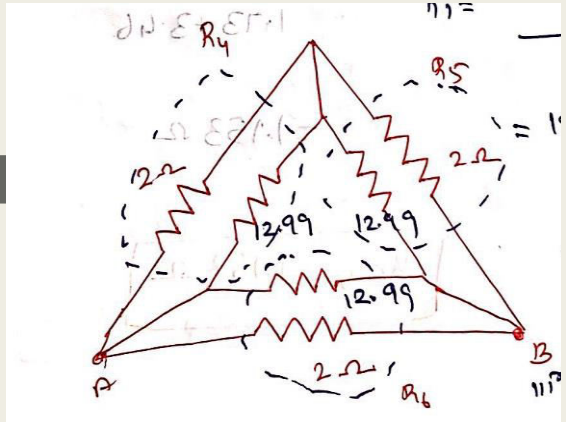


$$R_{series} = 1.33 + 3$$
$$R_{series} = 4.33\Omega$$

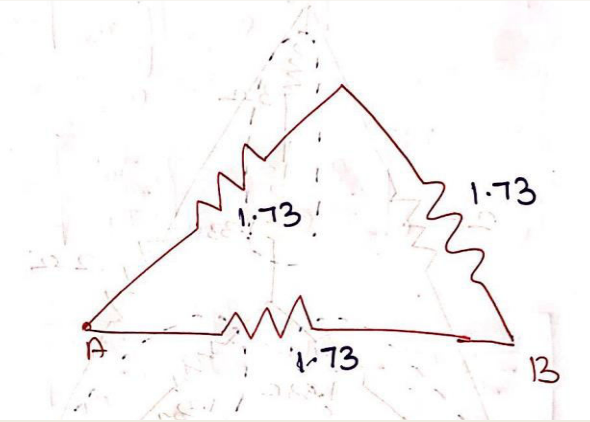


$$R_1 = \frac{(4.33 * 4.33) + (4.33 * 4.33) + (4.33 * 4.33)}{4.33 + 4.33 + 4.33}$$

$$R_1 = R_2 = R_3 = 12.99$$



$$R_{parallel} = \frac{2 * 12.99}{2 + 12.99} = 1.73$$



$$R_{AB} = 1.153\Omega$$

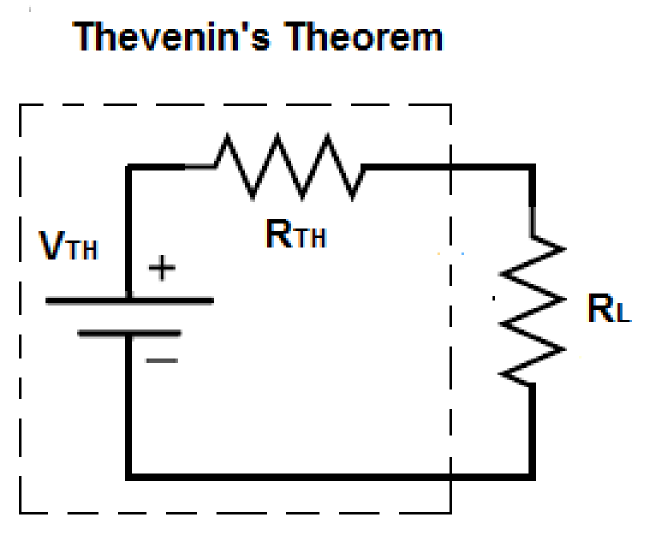
THANK YOU

THEVENIN'S THEOREM

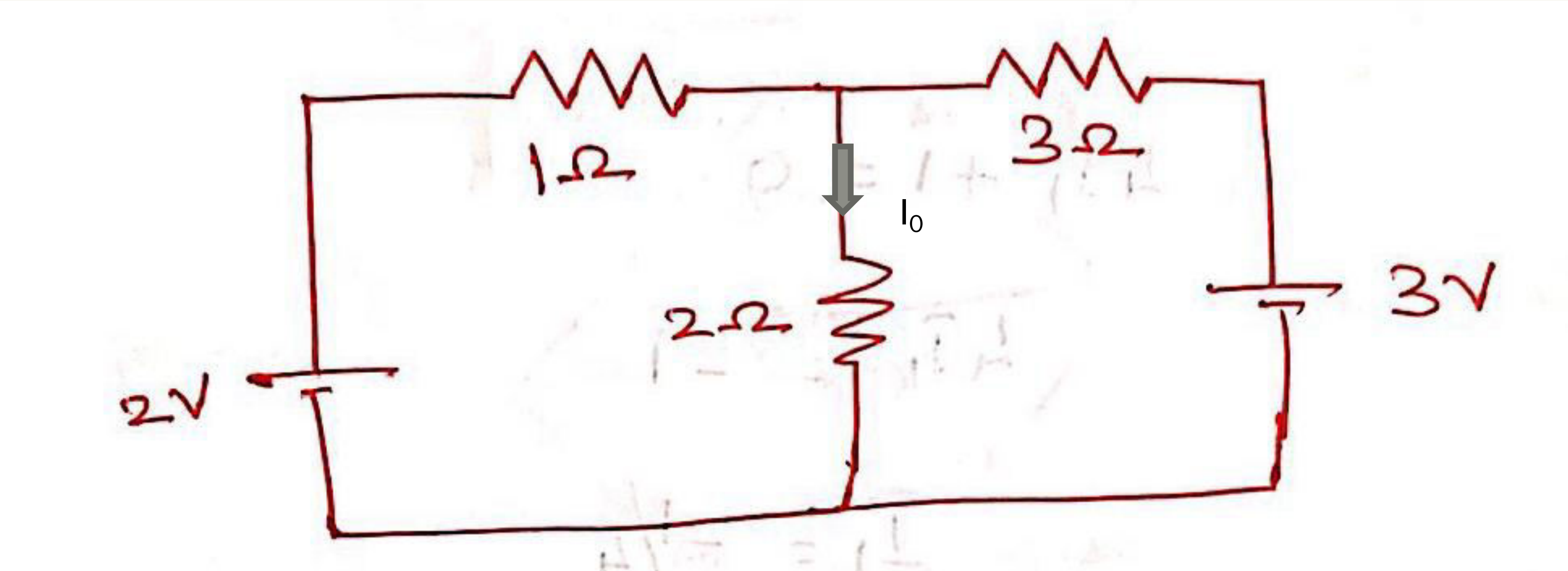
Mr. J. Ajay Daniel

THEVENIN'S THEOREM

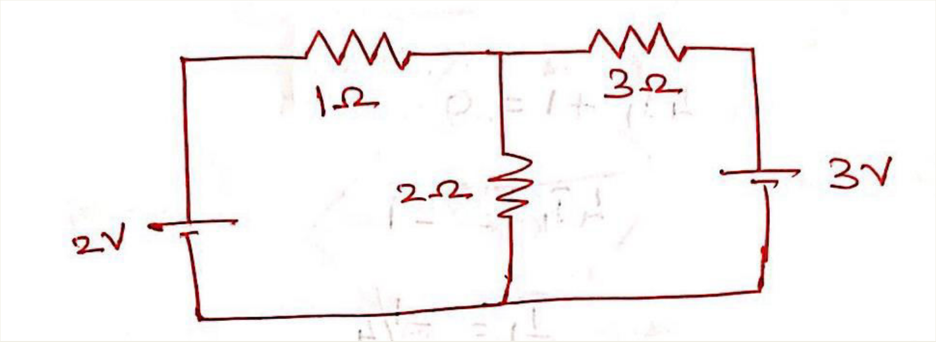
- **Thevenin's Theorem** states that "Any linear circuit containing several voltages and resistances can be replaced by just one single voltage in series with a single resistance connected across the load
- STEP 1: **Find the value of R_{TH}** by removing the load (Resistor through which we have to calculate current) by open circuiting any current source present and short circuit any voltage source present
- STEP 2: Find the value of V_{TH} by removing the load and finding the voltage across the open circuited terminals
- STEP 3: Draw its equivalent circuit
- STEP 4: Use ohms law to find the current through Load
- (i.e) $I_{TH} = \frac{V_{TH}}{R_{TH} + R_L}$



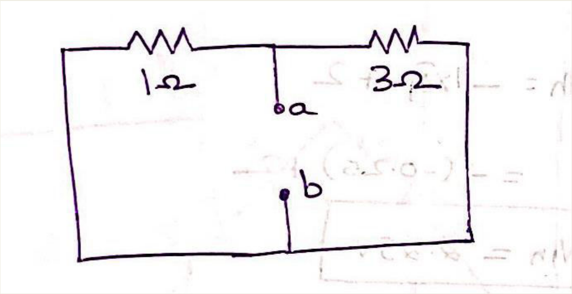
Using Thevenin's equivalent circuit calculate the current I_o, through 2Ω resistor



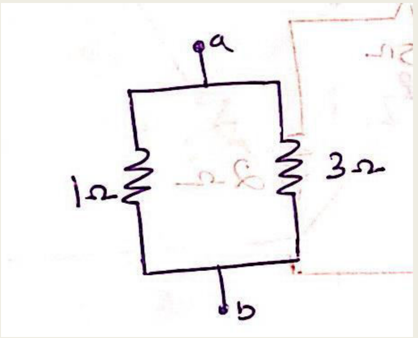
Using Thevenin's equivalent circuit calculate the current I_o, through 2Ω resistor



- STEP 1: Determine Rth by removing load, short circuiting voltage source and open circuiting current source

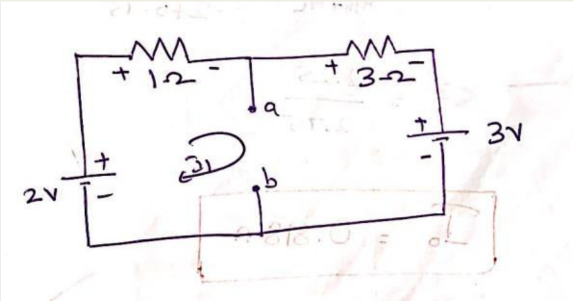


- Redraw the Circuit



$$R_{TH} = \frac{1X3}{1+3}$$
$$= {}^{3}/_{4}$$
$$= 0.75\Omega$$

- STEP 2: Find Vth by removing the load



- By KVL

$$I_1 + 3I_1 + 3 - 2 = 0$$
$$4I_1 + 1 = 0$$
$$4I_1 = -1$$
$$I_1 = -0.25A$$

- Assume a terminal a and b at the opened load.
- Assume an imaginary current which starts from a and end at b.
- it can take any direction to reach b
- By using both directions also the magnitude has to be the same

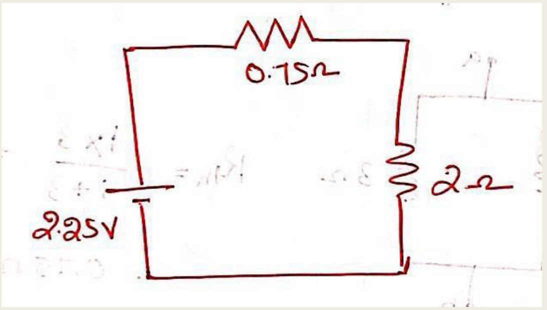
a) Choose the left path first

$$V_{th} = -I_1 + 2$$
$$V_{th} = -(-0.25) + 2$$
$$V_{th} = 2.25V$$

a) Choose the right path

$$V_{th} = 3I_1 + 3$$
$$V_{th} = 3(-0.25) + 3$$
$$V_{th} = -0.75 + 3$$
$$V_{th} = 2.25V$$

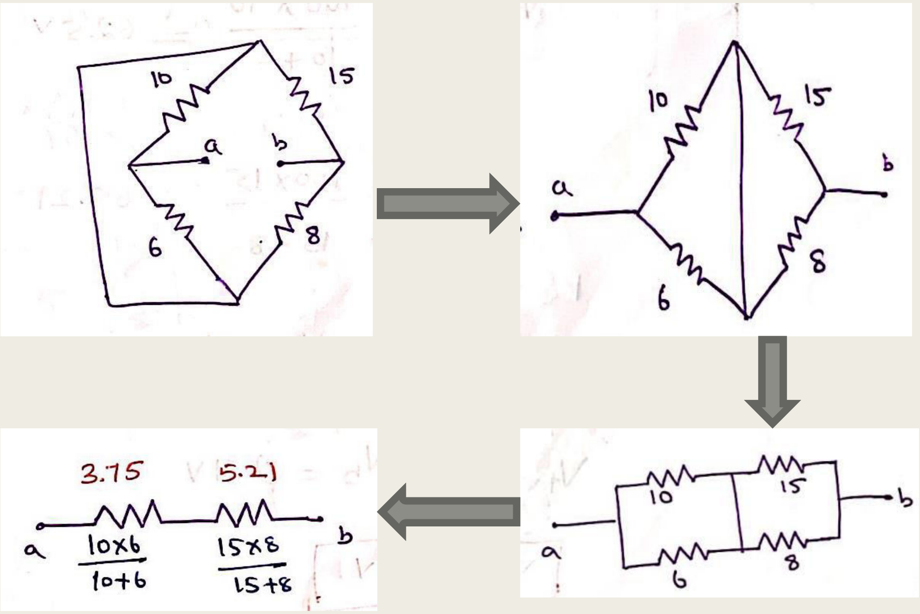
STEP 3: Draw the equivalent Circuit

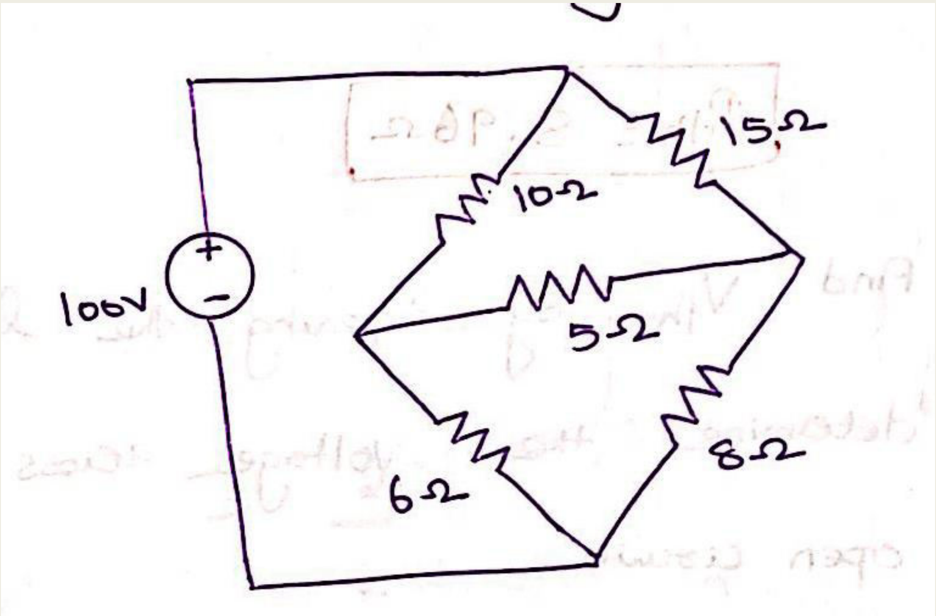


$$I_{2\Omega} = \frac{V_{th}}{R_{th} + R_L}$$
$$I_{2\Omega} = \frac{2.25}{2 + 0.75}$$
$$I_{2\Omega} = 0.818A$$

Using Thevnin's Theorem Find The Current Through 2Ω Resistor

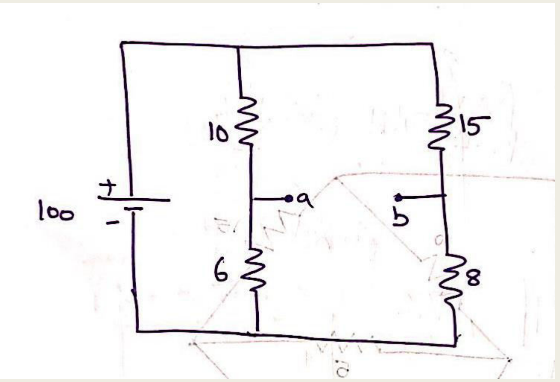
- STEP 1: Determine Rth by removing load, short circuiting voltage source and open circuiting current source





- $R_{TH} = 3.75 + 5.21 = 8.96\Omega$

- STEP 2: Find Vth by removing the load



- By using voltage division rule

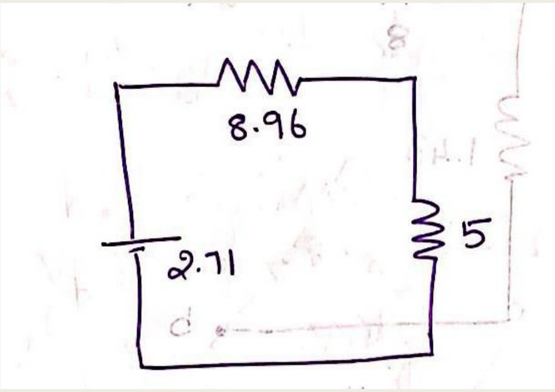
$$V_a = \frac{100 * 10}{10 + 6} = 62.5V$$

$$V_b = \frac{100 * 15}{15 + 8} = 65.21V$$

$$V_{th} = V_a - V_b = 62.5 - 65.21$$

$$\boldsymbol{V_{th} = -2.71V}$$

- STEP 3: Draw the equivalent Circuit

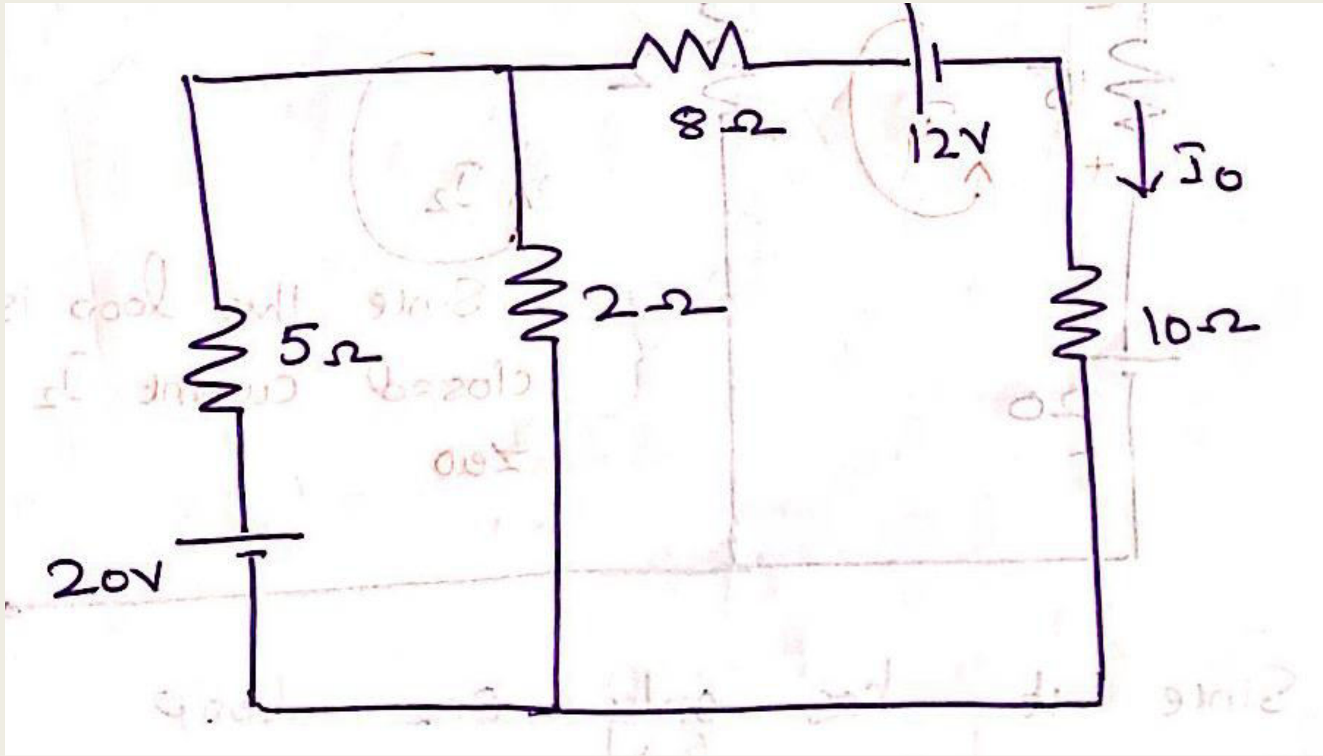


$$I_{5\Omega} = \frac{V_{th}}{R_{th} + R_L}$$

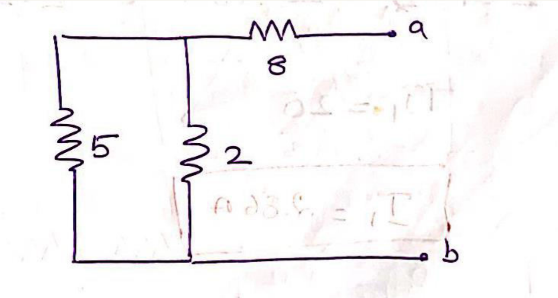
$$I_{5\Omega} = \frac{2.71}{8.96 + 5}$$

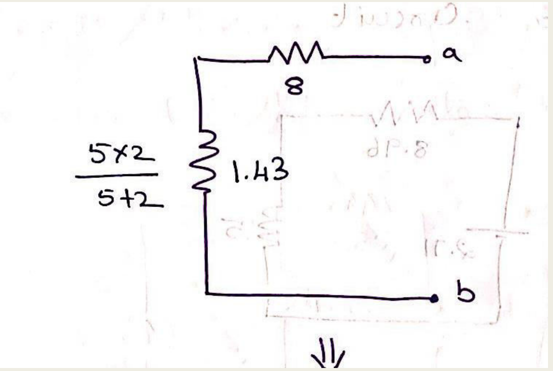
$$\boldsymbol{I_{5\Omega} = 0.19A}$$

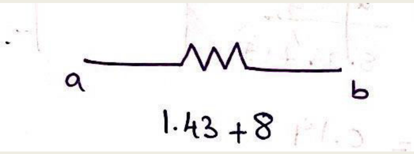
Using thevenin's theorem find the current I_0 in the circuit shown below



- STEP 1: Determine Rth by removing load, short circuiting voltage source and open circuiting current source

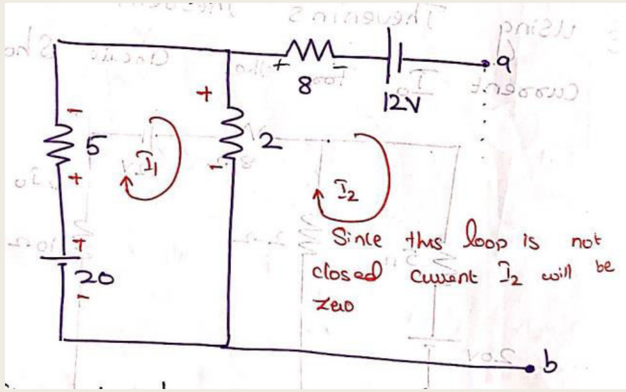






$$\boldsymbol{R_{TH} = 1.43 + 8 = 9.43\Omega}$$

- STEP 2: Find Vth by removing the load



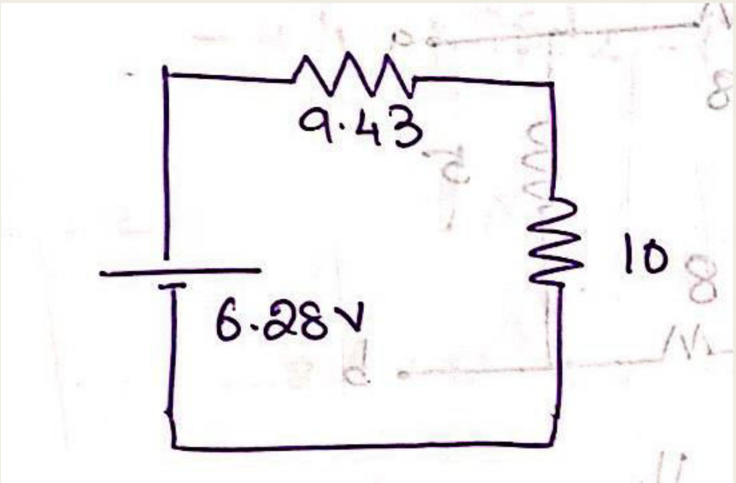
$$2(I_1 - I_2) - 20 + 5I_1 = 0$$

As loop 2 is open circuited $I_2 = 0$

$$7I_1 = 20$$
$$I_1 = 2.86A$$
$$V_{th} = -12 - 8I_2 + 2(I_1 - I_2)$$
$$V_{th} = -12 + 2I_1$$
$$V_{th} = -12 + 2 * 2.86$$

$$\boldsymbol{V_{th} = -6.28V}$$

- STEP 3: Draw the equivalent Circuit



$$I_{10\Omega} = \frac{V_{th}}{R_{th} + R_L}$$

$$I_{10\Omega} = \frac{6.28}{9.43 + 10}$$

$$\boldsymbol{I_{10\Omega} = 0.32A}$$

THANK YOU