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Assignment-1
DC Circuit

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1. Define following Terms.

a. Node

A point where two or more than two elements are joined together is called a node.

b. Branch

An element or a number of elements connected b/w two nodes constitutes a branch.

c. Loop

A closed path for the flow of current is called a loop.

d. Mesh

A loop that does not contain any others loops within it is called a mesh.

e. Active Elements

An independent source which can deliver or absorb energy continuously is called an active elements.

f. Passive element

Passive component which are consumed the energy or store the energy are known as Passive componat.

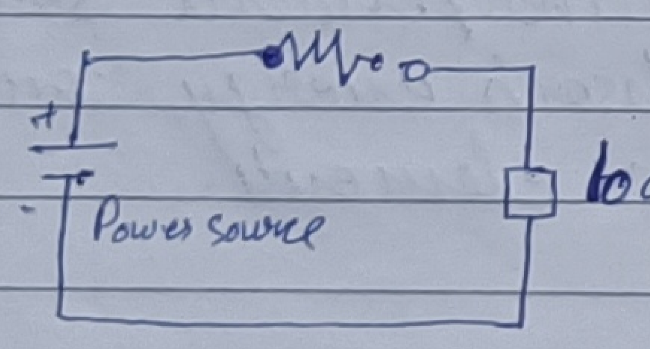
Parameters like resistance, inductance and capacitance are called passive elements.

g. Junction point

Junction is a point at which three and more elements joined together is known as Junction point

2. Explain concept of open circuit in series.

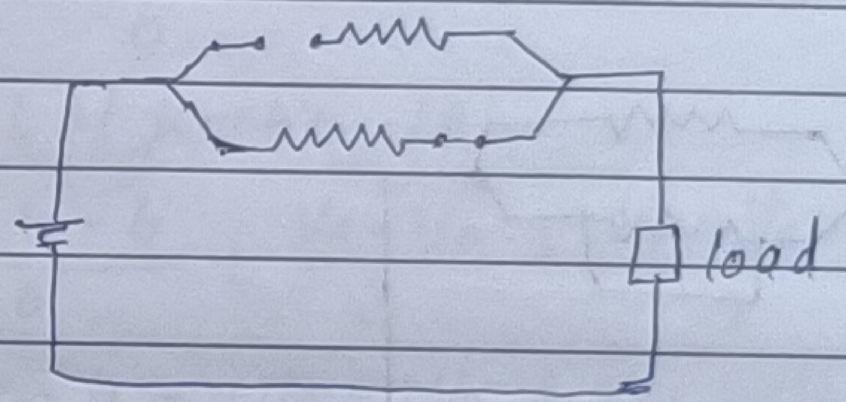
Ans: A circuit in which the continuity is broken due to which the electric current can not flow is known as the open circuit. In an open circuit the current flowing is zero



Open Circuit

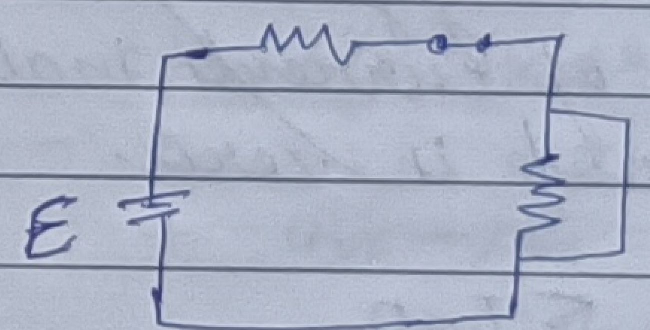
3. Explain concept of open circuit in parallel.

Ans: A parallel circuit has more than one path for current to flow. If one of the path is opened, current will continue to flow as long as a complete path is provided by one or more of the remaining paths.



4. Explain concept of short circuit in series.

Ans A short in a series circuit causes the current to increase above its normal value. A short circuit means the voltage source gets directly connected to ground giving current a path

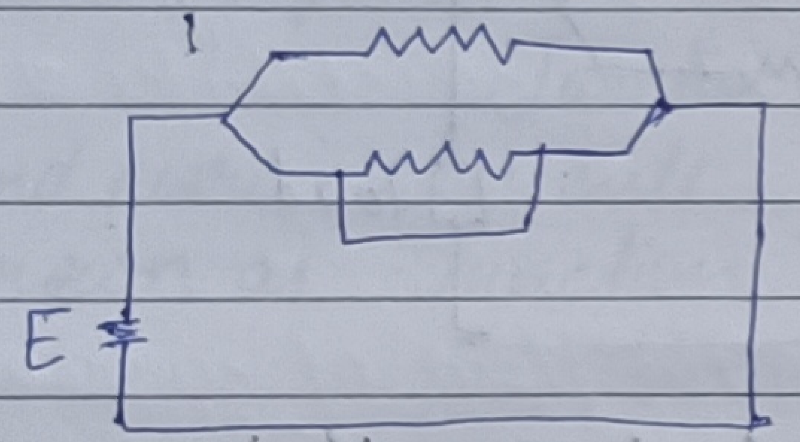


Short circuit in series.

5. Explain concept of short circuit in parallel.

Ans

As in a series circuit, if a branch in a parallel circuit develops a short extremely high currents may flow through the short circuit. The voltage across all branches of a parallel circuit will be zero with a short circuit.

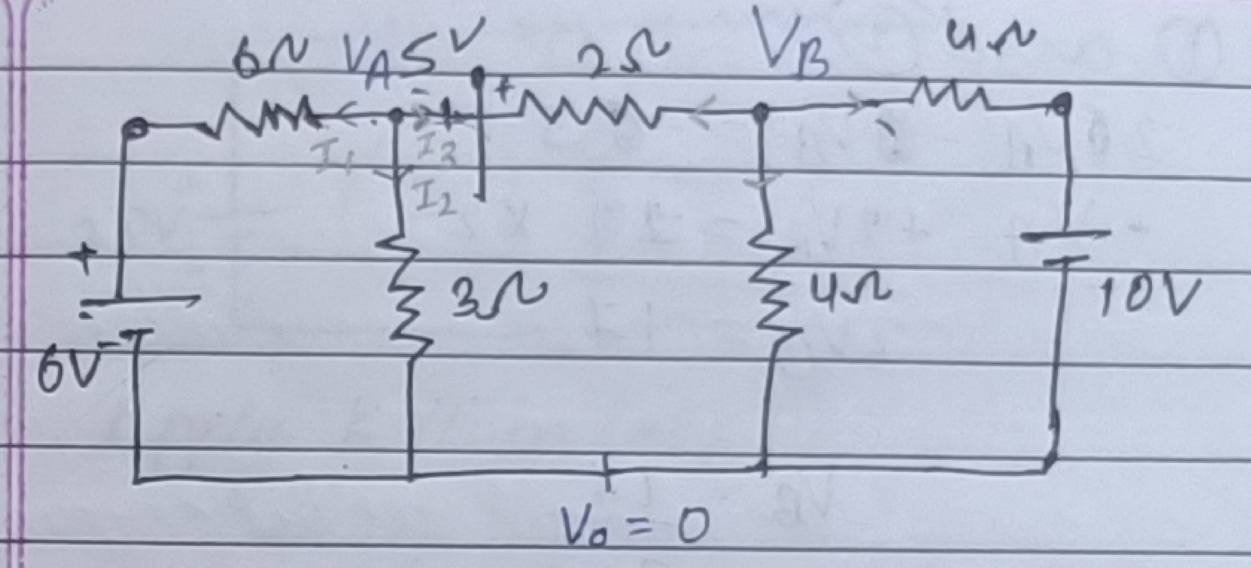


6. Explain Kirchhoff's current law with explanation

Ans. KCL states that the sum of the current flowing towards a node is equal to the sum of current flowing away from that node, the algebraic sum of currents in all the branches meeting at a node is zero.

$$\Sigma I = 0$$

Ex



Find the current in 3Ω resistor using KCL

Soln

$$I_1 = \frac{V_A - V_0 - 6}{6}$$

Applying KCL at junction (A)

$$\frac{V_A - V_0 - 6}{6} + \frac{V_A - V_0}{3} + \frac{V_A - V_B + 5}{2} = 0$$

$$\frac{V_A - V_0 - 6 + 2V_A - 2V_0 + 3V_A - 3V_B + 15}{6} = 0$$

$$6V_A - 3V_B = -9 \quad \text{—} (1)$$

Applying KCL at junction (B)

$$\frac{V_B - V_A - 5}{2} + \frac{V_B - V_0}{4} + \frac{V_B - V_0 - 10}{4} = 0$$

$$\frac{2V_B - 2V_A - 10 + 2V_B - 2V_0 + V_B - V_0 - 10}{4} = 0$$

$$4V_B - 2V_A = 20$$

$$-V_A + 2V_B = 10 \quad \text{—} (2)$$

From eqⁿ ① and ②

$$2V_A - V_B = -3$$
$$-V_A + 2V_B = 10 \times 2$$
$$3V_B = 17$$
$$V_B = \frac{17}{3}$$
$$V_B = 5.66\ V$$
$$V_A = 1.33\ V$$

Current through 3Ω R

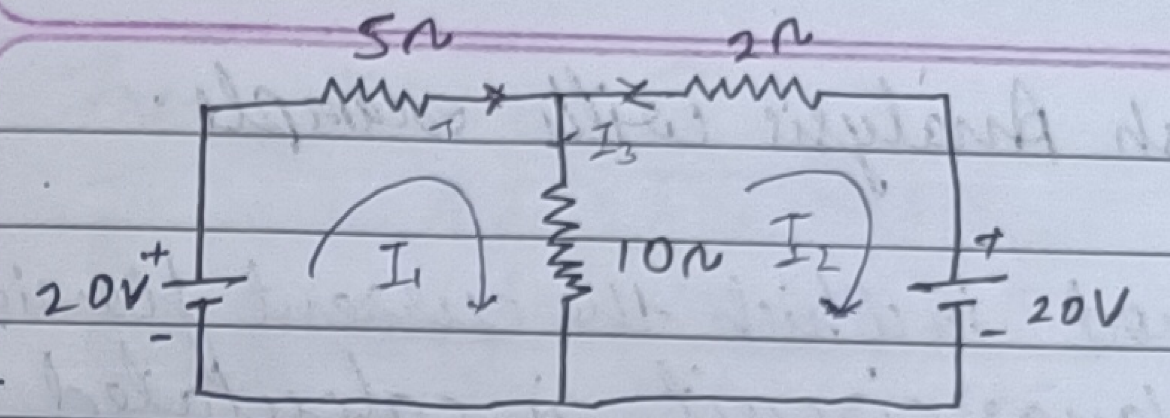
$$I_{(3\Omega)} = \frac{V_A - V_0}{3} = \frac{1.333}{3} = 0.444\ \text{Amp}$$

7. Explain kirchhoff's voltage Low with explanation.

Ans: KVL is state that the algebraic sum of all the potential difference in a close loop is equal to zero.

$$\Sigma V = 0$$

Ex.



⇒ Apply KVL in loop ①

$$-20 + 5I_1 + 10(I_1 - I_2) = 0$$
$$-20 + 5I + 10I_1 - 10I_2 = 0$$
$$15I_1 - 10I_2 = 20 \quad \text{— ①}$$

Apply KVL in loop ②

$$20 + 2(I_2) + 10(I_2 - I_1) = 0$$
$$20 + 2I_2 + 10I_2 - 10I_1 = 0$$
$$-10I_1 + 12I_2 = -20 \quad \text{— ②}$$

$$15I_1 - 10I_2 = 20 \times 2$$
$$-10I_1 + 12I_2 = -20 \times 3$$
$$16I_2 = -20$$
$$I_2 = -1.25A$$
$$I_1 = 0.5\ A$$

$$I_3 = I_1 - I_2$$
$$= 0.5 + 1.25$$
$$= 1.75\ A$$

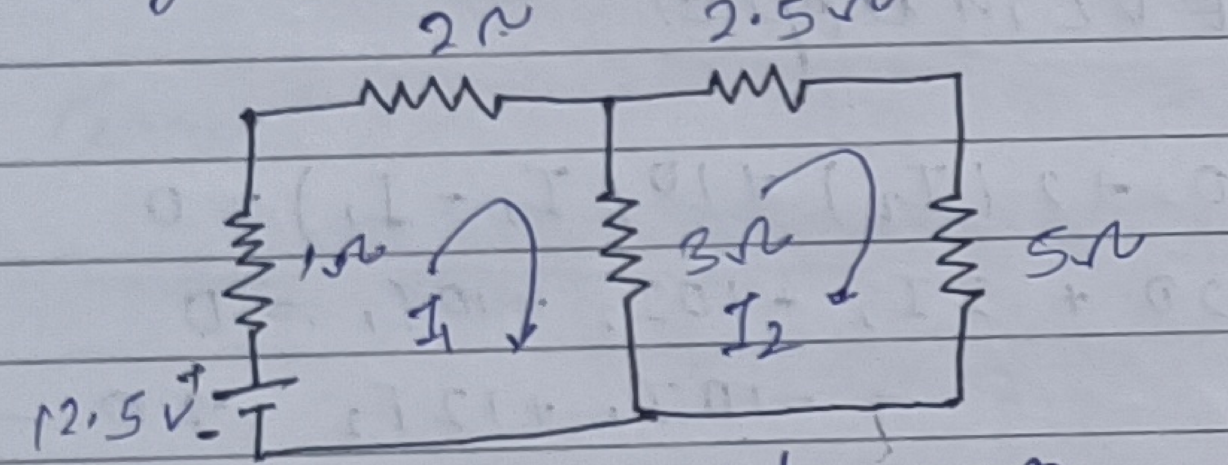
8. Explain Mesh Analysis with example.

Ans

The method in which the current flowing through a planar circuit is calculated.

A planar circuit is defined as the circuits that are drawn on the plane surface in which there are no wires crossing each other, Therefore, a mesh analysis can also be known as loop analysis or mesh-current method.

Ex.



Apply KVL to mesh (loop) ①

$$12.5 - I_1 - 2I_1 - 3I_1 + 3I_2 = 0$$

$$12.5 - 6I_1 + 3I_2 = 0$$

$$6I_1 - 3I_2 = 12.5 \quad —①$$

Apply KVL to mesh loop ②

$$-3I_2 + 3I_1 - 2.5I_2 - 5I_2 = 0$$

$$3I_1 - 10.5I_2 = 0 \quad —②$$

From eqn ① and ②

$$6I_1 - 3I_2 = 12.5$$

$$-3I_1 + 10.5I_2 = 0 \times 2$$

$$18 I_2 = 12.5$$

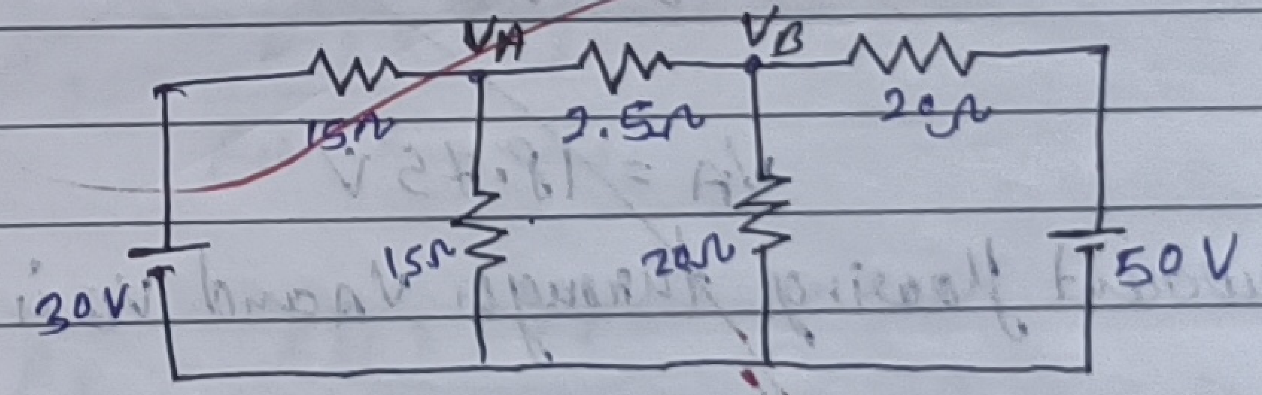
$$I_2 = 0.69\text{ A}$$

$$I_1 = 2.43\text{ A}$$

9. Explain concept Nodal Analysis with example.

Ans:- It is defined as the mathematical method for calculating the voltage distribution b/w the circuit nodes. The common point where two or more elements are connected. The nodal analysis is based on Kirchoff's current law (KCL) unlike Maxwell's mesh analysis which is based on Kirchhoff's voltage law.

Ex.



Find the current flowing through V_A and V_B.

Apply KCL to V_A

$$\frac{V_A - 30}{15} + \frac{V_A}{15} + \frac{V_A - V_B}{2.5} = 0$$

$$\frac{V_A - 30 + V_B + 6V_A - 6V_B}{15} = 0$$

$$V_A - 30 + V_B + 6V_A - 6V_B = 0$$

$$8V_A - 6V_B = 30 \quad -(1)$$

Apply KCl in V_B

$$\frac{V_B - A_B}{2.5} + \frac{V_B - 50}{20} + \frac{V_B}{20} = 0$$

$$8V_B - 8V_A + V_B - 50 + V_B = 0$$

$$10V_B - 8V_A = 50 \quad -(2)$$

From eq^n (1) and (2)

$$8V_A - 6V_B = 30$$

$$-8V_A + 10V_B = 50$$

$$4V_B = 80$$

$$V_B = 20\ V$$

$$V_A = 18.75\ V$$

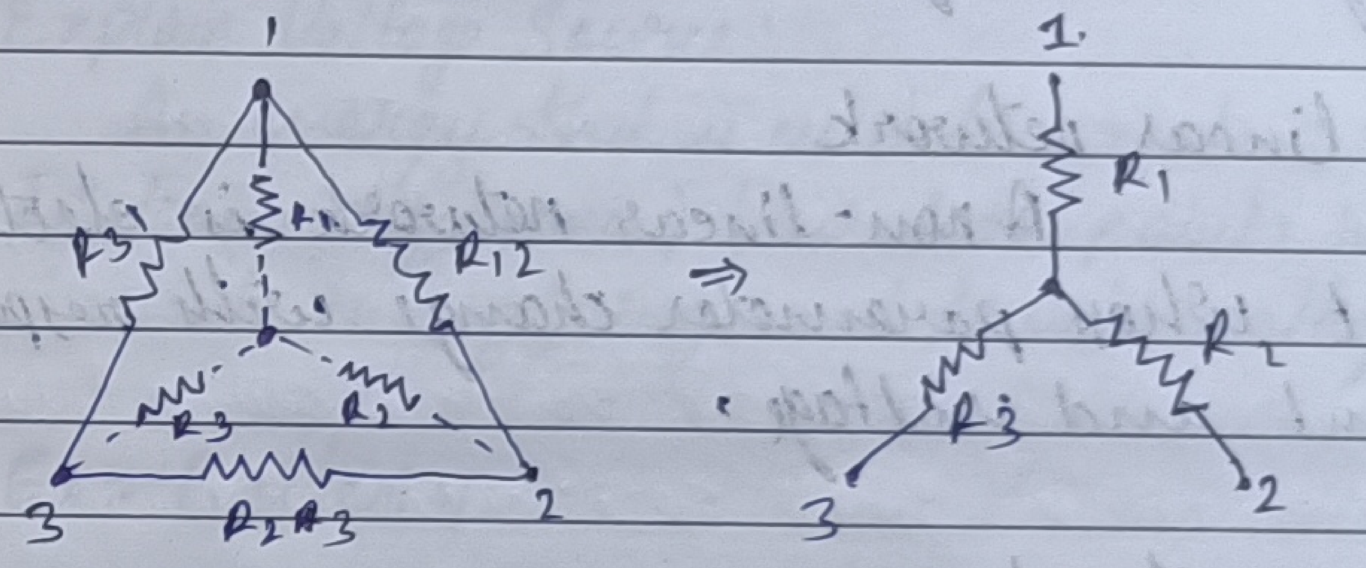
The current flowing through V_A and V_B is

$$\frac{V_A - V_B}{2.5} = \frac{18.75 - 20}{2.5} = -0.5\ A$$

10. Explain the delta to star transformation.

Sol^n

To convert a delta network to an equivalent star network we need to derive a transformation formula for equating the various resistors to each other b/w the various terminals. Consider the circuit below



$$R_1 = \frac{R_{12} \times R_{31}}{R_{12} + R_{23} + R_{31}}$$

$$R_2 = \frac{R_{12} \times R_{23}}{R_{12} + R_{23} + R_{31}}$$

$$R_3 = \frac{R_{31} \times R_{23}}{R_{12} + R_{23} + R_{31}}$$

11. Define the following terms

a. Linear network

A linear network that has constant parameters, such as resistance, Inductor and capacitors. These parameters do not chang with change in voltage or current.

b. non - linear network

A non-linear network is electric circuit whose parameter change with respect to current and voltage.

c. Active network

The element which supplies energy to the circuit or network is known as active network. The example of active network are voltage source or current source.

d. Passive network

The element which receive energy from the circuit is known as passive network. The example of passive network are resistor, inductance, capacitor.

12. Explain current source

Ans: The energy source that delivers a specified electric current to the circuit is referred to as a current source.

Ex:- constant speed motor driving a water pump.

13. Explain Voltage Source.

Ans:- An energy that is used to create a voltage (Potential difference) b/w two points in an electric circuit is ~~reff~~ referred to as a voltage circuit

Ex:- Batteries

14. Write the statement of superposition theorem.

Ans: Superposition theorem states that in any linear, active, bilateral network with component is the sum of the responses obtained from each source considered seperately and their internal resistance is replaced by all other sources.

11. e Bilateral Network

Bilateral network is one in which the relation between current and voltage do not change in either direction in the network.

15. Write the statement of Norton's theorem.

Ans: In any linear, active bilateral network consisting of some voltage source or current source and some resistance can be replace by some current source (I_N) in parallel with Norton resistance and in parallel with load resistance (R_N).

16. Write the statement of Thevenin Theorem

Ans: In any linear, active bilateral network consisting some voltage source or current source can be replaced by a single voltage source (V_{th}) and in series with single resistance (R_{th})

17. Write the limitation of superposition theorem.

Ans: - Superposition theorem is used to solve the network where two or more source exist.

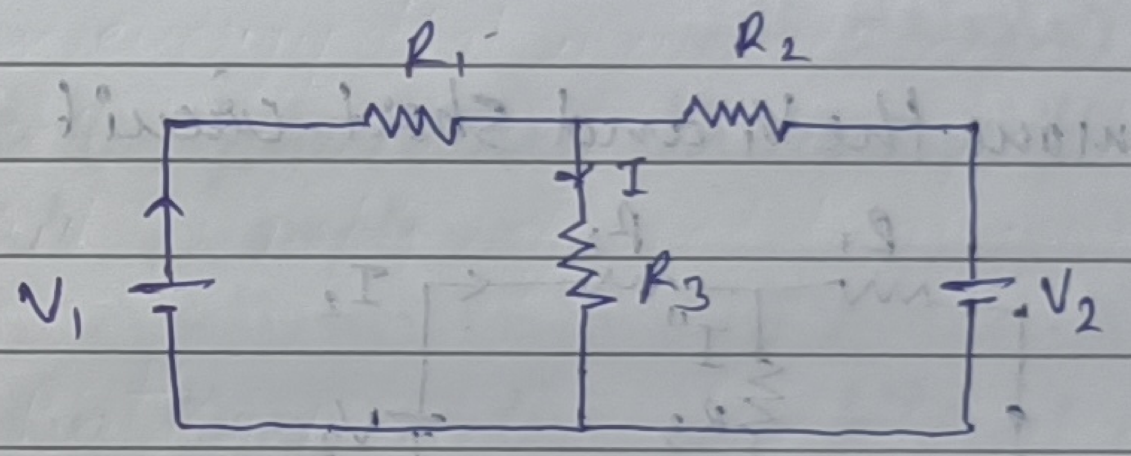
- It cannot be used to measure power.

- It is not applicable to unbalanced bridge circuits.

18. Explain the procedure superposition theorem with suitable example.

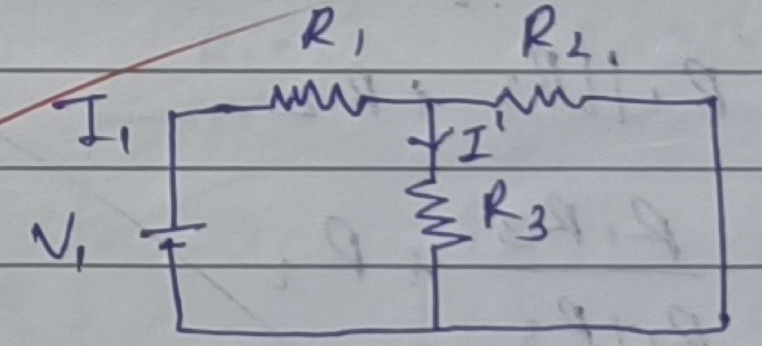
Ans:

The superposition theorem is used to analyze electrical circuits with multiple power sources. The theorem states that the response across any elements in the circuit is the sum of the responses obtained from each source considered separately.



Voltage source : Short

Step-1 Remove V_2 and short circuit



Step-2 Calculate R_{eq_1}

$$R_{eq_1} = R_2 \parallel R_3 + R_1$$

$$= \frac{R_2 \cdot R_3}{R_2 + R_3} + R_1$$

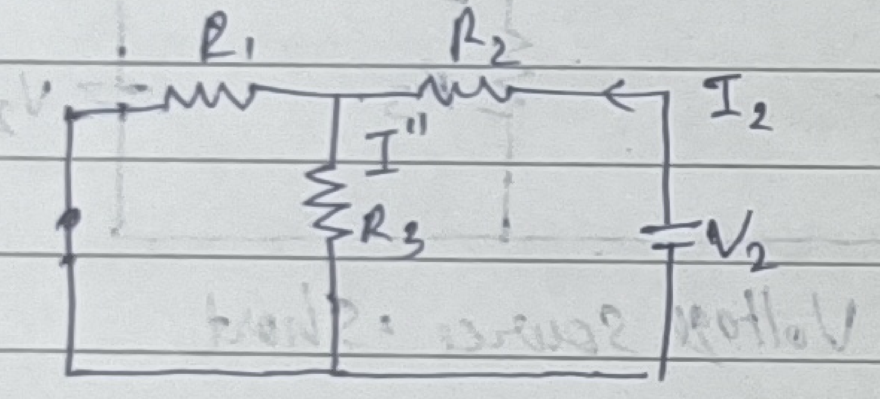
Step-3: Calculate I_1

$$I_1 = \frac{V_1}{Req_1}$$

Step-4 Calculate I'

$$I' = \frac{I_1 \times R_2}{R_2 + R_3}$$

Step-5 Remove the V_1 and short circuit



Step-6 Calculate Req_2

$$Req_2 = R_1 \| R_3 + R_2$$

$$= \frac{R_1 R_3}{R_1 + R_3} + R_2$$

Step-7 Calculate I_2

$$I_2 = \frac{V_2}{Req_2}$$

Step-8 Calculate I''

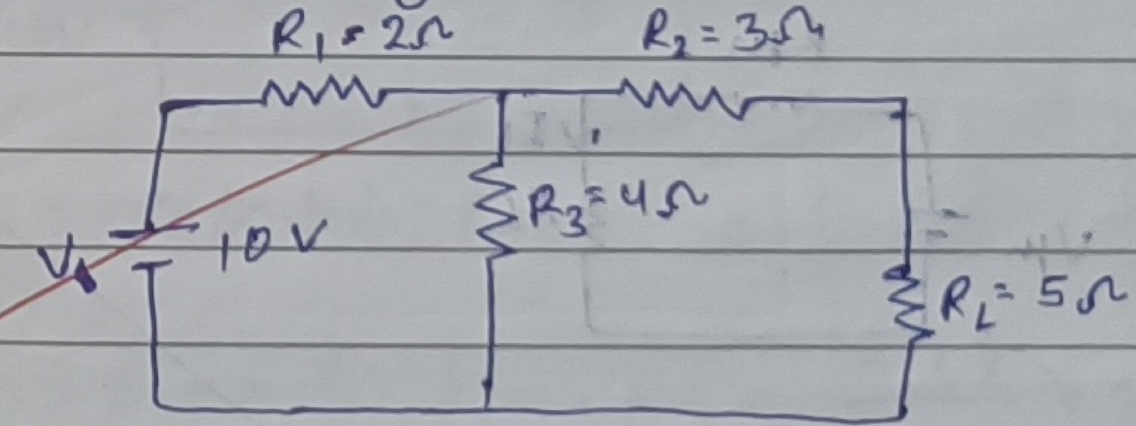
$$I'' = \frac{I_2 \times R_1}{R_1 + R_3}$$

Step-9 Total current

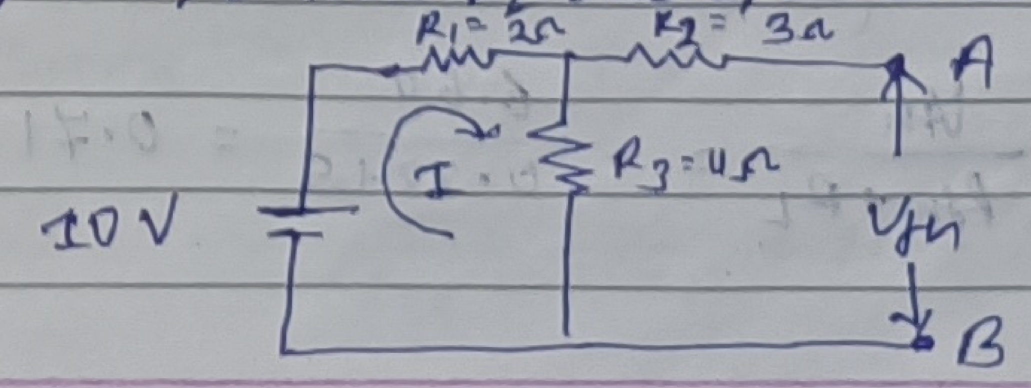
$$I = I' + I''$$

19. Explain the procedure thevenin's theorem with suitable example.

Sol^n: In any linear active ~~by~~ bilateral network consisting some voltage source or current source can be replaced by a single voltage source (V_{th}) and in series with single resistance (R_{th}).



Step-1 Remove R_L and open circuit



Step - 2 Calculate Req

$$R_{eq} = R_1 + R_3 = 2 + 4 = 6\,\Omega$$

Step - 3 Calculate I

$$I = \frac{V}{R_{eq}} = \frac{10}{6} = 1.66\ A$$

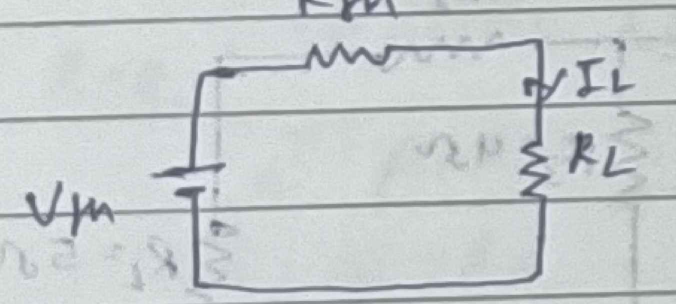
Step - 4 Calculate V_{th}

$$V_{th} = I \times R_3 = 1.66 \times 4 = 6.64\ V$$

Step - 5 Remove V and short circuit & Calculate R_{th}

$$R_{th} = \frac{R_1 R_3}{R_1 + R_3} + R_2 = \frac{2 \times 4}{2+4} + 3 = 4.33\,\Omega$$

Step - 6 Draw Equivalent circuit



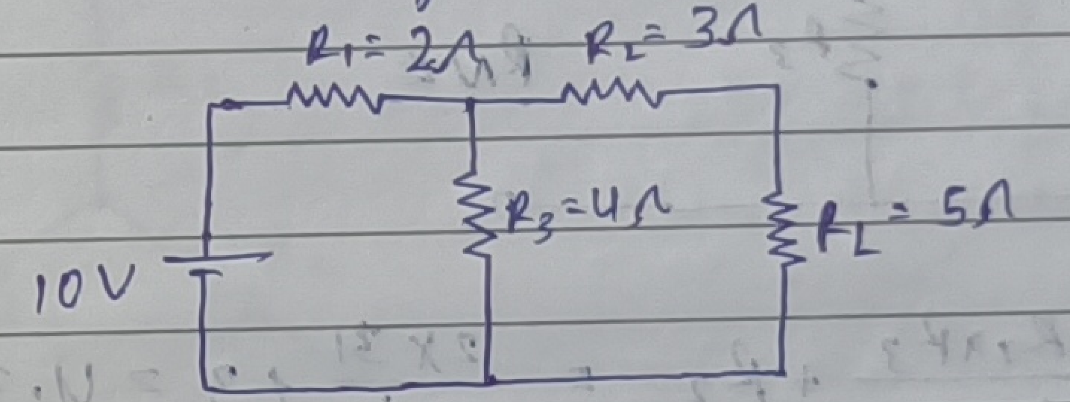
Step - 7 Calculate (I_L) load current

$$I_L = \frac{V_{th}}{R_{th} + R_L} = \frac{6.64}{4.33 + 5} = 0.71\ A$$

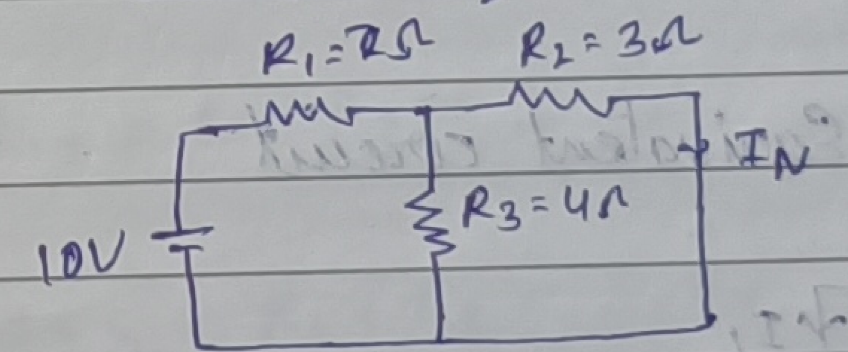
20. Explain the procedure Norton's theorem with sitable example.

Ans Norton's theorem states that any linear circuit can be replaced by a single current source in parallel with a single resistance.

The procedure for solving a circuit using Norton's theorem is as follows:



Step - 1 Remove R_L and short circuit



Step - 2 Calculate Req

$$R_{eq} = \frac{R_2 \times R_3}{R_2 + R_3} + R_1 = \frac{3 \times 4}{3+4} + 2 = 3.71\,\Omega$$

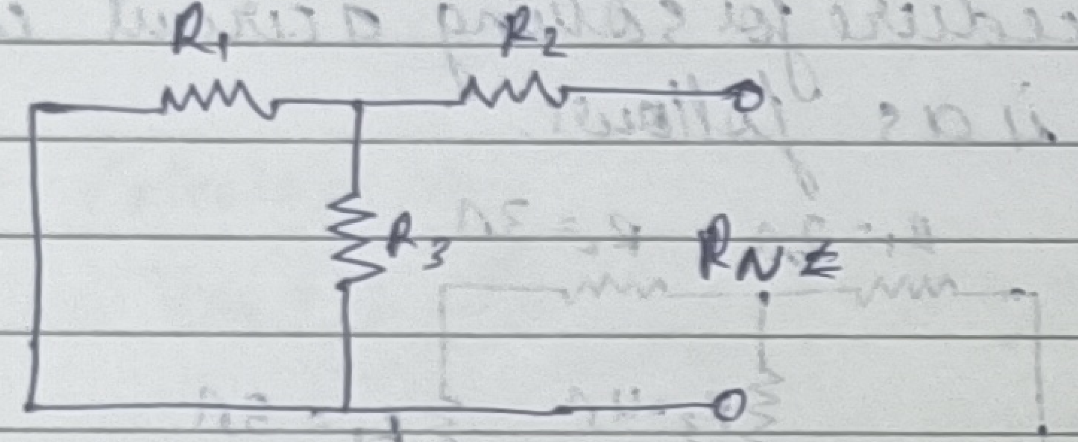
Step - 3 Calculate I

$$I = \frac{V}{R_{eq}} = \frac{10}{3.71} = 2.69\ A$$

Step-4 Calculate the Norton's current (I_N)

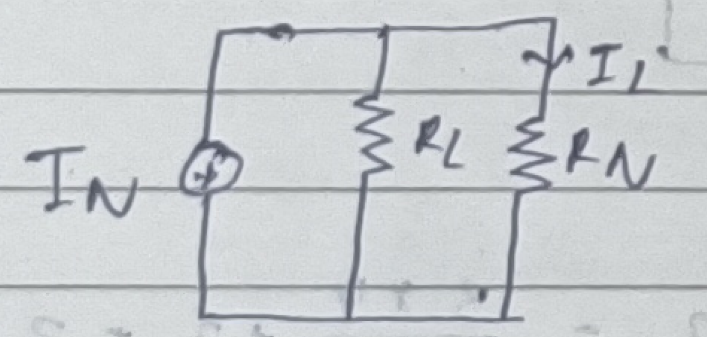
$$I_N = \frac{I \times R_3}{R_2 + R_3} = \frac{2.69 \times 4}{3+4} = 1.53\ A$$

Step-5. Open current source, short circuit and calculate Norton's Resistance (R_N)



$$R_N = \frac{R_1 \times R_3}{R_1 + R_3} + R_2 = \frac{2 \times 4}{2+4} + 3 = 4.33\ \Omega$$

Step-6 Draw Equivalent circuit

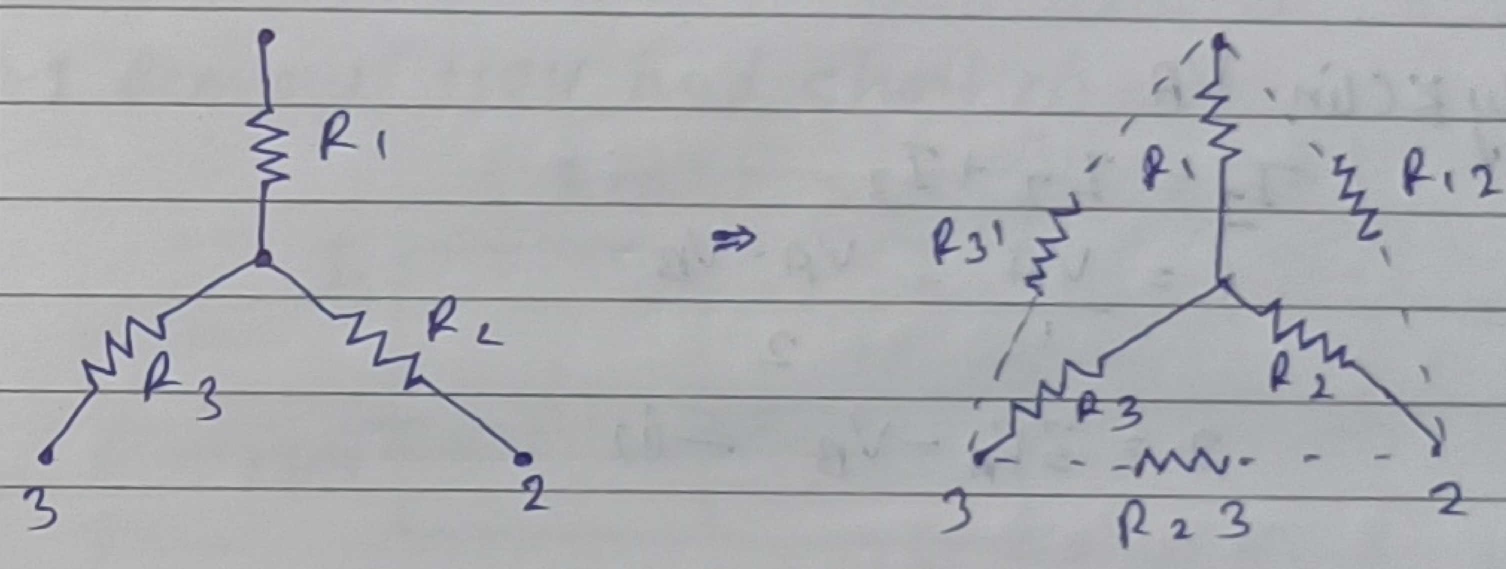


Step-7 Calculate Load current (I_L)

$$I_L = \frac{I_N \times R_N}{R_N + R_L} = \frac{1.53 \times 4.33}{4.33 + 5} = 0.71\ Amp.$$

21. Explain the star to delta transformation.

Ans: The value of the resistor on any one side of the delta. A network is the sum of all the two-product combinations of resistor in the star network divided by the star resistor located directly opposite the delta resistor being found.

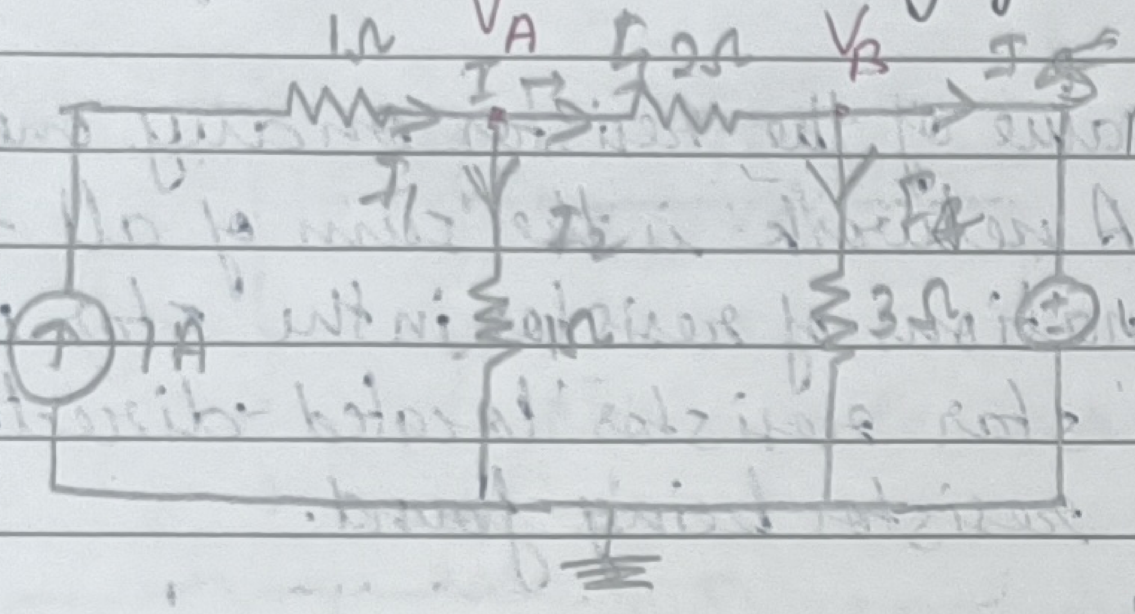


$$R_{12} = R_1 + R_2 + \frac{R_1 R_2}{R_3}$$

$$R_{23} = R_2 + R_3 + \frac{R_2 R_3}{R_1}$$

$$R_{31} = R_3 + R_1 + \frac{R_3 R_1}{R_2}$$

22. Find I in the circuit shown in figure 1.



SoM

Apply KCL in V_A

$I_1 = I_2 + I_3$

$= \frac{V_A}{1} + \frac{V_A - V_B}{2}$

$2 = 3V_A - V_B \quad \text{---(i)}$

Apply KCL in V_B

$I_3 = I_4 + I_5$

$\frac{V_A - V_B}{2} = \frac{V_B}{3} + \frac{V_B - 1}{1}$

$3V_A - 5V_B = 0 \quad \text{---(ii)}$

From eq^n (i) and (ii)

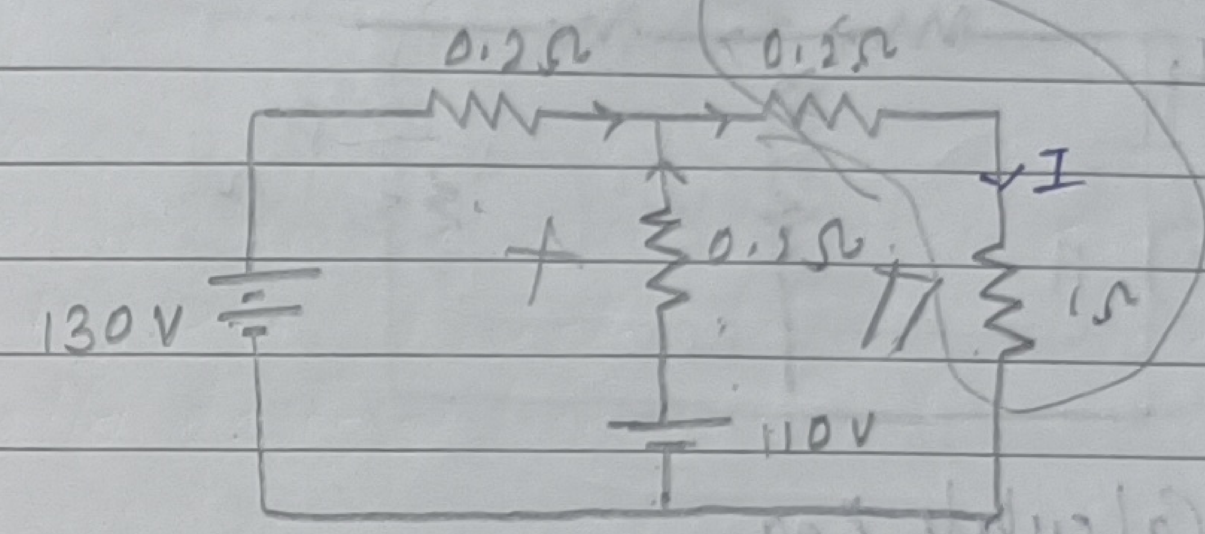
$V_A = 0.83\ V;\ V_B = 0.5\ V$

Current flowing in I

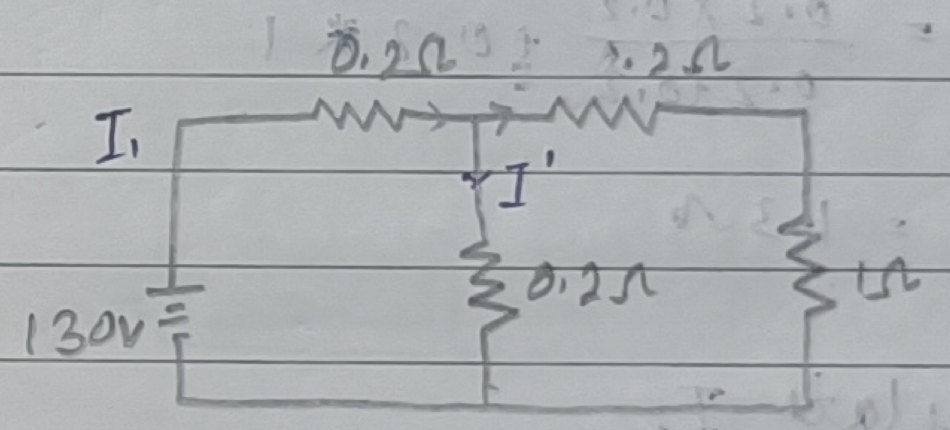
$I = I_2 = \frac{V_A - V_B}{2} = \frac{0.85 - 0.5}{2} = 0.165\ A$

23. Find current flowing through 1Ω resistor by using supersition theorem.

SoM



Step-1 Remove 110V and short circuit



Step-2 Calculate R_{eq_1}

$R_{eq_1} = \frac{0.2 \times 0.2}{0.2 + 0.2} + 0.2 + 1$

$= 1.3\Omega$

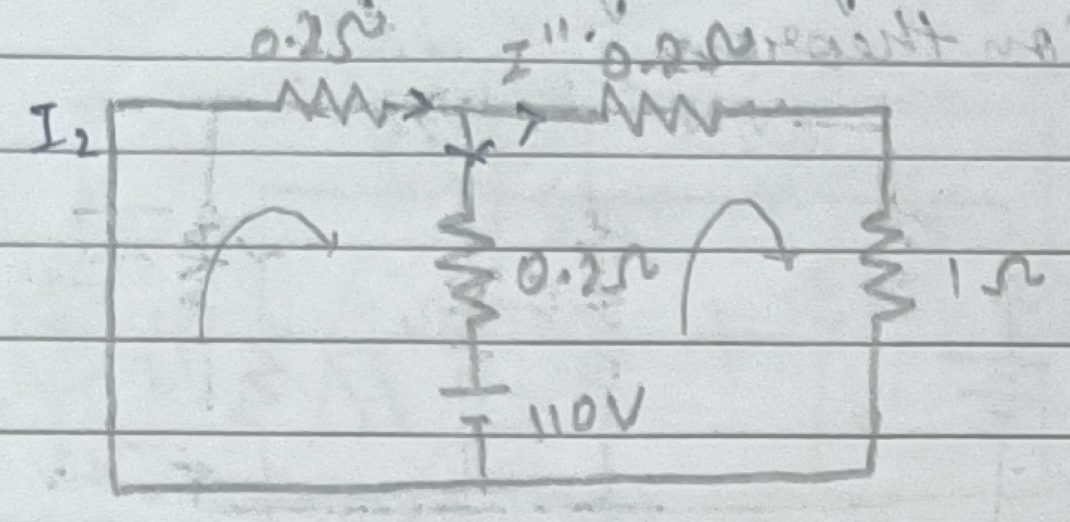
Step-3 Calculate I_1

$I_1 = \frac{V}{R_{eq_1}} = \frac{130}{1.3} = 100\ A$

Step-4 Calculate I'

$I' = \frac{I_1 \times (0.2)}{0.2 + 0.2} = \frac{100 \times 0.2}{0.4} = \frac{20}{0.4} = 50\ A$

Step-5 Remove the 130V and short circuit



Step-6 Calculate Req_2

$$Req_2 = \frac{0.2 \times 0.2}{0.2 + 0.2} + 0.2 * 1$$

$$= 1.3\Omega$$

Step-7 Calculate I_2

$$I_2 = \frac{V}{Req_2} = \frac{110}{1.3} = 84.62$$

Step-8 Calculate I''

$$I'' = \frac{I_2 \times 0.2}{0.2 + 0.2} = \frac{84.62 \times 0.2}{0.4} = \frac{16.924}{0.2}$$

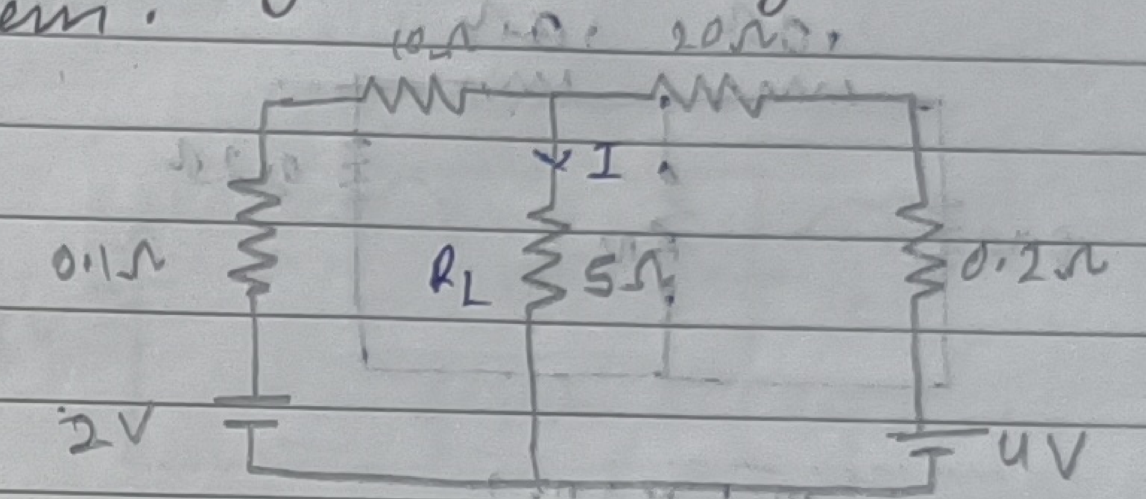
$$= 42.31\ A$$

$$I = I' + I'' = 50 + 42.31$$

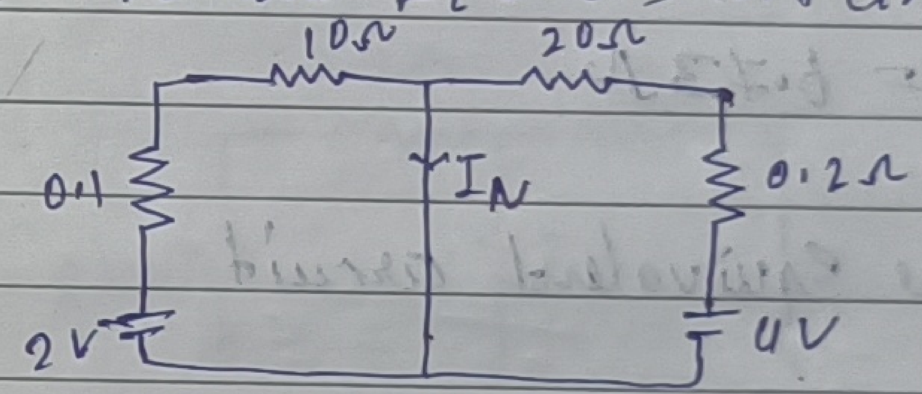
$$= 92.31\ A$$

24. Find current flowing through 5Ω using Norton theorem.

Sol^n



Step-1 - Remove R_L and short circuit



Step-2 Calculate Req.

$$Req = 30.3\Omega$$

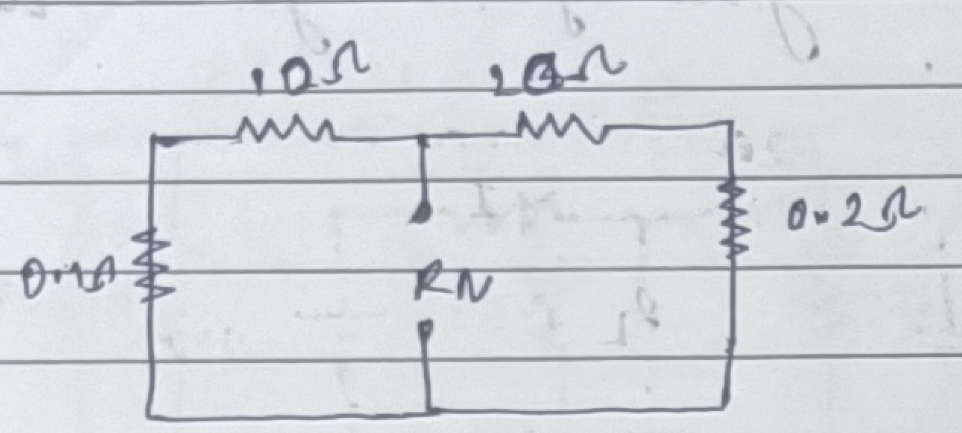
Step. 3 Calculate I

$$I = \frac{V}{Req} = \frac{4-2}{30.3} = \frac{\cancel{0.138}\ .2}{30.3} = 0.066\ A$$

Step-4 Calculate I_N

$$I_N = \frac{2}{10.1} + \frac{4}{20.2} = 0.396\ A$$

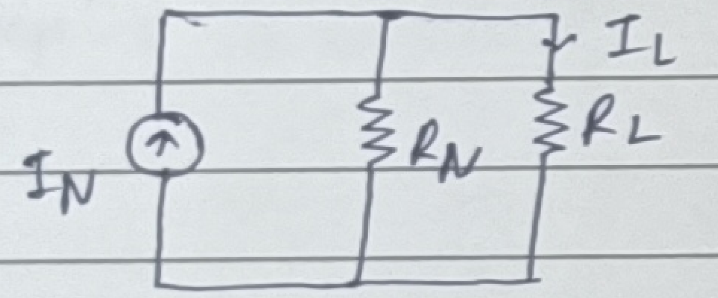
Step-5 Calculate R_N to short source and open R_L



$$R_N = \frac{10.1 \times 20.2}{10.1 + 20.2}$$

$$= 6.73\,\Omega$$

Step-6 Draw Equivalent circuit



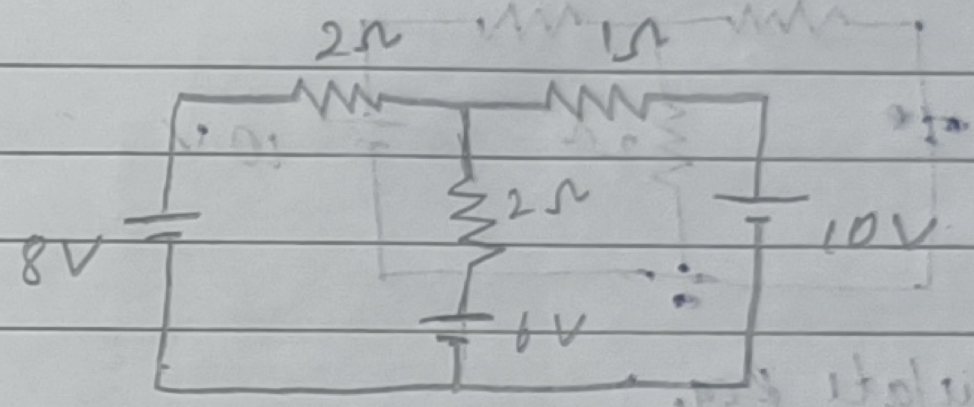
Step-7 Calculate load ~~to~~ current (I_L)
current following through 5Ω

$$I_L = \frac{I_N \times R_N}{R_N + R_L} = \frac{0.396 \times 6.73}{6.73 + .5}$$

$$= \frac{2.66}{4.73}$$

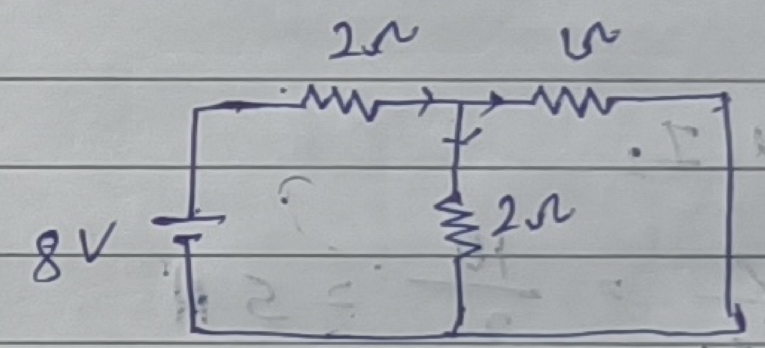
$$= 0.23\ A$$

25. Determine current through 1Ω resistor using superposition theorem



5oM

Step-1 Remove 6V and 10 V and Short Circuit



Step-2 Calculate Req.

$$R_{eq_1} = \frac{1 \times 2}{1+2} + 2 = 2.66\,\Omega$$

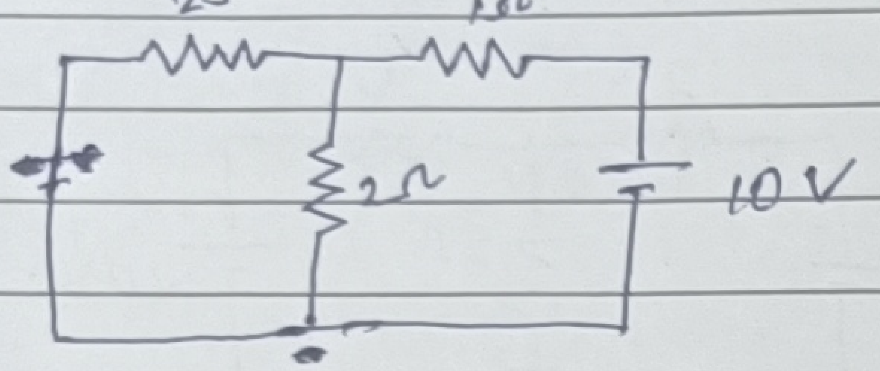
Step-3 Calculate I_1

$$I_1 = \frac{V}{R_{eq}} = \frac{8}{2.66} = \cancel{2.90}\ 3\ A$$

Step-4 Calculate I_1

$$I' = \frac{I_1 \times 2}{2+1} = \frac{3 \times 2}{2+1} = 8\ \cancel{1.5A}\ 2\ A$$

Step-5 Remove 8V and 10V short circuit



Step-6 Calculate R_{eq_2}:

$$R_{eq_2} = \frac{2\times2}{2+2} + 1 = 1+1 = 2\,\Omega$$

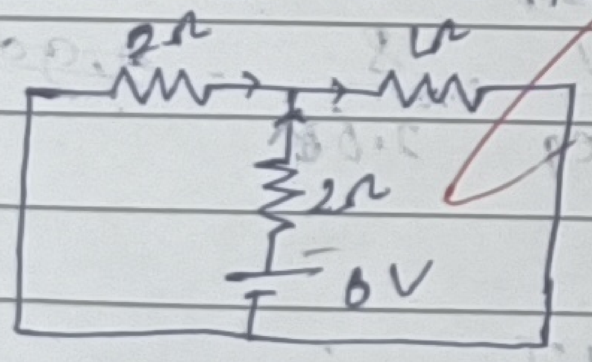
Step-7 Calculate I_2

$$I_2 = \frac{V}{R_{eq_2}} = \frac{10}{2} = 5\,A$$

Step-8 Calculate I''

$$I'' = \frac{I_2 \times 2}{2+2} = \frac{5\times2}{3} = \frac{10}{3} = \cancel{2.5}\ 3.33A$$

Step-9 Remove 8V and 10V short circuit



$$\frac{2\times1}{3u} + 2$$

$$6$$

Step-10 Calculate R_{eq_3}

$$R_{eq_3} = \frac{2\times2}{2+2} + 1 = 2$$

Step-11 Calculate I_3

$$I_3 = \frac{6}{2} = 3\,\Omega$$

Step-12 Calculate I'''

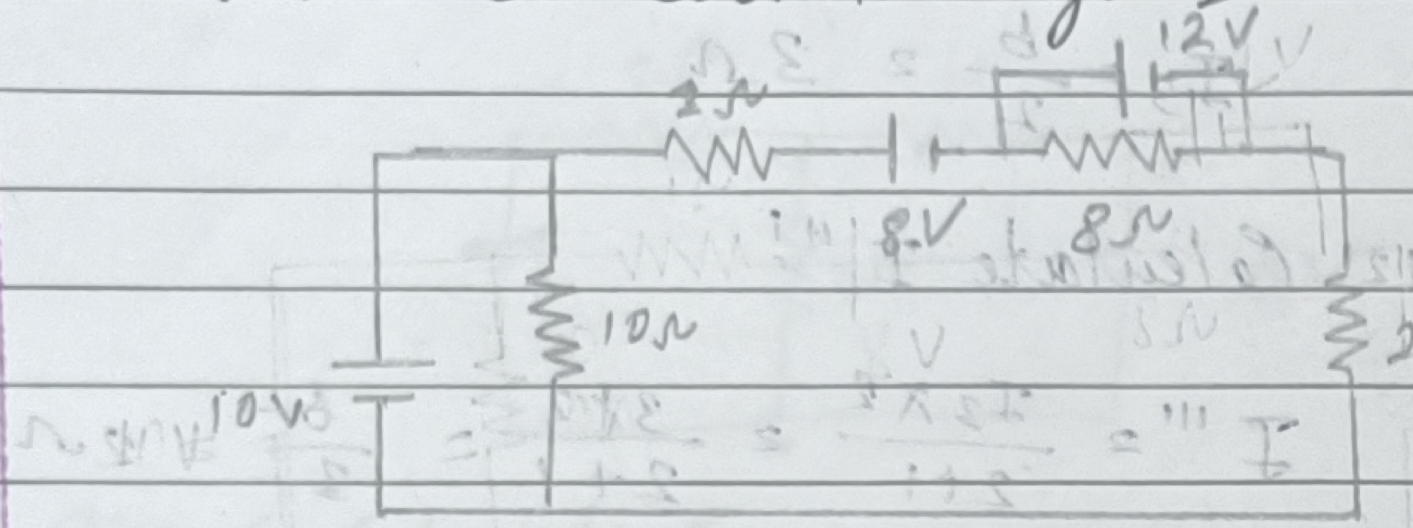
$$I''' = \frac{I_3\times2}{2+1} = \frac{3\times2}{2+1} = \frac{6}{3} = 2\,\Omega$$

Current through 1Ω resistor $I_{1\Omega}$:

$$I_{1\Omega} = I' + I''' - I''$$
$$= 2+2-3.33$$
$$= 4-3.33$$
$$I_{1\Omega} = 0.67\,A$$

26. Determine current through 10 Ω resistor.

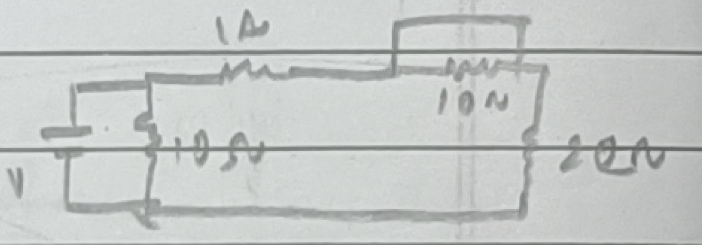
Solⁿ



Solⁿ ① ~~Remove~~ 12V and 8V and short circuit

$I = \frac{10}{6.77} = 1.47\,A$; $R_{eq} = 10 \parallel 21 = \frac{10 \times 21}{10 + 21} = 6.77$

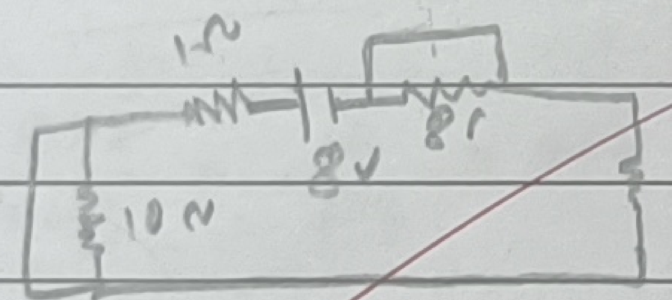
$I' = \frac{I \times 21}{21 + 10} = \frac{1.47 \times 21}{31} = 1\,A$



(ii) ~~Remove~~ Short 12V and 10V

$R_{eq} = 21\,\Omega$

$I = \frac{12}{21} = 0.57\,A$

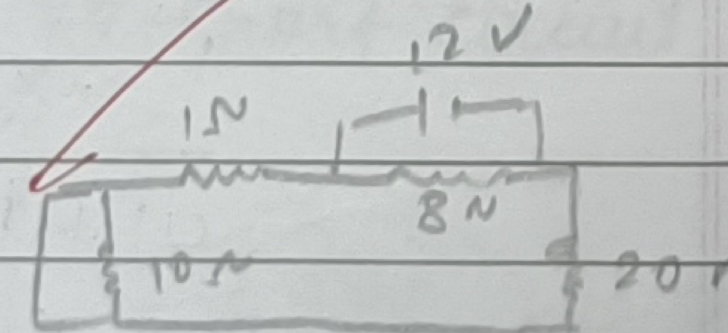


$I'' = \frac{I \times 0}{20 + 0} = 0$

(iii) Short 8V and 10V

$R_{eq} = 6.2\,\Omega$

$I = \frac{20}{6.2} = 3.22$



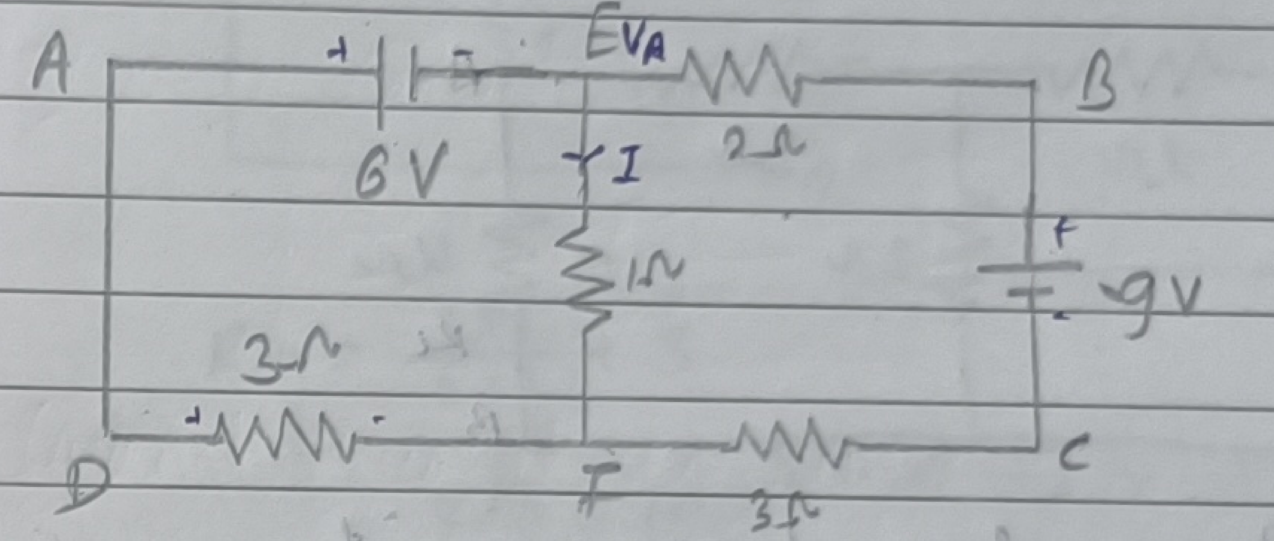
$I''' = \frac{I \times 0}{10 + 0} = 0$

So,

Current through 10Ω is $I_{10\Omega} = I' + I'' + I'''$

$I_{10\Omega} = 1\,A$.

27. Calculate the current that flows in the 1Ω resistor in the following circuit.



Solⁿ Apply ~~KVL~~ KCL at node V_A

$$\frac{V_A - 6}{3} + \frac{V_A}{1} + \frac{V_A - 9}{5} = 0$$

$$5V_A - 30 + 15V_A + 3V_A - 27 = 0$$

$$23V_A - 57 = 0$$

$$V_A = \frac{57}{23}$$

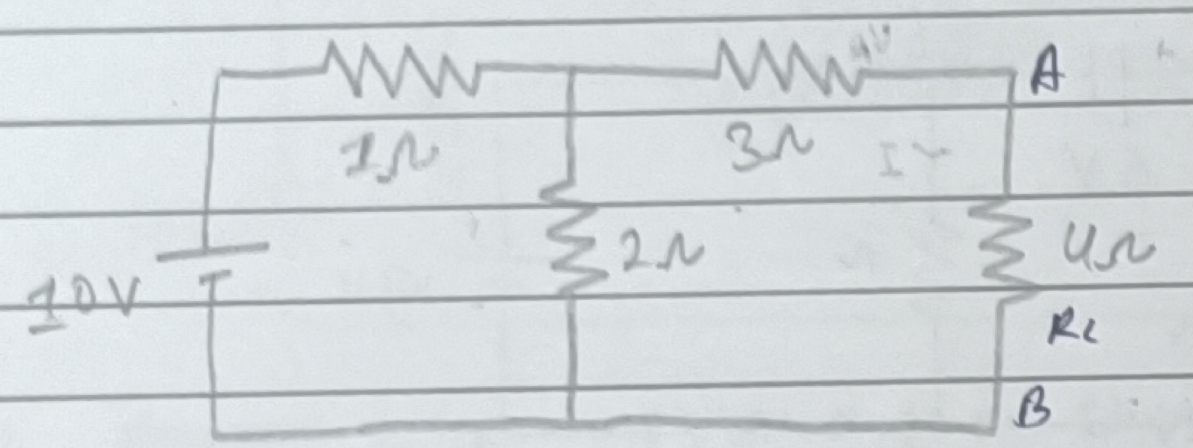
$$V_A = 2.47\,V$$

Current flow in 1Ω

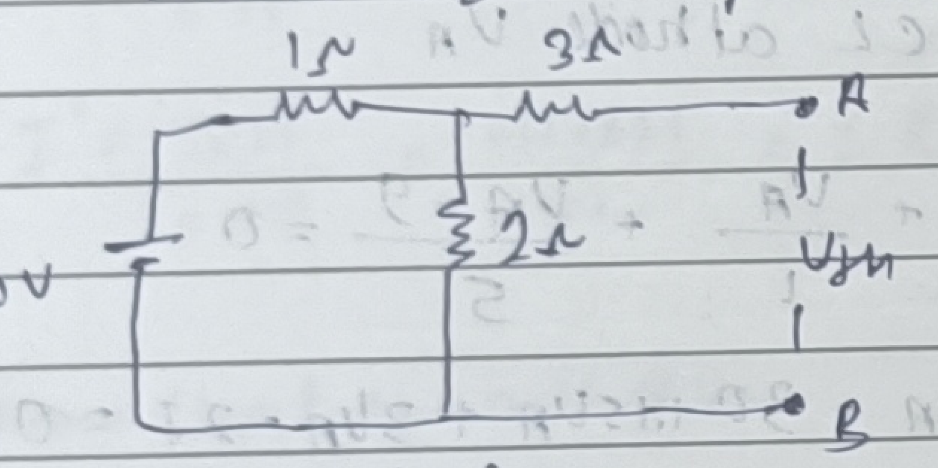
$$I = \frac{V_A}{1} = \frac{2.47}{1}$$

$$= 2.47\,A$$

28. Calculate the Thevenin resistance across the terminal AB for the following circuit.



Sol^n Step-1 Remove R_L and open circuit



Step-2 Calculate Req

$$R_{eq} = 2+1 = 3$$

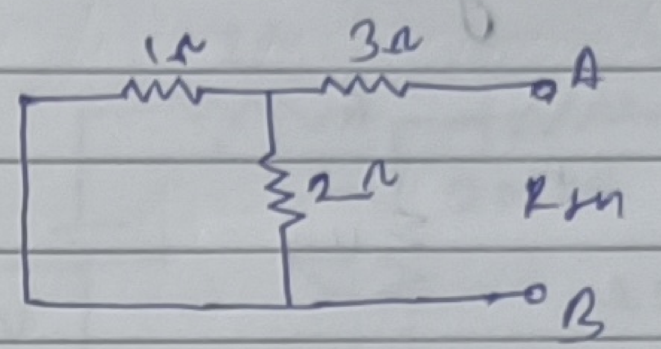
Step-3 Calculate I

$$I = \frac{V}{R_{eq}} = \frac{10}{3} = 3.33\ A$$

Step-4 Calculate V_{th}

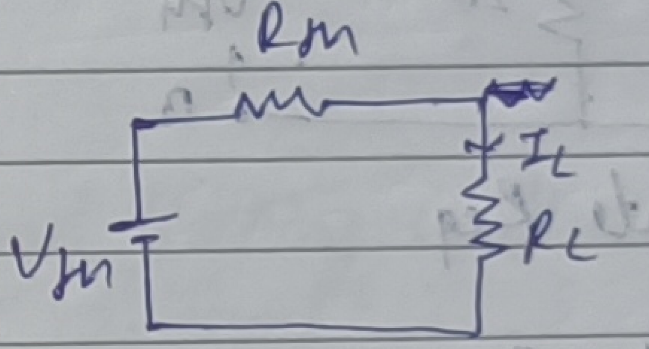
$$V_{th} = I \times 3 = 3.33 \times 2$$
$$= 6.66\ V$$

Step-5 Calculate R_{th}



$$R_{th} = \frac{2\times 1}{2+1} + 3$$
$$= 3.66\ \Omega$$

Step-6 Draw Equivalent circuit

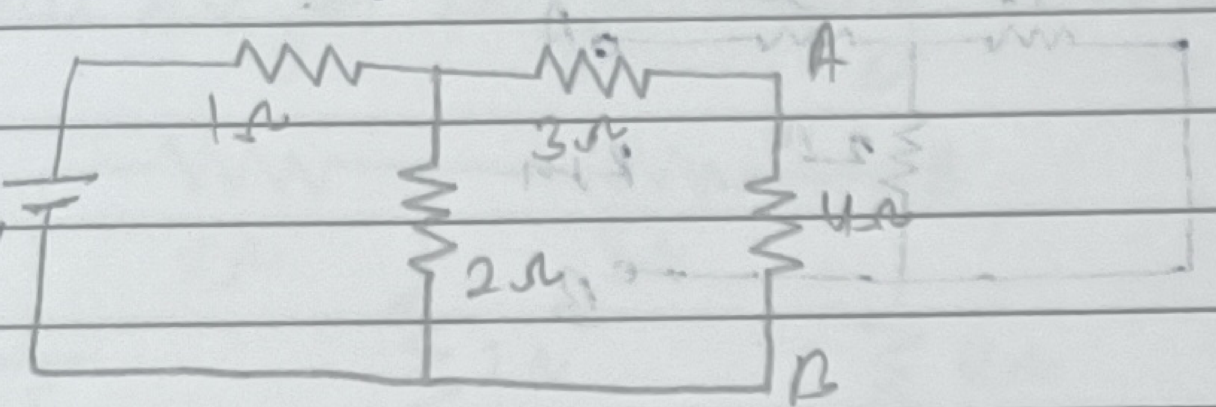


Step-7 Calculate I_L

$$I_L = \frac{V_{th}}{R_{th}+R_L} = \frac{6.66}{3.66+4}$$
$$= \frac{6.66}{7.66}$$
$$= 0.86\ A.$$

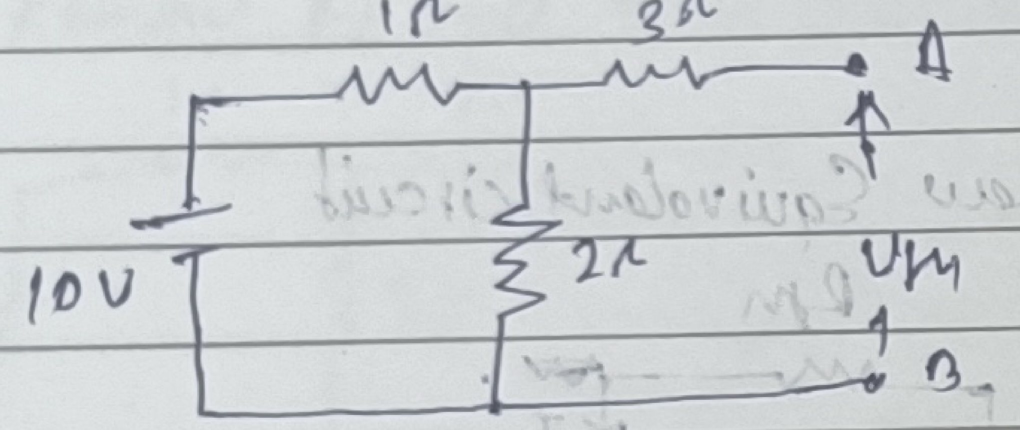
29. Calculate V_{th} for the given circuit.

Sol



Sol

Step-1 Remove R_L and Open circuit



Step-2 Calculate Req

$$Req = 2+1 = 3$$

Step-3 Calculate I

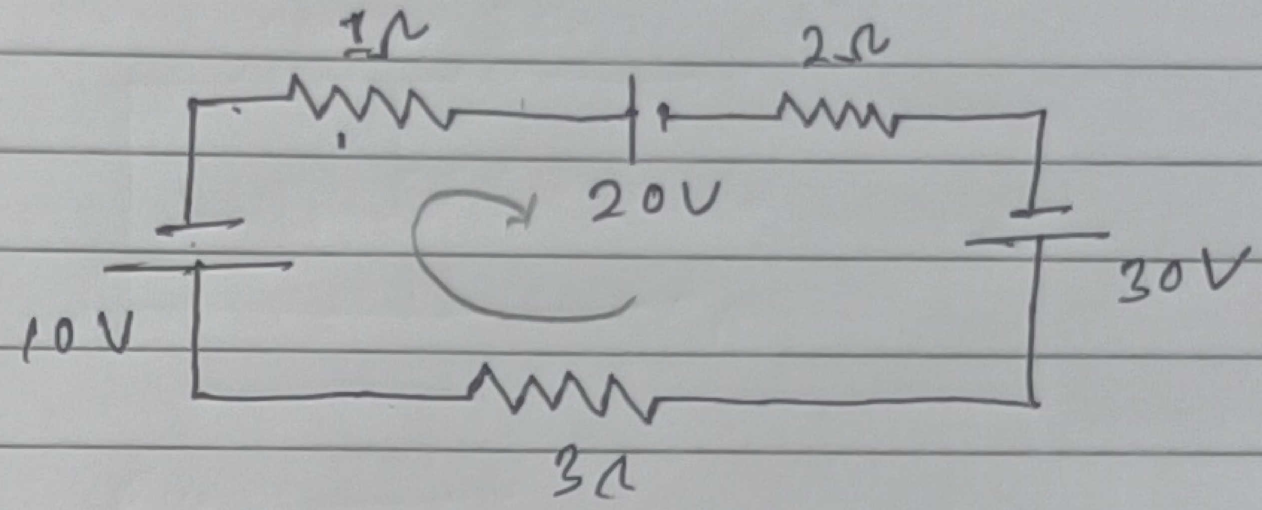
$$I = \frac{V}{Req} = \frac{10}{3} = 3.33\ A$$

Step-4 Calculate V_{th}

$$V_{th} = I \times 2 = 2 \cdot 3.33 = 6.66\ V$$
$$= 6.66\ V$$

Ans

30. What is the current in the circuit?



Sol Apply KVL in a loop

$$-10 + I - 20 + 2I + 30 + 3I = 0$$
$$5I = 0$$
$$I = 0$$

Current flowing in the closed loop is ~~always~~ zero current.