Fundamental of Electrical Engineering
UNIT-1
D.C Circuits

Course Structure(T+P)

Theory(T)

Name of the Course: Fundamental of Electrical Engineering

Course Code : BEE 101(First Sem.) / BEE 201(Second Sem.)

Practical(P)

Name of the Course: Basic Electrical Engineering Lab

Course Code : BEE 151(First Sem.) / BEE 251(Second Sem.)

Course Syllabus

Unit 1

D.C Circuits: Electrical circuit elements (R, L and C), Concept of active and passive elements, voltage and current sources, concept of linearity, unilateral and bilateral elements. Kirchhoff‟s laws, Mesh and nodal methods of analysis.

Unit 2

Steady- State Analysis of Single Phase AC Circuits: Representation of Sinusoidal waveforms – Average and effective values, Form and peak factors. Analysis of single phase AC Circuits consisting R-L-C combination (Series and Parallel) Apparent, active & reactive power, Power factor. Concept of Resonance in series & parallel circuits, bandwidth and quality factor.

Three phase balanced circuits, voltage and current relations in star and delta connections.

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Course Syllabus

Unit 3

Transformers: Magnetic circuits, ideal and practical transformer, equivalent circuit, losses in transformers, regulation and efficiency.

Unit 4

Electrical machines: DC machines: Principle & Construction, Types, EMF equation of generator and torque equation of motor, applications of DC motors (simple numerical problems)

Three Phase Induction Motor: Principle & Construction, Types, Slip-torque characteristics, Applications (Numerical problems related to slip only)

Single Phase Induction motor: Principle of operation and introduction to methods of starting, applications. Three Phase Synchronous Machines: Principle of operation of alternator and synchronous motor and their applications

Course Syllabus

Unit 5

Electrical Installations: Introduction of Switch Fuse Unit (SFU), MCB, ELCB, MCCB, ACB. Types of Wires, Cables and Bus-bars. Fundamentals of earthing and lightning protection. Types of Batteries.

Text Books / Reference Books

- T1. D. P. Kothari and I. J. Nagrath, “Basic Electrical Engineering”, McGraw Hill.
- T2. D. C. Kulshreshtha, “Basic Electrical Engineering”, McGraw Hill.
- T3. Ritu Sahdev, “Basic Electrical Engineering”, Khanna Publishing House.
- T4. S. Singh, P.V. Prasad, “Electrical Engineering: Concepts and Applications” Cengage
- R1. E. Hughes, “Electrical and Electronics Technology”, Pearson, 2010.
- R2. L. S. Bobrow, “Fundamentals of Electrical Engineering”, Oxford University Press.
- R3. V. D. Toro, “Electrical Engineering Fundamentals”, Pearson India

Course Outcomes

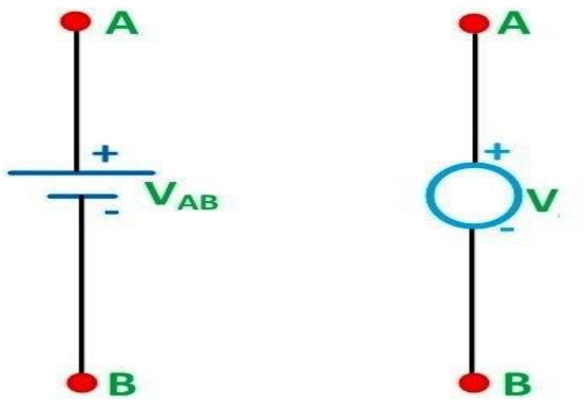
Course Outcome	Statement (On completion of this course, the student will be able to)
CO1	Apply Kirchhoff's laws in solving DC Circuits.
CO2	Understand the steady state behavior of single phase and three phase A.C circuits.
CO3	Identify the application areas of a single phase two winding transformer and calculate their efficiency.
CO4	Elaborate the working principle of D.C and A.C electrical machines with their application.
CO5	Explain the working of low voltage electrical installation Equipment.

LECTURE-1

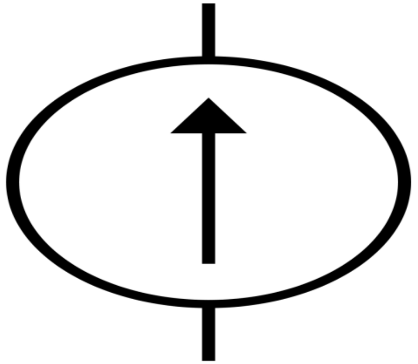
CONTENT

- Concept of Network and Circuit
- Classification of Electrical Network
  - Active & Passive Network
  - Unilateral & Bilateral Network
  - Linear & Non-Linear Network
- Ohm's Law
- Types of Sources
  - Voltage Source
    - Ideal Voltage Source
    - Practical Voltage Source
  - Current Source
    - Ideal Current Source
    - Practical Current Source
- Source Transformation

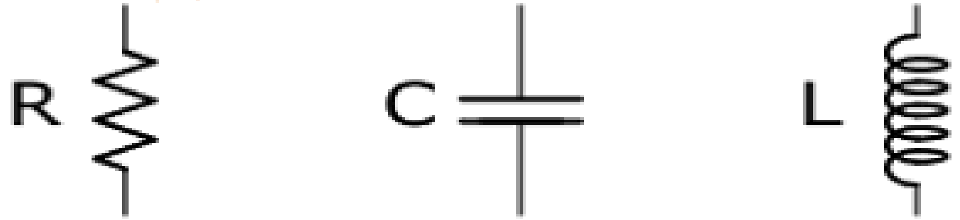
Electrical Elements



DC VOLTAGE SOURCE



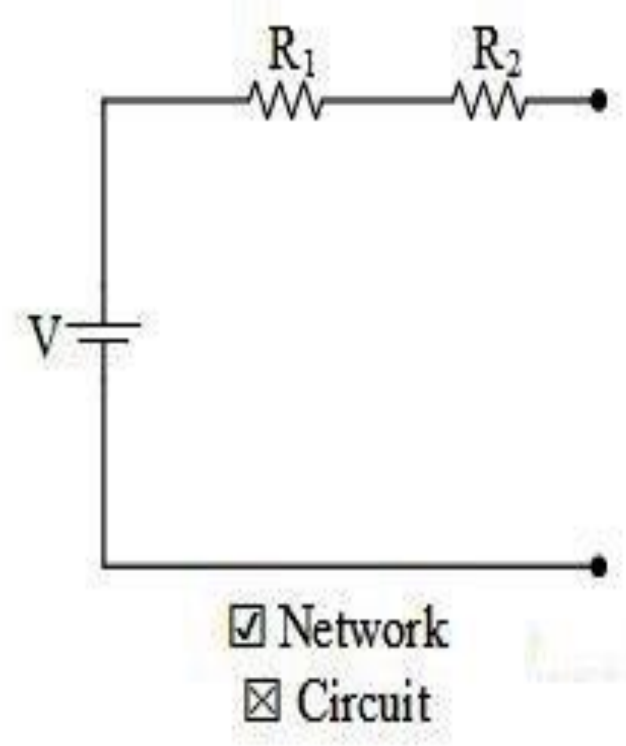
DC CURRENT SOURCE

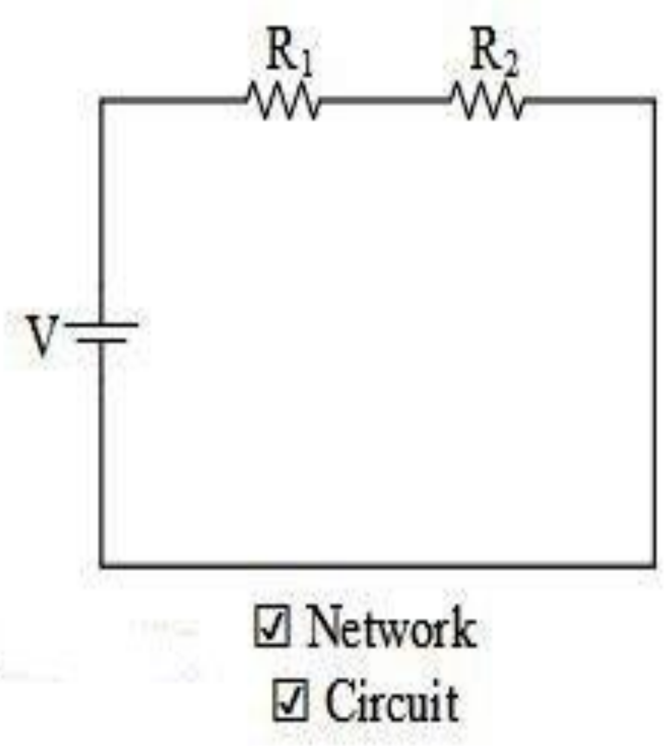


RESISTOR CAPACITOR INDUCTOR

Concept of Network and Circuit

Network	Circuit
• A combination of various electric elements like Resistor, Inductor, Capacitor, Voltage source & Current source) etc. in which there may or may not be close path is called an electrical network.	• A combination of various electrical elements like Resistor, Inductor, Capacitor, Voltage source & Current source) etc. in which there is a close path is called an electrical circuit.


R1
R2
V
☑ Network
☒ Circuit


R1
R2
V
☑ Network
☑ Circuit

Classification of Electrical Network

Based on Energy	Based on Direction	Based on Linearity
Active	Unilateral	Linear
Passive	Bilateral	Non Linear

Based on Energy

Active Element	Passive Element
• An element which can supply or delivered energy is called Active Element. • For e.g.- Voltage Source, Current Source, Battery, Generator, Transistor etc.	• An element which can dissipate or absorbs energy is called Passive Element. • For e.g.- Resistor, Capacitor, Inductor, Diode (General Purpose Diode)

Based on Direction

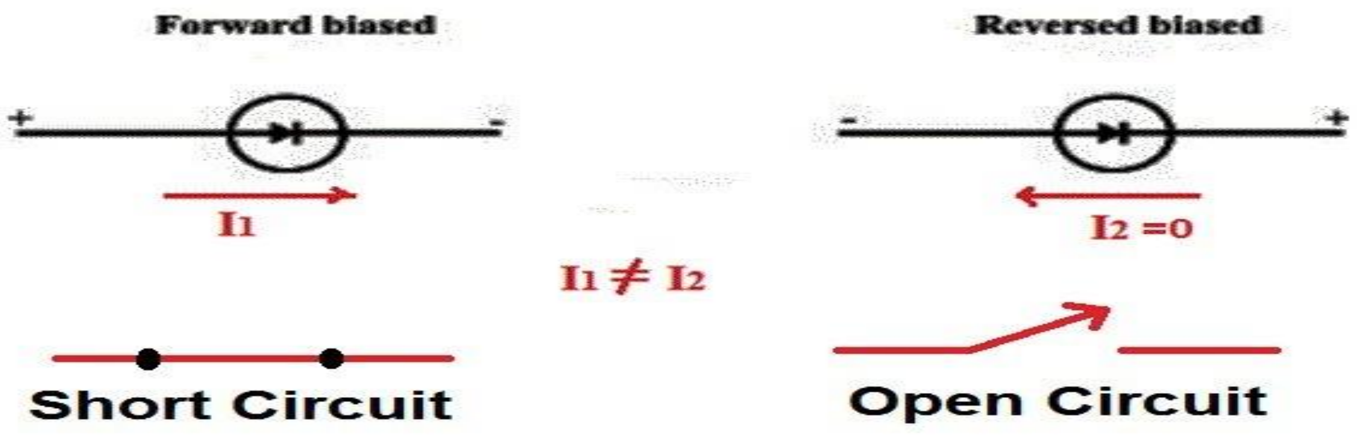
Unilateral Element

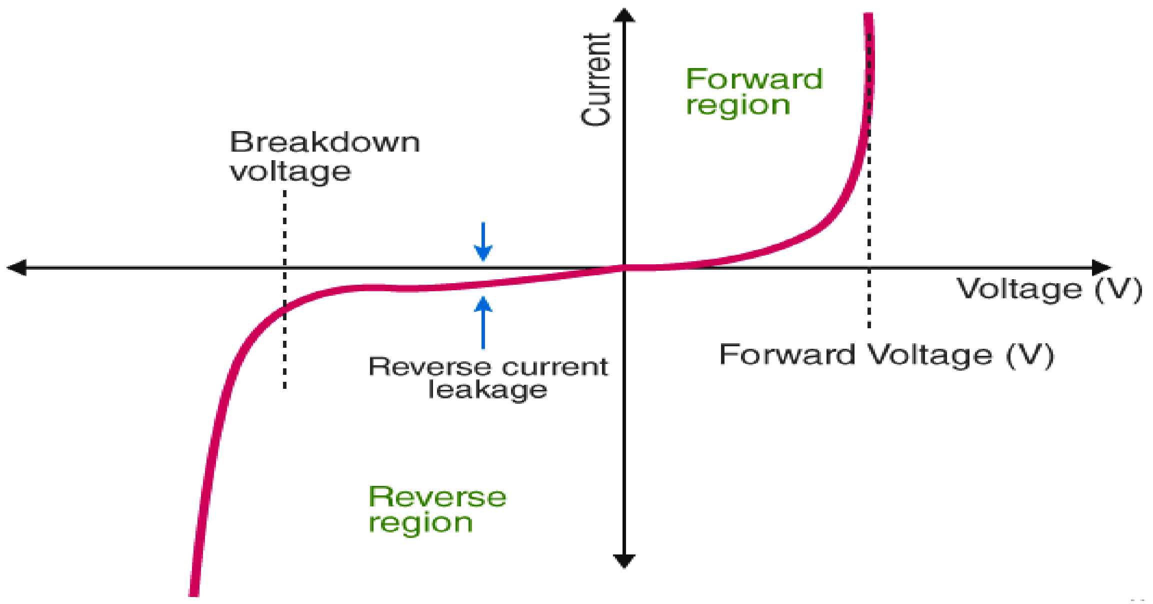
- An element which V-I characteristics changes with change in direction of current is called Unilateral Element
- For e.g.- Diode.

Bilateral Element

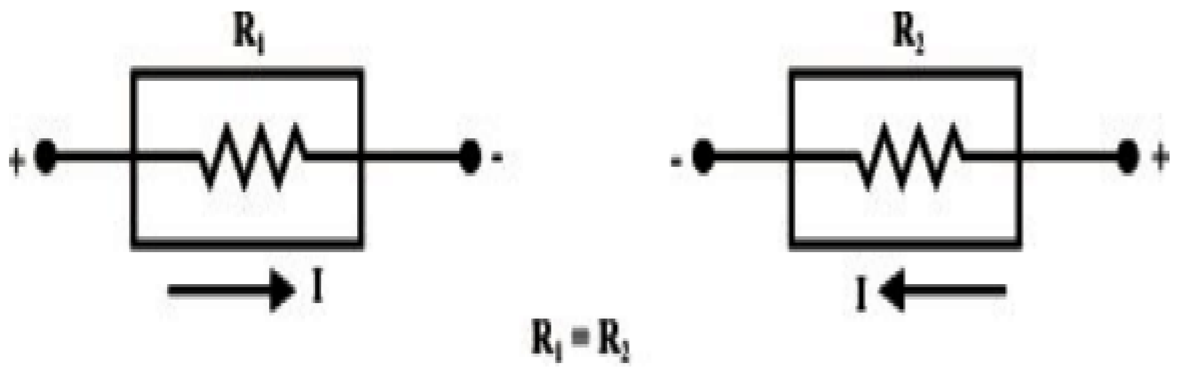
- An element which V-I characteristics does not changes with change in direction of current is called Bilateral Element
- For e.g.- Resistor, Capacitor and Inductor.

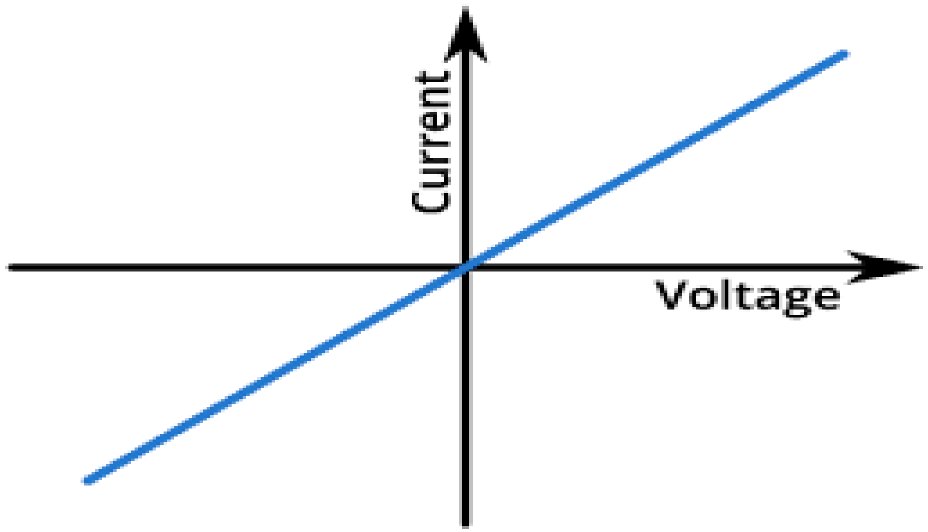
Unilateral Element:-





Bilateral Element:-





Based on Linearity

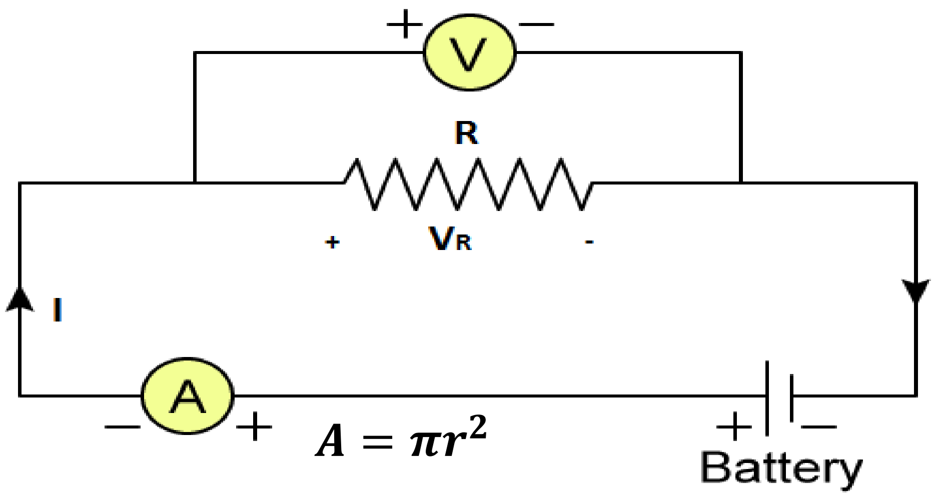
Linear Element	Non-Linear Element
• An Element which obey the principle of Ohm's law is called Linear Element or an element which obey the principle of superposition and homogeneity is also called Linear element. • For e.g.- Resistor, Inductor and Capacitor.	• An Element which does not obey the principle of Ohm's law is called Non-Linear Element or an element which doesn't obey the principle of superposition and homogeneity is also called Non-Linear element. • For e.g.- Diode

Ohm’s Law

- **Statement:-**Voltage drop across a conductor is directly proportional to the current passing through that elements if atmospheric condition (temperature, pressure and humidity etc.) kept constant.

Ohm’s Law

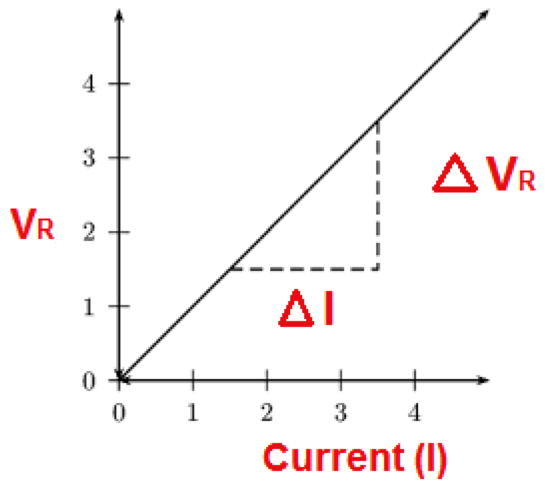
- **Explanation:-**



$A = \pi r^2$

$$V_R \propto I$$

$$V_R = R * I$$



$$R = \frac{\triangle V_R}{\triangle I}$$

Types of Sources

- **Voltage Source**
  - Ideal Voltage Source
  - Practical Voltage Source
- **Current Source**
  - Ideal Current Source
  - Practical Current Source

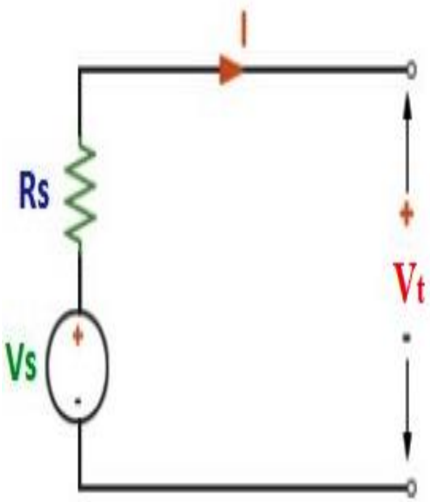
Voltage Source

- **Ideal Voltage Source:-** It gives constant voltage across its terminals irrespective of current drawn through its terminals.

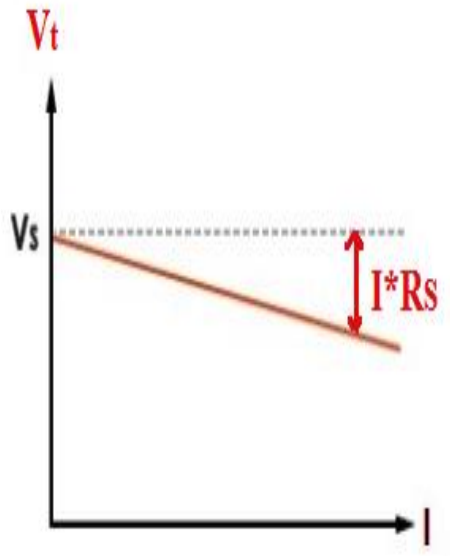
$$V_L \text{ or } V_t(\text{Load or Terminal Voltage}) = V_s\,(\text{Supply Voltage})$$

- **Note:-** Internal resistance of Ideal Voltage Source is Zero. **[R_S= 0]**

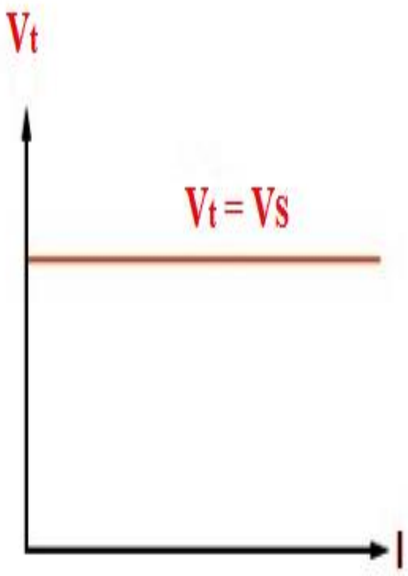
- **Practical Voltage Source:-** It doesn't gives constant voltage and have some small internal resistances. That's why It's terminal voltage dependent on load current.



Practical Voltage Source



Practical Voltage Source Graph



Ideal Voltage Source Graph

$$By\ KVL: -\downarrow V_t\ or\ \downarrow V_L = (V_S - \uparrow I_L R_S)$$

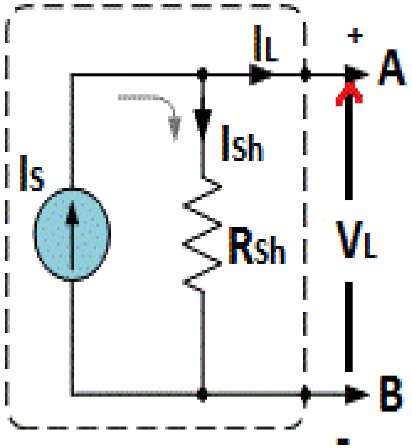
Current source

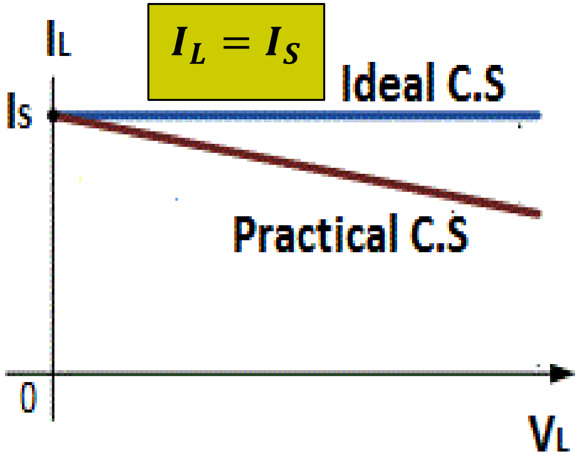
- **Ideal Current Source:-** Source which gives constant Load current at its terminal irrespective of the load voltage or terminal voltage is called Ideal Current Source.

$$I_L\,(Load\ Current) = I_s\,(Supply\ Current\ or\ Source\ Current)$$

- **Note:-** Internal resistance of Ideal Current Source is Infinite. [R_{sh}= ∞]

- **Practical Current Source:-** It doesn't gives constant Load Current and have very high internal resistances. That's why It's Load Current dependent on Load Voltage or its terminal Voltage.





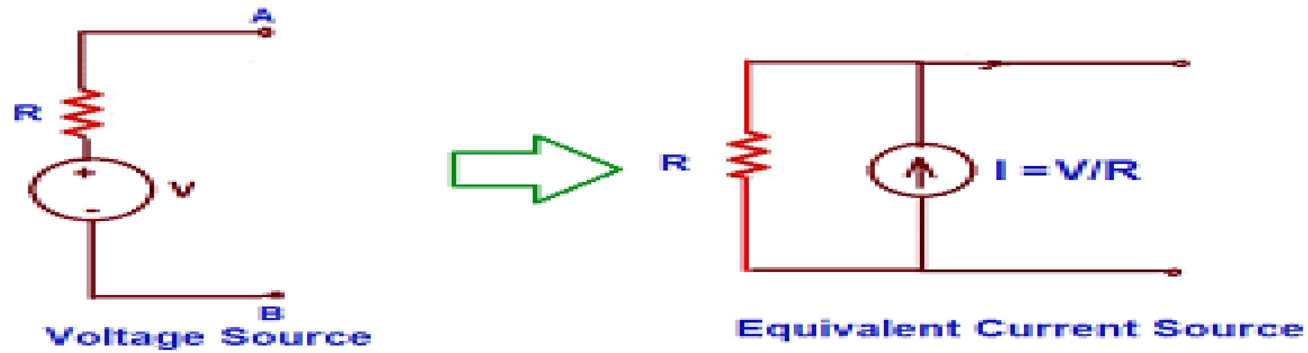
$$By\ KCL:- \quad I_S = I_{sh} + I_L$$

$$I_L = I_S - I_{sh}$$

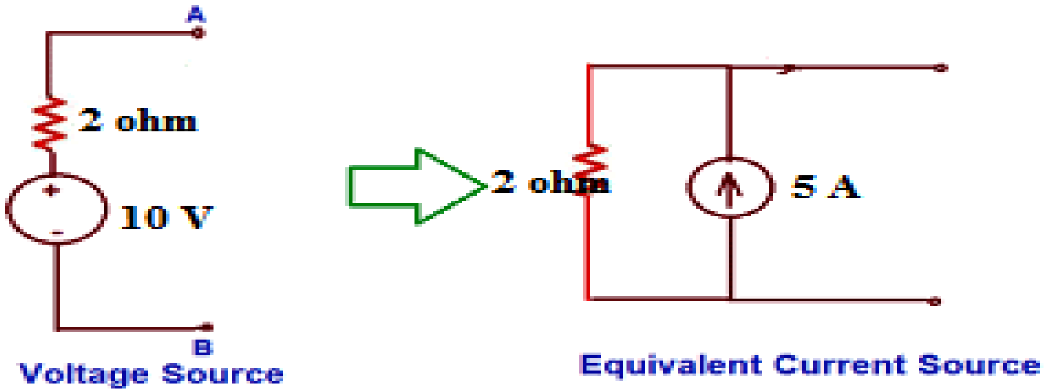
$$\downarrow I_L = I_S - \frac{\uparrow V_L}{R_{sh}}$$

Source Transformation

- Voltage Source → Current Source

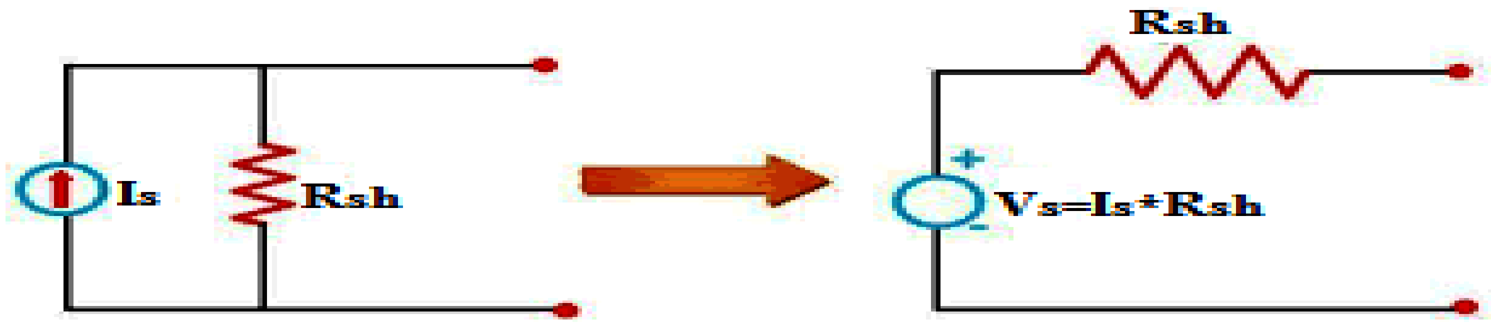


- For e.g.-

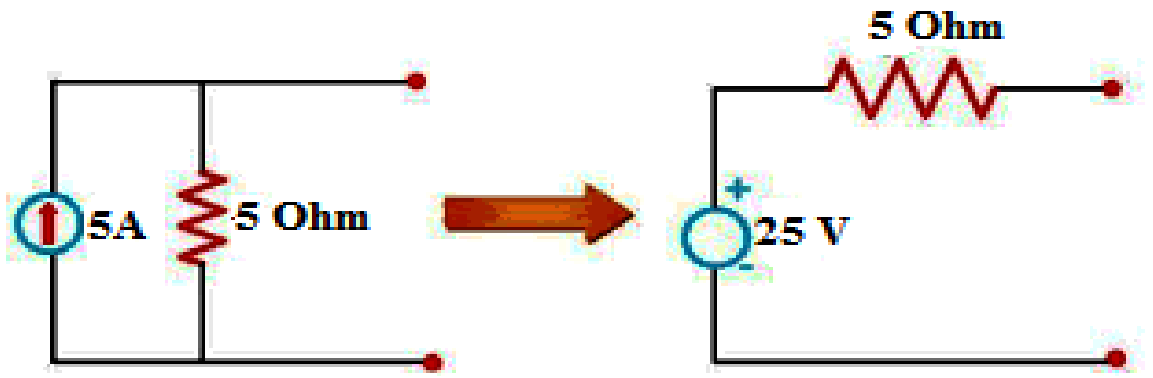


Source Transformation

- Current Source → Voltage Source



- For e.g.-



LECTURE-2

CONTENT

- Kirchhoff's Law
  - Kirchhoff's Current Law
  - Kirchhoff's Voltage Law
- Current Division Rule
- Voltage Division Rule
- Basic Concept Related to Node, Junction, Branch, Mesh and Loop

Kirchhoff's Law

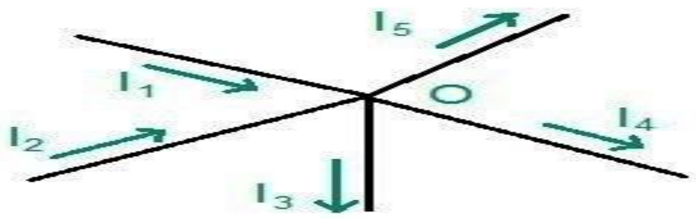
Kirchhoff's Law

- First Law (Kirchhoff's Current Law)
- Second Law (Kirchhoff's Voltage Law)

Kirchhoff's Current Law

- **Statement:-** It is based on **"Law of Conservation of Charge."** It states that the algebraic sum of currents at the junction at any instant is equal to zero.

$$\sum_{j=1}^{k} I_j = 0$$



Applying KCL:-

$$I_1 + I_2 - I_3 - I_4 - I_5 = 0$$

$$I_1 + I_2 = I_3 + I_4 + I_5$$

Kirchhoff’s Current Law

- **Concept:-** It is based on **“Law of Conservation of Charge.”**

$$\frac{dq_1}{dt} + \frac{dq_2}{dt} - \frac{dq_3}{dt} - \frac{dq_4}{dt} - \frac{dq_5}{dt} = 0$$

$$dq_1 + dq_2 - dq_3 - dq_4 - dq_5 = 0$$

- i.e. number of electron per second enter the node is equal to the number of electron leave the node.

Kirchhoff’s Current Law

- **Application:-** In Nodal Analysis and to determine a branch current.

- **Limitations:-** **1.** Only apply at a node where more than two branches are connect.

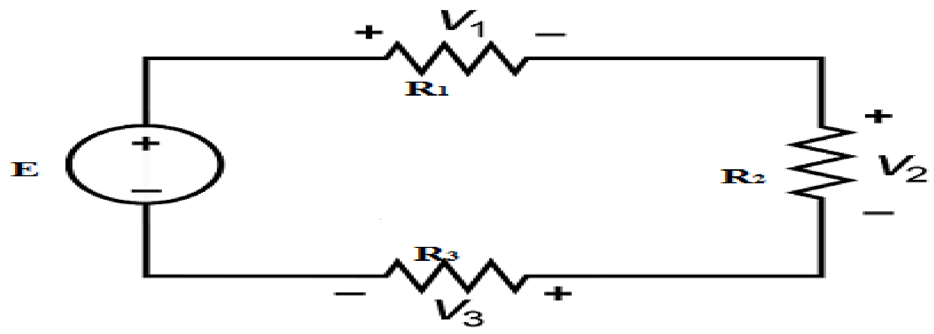
  2. Only applicable in a Lumped Network.

Kirchhoff's Voltage Law

- **Statement:-** It is based on **"Law of Conservation of Energy."** It states that the algebraic sum of voltages in a close path (Mesh or Loop) is equal to zero.

$$\sum_{j=1}^{k} V_j = 0$$

Where:- V_j is the voltage drop or voltage rise across the j_{th} element in a close path and there are K elements.



Kirchhoff's Voltage Law

$$H = H_1 + H_2 + H_3$$

Where:- $H \rightarrow$ Energy supplied by the source E

$H1, H2 \;\&\; H3 \rightarrow$ Energy dissipate from R1, R2 & R3 respectively.

In electrical circuit, work done is equivalent to energy and work done per unit charge is known as voltage. So:-

$$\frac{W}{Q} = \frac{W_1}{Q} + \frac{W_2}{Q} + \frac{W_3}{Q}$$

$$E = V_1 + V_2 + V_3$$

$$E - V_1 - V_2 - V_3 = 0$$

- The above equation is the direct mathematical statement of Kirchhoff's voltage law.
- **Note:-** All **voltage drops are treated as a negative sign** and **voltage rise are treated as a positive sign** or vice-versa.
- **Application:-**

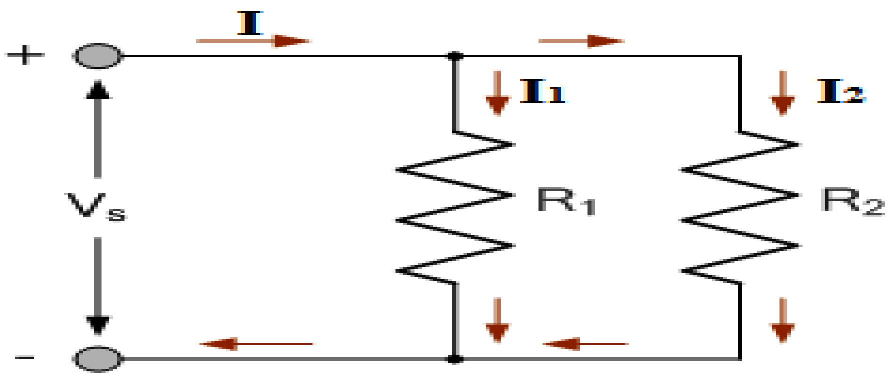
1. In Mesh Analysis (to determine a mesh or branch current).
2. To determine a voltage across an electrical element.

- **Limitations:-**

1. Only applicable in a Lumped Network.
2. There should be a close path.

Current Division Rule

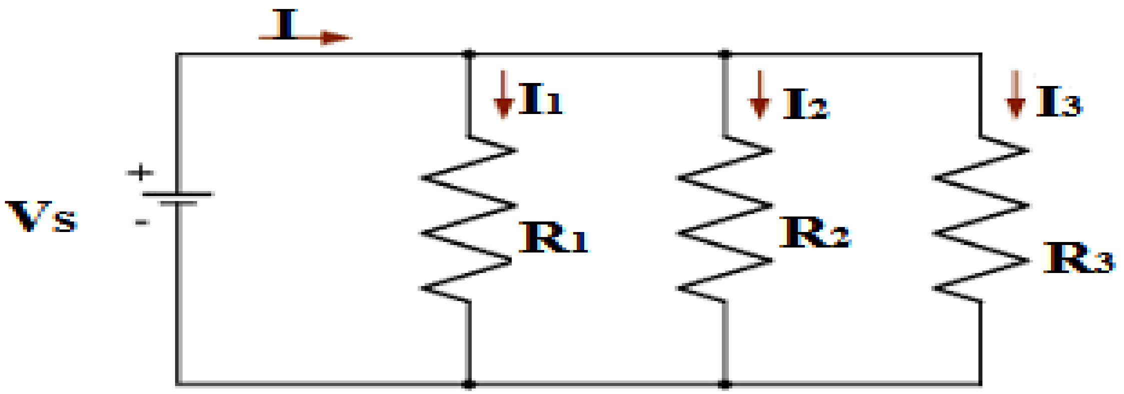
- Current division always takes place in parallel path.



$$I_1 = I * [\ \frac{R_2}{R_1 + R_2}\ ]$$

$$I_2 = I * [\ \frac{R_1}{R_1 + R_2}\ ]$$

Current Division Rule



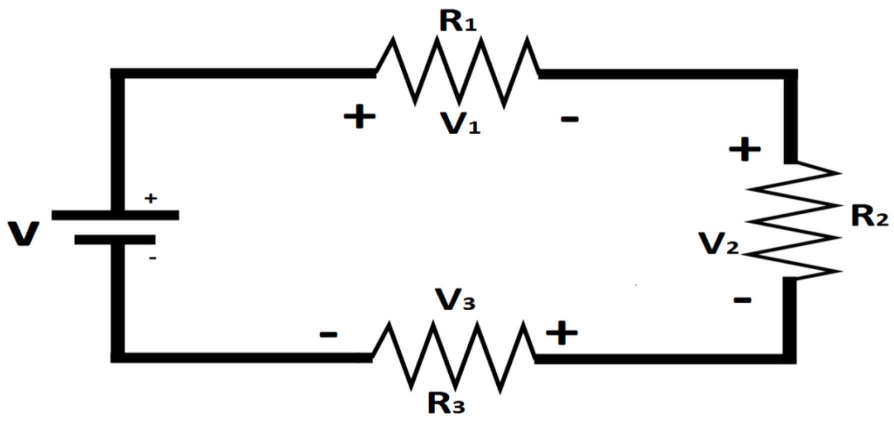
$$I_1 = I * [\ \frac{(R_2 IIR_3)}{(R_2 IIR_3)+R_1}\ ]$$

$$I_2 = I * [\ \frac{(R_1 IIR_3)}{(R_1 IIR_3)+R_2}]$$

$$I_3 = I * [\ \frac{(R_1 IIR_2)}{(R_1 IIR_2)+R_3}]$$

Voltage Division Rule

- Voltage division always takes place in series.

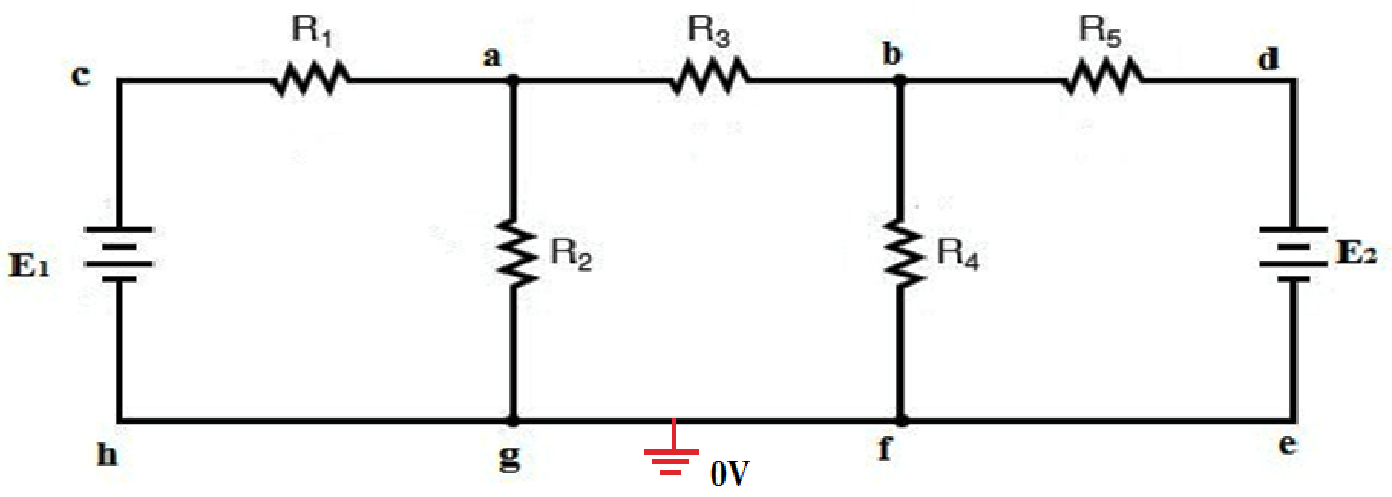


$$V_1 = V * [\frac{R_1}{R_1 + R_2 + R_3}]$$

$$V_2 = V * [\frac{R_2}{R_1 + R_2 + R_3}]$$

$$V_3 = V * [\frac{R_3}{R_1 + R_2 + R_3}]$$

Basic Concept Related to Node, Junction, Branch, Mesh and Loop



Node:- The point at which two or more than two circuit elements are connected is known as Node. In the above figure a, b, c, d & g are Nodes.

Total number of Nodes (N) = 5

- **Junction:-** It is the point in a network where three or more than three circuit elements are connected. It is also called a **“Principal Node”.**

  In the given figure a , b & g are Junctions.

Number of Junction (J) = 3

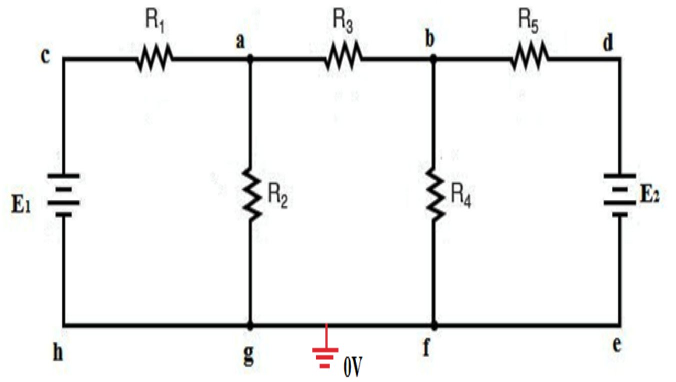
- **Reference Node:-** The Node which is at zero potential or ground potential is known as **“Reference Node”** or **“Datum Node”.**

  In the given figure h , g , f & e are combine a single node which is **“Reference Node”** or **“Datum Node”** i.e. number of reference node is always one.

- **Branch:-** It contains elements. It is that part of a network which lies between nodes.

  In the given figure:-

Number of Branch (B) = 7

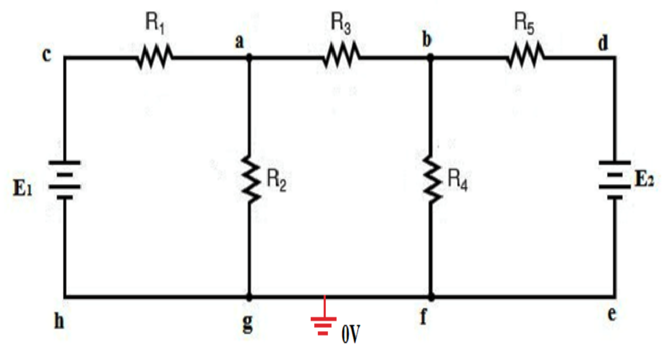


- **Mesh:-** It is the shortest close path which is a part of loop. It can't be further divided into other close path. **"Every Mesh is a Loop but every Loop is not a Mesh".** For e.g.- caghc , abfga & bdefb

Number of Mesh (M) = 3

- **Loop:-** It is an any close path of the Network. For e.g.- caghc , abfga , bdefb , cabfghc , abdefga & cabdefghc.

Number of Loop (L) = 6



- **Note:-**

$$M = B - N + 1$$

Where:-

M :- Number of Mesh

B:- Number of Branch

N:- Number of Node

LECTURE-3

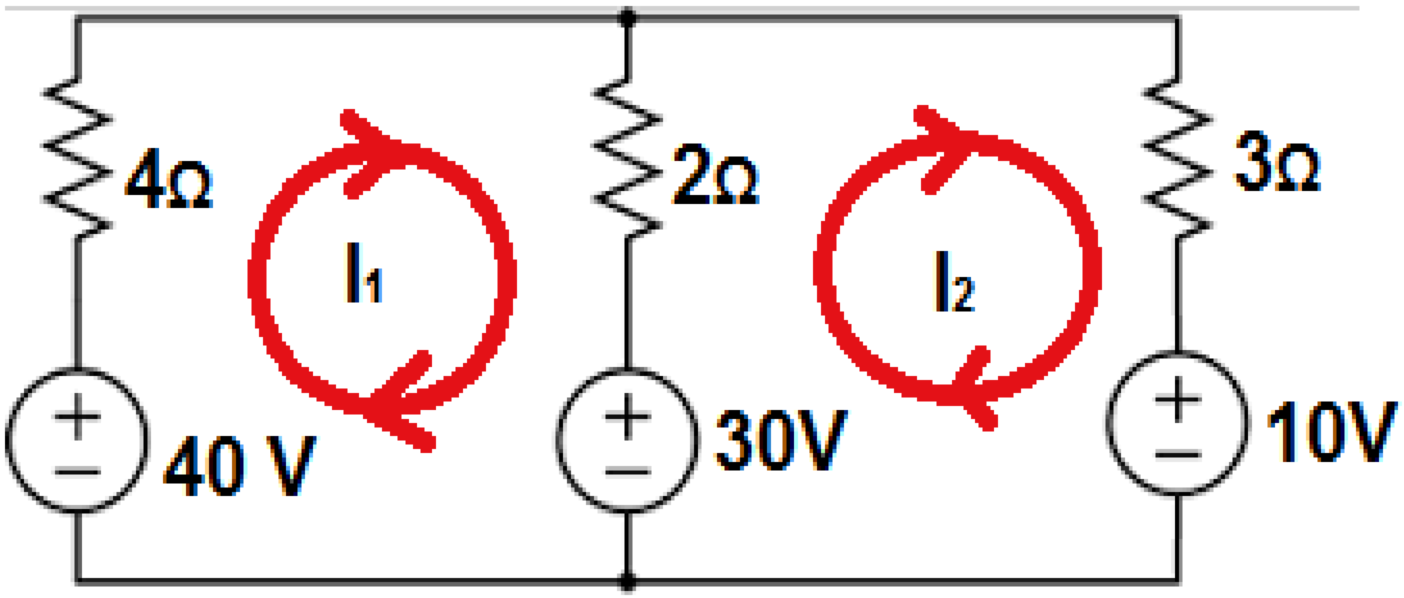
Mesh Analysis

Mesh Analysis

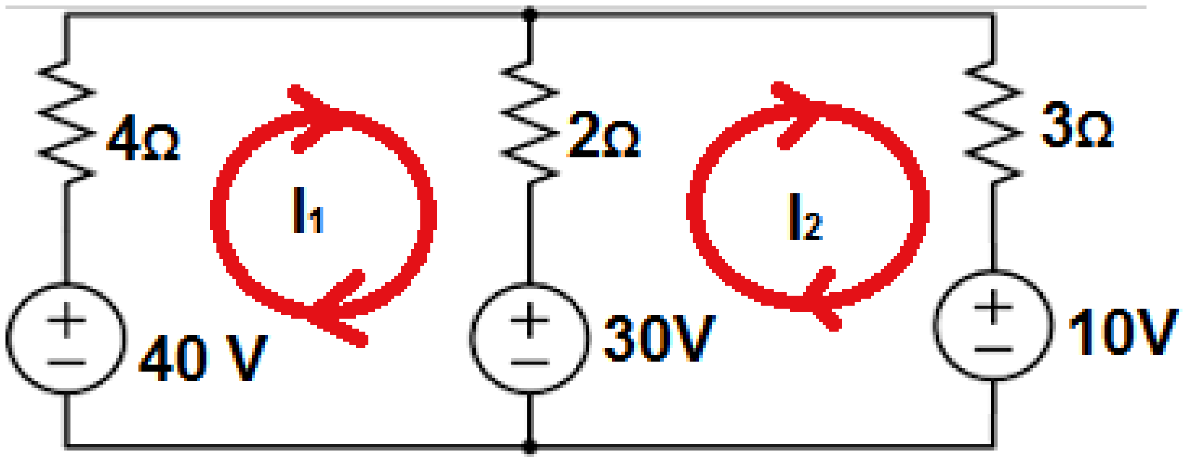
- **Step 1:-** Identify the number of Mesh in the circuit.
- **Step 2:-** Assume current in each Mesh (any direction).
- **Step 3:-** Apply KVL in each Mesh and write Mesh equation for each Mesh.
- **Step 4:-** Solve the Mesh equation and find Mesh current.
- **Note:-**

Number of Mesh Equation = Number of Mesh

Problem:- Find out the current in 2Ω resistance in the given figure using Loop analysis.



Solution:-



Apply KVL in each mesh:-

Mesh (1):-

$$40 - 4I_1 - 2(I_1 - I_2) - 30 = 0$$

$$6I_1 - 2I_2 = 10 \ldots\ldots\ldots\ldots\ldots\ldots\ldots (i)$$

Mesh (2):-

$$30 - 2(I_2 - I_1) - 3I_2 - 10 = 0$$

$$-2I_1 + 5I_2 = 20 \ldots\ldots\ldots\ldots\ldots\ldots. (ii)$$

By solving equation (i) & (ii) we get:-

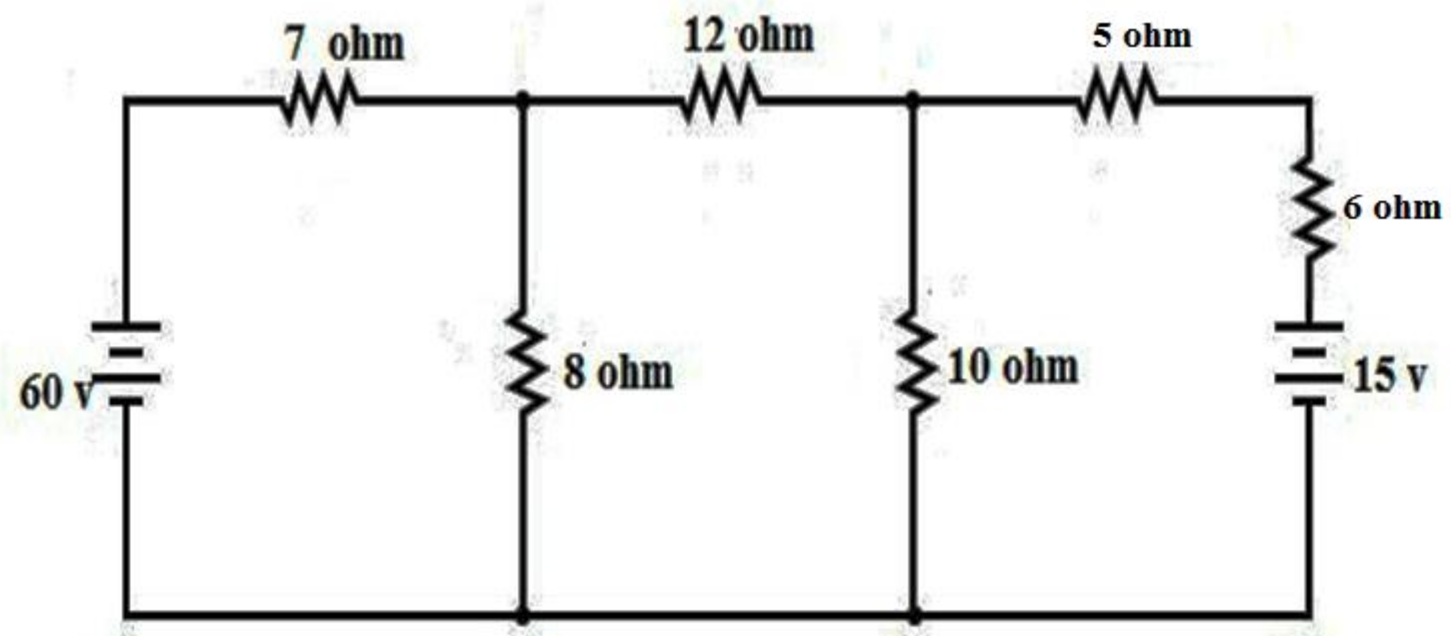
Mesh Currents:-

$$I_1 = 3.46\ A\ ;\ I_2 = 5.38\ A$$

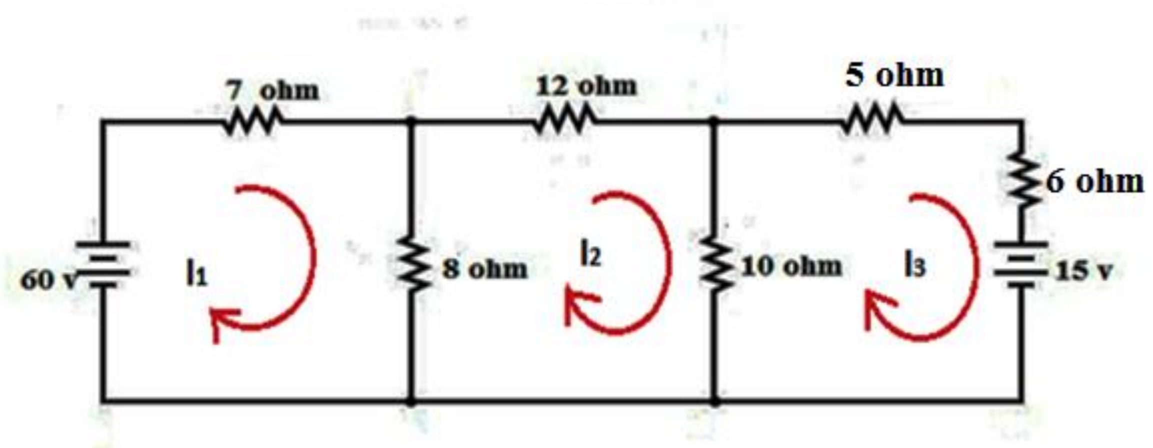
$$\downarrow I_{2\Omega} = I_1 - I_2 = -1.92\ A$$

Answer

Problem:-To find out the Mesh Current in the given circuit.



Solution:-



Apply KVL in each mesh:-

Mesh (1):-

$$60 - 7I_1 - 8(I_1 - I_2) = 0$$

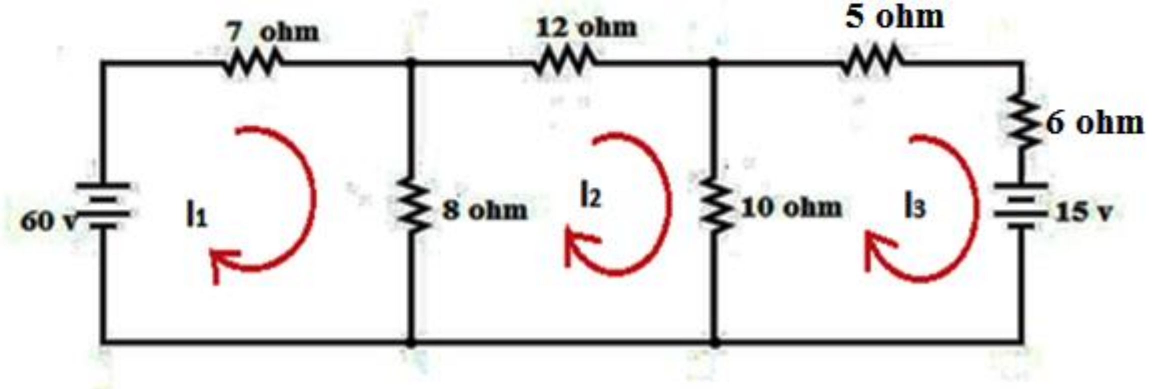
$$15I_1 - 8I_2 + 0I_3 = 60 \ldots\ldots\ldots\ldots\ldots\ldots\ldots(i)$$

Mesh (2):-

$$-12I_2 - 10(I_2 - I_3) - 8(I_2 - I_1) = 0$$

$$8I_1 - 30I_2 + 10I_3 = 0 \ldots\ldots\ldots\ldots.(ii)$$

Solution:-



Mesh (3):-

$$-15 - 10\,(I_3 - I_2) - 5I_3 - 6I_3 = 0$$

$$0\,I_1 + 10I_2 - 21I_3 = 15 \ldots\ldots\ldots\ldots\ldots\ldots\ldots (iii)$$

By solving equation (i), (ii) & (iii) we get:-

- Mesh Currents:-

$$I_1 = 4.632\ A\ ;\ I_2 = 1.185\ A\ ;\ I_3 = -0.15\ A$$

Answer

- Branch Currents:-

$$I_{7\Omega} = I_1 = 4.632\ A$$

$$I_{8\Omega} = (I_1 - I_2) = 3.447\ A \downarrow$$

$$I_{12\Omega} = I_2 = 1.185\ A$$

$$I_{10\Omega} = (I_2 - I_3) = 1.335\text{A}$$

$$I_{5\Omega} = I_3 = -0.15\ A$$

$$I_{6\Omega} = I_3 = -0.15\ A$$

Answer

- **Voltage Drop:-**

$$V_{5\Omega} = I_{5\Omega} * 5 = I_3 * 5 = -0.15 * 5$$

$$V_{5\Omega} = -0.75\ V$$

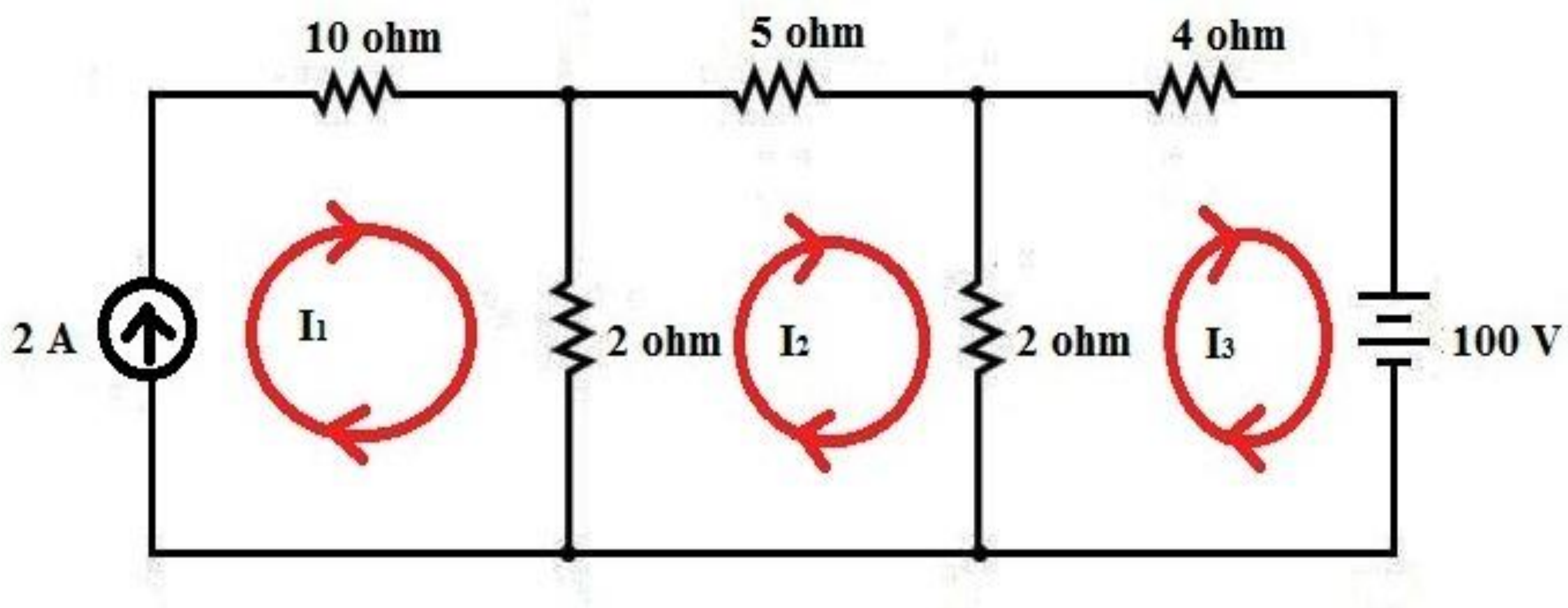
Answer

- **Power Loss:-**

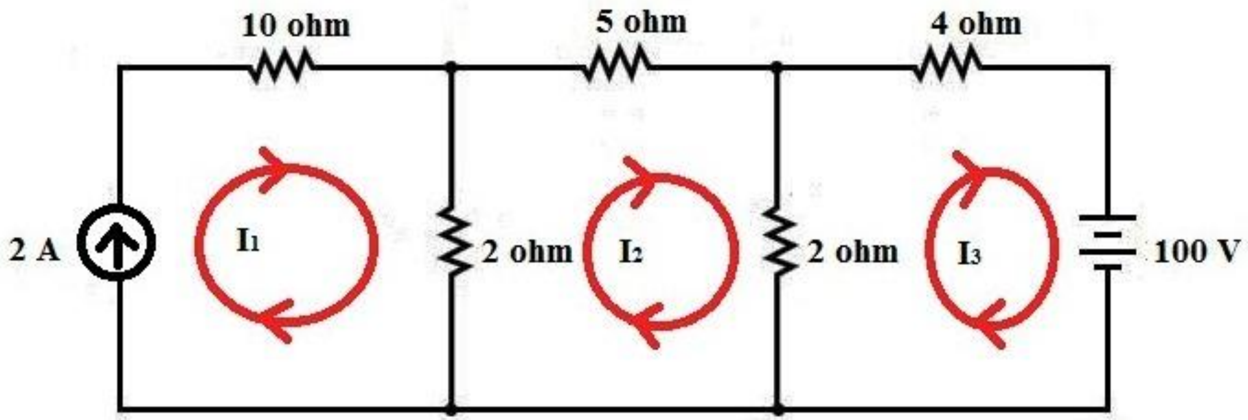
$$P_{5\Omega} = {I_{5\Omega}}^2 * 5 = (-0.15)^2 * 5 = 0.1125\ W$$

Answer

Problem:- Apply Mesh analysis and obtain the current through 5 Ω resistor in the given circuit.



Solution:-



Apply KVL in each mesh:-

Mesh (1):-

$$I_1 = 2\ A \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots (i)$$

Mesh (2):-

$$-5I_2 - 2(I_2 - I_3) - 2(I_2 - I_1) = 0$$

$$9I_2 - 2I_3 = 4 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (ii)$$

Mesh (3):-

$$-100 - 2\ (I_3 - I_2) - 4I_3 = 0$$

$$2I_2 - 6I_3 = 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots (iii)$$

By solving equation (ii) & (iii) we get:-

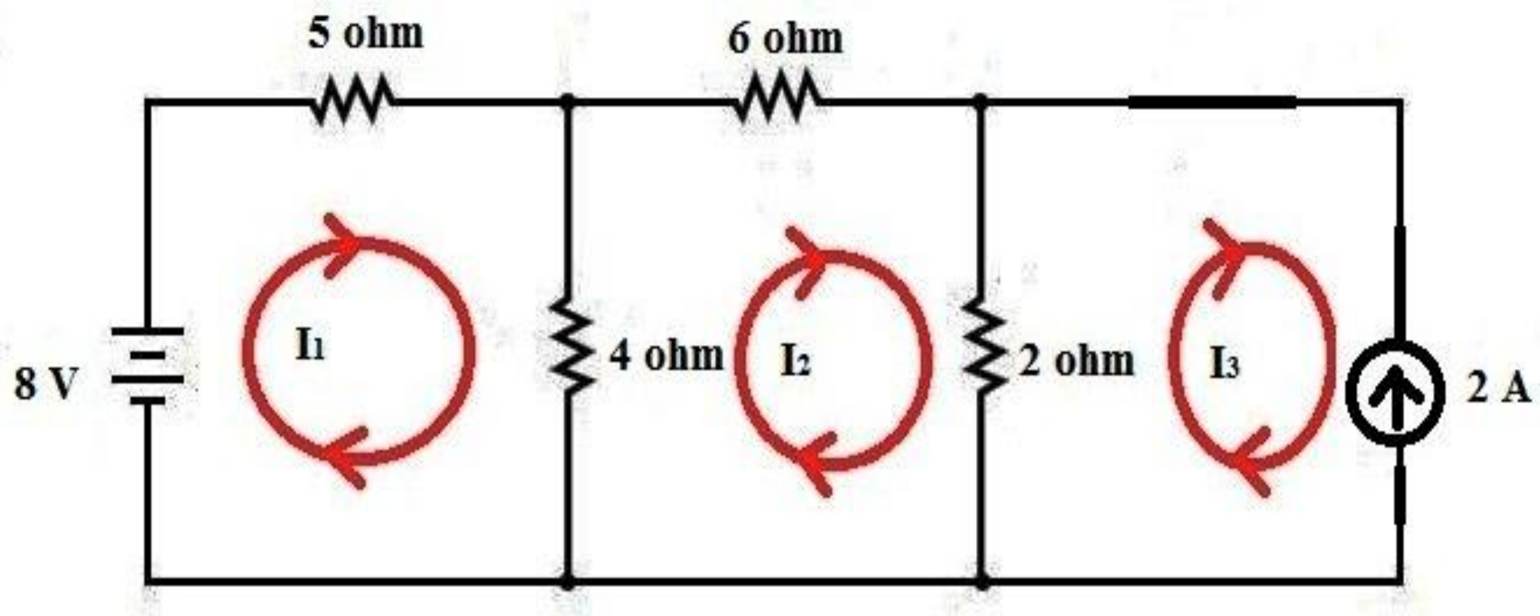
Mesh Currents:-

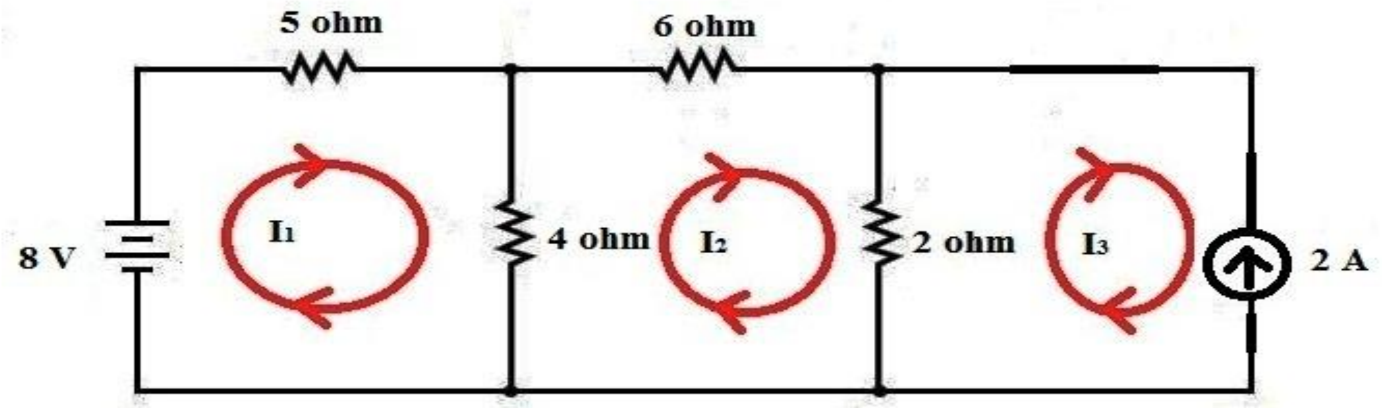
$$I_2 = -3.52\ A\ ;\ I_3 = -17.84\ A$$

$$I = I_{5\Omega} = I_2 = -3.52\ A$$

Answer

Problem:- Determine current in 4Ω resistor by using Mesh analysis in the circuit shown in figure below.





Solution:-

Apply KVL in each mesh:-

Mesh (3):-

$$I_3 = -2\ A \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (i)$$

Mesh (1):-

$$8 - 5I_1 - 4\,(I_1 - I_2) = 0$$

$$9I_1 - 4I_2 = 8 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (ii)$$

Mesh (2):-

$$-6I_2 - 2(I_2 - I_3) - 4(I_2 - I_1) = 0$$

$$4I_1 - 12I_2 = 4 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (iii)$$

By solving equation (ii) & (iii) we get:-

Mesh Currents:-

$$I_1 = 0.869\ A\ ;\ I_2 = -0.043\ A$$

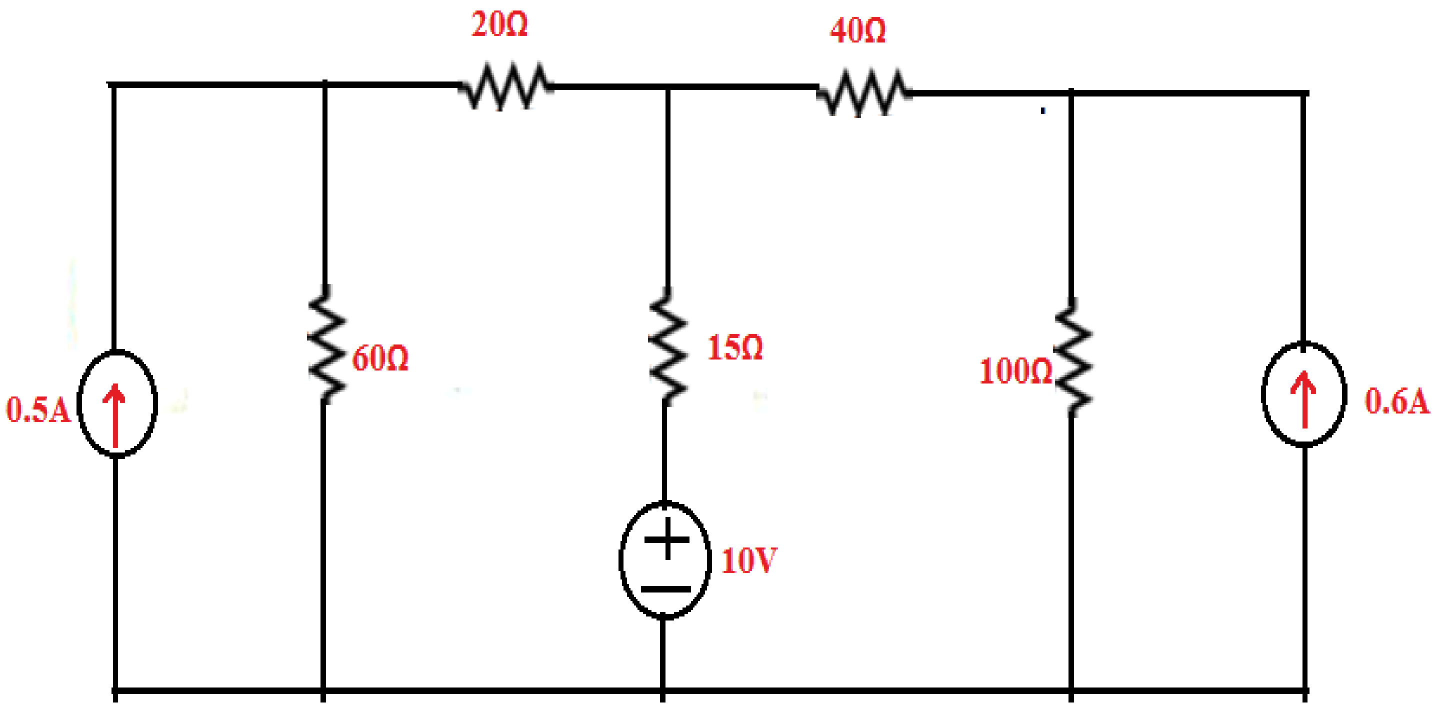
$$\downarrow I_{4\Omega} = I_1 - I_2 = 0.1299\ A$$

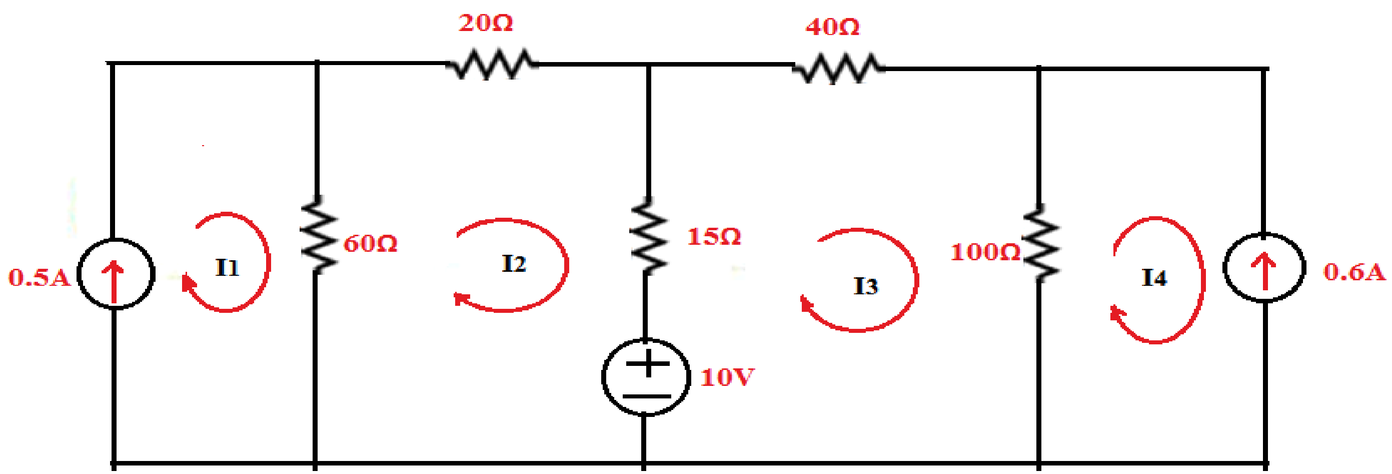
Answer

LECTURE-4

Mesh Analysis

Problem:- Using Mesh analysis find out the current in 20Ω, 40Ω and 15Ω resistor in the given circuit.





Solution:-

Apply KVL in each mesh:-

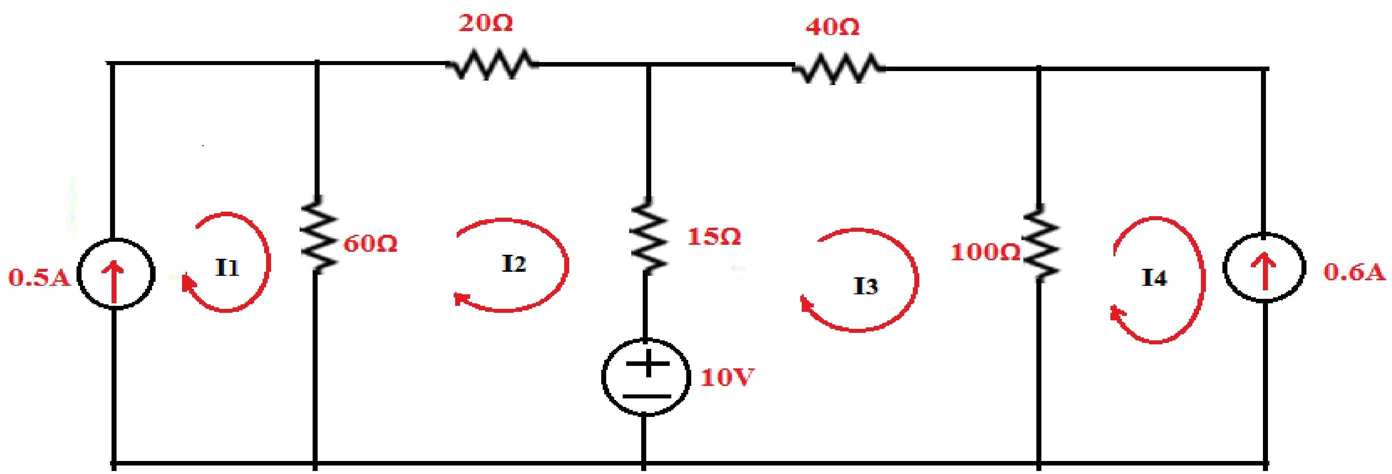
Mesh (1):-

$$I_1 = 0.5\ A \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (i)$$

Mesh (2):-

$$-10 - 60\,(I_2 - I_1) - 20I_2 - 15\,(I_2 - I_3) = 0$$

$$-95I_2 + 15I_3 = -20 \quad \ldots\ldots\ldots\ldots\ldots\ldots (ii)$$



Mesh (4):-

$$I_4 = -0.6\,A \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (iii)$$

Mesh (3):-

$$10 - 15\,(I_3 - I_2) - 40I_3 - 100(I_3 - I_4) = 0$$

$$15I_2 - 155I_3 = 50 \ldots\ldots\ldots\ldots\ldots\ldots\ldots (iv)$$

By solving equation (ii) & (iv) we get:-

Mesh Currents:-

$$I_2 = 0.162\ A\ ;\ I_3 = -0.306\ A$$

Branch Currents:-

$$I_{20\Omega} = I_2 = 0.162\ A$$

Answer

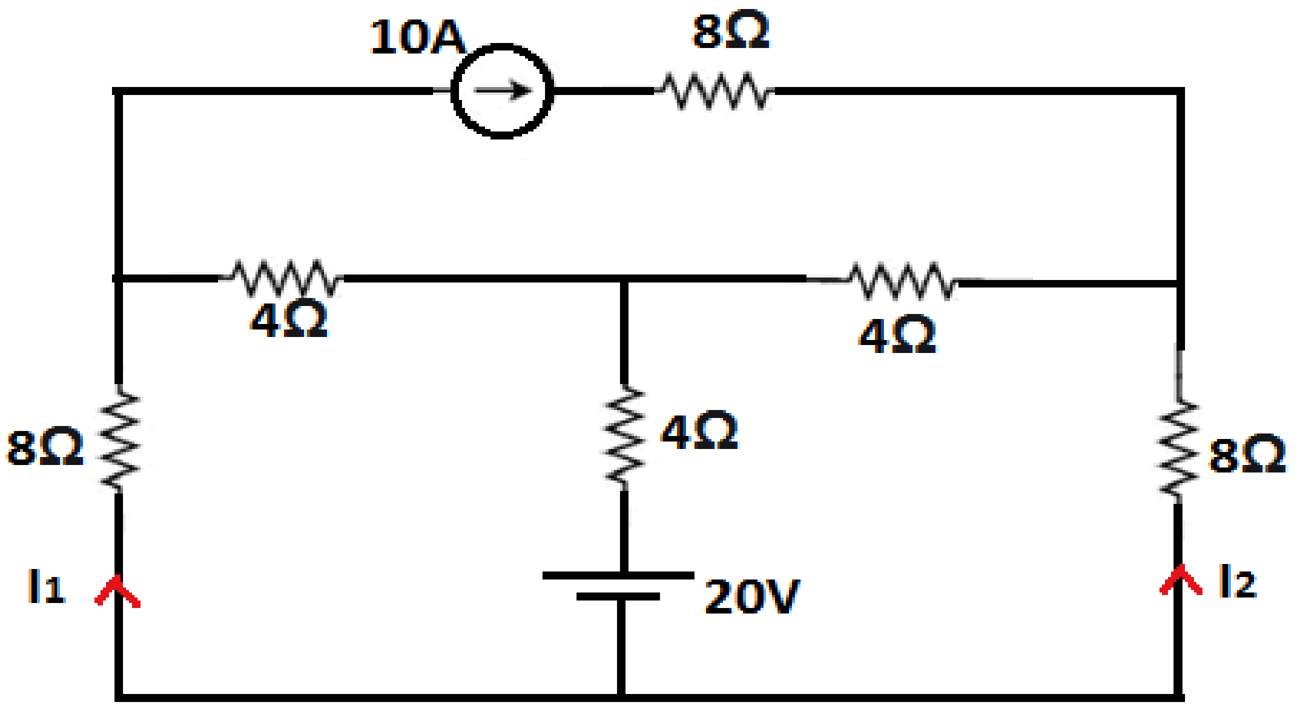
$$I_{40\Omega} = I_3 = -0.306\ A$$

Answer

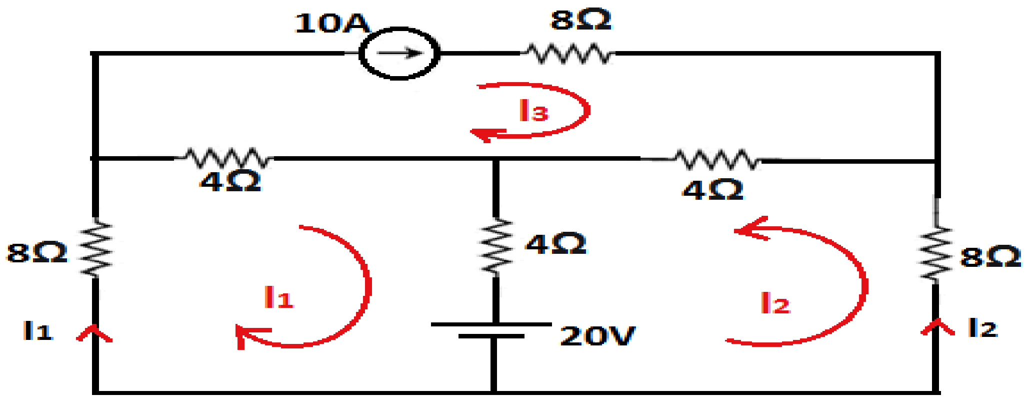
$$I_{15\Omega} = (I_2 - I_3) = 0.468A$$

Answer

Problem:- Calculate I_1 & I_2 by using Mesh analysis.



Solution:-



Apply KVL in each mesh:-

Mesh (3):-

$$I_3 = 10\ A$$

Mesh (1):-

$$-20 - 8I_1 - 4(I_1 - 10) - 4(I_1 + I_2) = 0$$

$$16I_1 + 4I_2 = 20 \dots\dots\dots\dots (i)$$

Mesh (2):-

$$-20 - 8I_2 - 4\ (I_2 + 10) - 4(I_1 + I_2) = 0$$

$$4I_1 + 16I_2 = -60 \dots\dots\dots\dots (ii)$$

By solving equation (i) & (ii) we get:-

Mesh Currents:-

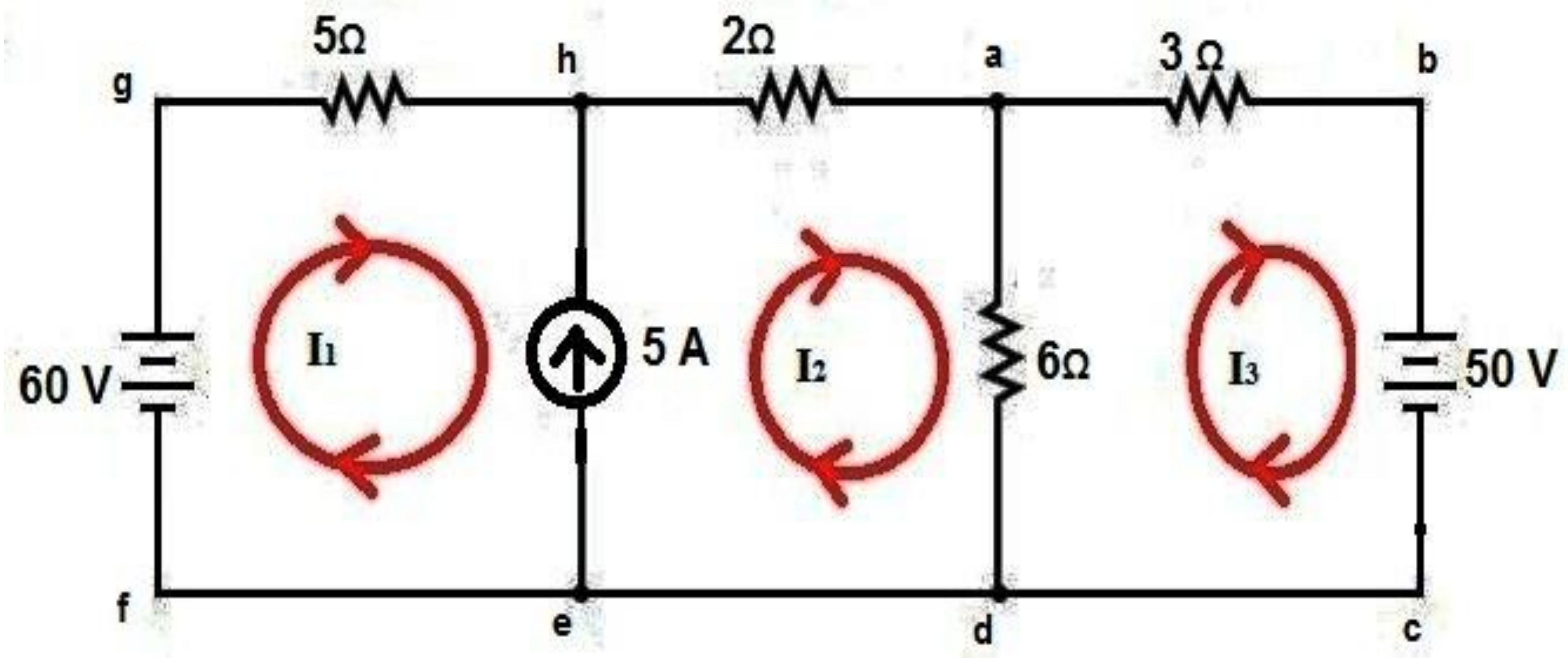
$$I_1 = 2.33\ A\ ;\ I_2 = -4.33A$$

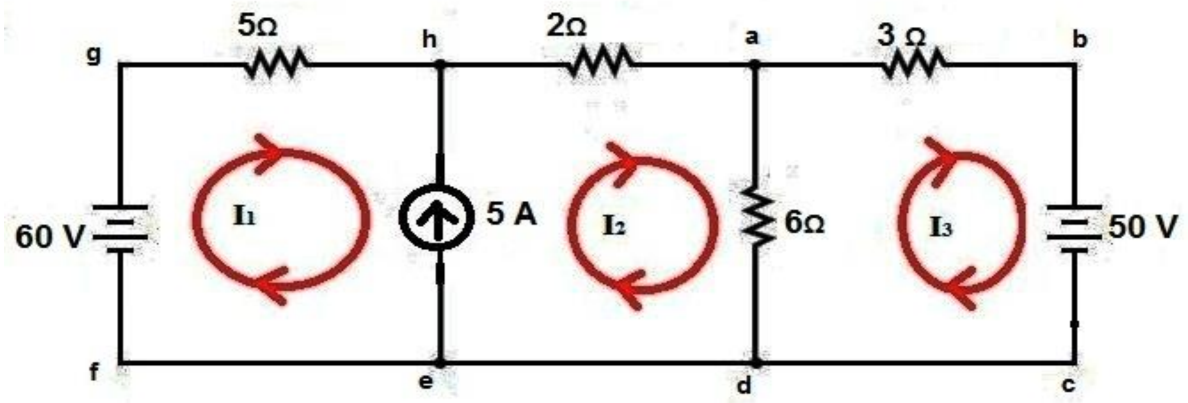
Answer

Super-Mesh

- If a current source is common between two Mesh then it is called a Super-Mesh. In this case don't directly apply KVL in both Mesh. Apply KVL to the Super-Mesh (Combined Mesh) and apply KCL at common Node to establish the relation between Mesh Current and Current Source.

Problem:- Find out the Mesh Current in the given figure using Mesh analysis.





- Branch h-e consists current source between Mesh-1 and Mesh-2. That’s why it is a Super-Mesh:-

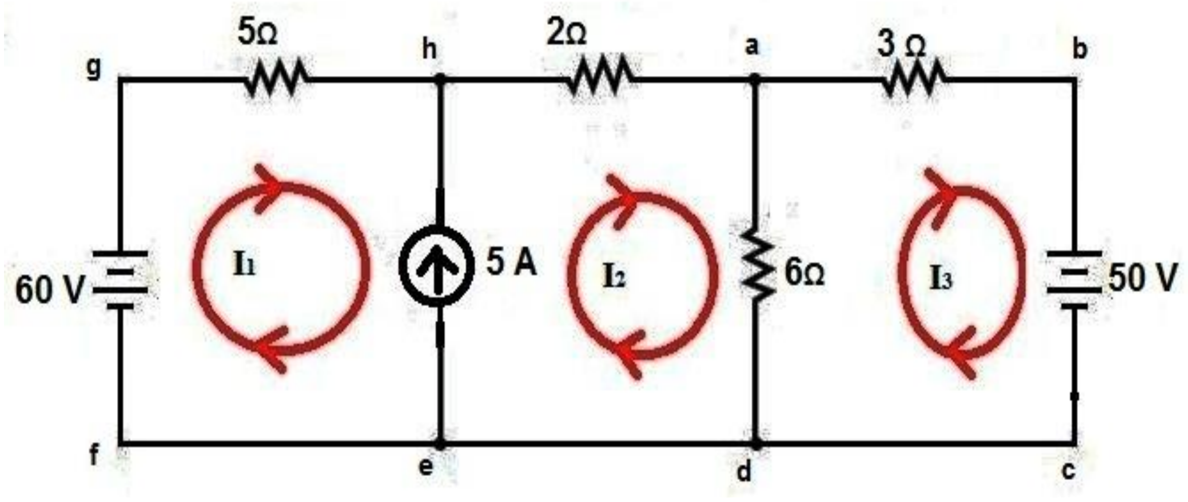
Now apply **KVL to Super-Mesh** (g-h-a-d-e-f-g):-

Apply KVL in Mesh-3 :-

$$5I_1 - 2I_2 - 6\,(I_2\ -\ I_3) + 60 =\ 0$$
$$5I_1 + 8I_2 -\ 6I_3 = 60 \ldots\ldots\ldots\ldots\ldots\ldots\ldots(i)$$

Apply KCL at Node h:-

$$I_1 + 5 = I_2$$
$$-I_1 + I_2 = 5\ \ldots\ldots\ldots\ldots\ldots\ldots(ii)$$



Apply KVL in Mesh-3 :-

$$-50 - 6(I_3 - I_2) - 3I_3 = 0$$
$$6I_2 - 9I_3 = 50 \;\ldots\ldots\; (iii)$$

By solving equation (i),(ii) & (iii) we get:-

Mesh Currents:-

$$I_1 = 0.74\,A\,;\; I_2 = 5.74\,A\,; I_3 = -1.72\,A$$

Answer

LECTURE-5

Nodal Analysis

Nodal Analysis

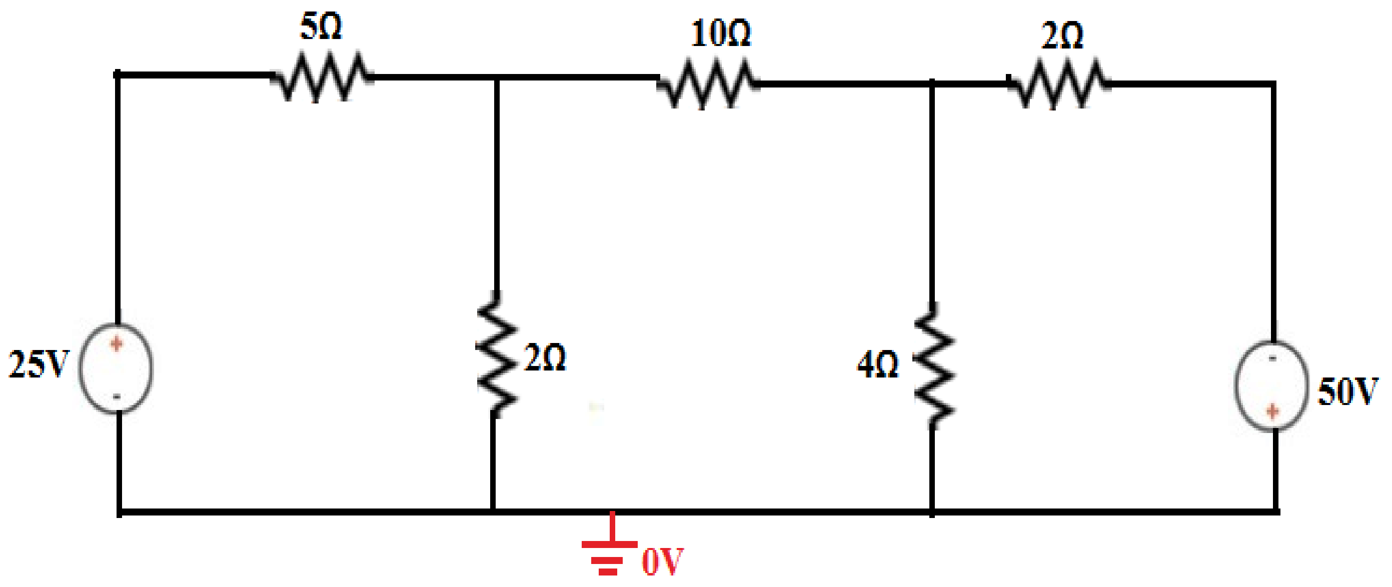
- **Step 1:-** Take a reference Node at generally ground (V=0).
- **Step 2:-** Identify number of Nodes.
- **Step 3:-** Assume current in each branch (Any direction).
- **Step 4:-** Apply KCL at each Node and make equations.
- **Note:-**

Number of Node Equations = (N – 1)

Where N is a Principal Node

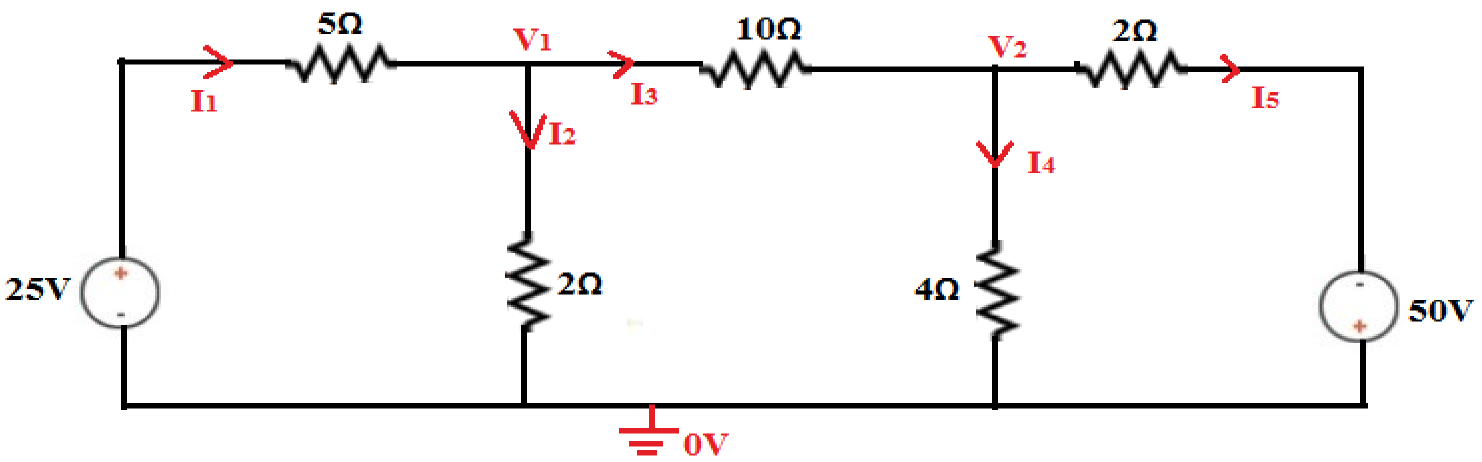
- **Step 5:-** Solve equations to find Node voltages.
- **Step 6:-** Put Node voltages in equations to find out Branch Currents.

Problem:- Using Nodal analysis find out current in 10Ω resistance.



Solution:-

Node (N) = 3
So number of Nodal Equation = (N-1) = 2



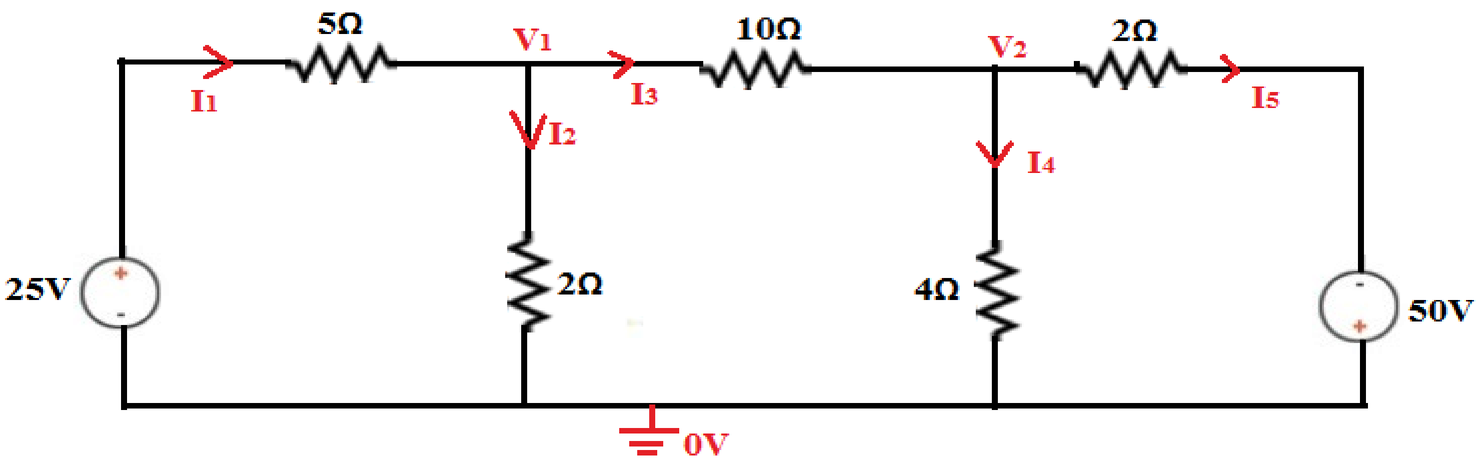
Apply KCL at Node-1:-

$$I_1 = I_2 + I_3$$

$$I_1 - I_2 - I_3 = 0$$

$$\frac{25 - V_1}{5} - \frac{V_1}{2} - \frac{V_1 - V_2}{10} = 0$$

$$-8V_1 + V_2 = -50 \quad \text{.................} \text{ (i)}$$



Apply KCL at Node-2:-

$$I_3 = I_4 + I_5$$

$$I_3 - I_4 - I_5 = 0$$

$$\frac{V_1 - V_2}{10} - \frac{V_2}{4} - \frac{V_2 + 50}{2} = 0$$

$$2V_1 - 17V_2 = 500 \quad \text{.................. (ii)}$$

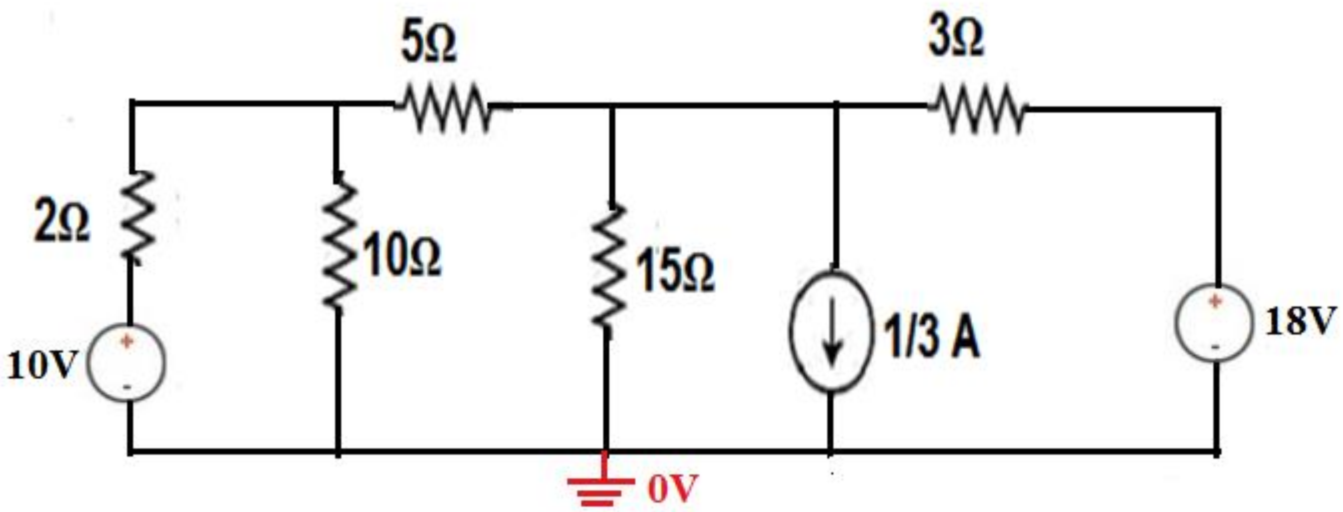
By solving equation (i) & (ii) we get:-

$$V_1 = 2.61\, V\ ;\ V_2 = -29.10\, V$$

$$I_3 = \frac{V_1 - V_2}{10} = 3.171\, A$$

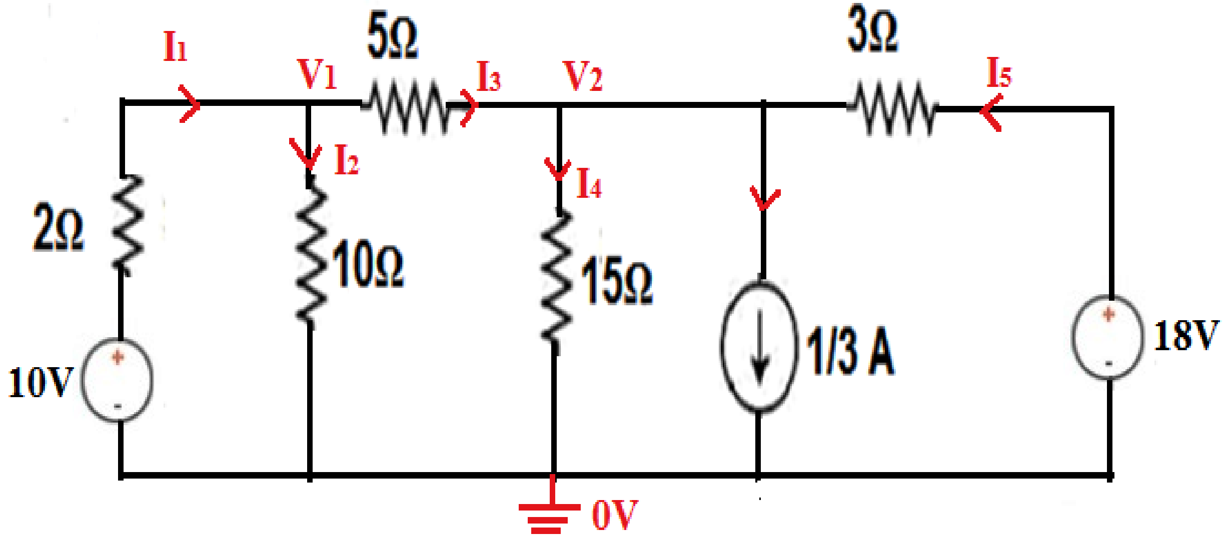
Answer

Problem:- Determine Current through 15Ω resistance by Node analysis.



Solution:-

Node (N) = 3
Number of Nodal Equation = (N-1) = 2



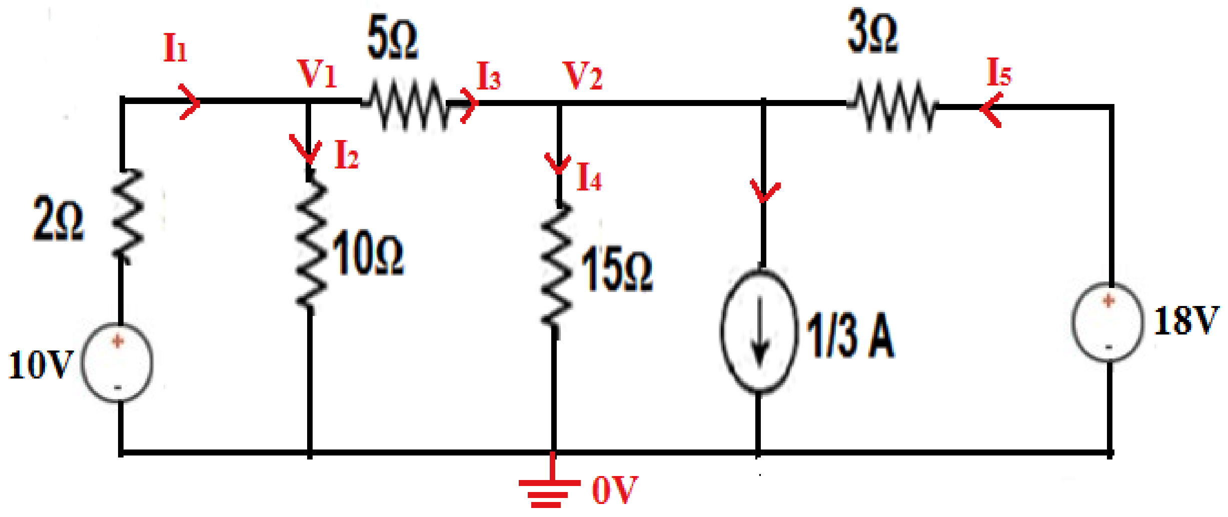
Apply KCL at Node-1:-

$$I_1 = I_2 + I_3$$

$$I_1 - I_2 - I_3 = 0$$

$$\frac{10 - V_1}{2} - \frac{V_1}{10} - \frac{V_1 - V_2}{5} = 0$$

$$8V_1 - 2V_2 = 50 \quad \text{.................} \text{(i)}$$



Apply KCL at Node-2:-

$$I_3 + I_5 = I_4 + \frac{1}{3}$$

$$I_3 - I_4 - \frac{1}{3} + I_5 = 0$$

$$\frac{V_1 - V_2}{5} - \frac{V_2}{15} - \frac{1}{3} + \frac{18 - V_2}{3} = 0$$

$$3V_1 - 9V_2 = -85 \quad \text{.................. (ii)}$$

By solving equation (i) & (ii) we get:-

$$V_1 = 9.39\ V\ ;\ V_2 = 12.57\ V$$

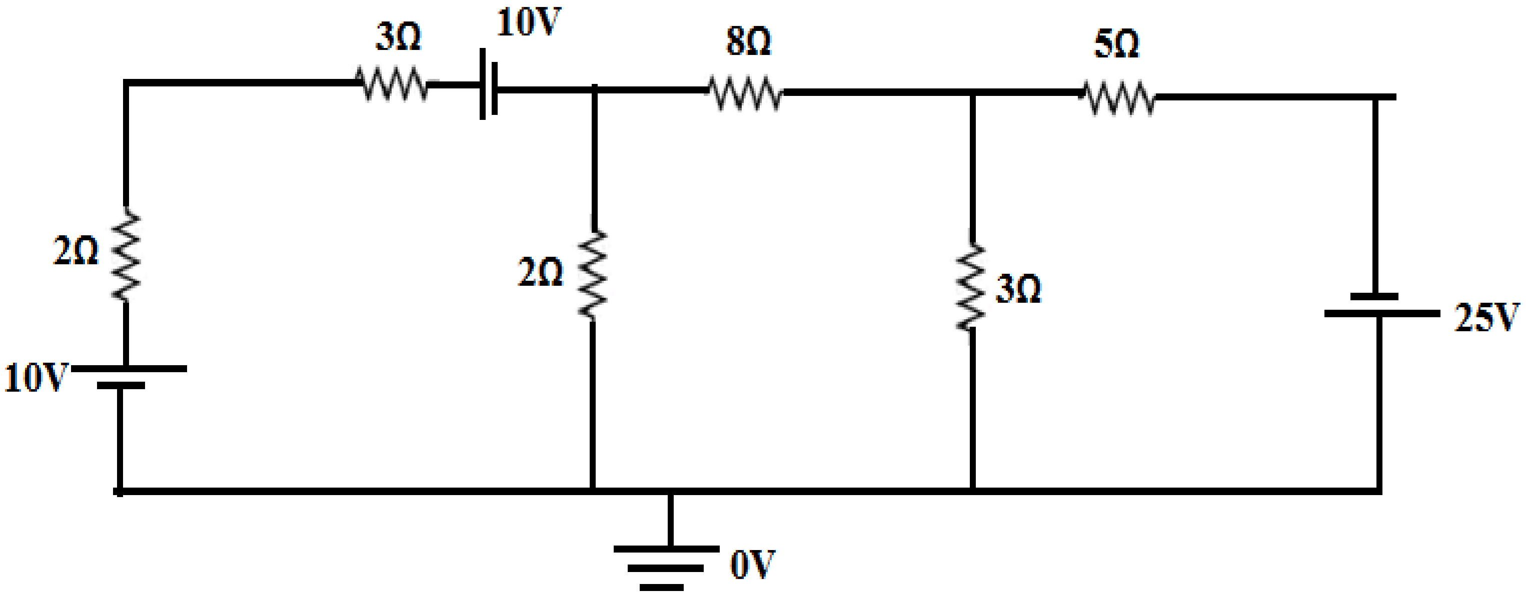
$$I_4 = \frac{V_2}{15} = 0.838\ A$$

Answer

LECTURE-6

Nodal Analysis

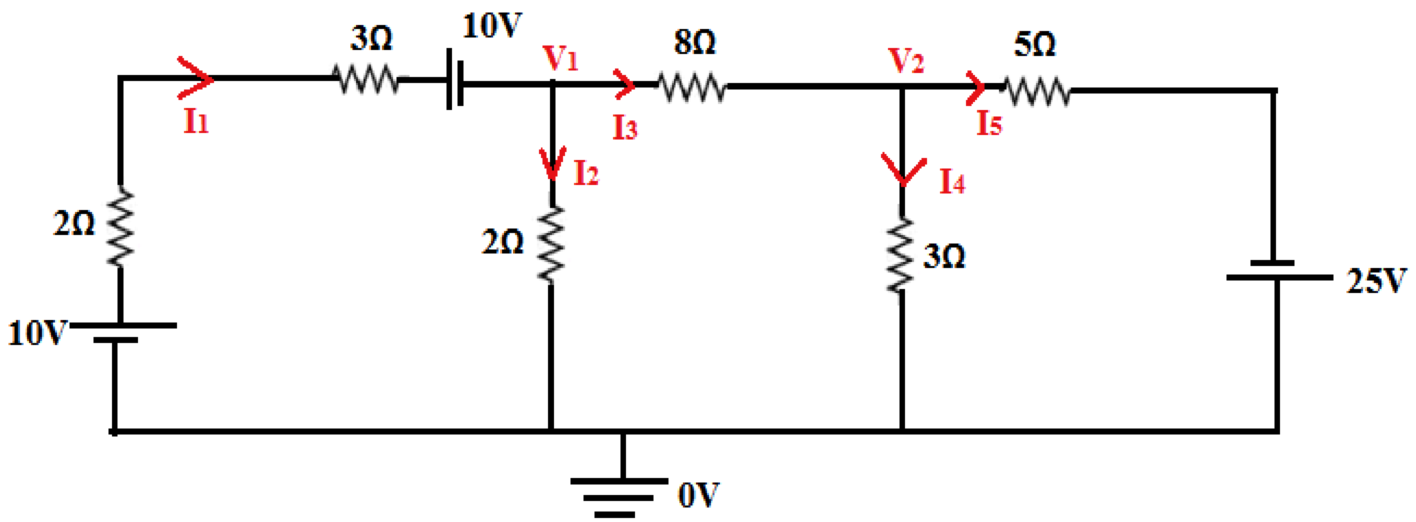
Problem:- Determine Current through 8Ω resistance by Node analysis.



Solution:-

Node (N) = 3

Number of Nodal Equation = (N-1) = 2



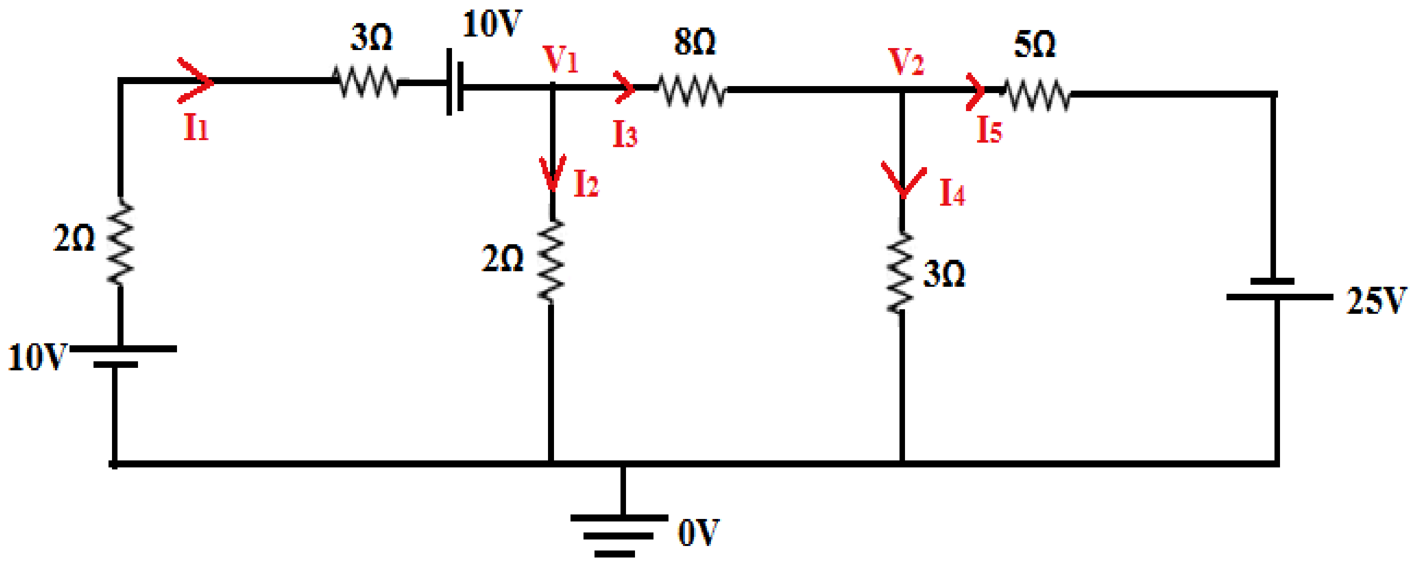
Apply KCL at Node-1:-

$$I_1 = I_2 + I_3$$

$$I_1 - I_2 - I_3 = 0$$

$$\frac{10 - 10 - V_1}{5} - \frac{V_1}{2} - \frac{V_1 - V_2}{8} = 0$$

$$33V_1 - 5V_2 = 0 \quad \text{.................} \text{ (i)}$$



Apply KCL at Node-2:-

$$I_3 = I_4 + I_5$$

$$I_3 - I_4 - I_5 = 0$$

$$\frac{V_1 - V_2}{8} - \frac{V_2}{3} - \frac{V_2 + 25}{5} = 0$$

$$15V_1 - 79V_2 = 600\text{..........} \text{(ii)}$$

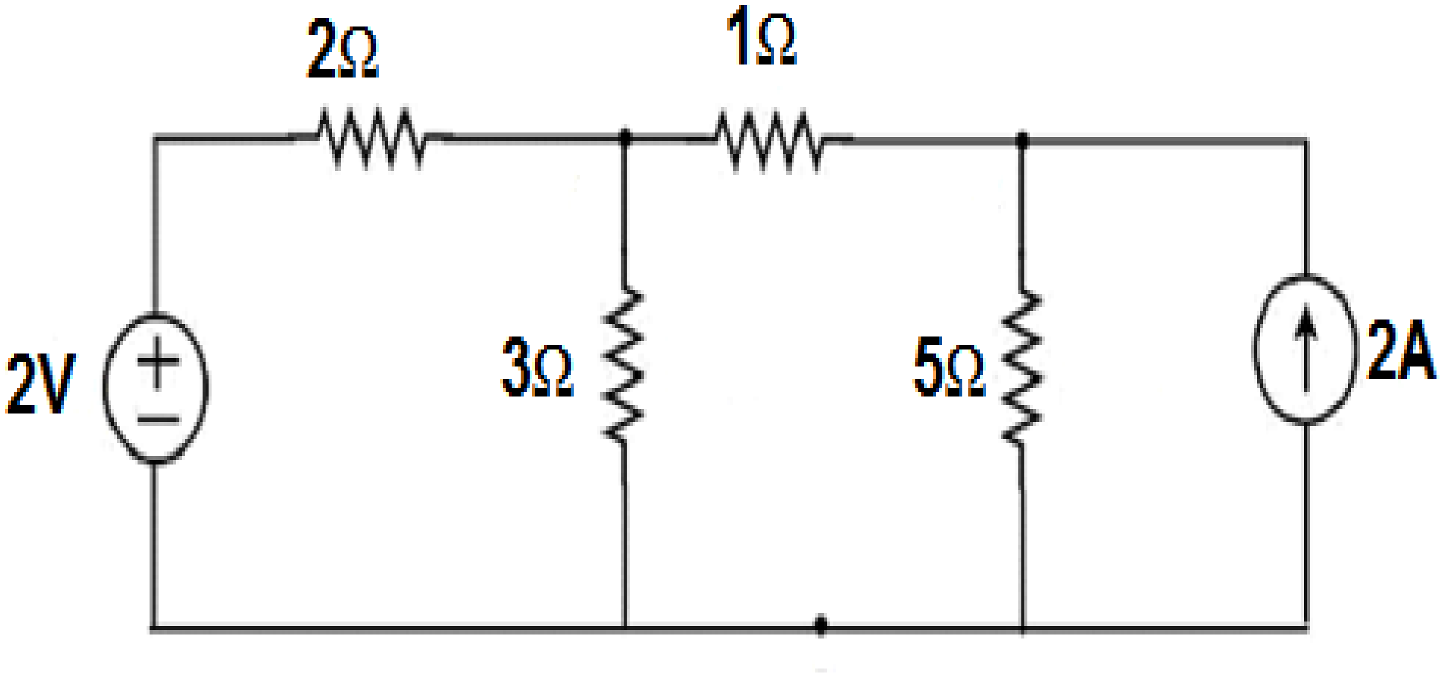
By solving equation (i) & (ii) we get:-

$$V_1 = -1.184\,V \; ; \; V_2 = -7.819\,V$$

$$I_{8\Omega} = I_3 = \frac{V_1 - V_2}{8} = 0.829\,A$$

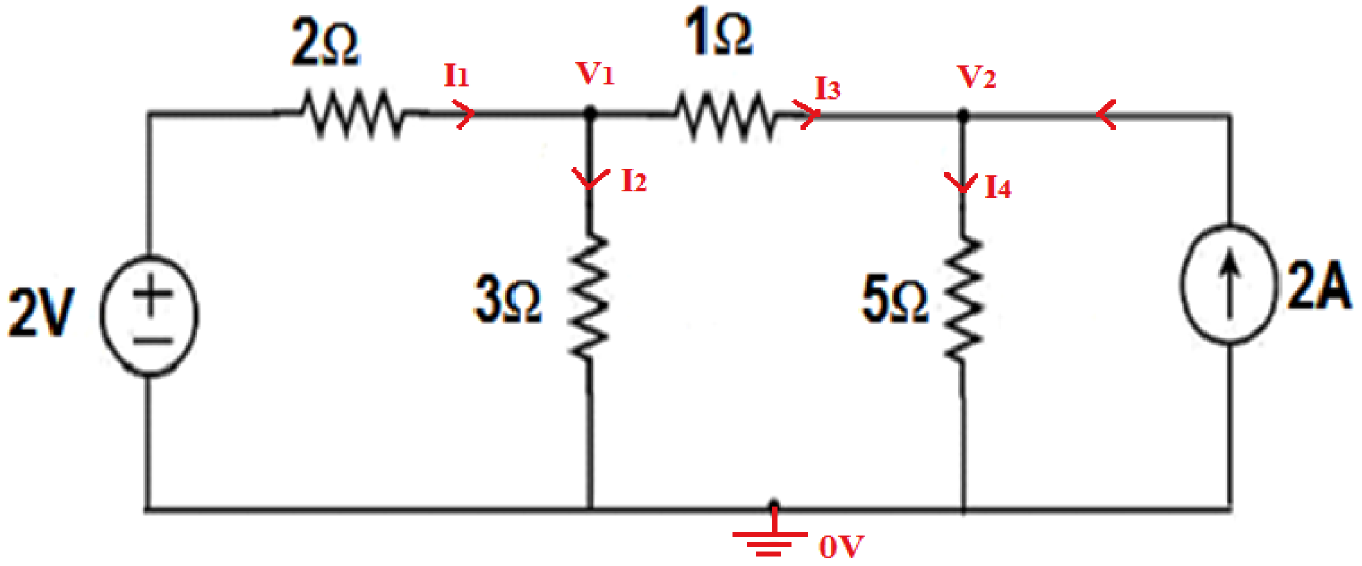
Answer

Problem:- Using Nodal analysis find the current through 1Ω resistance.



Solution:-

Node (N) = 3
Number of Nodal Equation = (N-1) = 2



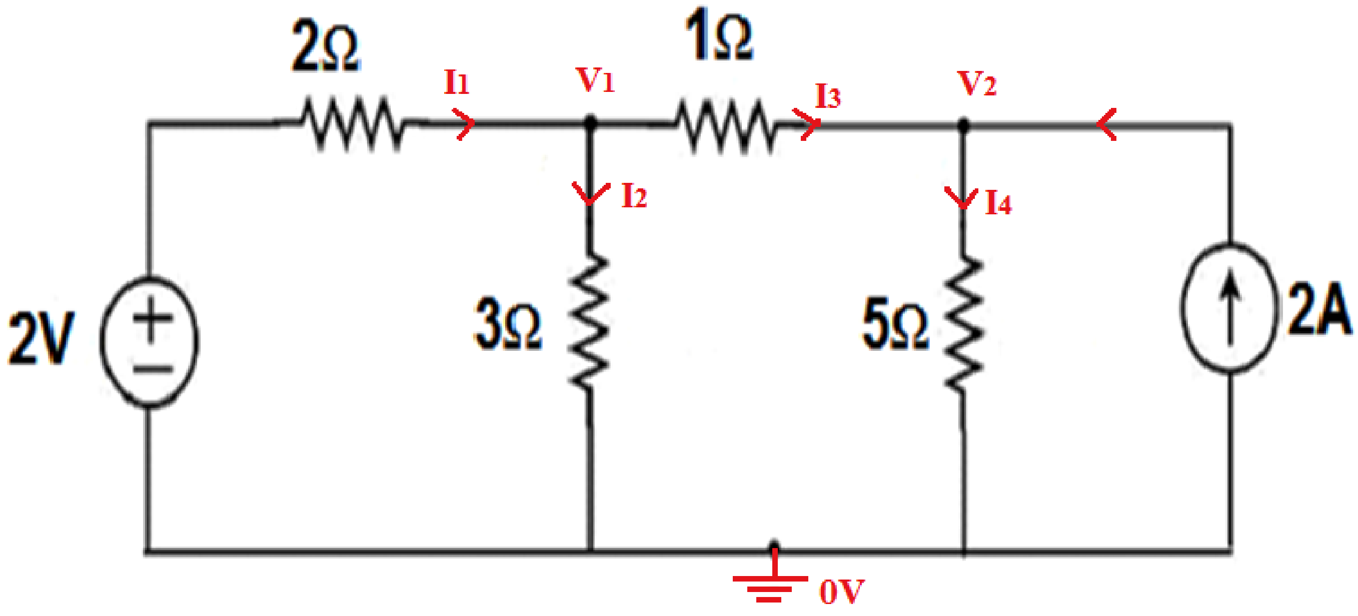
Apply KCL at Node-1:-

$$I_1 = I_2 + I_3$$

$$I_1 - I_2 - I_3 = 0$$

$$\frac{2 - V_1}{2} - \frac{V_1}{3} - \frac{V_1 - V_2}{1} = 0$$

$$11V_1 - 6V_2 = 6 \quad \text{................ (i)}$$



Apply KCL at Node-2:-

$$I_3 + 2 = I_4$$

$$I_3 - I_4 + 2 = 0$$

$$\frac{V_1 - V_2}{1} - \frac{V_2}{5} + 2 = 0$$

$$-5V_1 + 6V_2 = 10 \ldots\ldots\ldots\ldots \text{(ii)}$$

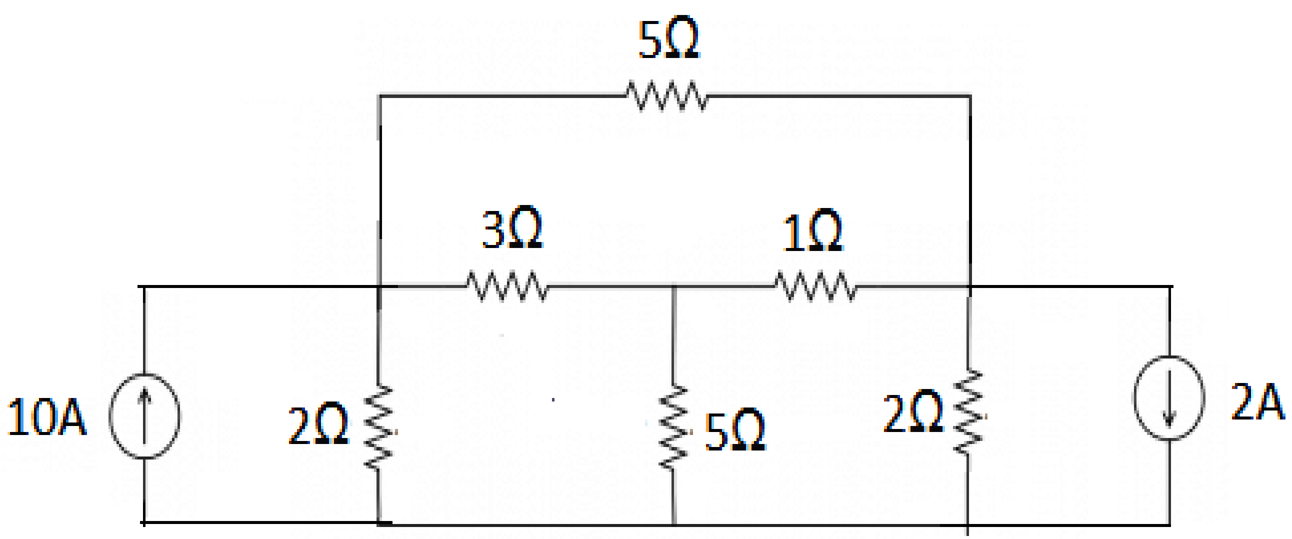
By solving equation (i) & (ii) we get:-

$$V_1 = 2.66V\ ;\ V_2 = 3.88\ V$$

$$I_{1\Omega} = I_3 = \frac{V_1 - V_2}{1} = -1.22\ A$$

Answer

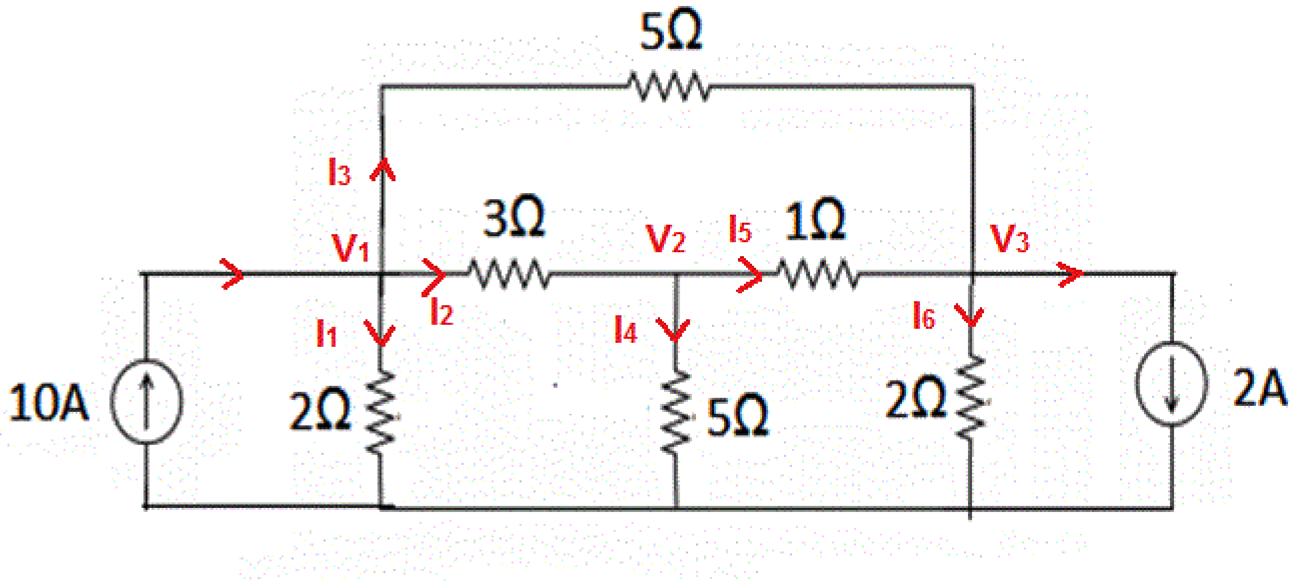
Problem:- Find the current in all resistances using Nodal analysis. **(AKTU 2022-2023 EVEN SEM.)**



Solution:-

Node (N) = 3

So number of Nodal Equation = (N-1) = 2



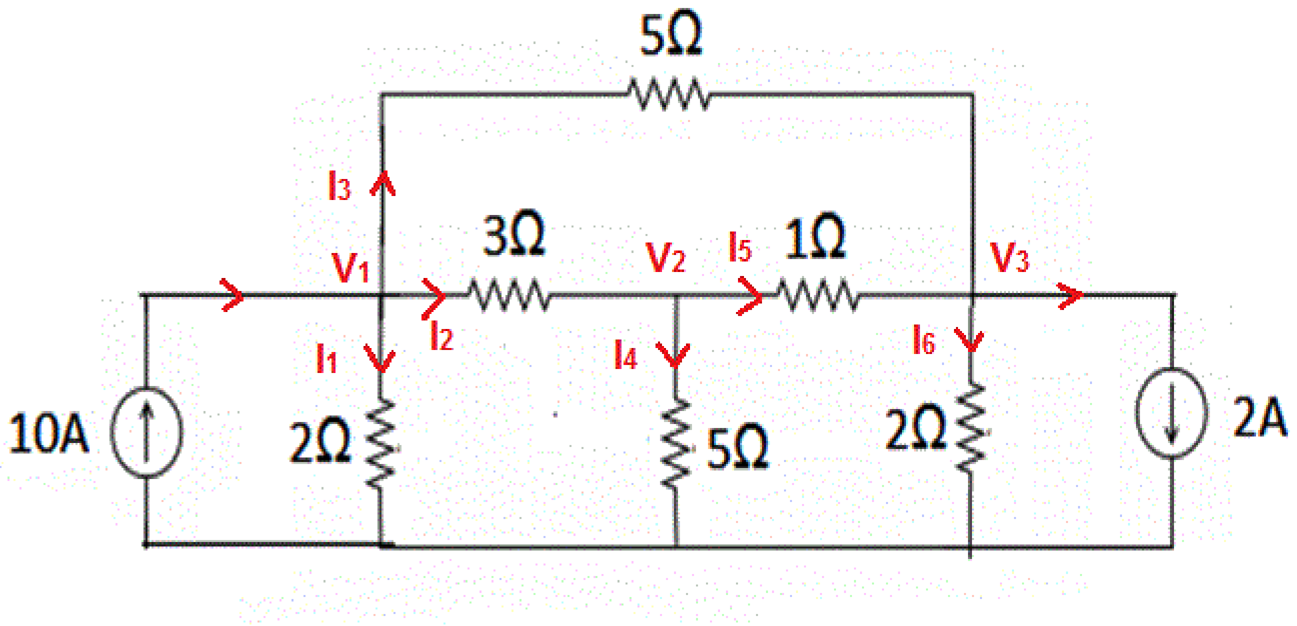
Apply KCL at Node-1:-

$$10 = I_1 + I_2 + I_3$$

$$10 - I_1 - I_2 - I_3 = 0$$

$$10 - \frac{V_1}{2} - \frac{V_1 - V_2}{3} - \frac{V_1 - V_3}{5} = 0$$

$$31V_1 - 10V_2 - 6V_3 = 300 \quad \text{.................. (i)}$$



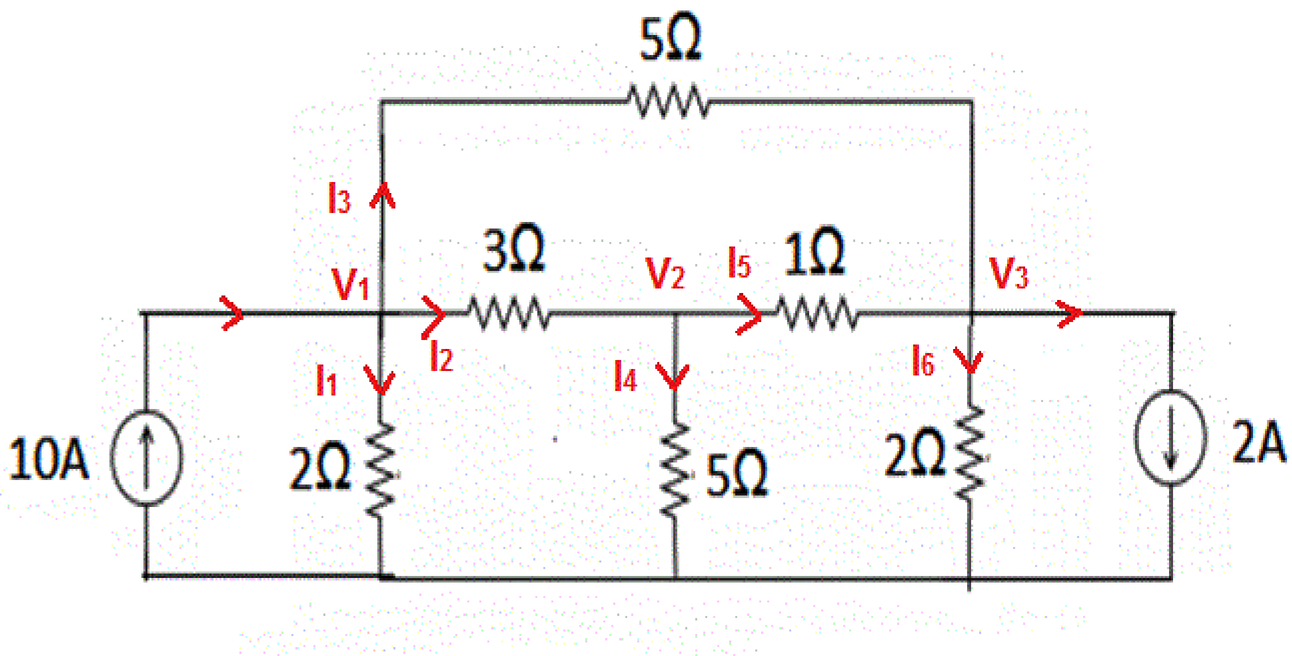
Apply KCL at Node-2:-

$$I_2 = I_4 + I_5$$

$$I_2 - I_4 - I_5 = 0$$

$$\frac{V_1 - V_2}{3} - \frac{V_2}{5} - \frac{V_2 - V_3}{1} = 0$$

$$-5V_1 + 23V_2 - 15V_3 = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(ii)}$$



Apply KCL at Node-3:-

$$I_3 + I_5 = I_6 + 2$$

$$I_3 + I_5 - I_6 - 2 = 0$$

$$\frac{V_1 - V_3}{5} + \frac{V_2 - V_3}{1} - \frac{V_3}{2} - 2 = 0$$

$$2V_1 + 10V_2 - 17V_3 = 20\text{..............(iii)}$$

By solving equation (i) , (ii) & (iii) we get:-

$$V_1 = 11.58\,V\ ;\ V_2 = 4.28\,V\ ;\ V_3 = 2.70\,V$$

$$I_3 = \frac{V_1 - V_3}{5} = 1.776\,A$$

$$I_2 = \frac{V_1 - V_2}{3} = 2.43\,A$$

$$I_1 = \frac{V_1}{2} = 5.79\,A$$

Answer

$$I_4 = \frac{V_2}{5} = 0.856\,A$$

$$I_5 = \frac{V_2 - V_3}{1} = 1.58\,A$$

$$I_6 = \frac{V_3}{2} = 1.35\,A$$

Answer

Problems

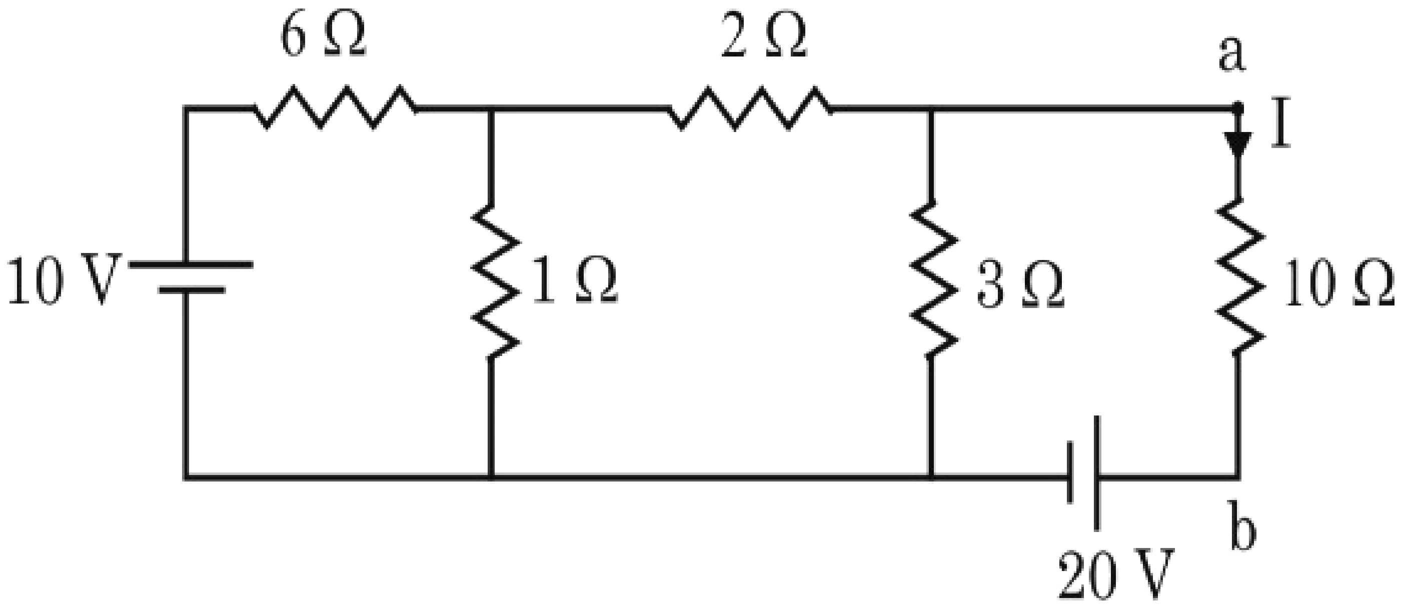
Mesh analysis

&

Nodal Analysis

Mesh Analysis

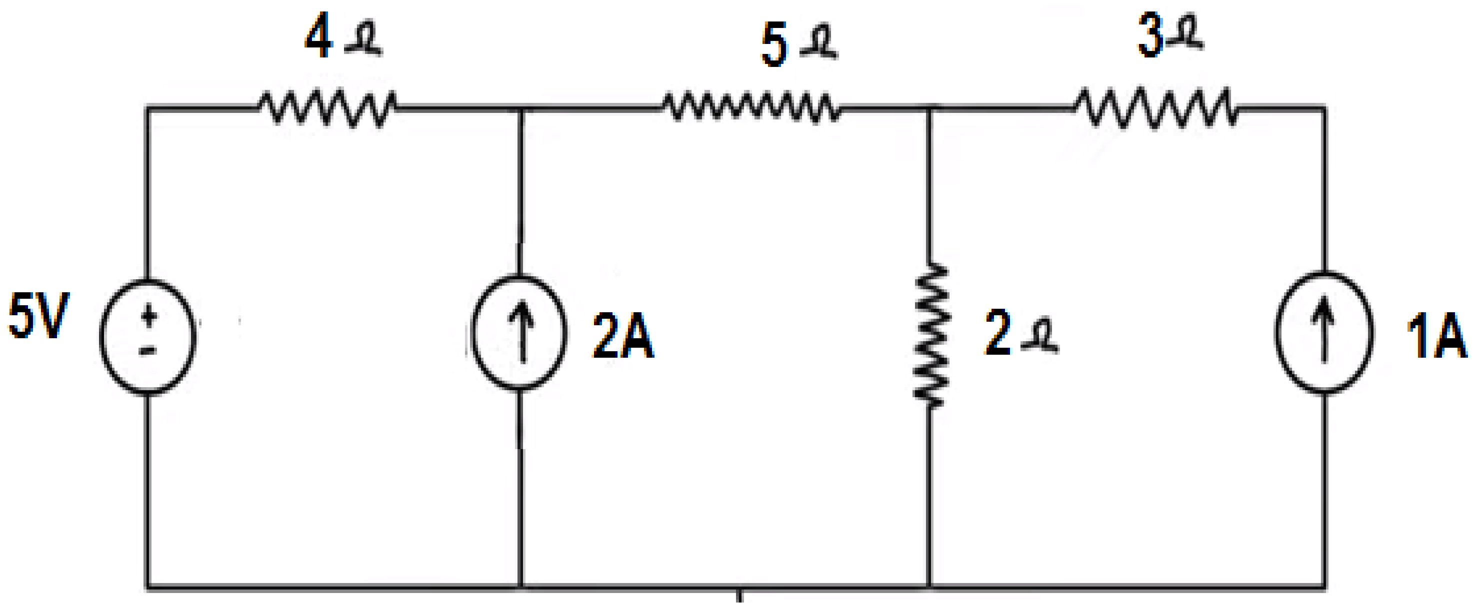
Problem:1 Find the current I in figure given below using mesh analysis.



Ans:

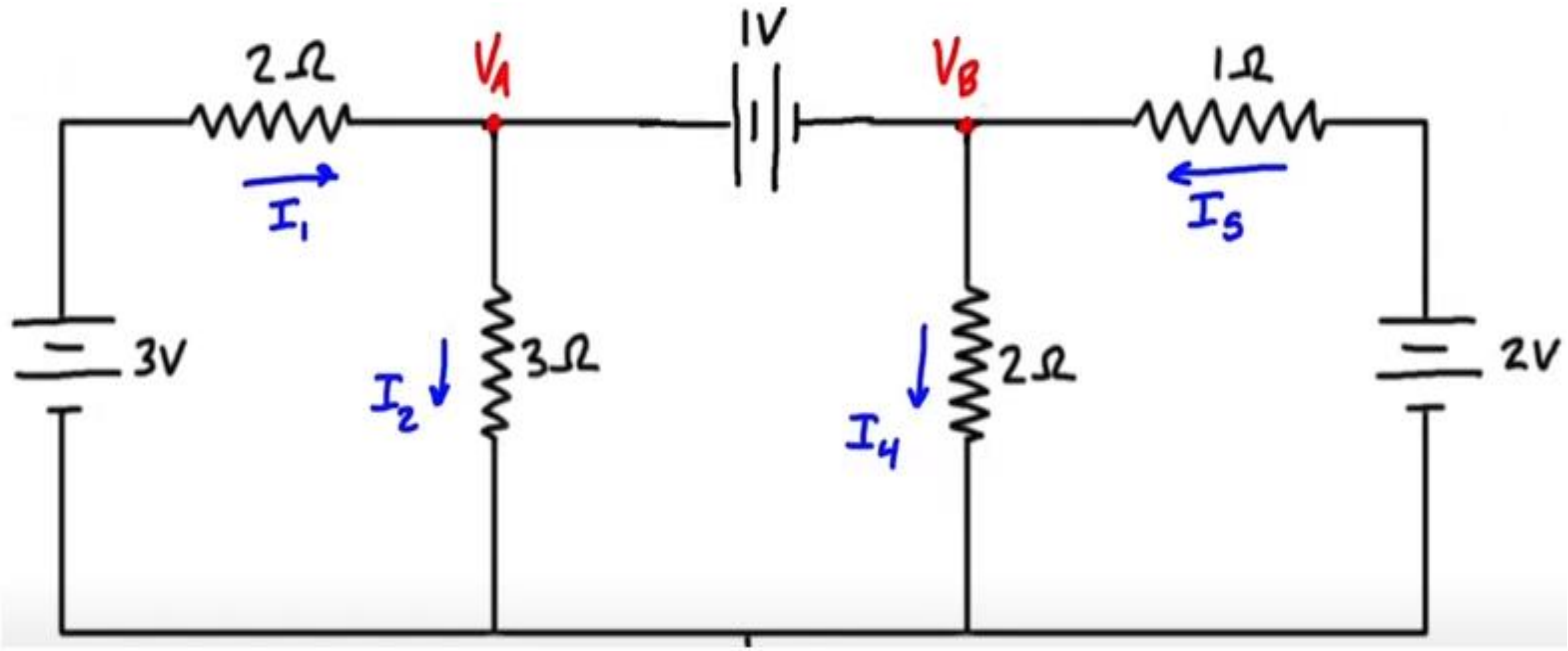
Super-mesh

Problem: 2 Find the current in all branches by using mesh analysis.



Super-node

Problem: 3 Calculate the resistive branch current by using nodal analysis.



THANK YOU