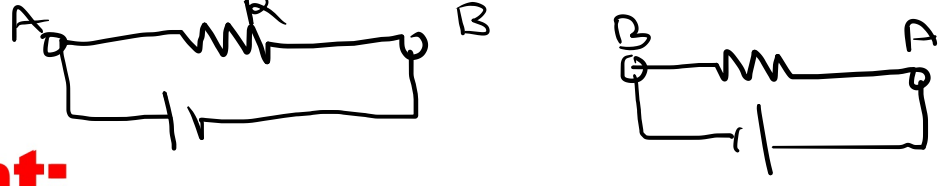
Network Analysis

Important Definitions:

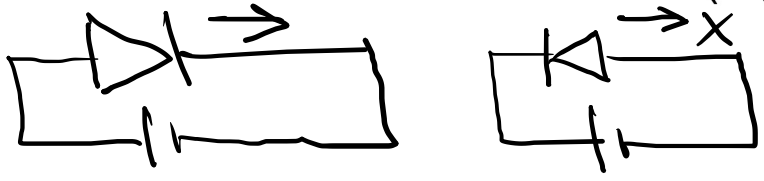
Bilateral Circuit/element:

The circuit/element whose properties or characteristics are same in both directions. (e.g. Transmission lines or resistors)



Unilateral Circuit/element:

The circuit/element whose properties or characteristics are not same in both directions. (e.g. diode, Transistors)



Electric Network: It is combination of various electrical elements connected in any manner.

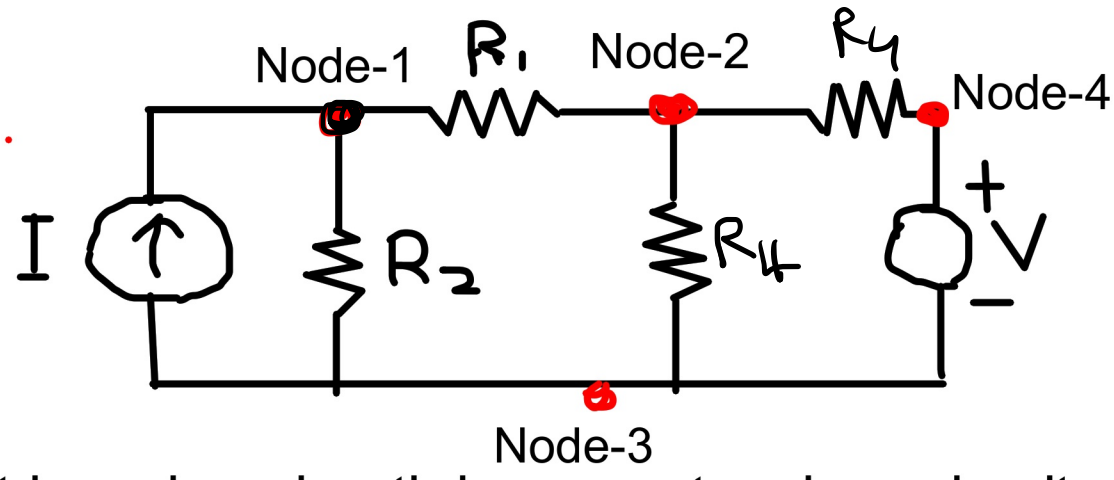
Passive Network: It is a network which does not contain any source of energy.

Active Network: It is a network which contains atleast one source of energy.

Network Analysis using Mesh current Method

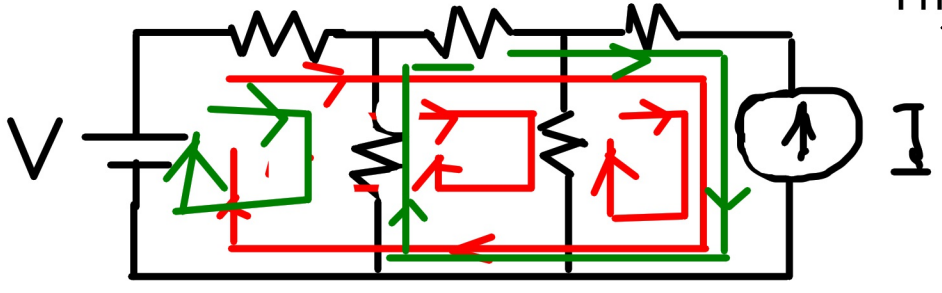
Important Definitions: (Maxwell's Current method)

Node: It is a junction where two or more circuit elements are connected.



Loop: It is a closed path in any network or circuit.

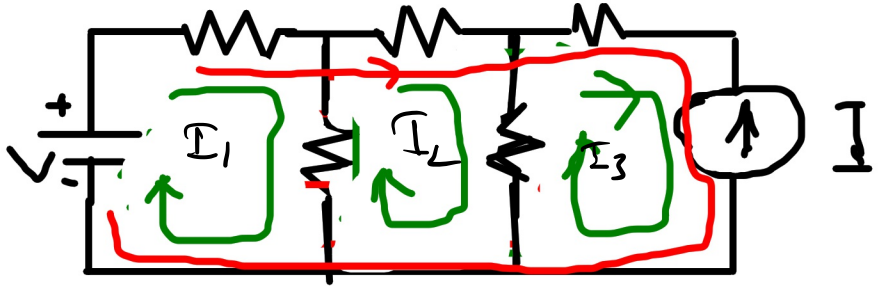
There are many loops.



Mesh : It is a loop which does not have loop inside it.

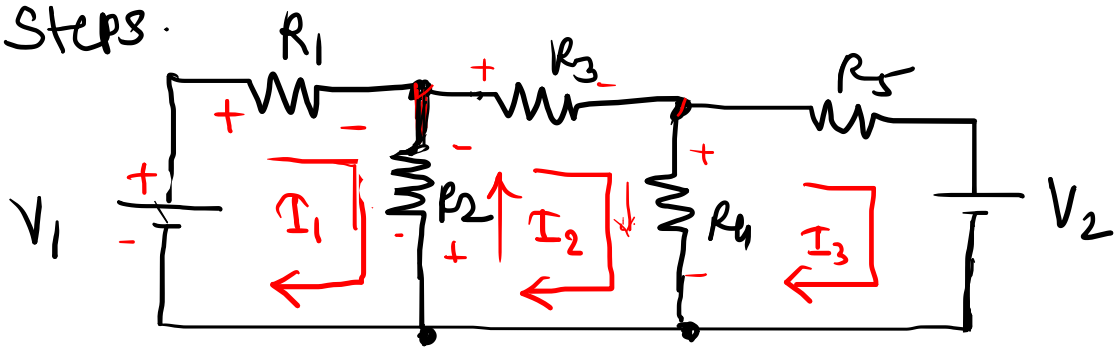
Only loops marked with green are Mesh.

The loops marked with red is not a Mesh.



Mesh Current method or Mesh Analysis

⇒ Steps.



Common branches ⇒ R_2, R_4

Uncommon branches ⇒ V_1, R_1, R_3, R_5, V_2

① Identify meshes. (3)

② Mark mesh current (I_1, I_2, I_3) [Unknown quantity mesh current)

③ Write KVL to All mesh.

KVL to mesh (I)

$$V_1 - I_1R_1 - (I_1 - I_2)R_2 = 0$$

$$(R_1 + R_2)I_1 - I_2R_2 = V_1 \quad \text{---} (1)$$

KVL to mesh (II)

$$-I_2R_3 - (I_2 - I_3)R_4 - (I_2 - I_1)R_2 = 0$$

$$I_1R_2 - (R_3 + R_4 + R_2)I_2 + R_4I_3 = 0 \quad \text{---} (II)$$

KVL to mesh (III)

$$-I_3R_5 - V_2 - (I_3 - I_2)R_4 = 0$$

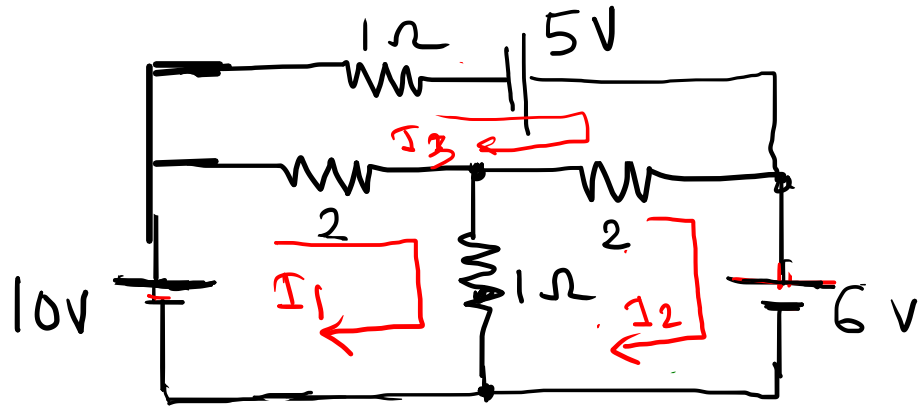
$$I_2R_4 - (R_4 + R_5)I_3 = V_2 \quad \text{---} (III)$$

Solving (I) (II) & (III) to get I_1 I_2 I_3

$IR_2 = (I_1 - I_2)\downarrow$ $(I_2 - I_1)\uparrow$

Type-1: Network consisting of only voltage sources (no current sources)

Ex.1)



Find current flowing through 1Ω resistors.

99 ES / 99 MS

⇒ Identify mesh & mark mesh current.

⇒ KVL to mesh (I)

$10 - 2(I_1 - I_3) - 1(I_1 - I_2) = 0$

$3I_1 - I_2 - 2I_3 = 10$ --- (1)

⇒ KVL to mesh (II)

$-2(I_2 - I_3) - 6 - 1(I_2 - I_1) = 0$

$I_1 - 3I_2 + 2I_3 = 6$ --- (2)

⇒ KVL to mesh (III)

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

$2I_1 + 2I_2 - 5I_3 = -5$ --- (3)

Solving (1), (2) & (3)

$I_1 = 12A$

$I_2 = 8A$

$I_3 = 9A$

$I_{1\Omega} = I_3 = 9A (\rightarrow)$

Network Analysis

Important Definitions:

Circuit: It is a conducting path through which an electric current either flows or is intended to flow.

Parameters: The elements of an electric circuit such as resistance, inductance, capacitance. (Parameters may be lumped i.e. they can be represented independently from the circuit or distributed i.e. they can not be represented separately.)

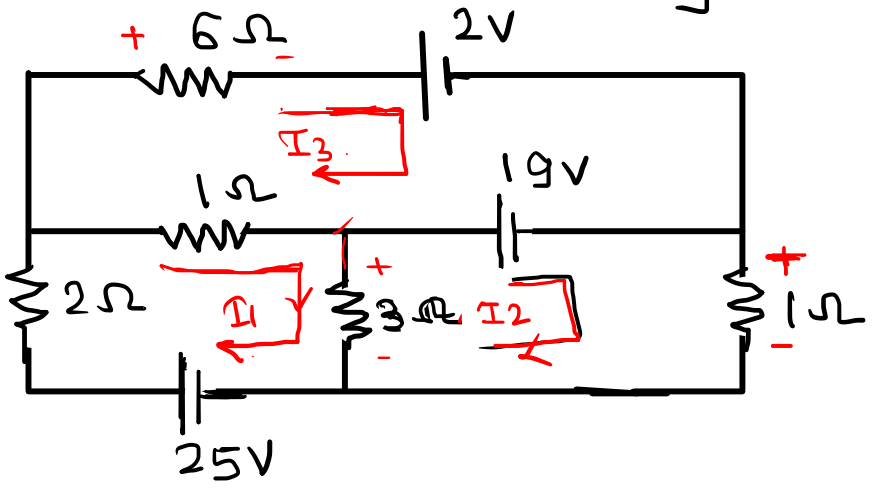
Linear Circuit/element: If the parameters of a circuit/element are constant, i.e. they do not change with voltage/current, the circuit is known as linear circuit. (e.g. Resistor, inductor, capacitor)

Nonlinear Circuit/element: If the parameters of a circuit/element are not constant, i.e. they change with voltage/current, the circuit is known as nonlinear circuit. (e.g. Diode, Transistor, capacitor)

Type-1: Network consisting of only voltage sources (no current sources)

EX.2] Find Current flowing through 6Ω resistor

2.95A



⇒ Identify meshes and mark mesh current.

⇒ KVL to mesh (I)

$$25 - 2I_1 - 1(I_1 - I_3) - 3(I_1 - I_2) = 0$$

$$6I_1 - 3I_2 - I_3 = 25 \quad \text{— (1)}$$

⇒ KVL to mesh-(II)

$$-19 - I_2 - 3(I_2 - I_1) = 0$$

$$3I_1 - 4I_2 = 19 \quad \text{--- (2)}$$

KVL to mesh (III)

$$-6I_3 - 2 + 19 - 1(I_3 - I_1) = 0$$

$$I_1 - 7I_3 = -17 \quad \text{-- (3)}$$

Solving (I), (II) & (III)

$$I_1 = 3.65A$$

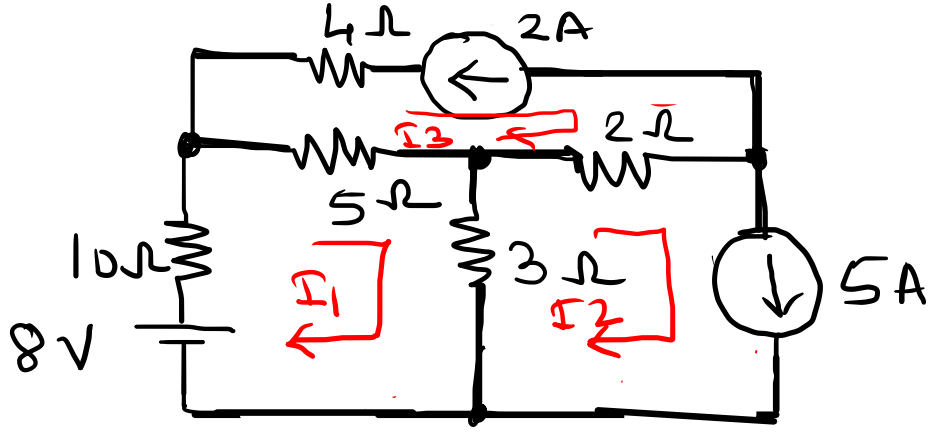
$$I_2 = -2A$$

$$I_3 = 2.95A$$

$$I_{6\Omega} = I_3 = 2.95A$$

Type 2: Network consisting both voltage and current sources. Current source on the uncommon branch of Mesh.

Find voltage across 10Ω.



⇒ Identify mesh & mark mesh current

⇒ Current Sources 2A & 5A are residing (appears) on Un-Common branch of mesh ③ & mesh ② respectively. So no need to apply KVL to mesh ② & ③.

The value of mesh current is value of current with appropriate direction of current source.

$I_2 = 5A$

$I_3 = -2A$

⇒ Apply KVL to mesh ①

$$8 - 10I_1 - 5(I_1 - I_3) - 3(I_1 - I_2) = 0$$

$$8 - 10I_1 - 5(I_1 + 2) - 3(I_1 - 5) = 0$$

$$8 - 10I_1 - 5I_1 - 10 - 3I_1 + 15 = 0$$

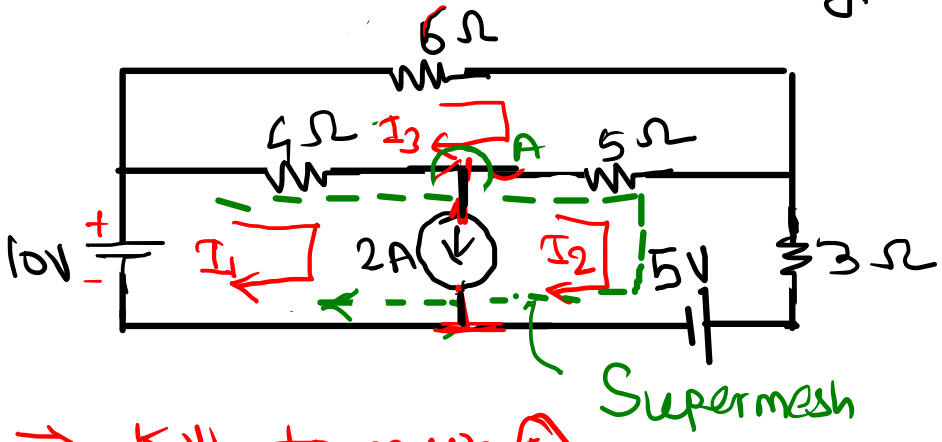
$$18I_1 = 13$$

$$I_1 = \frac{13}{18} A$$

$$V_{10\Omega} = 10 \times \frac{13}{18} = \frac{130}{18} = 7.22V$$

Type 3: Network consisting both voltage and current sources. Current source on the common branch of two Mesh. (Super mesh)

Ex. ① Find current flowing 6Ω resistor.



⇒ KVL to mesh (I)

$10 - 4(I_1 - I_3) - [?] = 0$

⇒ Represent current source appearing on common branch in terms of two mesh current

KCL at node (A)

KCL at node (A)

$I_1 = 2 + I_2$

$I_1 - I_2 = 2$ --- (i)

⇒ Apply KVL to supermesh keeping I_1 & I_2 mesh current intact

$10 - 4(I_1 - I_3) - 5(I_2 - I_3) - 3I_2 - 5 = 0$

$4I_1 + 8I_2 - 9I_3 = 5$ --- (ii)

⇒ KVL to mesh-(III)

$-4(I_3 - I_1) - 6I_3 - 5(I_3 - I_2) = 0$

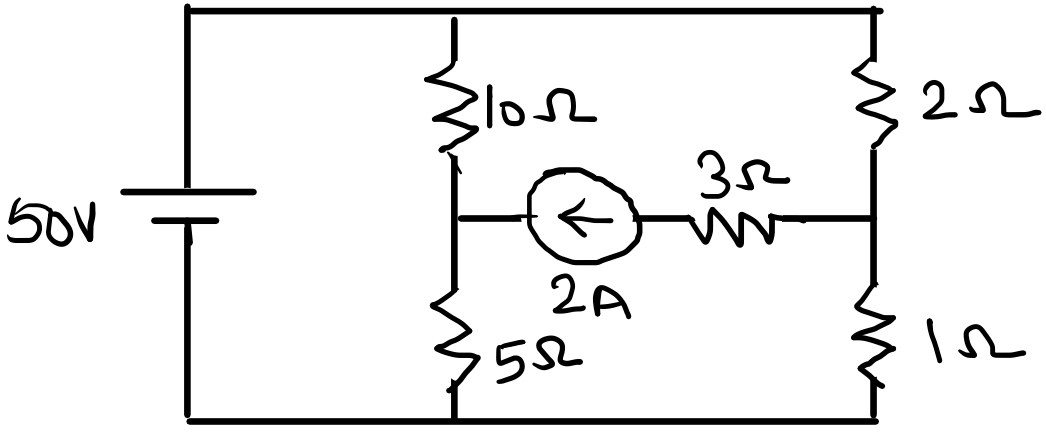
$4I_1 + 5I_2 - 15I_3 = 0$ --- (iii)

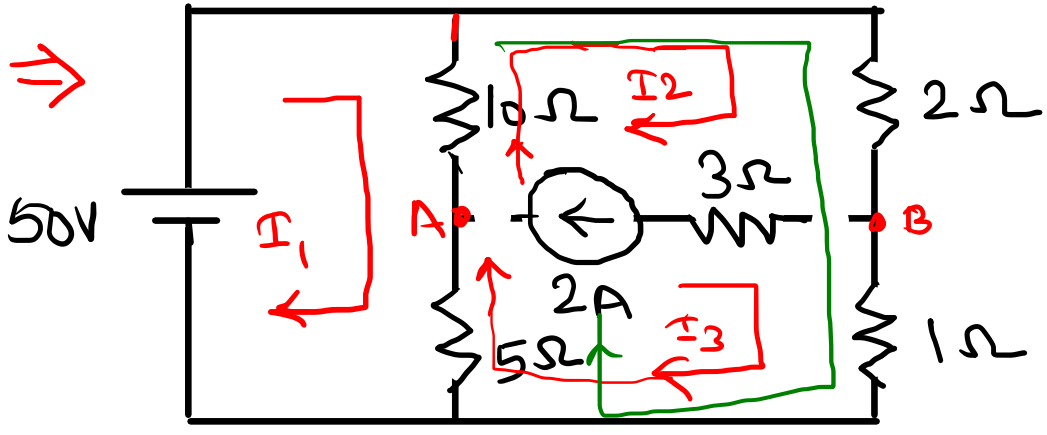
Solving (i) (ii) and (iii)

$I_1 = 2.27A$, $I_2 = 0.27A$, $I_3 = 0.69A$

$I_{6\Omega} = I_3 = 0.69A$

Ex ② Find current in 5Ω resistor





⇒ Current source 2A appears on Common branch of mesh ② & ③ So it is super mesh case.

→ KCL at node A

$2 + I_3 = I_2$

KCL at node ⑧

$I_2 = 2 + I_3$

$I_2 - I_3 = 2$ ---①

→ KVL to supermesh

$-10(I_2 - I_1) - 2I_2 - 1(I_3) - 5(I_3 - I_1) = 0$

$-10I_2 + 10I_1 - 2I_2 - I_3 - 5I_3 + 5I_1 = 0$

$15I_1 - 12I_2 - 6I_3 = 0$ ---②

→ KVL to mesh ①

$50 - 10(I_1 - I_2) - 5(I_1 - I_3) = 0$

$15I_1 - 10I_2 - 5I_3 = 50$ --③

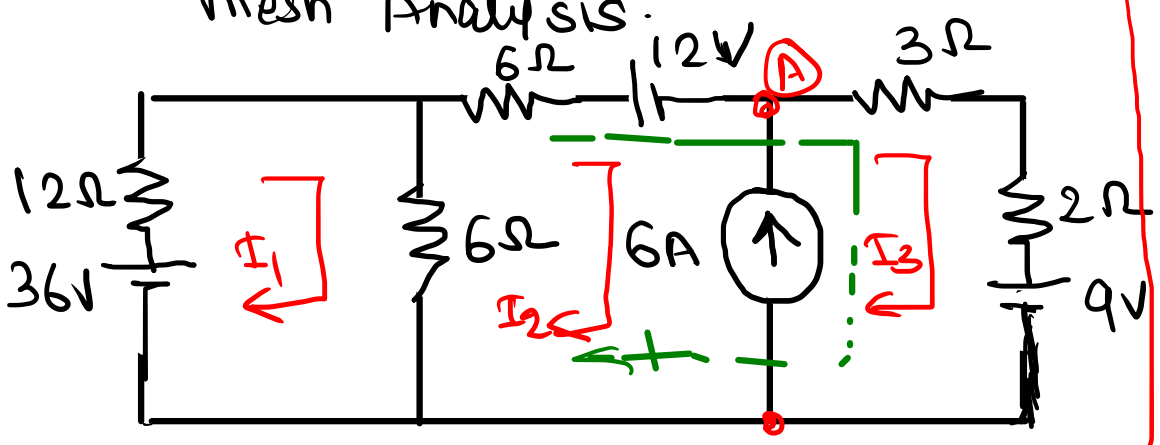
Solving equn ①, ② and ③

$I_1 = 20A$ $I_2 = 17.33A$, $I_3 = 15.33A$

$I_{5\Omega} = (I_1 - I_3) \downarrow =$

$I_{5\Omega} = (20 - 15.33) = 4.67A \downarrow$

Ex ③ Find power dissipated on 6Ω resistor using mesh Analysis.



⇒ Power dissipation = I^2R

⇒ 6A Current source appears on Common branch of mesh ② & ③ so it is Supermesh case.

KCL at node (A)

$I_2 + 6 = I_3$

$I_2 - I_3 = -6$ — ①

⇒ KVL to Supermesh

$-6(I_2 - I_1) - 6I_2 - 12 - 3I_3 - 2I_3 - 9 = 0$

$6I_1 - 12I_2 - 5I_3 = 21$ — ②

⇒ KVL to mesh (I)

$36 - 12I_1 - 6(I_1 - I_2) = 0$

$18I_1 - 6I_2 = 36$ — ③

Solving ①, ② & ③

$I_1 = 1.133A$, $I_2 = -2.6A$, $I_3 = 3.4A$

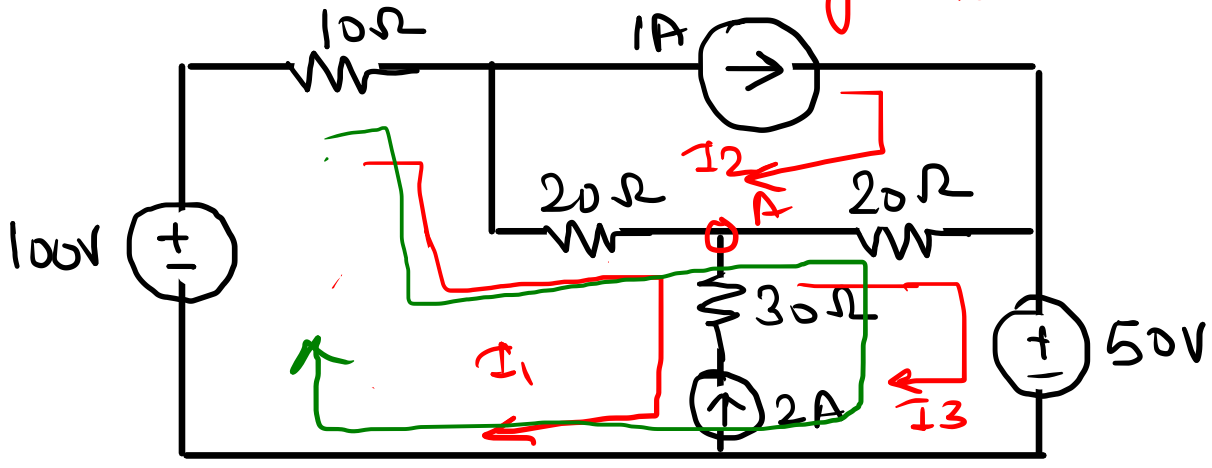
$I_{6\Omega} = I_2 = -2.6A$

$I_{6\Omega} = (I_1 - I_2) A = (1.13 + 2.6)$

$P_d = (I_2^2 \times 6)$ | $P_d = I_{6\Omega}^2 \cdot 6 =$

$P_d = 40.56$ Watts | $P_d = (3.79)^2 \times 6 = 83.9$ Watts

Ex ④ Find current through 10Ω resistor.



⇒ Current source (1A) appears on un-common branch of mesh ②

$\therefore \boxed{I_2 = 1A}$

⇒ 2A appears on common branch of mesh ① & ② So Supermesh

KVL at (A)

$I_1 + 2 = I_3$

$I_1 - I_3 = -2$ ---- ①

⇒ KVL to Supermesh

$100 - 10I_1 - 20(I_1 - I_2) - 20(I_3 - I_2) - 50 = 0$

$100 - 10I_1 - 20I_1 + 20 \times 1 - 20I_3 + 20 \times 1 - 50 = 0$

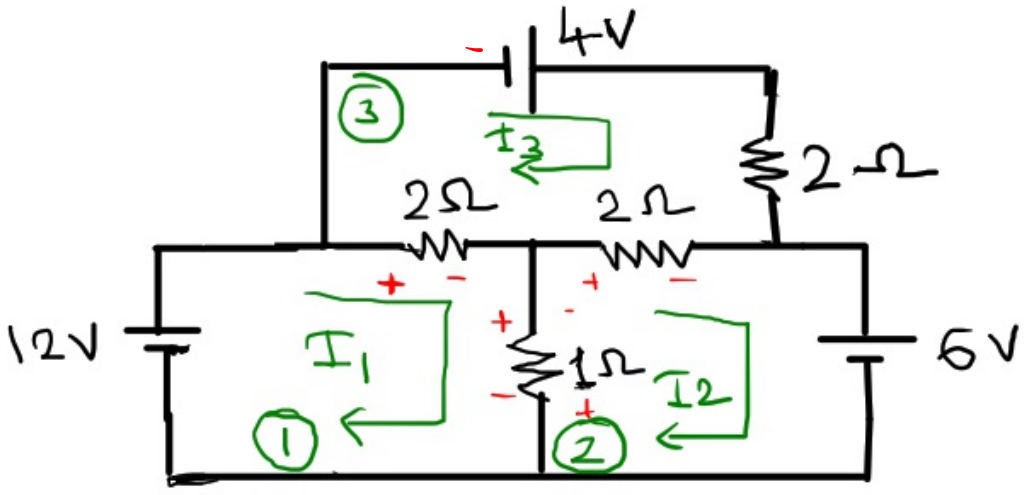
$30I_1 + 20I_3 = 90$ -- ②

solving ① & ②

$I_1 = 1A$, $I_3 = 3A$

$\boxed{I_{10\Omega} = I_1 = 1A}$

Example: Find Current through 1Ω resistor.



⇒ KVL to mesh (1)

$$12 - 2(I_1 - I_3) - 1(I_1 - I_2) = 0$$

$$3I_1 - I_2 - 2I_3 = 12 \quad \text{---} (1)$$

⇒ KVL to mesh (2)

$$-2(I_2 - I_3) - 6 - 1(I_2 - I_1) = 0$$

$$I_1 - 3I_2 + 2I_3 = 6 \quad \text{---} (11)$$

⇒ KVL to mesh (3)

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

$$2I_1 + 2I_2 - 6I_3 = -4 \quad \text{---} (111)$$

Solving (1) (11) & (111)

$$I_1 = 8.75A$$

$$I_2 = 4.25A$$

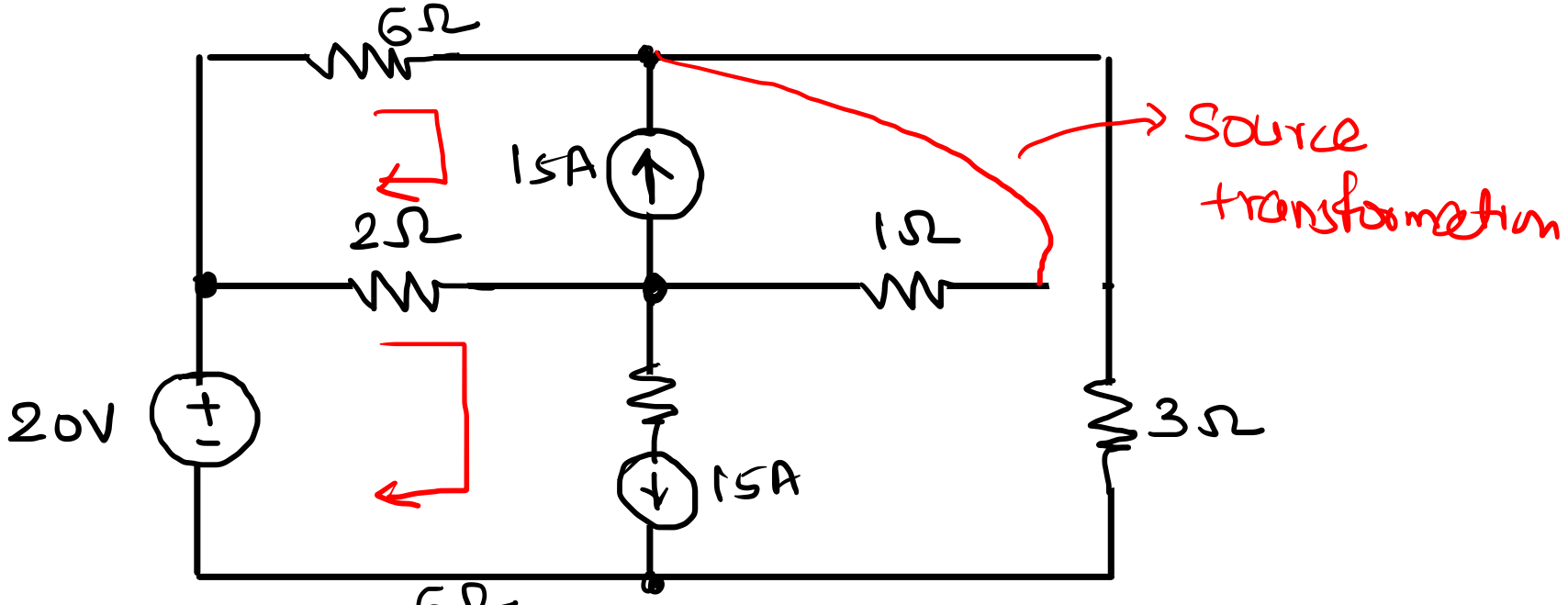
$$I_3 = 5A$$

⇒ $I_{1\Omega} = (I_1 - I_2)\downarrow$

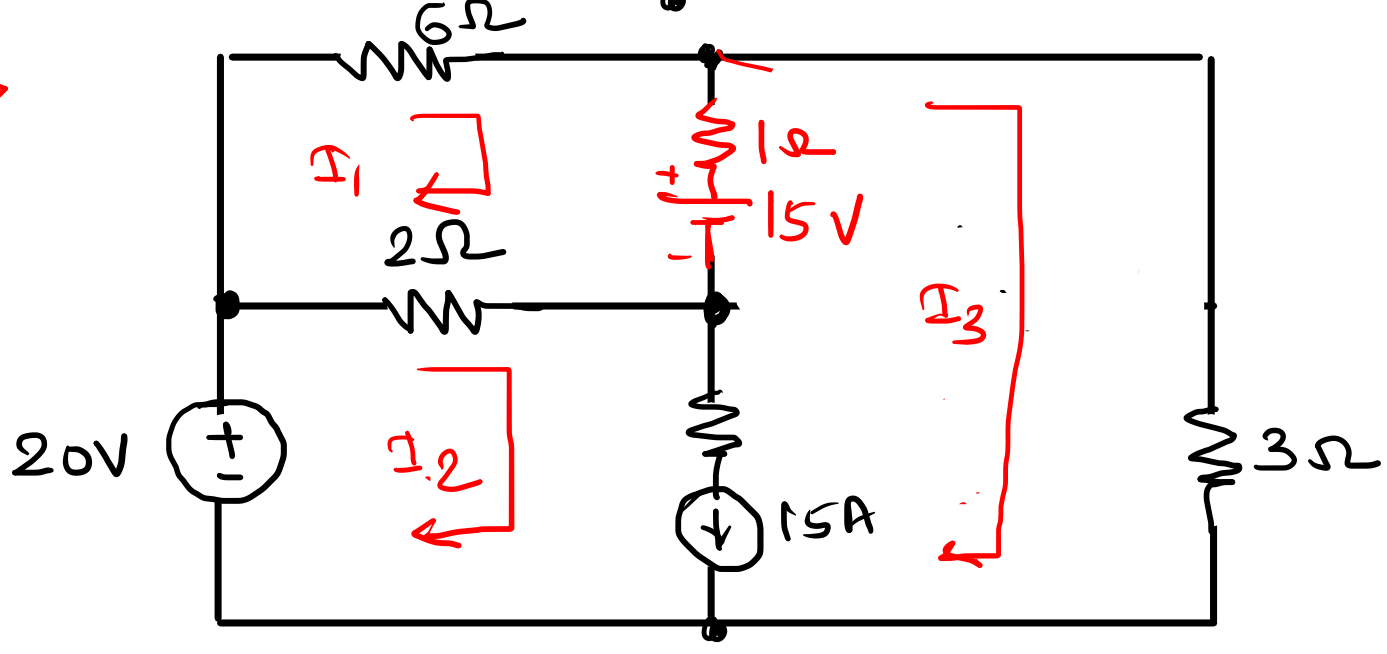
$I_{1\Omega} = (8.75 - 4.25) = 4.5A \downarrow$

Practice Numerical

EX.⑤ Find current in 3Ω resistor

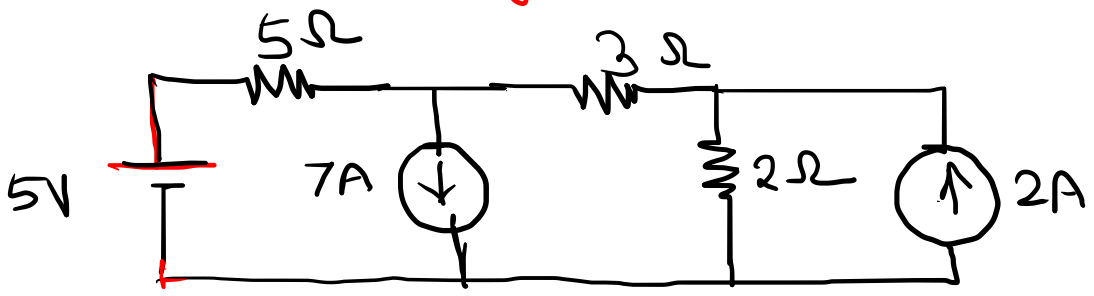


⇒



Practice Numerical

⇒ Find current through 2Ω resistor. Using mesh Analysis.



⇒ Current flowing through 15Ω resistors