Electrical Technology Terminology :-

1) charge :- Basic property of any matter which made with elementary particles which governs the forces when it is placed in electrical or magnetical field.

Generally, charge is of two types (electrically)

* Electrically positive (protons have it)
* Electrically negative (electrons have it)

→ $1p^+ = +1.62 \times 10^{-19}$ columb

→ $1e^- = -1.62 \times 10^{-19}$ coloumb

* Unit of charge = Coloumb

→ $1e^- = -1.62 \times 10^{-19}$ coloumb

→ Coloumb $= \frac{1}{+1.62 \times 10^{-19}}$ e^- {-ve neglected}

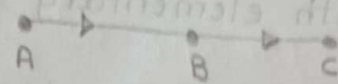
→ 1 coloumb $= 6.24 \times 10^{18}$ e^-

i.e 6.24×10^{18} number of electrons constitute the exact value of 1 coloumb

* Charge is denoted by letter "Q" (or q)

{ matter → atom → sub atomic particles — Electrically charged
Electrically neutral

Properties of charge :

* Consider the charge in a circuit, then the algebraic sum of charge in a circuit is always equal to zero. 

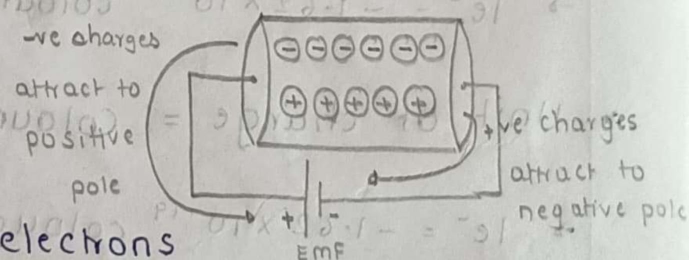
{net charge on B=0}

* Like charges repell each other, unlike ~~r~~ charg attract each other like magnets

2) Electric Current (I) :-

Generally Electric current is defined as flow of charges or flow of electrons.

* Here -ve charges are electrons.



* By observing, electrons are travelling from negative pole to positive pole But current flows from positive to negative pole {current is flow of electrons}

→ Actually current flows -ve to +ve pole only. But according to certification by International organisation of EEE, current is flowed from positive (+) to negative (-) pole.

This is known as "conventional current direction"

* Mass of electron = $\frac{\text{mass of proton}}{1837}$

* As electron is lighter, current flow involves in flow of electrons only

Formula & Unit

current $(I) = \frac{Q}{t}$

$\boxed{i = \frac{q}{t}} = \frac{\text{Coloumb}}{\text{time}}$ or Ampere. $= \frac{6.24 \times 10^{18} e^-}{1 \text{ sec}}$

i.e To produce 1ampere of current, 6.24×10^{18} electrons should move in one second.

Ex:- Fan consumes 80 watt Power, and we get 230 volts of voltage

$\rightarrow I = \frac{P}{V} = \frac{80}{230} = 0.35 A$

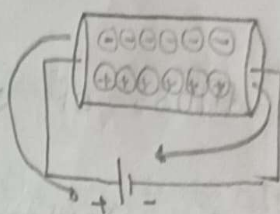
* 0.35 amp is cause of speed of fan.

3) Voltage or Electric Potential:

In absence of current charges bound together & flows in different direction.

* When current is applied to circuit. charges separate and gain potential energy.

* The potential difference b/w two charged bodies is called Electric voltage.



* In other words, "the amount of work done for a unit charge to create the movement"

$$V = \frac{\text{Energy}}{\text{charge}} = \boxed{\frac{J}{C} = \text{Volts}}$$

4) Electrical Energy (w):- The capacity to do some work, per unit charge is known as Energy.

we know $V = \frac{W}{Q}$

→ $W = VQ$

→ $W = V \cdot I \cdot t$

→ $W = P.t$ {watt · second or Joule}

Kilowatt - hour = 1unit

calculated by Energy meter

* Product of electrical power and time is known as Electrical energy.

Ex: 6fans. each consuming 80 w power & for 2pm to 5pm

6 x 80w = 480 watt = 0.48 kw

$= 0.48\ kw \times 3\ hours$

$= 1.44$ kilowatt hour (or) unit

* My Household unit consumption:-

6 lights for 8 hours {10 watt / hour} = 0.48 kwh

2 fans for 10 hours {8 watt / hour} = 0.1.60 kwh

1 fridge for 24 hours {150 watt / hour} = 3.60 kwh

1 motor pumph for $\frac{1}{2}$ hour {1 unit /hour} = 0.50 kwh

1 TV for 4 hours {100 watt / hour} = 0.40 kwh

* Total kilowatt hours (units)

$= 0.48 + 0.1.60 + 3.60 + 0.50 + 0.40$

= ~~6.58~~ 5.14 units per day {× 30 for month}

= ~~197.4~~ 154.2 units per month {Actual units = 179 units}

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5) Power (P) :- The ability to do some work per unit time is known as power.

* Unit of power = watt

* $\boxed{P = \frac{W}{t}}$ {W = energy or work done}

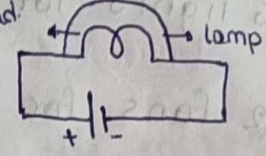
* $P = \frac{W}{t} = \frac{W}{Q} \times \frac{Q}{t}$

$\boxed{P = V \cdot I}$ {watts}

$\boxed{\text{Volt} \cdot \text{Amp} = \text{watt}}$

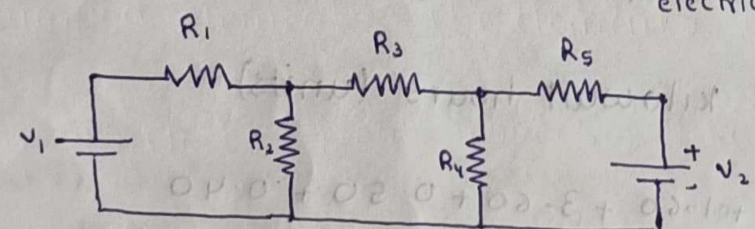
Basic definitions of electric circuit :-

Circuit :- A simple closed path with source and load or with active & passive sources / load. is known as circuit.



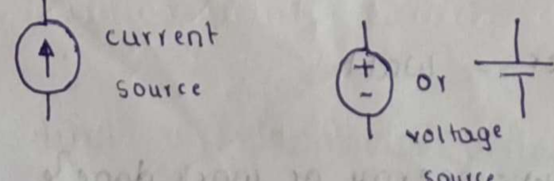
* **Electroic Network :-**

Interconnection of different electrical elements or interconnection of different electrical sub-circuits.



1) * **Active elements :-** The elements which supplies or generates electrical energy to rest part of the circuit are known as Active elements.

Ex : Battery, voltage source, generator etc.



2) * **Passive elements :** The elements which consumes / recieves or take the electrical energy from Active elements are known as Passive elements.

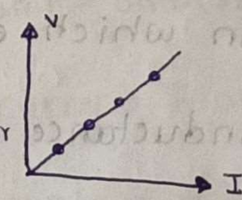
Ex : Resistors, Inductors, capacitors

* Active elements & passive elements are known as Network elements.

3) Linear elements :- The elements which always obey linearity principle are known as linear elements.

* Principle of linearity :- If the graphical relation or representation b/w voltage and current is a straight line.

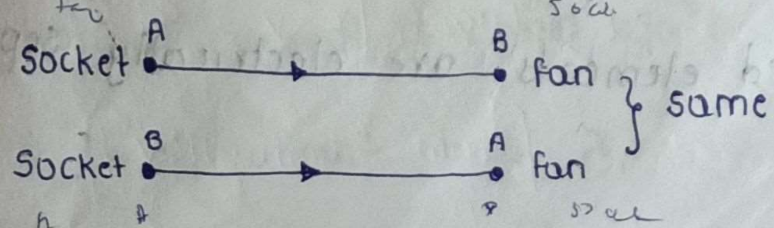
Ex :- Resistor, inductor, capacitor



4) Non-linear elements :- The elements which doesnot obey principle of linearity are known as non-linear elements.

Ex :- Diode.

5) Bi-lateral elements :- The elements which holds the relationship between voltage & current is same in either direction of current flow through it



Ex: resistors, inductor, capacitor etc.

6) Unilateral elements :- Elements which doesnot hold the relationship b/w Voltage and current as same in either direction of current flow through it.

Ex: Diode, semi-conducting devices {allows current in only one direction}

7) Lumped elements :- The elements or systems in which electrical properties like resistance inductance & capacitance etc are assumed to be located on a small space of circuit.

* Lumped elements are not electrically separable

Ex: Resistor, inductor & capacitor in labs.

8) Distributed elements : The elements or systems in which electrical properties like resistance, inductance & capacitance etc.. are assumed to be distributed across the entire circuit.

* Distributed elements are electrically separable

* Resistance in lumped element = concentrated resistance

* Resistance in distributed element = distributive resistance

Ex: Transmission distribution lines.

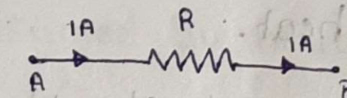
* Circuit parameters :-

1) Resistor (R)

2) Inductor (L)

3) Capacitor (C)

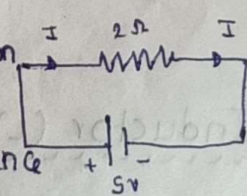
1) Resistor (R) :- The element which opposes the flow of the current through it is known as Resistor.



, unit = ohm (Ω)

* Resistor should oppose the current flow, but the current at point A & point B are same (no loss of current). because ...

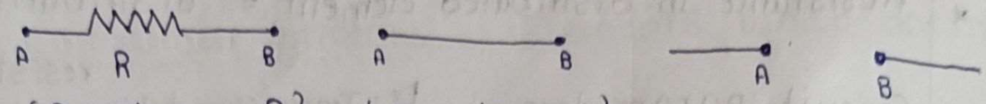
Consider a resistor of 2Ω connected to 5 Volt source. After connection is made, the total resistance is distributed among the circuit.



Current in the circuit = $I = \frac{V}{R} = \frac{5}{2} = 2.5$ amp

* 2.5 amp is current produced after the opposition of current is done. So there is no change is ~~th~~ of current b/w A & B points.

Representation of resistor (R):



{Resistance = R} {Resistance = 0} {Resistance = ∞}

Formula:

$\boxed{V = IR}$ → $\boxed{R = \frac{V}{I}}$ → $\boxed{I = \frac{V}{R}}$

Volts Ω amp

Power desipated = $\boxed{P = \frac{V^2}{R}}$ or $\boxed{P = I^2 R}$

* Resistor desipates the electrical energy in the form of heat.

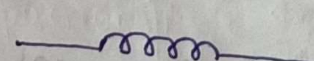
* Opposition is required should be in limit only {i.e Resistance should be not so high or not so low}

→ Energy desipated by resistor $\boxed{(\omega) = P.t}$

$= \boxed{V \cdot I \cdot t}$ or $\boxed{I^2 R t}$ or $\boxed{\frac{V^2}{R} t}$

2) Inductor (L): The element which opposes the sudden change of current in the circuit is known as Inductor (L).

Unit = Henry (H)



$L = R + jx$ {jx = reactance}

* Inductance (L) is combination of Resistance and Reactance.

* Voltage across the inductor $\boxed{(V) = L \cdot \frac{di}{dt}}$

* Current through the inductor

→ $V = L \cdot \frac{di}{dt}$

→ $di = \frac{1}{L} \cdot v \cdot dt$

Integrating on both sides from 0 to t

$$\int_0^t di = \frac{1}{L}\int_0^t v \cdot dt$$

$\boxed{i(t) = \frac{1}{L}\int_0^t v \cdot dt}$ amperes.

* Power consumed by inductor

$P = V \cdot I$

$P = L \cdot \frac{di}{dt} \cdot I$

$\boxed{P = L \cdot I \cdot \frac{di}{dt}}$ watts

** Inductor stores the energy in electromagnetic form. we know total energy $(w) = P \cdot t$

→ $\int_0^t w = \int_0^t P \cdot t \; dt$

$= \int_0^t LI \cdot \frac{di}{dt} \, dt$

$= L \int_0^t i \cdot di$

$\boxed{\text{Energy}(w) = \frac{1}{2} Li^2}$ Joules

L = inductance of inductor in Henry

i = current through inductor (Amp).

3) Capacitor (c) :-

Any 2 conducting plates which are separated by an insulating medium, then it exhibits the property of a capacitor in presence of current flow. Representation $\dashv\vdash^{c}$ or $\dashv($ ^{c}

* The insulating medium is also called dielectric medium.

→ The element which oposses the sudden change of voltage across the circuit is known as capacitor (c).

* The value of capacitance is high for a parti-cular capacitor if the capacity to store the charge is high for unit voltage.

Similarly low capacitance if the capacity to store the charge is low for unit charge.

* Current through capacitor → $\boxed{i = C\frac{dv}{dt}}$ amp.

* Voltage across capacitor : $dv = \frac{1}{C} \cdot i \cdot dt$

$\int_0^t dv = \frac{1}{C}\int_0^t i \cdot dt \longrightarrow \boxed{V(t) = \frac{1}{C}\int_0^t i \cdot dt}$ volts.

* Capacitor stores energy in electrostatic form

(1) * Energy (w) = P. & capacity to do work.

$\{w = v \cdot c \cdot \frac{dv}{dt}\}$ Power consumed by inductor

$$\int_0^t w \, dt = \int_0^t v \cdot c \cdot \frac{dv}{dt} \, dt$$

$\boxed{w(t) = \frac{1}{2} cv^2}$ Joules {Energy}

* Power consumed by the capacitor.

→ $P = V \cdot I$

$\{ i = c \frac{dv}{dt} \}$

→ $\boxed{P = V \cdot C \cdot \frac{dv}{dt}}$ ~~volts~~. watts.

* C = capacitance of capacitor in "Farad"

v = voltage across capacitor in "volts"

Energy sources :-

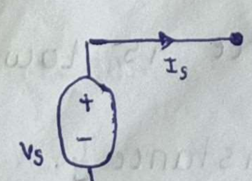
* Independent sources :

1) Ideal Voltage source :-

The source which supplies constant magnitude of source voltage, independent of source current is known as Ideal voltage source.

I_s = source current

V_s = source voltage.

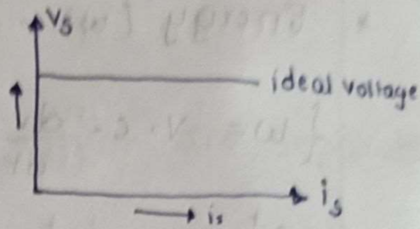


* It is a 2 terminal element

* It is an active element.

* Voltage = constant.

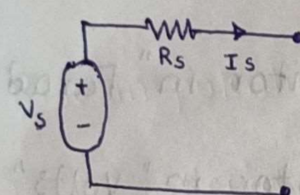
Graph



2) Practical Voltage Source:

* It is a 2 terminal active element.

* The source which produces the source voltage which slightly decreases with increase in source current is called Practical voltage source

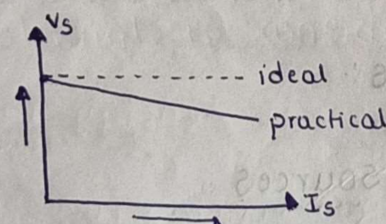


V_S = source voltage

R_S = source resistance (Low)

I_S = source current.

Graph



voltage (IR) decreases with increase in current.

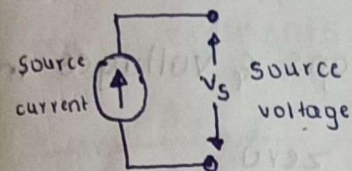
NOTE

* The internal resistance for Ideal voltage source is always zero { $\underset{A}{\circ}\overset{\Omega=0}{\text{———}}\underset{B}{\circ}$ }

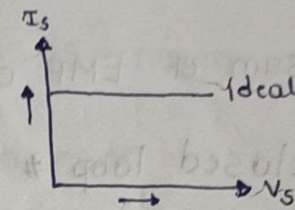
* The internal resistance for practical voltage source is Low { contains some internal resistance }.

3) Ideal Current source :-

The current source which supplies the constant current, independent of source voltage is called Ideal Current source.

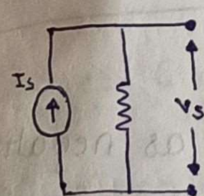


Graph

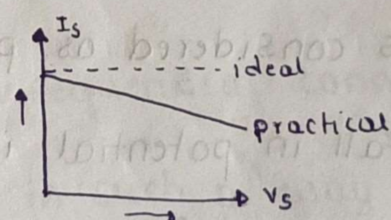


Practical

4) Passive Current Source :- The current source which supplies current which decreases with increases in voltage is called Passive current source.



Graph :

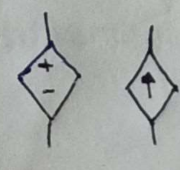


NOTE :

* The internal resistance of Ideal current source is infinite { A $\Omega = \infty$ B }

* The practical current source have internal resistance, which is very high.

* Dependent sources representation.



* **Kirchoff's Laws:**

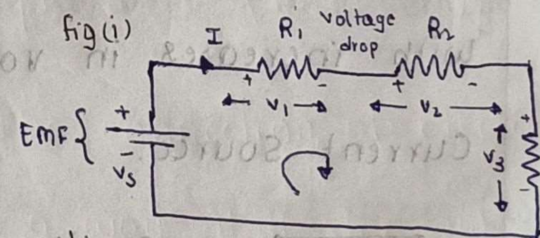
1) Kirchoff voltage law
2) Kirchoff current law.

1) **Kirchoff Voltage law:-** It states that the algebraic sum of EMF or voltage drops & voltages in a closed loop # is equal to zero.

* Voltage accross source is known as EMF
* Voltage across resistors is known as voltage drop.

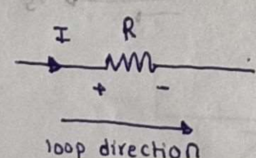
→ **Sign convention**

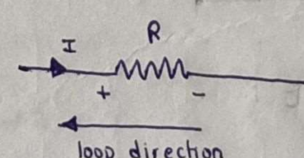
fig (i)



* Rise in potential is considered as positive
* Fall in potential is considered as negative.

Ex :





(+ to −) so fall in potential = $-IR$

(− to +) so Rise in potential = $+IR$

* for fig (i)

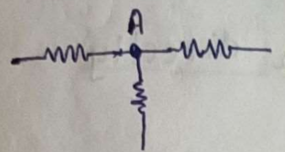
$-IR_1 - IR_2 - IR_3 + V_S = 0$

$V_S - V_1 - V_2 - V_3 = 0$

→ $\boxed{V_S = V_1 + V_2 + V_3}$ //

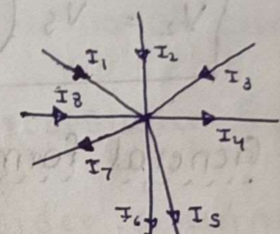
2) Kirchoff current law: This law states that the algebraic sum of currents at a point or node or junction is equal to zero.

Node: It is a point which connects two or more elements. The point is known as node.



Point A is a node

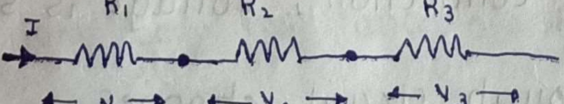
* From kirchoff current law,



we get $I_1 + I_3 + I_2 + I_8 - I_4 - I_5 - I_6 - I_7 = 0$

i.e $I_1 + I_2 + I_3 + I_8 = I_4 + I_5 + I_6 + I_7$

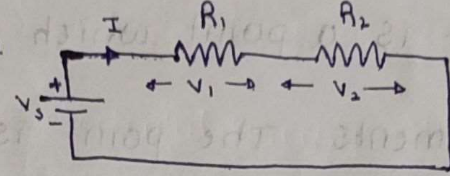
* 1) Series Circuit: The ~~ear~~ sequential connection of electrical elements in such a way that end point of one element is connected to starting point the next element.



* In series connection, current is alway same and voltage accross circuit changes.

* Resistance (Total) = $R_1 + R_2 + R_3 + \dots + R_n$

* Voltage division Rule : only applicable for series connection. If we want to determine a particular voltage in the circuit, we use this rule. Ex

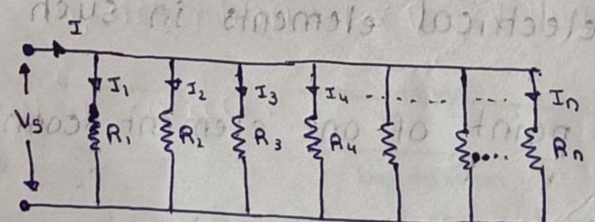


If we want to determine V_2 directly.

$$\boxed{V_2 = V_S \left(\frac{R_2}{R_1 + R_2} \right)}$$

* General formula : $\boxed{V_n = V_{Total} \left(\frac{R_n}{R_1 + R_2 + \dots + R_n} \right)}$

→ * 2) Parallel circuit : The connection of electrical elements in such a way that the starting and ending points of all the elements are same



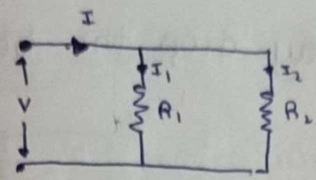
* In parallel connection, Voltage is same and current through circuit changes

* $\frac{1}{\text{Resistance (Total)}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots + \frac{1}{R_n}$

* Current division rule : only applicable for ~~serve~~ parallel connection. If we want to

determine a particular current in circuit, we use this rule.

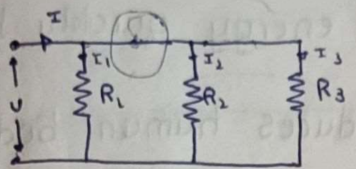
Ex:



$$I_1 = I\left(\frac{R_2}{R_1+R_2}\right) \text{ opposite resistance}$$

$$I_2 = I\left(\frac{R_1}{R_1+R_2}\right) \text{ opposite resistance}$$

Ex



$$I_1 = I\left[\frac{\dfrac{1}{\frac{1}{R_2}+\frac{1}{R_3}}}{R_1 + \left(\dfrac{1}{\frac{1}{R_2}+\frac{1}{R_3}}\right)}\right]$$

* General formula: Let there n no. of currents with n no. of resistors of resistance R_1, R_2, R_3, ... R_n respecitively. Consider a ~~current~~ I_a resistor of resistance R_a & current through it is I_a

$$\text{Now } I_a = I\left[\frac{\dfrac{1}{\frac{1}{R_1}+\frac{1}{R_2}+\cdots+\frac{1}{R_{a-1}}+\frac{1}{R_{a+1}}+\cdots\frac{1}{R_n}}}{R_a + \left[\dfrac{1}{\frac{1}{R_1}+\frac{1}{R_2}+\cdots+\frac{1}{R_{a-1}}+\frac{1}{R_{a+1}}+\cdots\frac{1}{R_n}}\right]}\right]$$

H.W * Range of resistance in human body

* The total body resistance of the person is composed of the very internal body resistance {approx 300Ω} But skin has higher resistance.

The skin contact resistance will usually be between 1000 and 100,000Ω of resistance.

* Under Dry conditions, the resistance offered by the human body may be as high $\boxed{100,000\ \Omega}$

* Wet or broken skin may drop the body's resistance to $\boxed{1000\ \Omega}$

* High voltage electrical energy quickly breaks down human skin which reduces human body's resistance to $\boxed{500\ \Omega}$

→ Ohm's law : Ohm's law states that the current through a conductor is directly proportional to the voltage across it.

$I \propto V$ { But $V = IR$ }

If we consider $V \propto I$, then $V = IR$

* According to definition $I \propto V$ { then $I = kV$ }

This is also correct.

$I \propto V$
$I = GV$ { G = propotional constant }

Here G is known as conductance

"Conductance" is an expression of the ease with which electric current flows through materials like metals.

* In electrical purposes, conductance is very rarely considered. So we don't use the expression $\boxed{I = G \cdot V}$. But resistance (R) is used regularly. So, $\boxed{V = IR}$ expression is used to determine Ohm's law.

Problems:

1) If a 70 Joules energy is available for every 30 coloumb charge. what is voltage.

A Given Energy (ω) = 70 J

Charge (Q) = 30 C

$$V = \frac{\omega}{Q} = \frac{70}{30} = \boxed{2.33 \text{ volts}}$$

2) What is the power in watts if energy = 50 J is used in 2.5 seconds

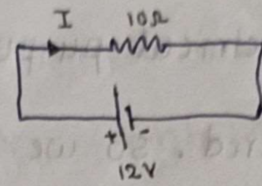
A Given Energy (ω) = 50 J

time (t) = 2.5 sec

$$P = \frac{\omega}{t} = \frac{50}{2.5} = \boxed{20 \text{ watts}}$$

3) A 10 ohms resistor is connected across 12 V battery. How much current flows through the resistor.

A $I = \frac{12}{10} = 1.2$ Amp



4) Current in a 2 Henry inductor varies at the rate of 2 amp per second. Find the voltage across inductor and energy stored in inductor in magnetic field after 2 seconds.

A $L = 2H$

$\frac{di}{dt} = 2 Amp/s$

$V = L \cdot \frac{di}{dt} = 2 \times 2 = \boxed{4 volts}$

Energy $(\omega) = \frac{1}{2} L I^2$

$\omega = \frac{1}{2}(2)(4)^2$ {current for 2 sec = 4 amp

$\boxed{\omega = 16 J}$

5) Capacitor having capacitance of 2 μF is charged to a voltage of 1000 v. Calculate the stored energy in Joules.

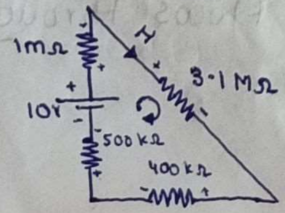
A $C = 2\mu F = 2 \times 10^{-6} F$

$V = 1000 V$

Energy $(\omega) = \frac{1}{2} CV^2 = \frac{1}{2}(2 \times 10^{-6})(1000)^2$

$= \boxed{1J}$

6) For the circuit shown below, determine the voltage across each resistor.



* Apply KVL to the above circuit

* $3.1\,m\Omega = 3.1 \times 10^6\,\Omega$

* $400\,k\Omega = 400 \times 10^3\,\Omega = 4 \times 10^5\,\Omega = \underline{0.4\,m\Omega}$

→ $+10 - I(1\,m\Omega) - I(3.1\,m\Omega) - I(0.4\,m\Omega) - I(0.5\,m\Omega) = 0$

→ $10 - I - 3.1I - 0.4I - 0.5I = 0$ { in mega ohm }

→ $10 + (-I - 3.1I - 0.4I - 0.5I)\,M\Omega = 0$

→ $10 - (5I) \times 10^6\,\Omega = 0$

→ $10 = 5I \times 10^6$

→ $I = 2 \times 10^{-6}\,A$

→ $\boxed{I = 2\,\mu A}$

* $V_{1m\Omega} = (2 \times 10^{-6} A)(1 \times 10^6 \Omega) = \boxed{2V}$

* $V_{3.1m\Omega} = (2 \times 10^{-6} A)(3.1 \times 10^6 \Omega) = \boxed{6.2V}$

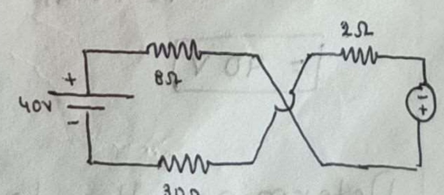
* $V_{400k\Omega} = (2 \times 10^{-6} A)(0.4 \times 10^6 \Omega) = \boxed{0.8V}$

* $V_{500k\Omega} = (2 \times 10^{-6} A)(0.5 \times 10^6 \Omega) = \boxed{1V}$

6) In the circuit shown in figure, Find

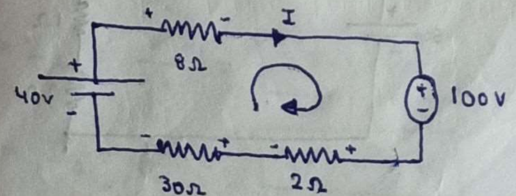
i) Current (I)

(ii) Voltage (v) across 30Ω



{ not connected }

A: Redraw above circuit



Apply kvl to above circuit.....

$+40 - I(8) - 100 - 2I - 30I = 0$

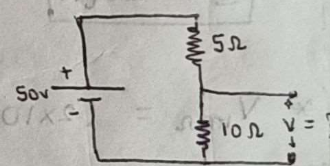
$-60 - 40I = 0$

$= I = \frac{-60}{40} = -1.5A$

$= \boxed{I = -1.5A}$ current in circuit is 1.5A which is in opposite direction of assumed loop direction

* $V_{30\Omega} = 1.5A\,(30) = \boxed{45\text{ volts}}$

7) What is the voltage across 10Ω resistor in given circuit.

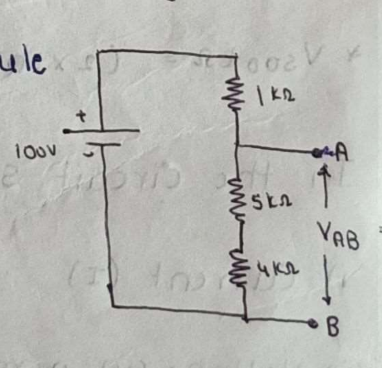


A Apply voltage division rule.

$V_{10\Omega} = 50\left(\frac{10}{10+5}\right) = \boxed{33.33V}$

8) Find the voltage b/w A & B in given circuit.

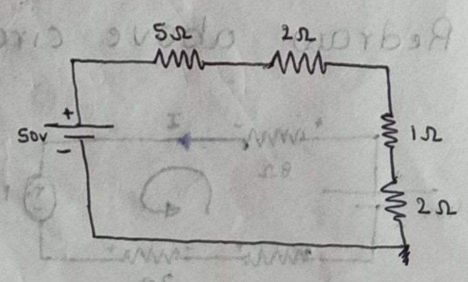
A Apply voltage division rule



$V_{AB} = 100\left(\frac{(5+4)k\Omega}{(1+5+4)k\Omega}\right)$

$\boxed{= 90V}$

9) Determine the total amount of power in given circuit



A Power $(P) = \frac{V^2}{R}$

$P_T = (50)^2/(5+2+2+1) = 250$ watt

$\boxed{P_T = 250 \text{ watt}}$ (or) $\{R_{Total} = R_1 + R_2 + R_3 + R_4 \{series\}\}$

$I = \frac{V}{R_T} = \frac{50}{10} = 5A$

$P_{5\Omega} = I^2R = 5^2 \times 5 = 125\ W$

$P_{2\Omega} = 5^2 \times 2 = 50W$

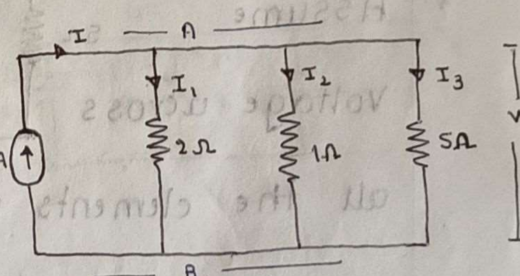
$P_{2\Omega} = 5^2 \times 2 = 50W$

$P_{1\Omega} = 5^2 \times 1 = 25W$

Total power consumed $= 125 + 25 + 50 + 50$

$= \boxed{250 \text{ watt}}$

10) Determine the current in all resistors in given circuit.



* Apply KCL to circuit

* Apply KCL to node A

$I = I_1 + I_2 + I_3 \quad \{I = 50A\}$

$= 50 = \frac{V}{2\Omega} + \frac{V}{1\Omega} + \frac{V}{5\Omega}$

$= 50 = V\left(\frac{1}{2} + \frac{1}{5} + 1\right)$

$= V = \frac{50}{1.7} = 29.4$ Volts

* $I_1 = \frac{V}{2\Omega} = \frac{29.4}{2\Omega} = \boxed{14.7 \text{ Amp}}$

* $I_2 = \frac{V}{1} = \boxed{29.4 \text{ Amp}}$

* $I_3 = \frac{V}{5} = \boxed{5.8 \text{ Amp}}$

(or) Apply current division rule

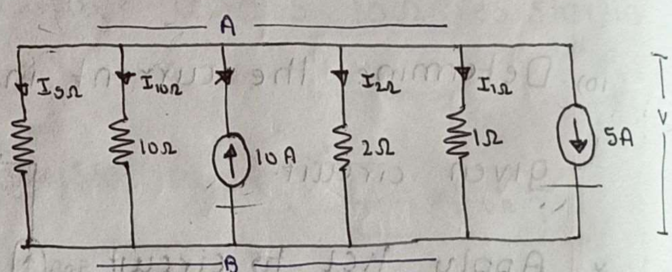
$$I_1 = 50\left[\frac{\left[\frac{1}{1+\frac{1}{5}}\right]}{2+\left[\frac{1}{1+\frac{1}{5}}\right]}\right]$$

$$I_1 = 50\left[\frac{5/6}{2+5/6}\right]$$

$$I_1 = 50\left[\frac{5}{17}\right]$$

$\boxed{I_1 = 14.7 \text{ Amp}}$ similarly we can find I_2 & I_3

11) For the circuit shown in figure, find the voltage across 10Ω resistor & current passing through it.



* Assume voltage across all the elements is 'V' volts.

Apply KCL to above circuit

* Apply KCL to node A

$$10 = I_{5\Omega} + I_{10\Omega} + I_{2\Omega} + I_{1\Omega} + 5$$

$$5 = I_{5\Omega} + I_{10\Omega} + I_{2\Omega} + I_{1\Omega} + 0.$$

$$5 = \frac{V}{5} + \frac{V}{10} + \frac{V}{2} + \frac{V}{1}$$

$$5 = V\left(\cancel{\tfrac{1}{5}} + 0.2 + 0.1 + 0.5 + 1\right)$$

$$5 = V(1.8)$$

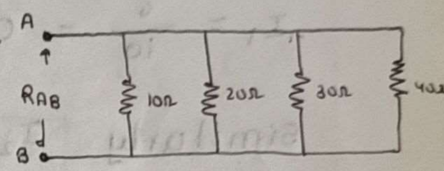
$V = 2.77$ Volts

V across $10\,\Omega$ resistor = $\boxed{2.77 \text{ Volts}}$

I through $10\,\Omega$ resistor = $\frac{V}{10} = \frac{2.77}{10}$

$= \boxed{0.277 \text{ Amp}}$

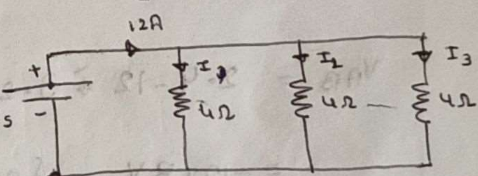
12) Determine the parallel resistance between A & B of given circuit.



A $\frac{1}{R_{AB}} = \frac{1}{10} + \frac{1}{20} + \frac{1}{30} + \frac{1}{40}$

$R_{AB} = \boxed{4.8\,\Omega}$

13) Determine the current through each resistor in the circuit shown in figure.



A Apply current division rule . . .

$$I_1 = 12 \left[\frac{\frac{4 \times 4}{4+4}}{4 + \frac{4 \times 4}{4+4}} \right]$$

$$I_1 = 12 \left[\frac{16/8}{4 + 16/8} \right]$$

$\boxed{I_1 = 4 \text{ Amp}}$ similarly $\boxed{I_2 = I_3 = 4 \text{ Amp}}$

Bcoz $R_1 = R_2 = R_3 = 4\,\Omega$

14) What is the voltage across A & B in the circuit shown in figure.

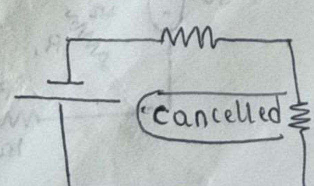
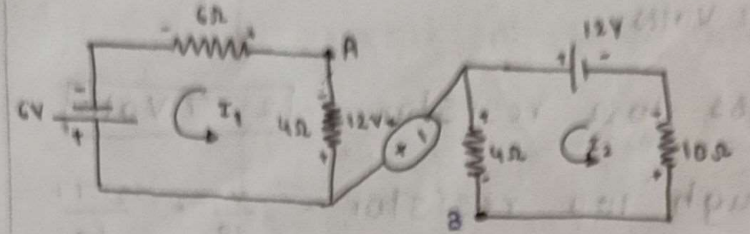


Diagram in next page

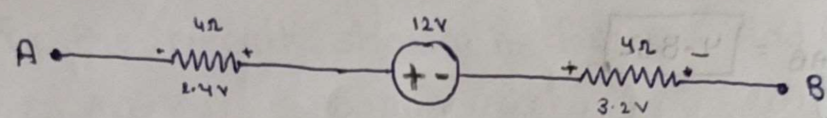


A Total resistance for $I_1 = 6 + 4 = 10\Omega$

Total voltage for $I_1 = 6V$

$I_1 = \frac{6}{10} = 0.6$ Amp

similarly $I_2 = \frac{12}{14} = 0.8$ Amp



$V_{4\Omega}$ (left) $= 0.6 \times 4 = 2.4V$

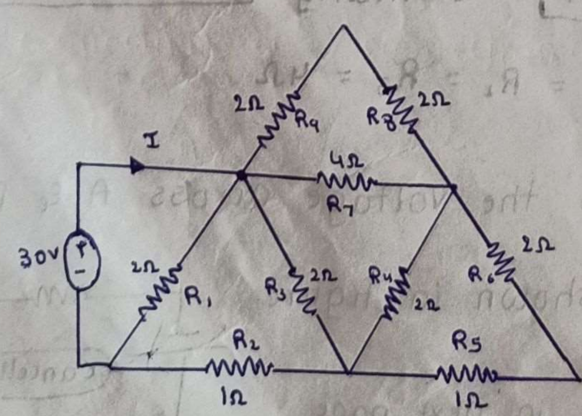
$V_{4\Omega}$ (Right) $= 0.8 \times 4 = 3.2V$

$V_{AB} = 2.4 - 12 - 3.2$

$= -12.8V$ {opposite to assumed direction}

Voltage across AB = $\boxed{12.8V}$

15) Determine the current delivered by the source in the circuit shown in figure.



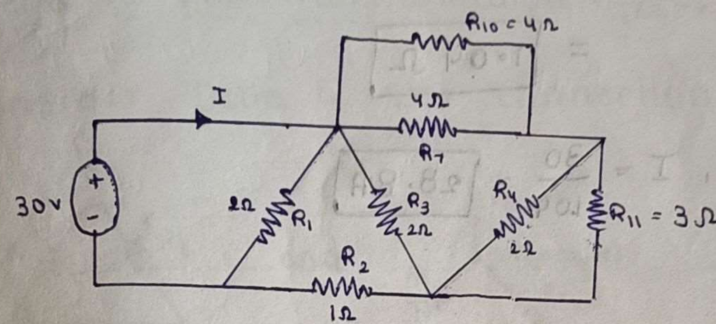
A In above circuit

(R_9 & R_8) and (R_5 & R_6) are in series

$R_{10} = R_9 + R_8 = 2+2 = 4\Omega$

$R_{11} = R_5 + R_6 = 2 + 1 = 3\Omega$

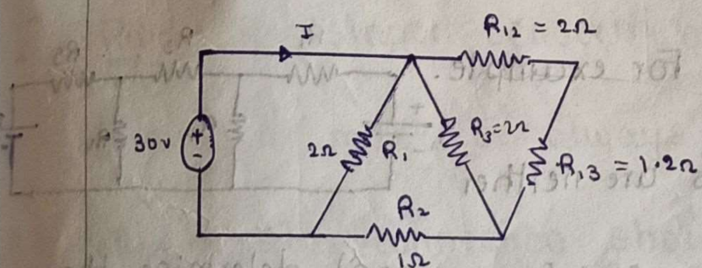
Now Redraw the circuit.



Now $R_{10} \parallel R_7 = \frac{4 \times 4}{4+4} = 2\Omega \rightarrow R_{12}$

Also $R_4 \parallel R_{11} = \frac{2 \times 3}{2+3} = 1.2\Omega \longrightarrow R_{13}$

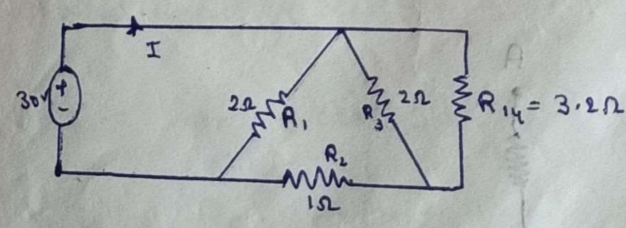
Redraw the circuit



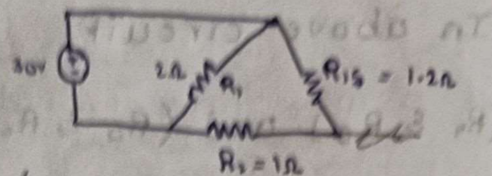
Now, R_{12} is in series with R_{13}

$= R_{12} + R_{13} = 2 + 1.2 = 3.2\Omega \rightarrow R_{14}$

Now Redraw the the circuit



$R_3 \parallel R_{14} = \frac{2 \times 3.2}{2+3.2} = 1.2\Omega \rightarrow R_{15}$

Now circuit is 

$\therefore R_{Total} = \dfrac{R_1 \times (R_2 + R_{15})}{R_1 + R_2 + R_{15}}$ { R_{15} & R_2 in series; $(R_{15} + R_2)$ & R_1 in parallel.

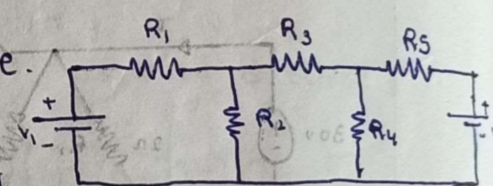
$= \dfrac{2 \times (2.2)}{2 + 2.2}$

$= \boxed{1.04\ \Omega}$

Hence, $I = \dfrac{30}{1.04} = \boxed{28.8\,A}$

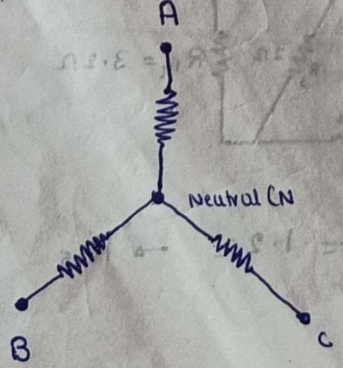
Star to delta & Delta to star transformation.

This process is used when the formula of total resistance in series & parallel connection donot work. For example.

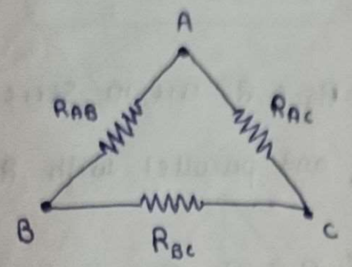


* Here R_4 & R_5 are neither in parallel or series. we can't determine the total resistance for it. The we use this process

→ "Star connection" (or) Y connection (or) T connection or λ.

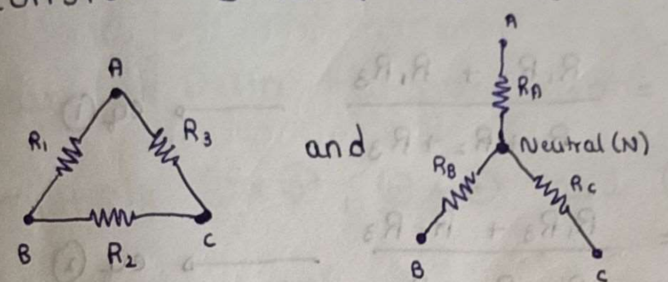


* Delta connection / π connection :-



① Delta to star transformation :- $\Delta \rightarrow \lambda$

consider Delta & star connections



* To make delta to star transformation possible, there is one important rule.

* Rule :- Resistance between any two points or terminals must be always same.

→ R_{AB} in star connection should be equal to R_{AB} in delta connection

* Now, in star connection

$R_A + R_B = R_{AB}$ { series }

$R_B + R_C = R_{BC}$ { series }

$R_A + R_C = R_{AC}$ { series }

* Now, from delta connection

$$R_{AB} = \frac{R_1(R_2+R_3)}{R_1+R_2+R_3}$$ { R_2 & R_3 in series themselves & parallel with R_1

$$R_{AC} = \frac{R_3(R_1+R_2)}{R_1+R_2+R_3}$$ { R_1 & R_2 are in series themselves and parallel with R_3

$$R_{BC} = \frac{R_2(R_1+R_3)}{R_1+R_2+R_3}$$ { R_1 & R_3 are in series themselves and parallel with R_2

* from the Rule,

$$R_A + R_B = \frac{R_1R_2 + R_1R_3}{R_1+R_2+R_3} \longrightarrow eq\ (1)$$

$$R_A + R_C = \frac{R_1R_3 + R_2R_3}{R_1+R_2+R_3} \longrightarrow eq\ (2)$$

$$R_B + R_C = \frac{R_1R_2 + R_2R_3}{R_1+R_2+R_3} \longrightarrow eq\ (3)$$

{ R_{AB} of star connection = R_{AB} of delta connection }

Now (1) - (2) + 3

$$\cancel{R_A} + \underline{R_B} - \cancel{R_A} - \cancel{R_C} + \underline{R_B} + \cancel{R_C} = \frac{R_1R_2 + \cancel{R_1R_3} - \cancel{R_1R_3} - \cancel{R_2R_3} + R_1R_2 + \cancel{R_2R_3}}{R_1+R_2+R_3}$$

$$= 2R_B = \frac{2R_1R_2}{R_1+R_2+R_3}$$

$$= \boxed{R_B = \frac{R_1R_2}{R_1+R_2+R_3}} \longrightarrow (4)$$

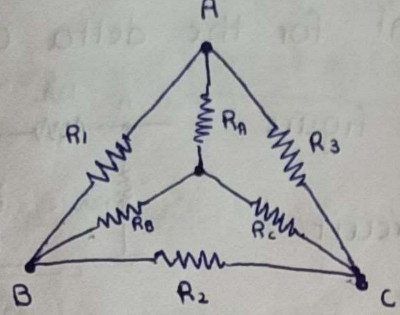
substitute in (1) & (3)

we get $\boxed{R_A = \frac{R_1R_3}{R_1+R_2+R_3}} \rightarrow (5)$

and $\boxed{R_C = \frac{R_2 R_3}{R_1 + R_2 + R_3}} \rightarrow$ 6

The resultant diagram is

"Δ-λ"



2 Star to Delta transformation:

multiply 4 × 5, 5 × 6 and 6 × 4 and all of them

$$R_A R_B + R_B R_C + R_C R_A = \frac{R_1^2 R_2 R_3 + R_2^2 R_1 R_3 + R_3^2 R_1 R_2}{(R_1 + R_2 + R_3)^2}$$

$$= \frac{R_1 R_2 R_3 \,(\cancel{R_1 + R_2 + R_3})}{(R_1 + R_2 + R_3)^{\cancel{2}}}$$

$$R_A R_B + R_B R_C + R_C R_A = \frac{R_1 R_2 R_3}{R_1 + R_2 + R_3}$$

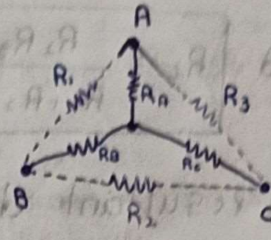
$$R_A R_B + R_B R_C + R_C R_A = \frac{R_1 R_3}{R_1 + R_2 + R_3} (R_2) \quad \text{from } 5$$

$$\boxed{R_2 = \frac{R_A R_B + R_B R_C + R_C R_A}{R_A}}$$

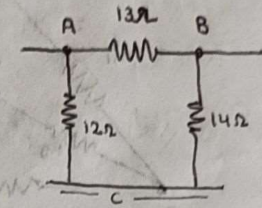
Similarly $\boxed{R_1 = \frac{R_A R_B + R_B R_C + R_C R_A}{R_C}}$

$$\boxed{R_3 = \frac{R_A R_B + R_B R_C + R_C R_A}{R_B}}$$

Resultant diagram

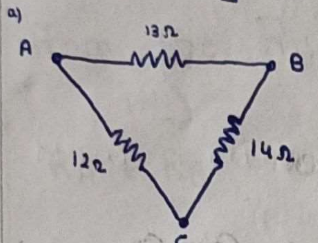


1Q Obtain the star connected equivalent for the delta connected circuit shown in figure



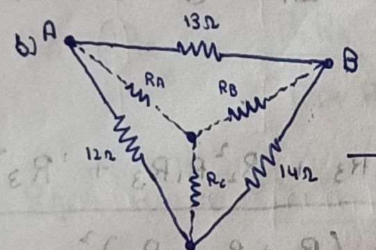
A Redrawing the circuit

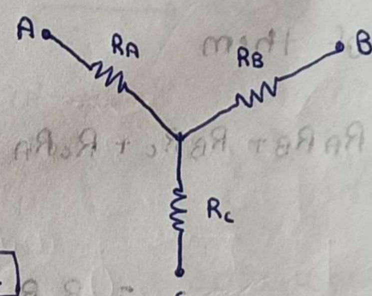
a)



Now convert the delta connection to star connection.

b)



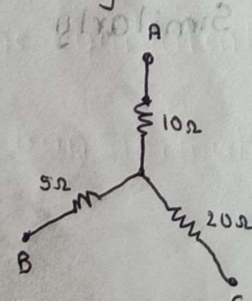


Now $R_A = \frac{12 \times 13}{12+13+14} = \boxed{4\Omega}$

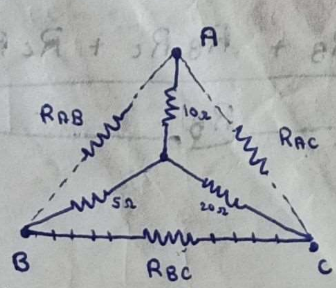
& $R_B = \frac{13 \times 14}{12+13+14} = \boxed{4.6\Omega}$

& $R_C = \frac{12 \times 14}{12+13+14} = \boxed{4.3\Omega}$

2Q Obtain the delta connected equivalent for the star connected circuit shown in figure.



A Convert into delta connection

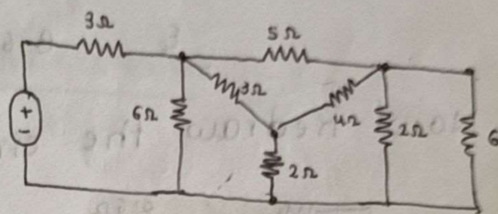


Now $R_{AB} = \dfrac{(10\times5)+(5\times20)+(20\times10)}{20} = \boxed{17.5\,\Omega}$

$R_{BC} = \dfrac{(10\times5)+(5\times20)+(20\times10)}{10} = \boxed{35\,\Omega}$

$R_{AC} = \dfrac{(10\times5)+(5\times20)+(20\times10)}{5} = \boxed{70\,\Omega}$

3Q Determine the current drawn by circuit shown in figure.

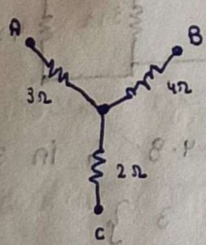


A In above circuit

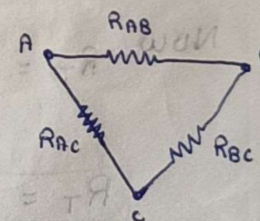
$I = \dfrac{V}{R_T}$, & 2Ω & 6Ω are in parallel (Right)

$2\Omega \,||\, 6\Omega = \dfrac{6\times2}{6+2} = \underline{\underline{1.5\,\Omega}}$

Further, 3Ω, 4Ω & 2Ω are in star connection



Now convert it into delta connection →



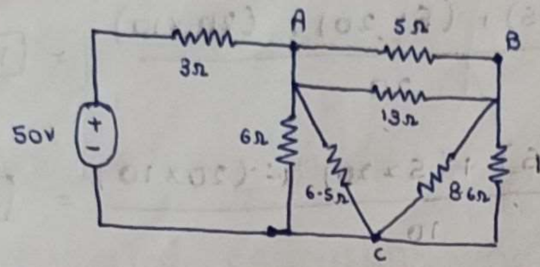
Now $R_{AB} = \dfrac{(3\times4)+(4\times2)+(2\times3)}{2} = 13\,\Omega$

$R_{BC} = \dfrac{(3\times4)+(4\times2)+(2\times3)}{3} = 8.6\,\Omega$

$R_{AC} = \dfrac{(3\times4)+(4\times2)+(2\times3)}{4} = 6.5\,\Omega$

* Redraw the circuit with these new values

$R_{AB} = \underline{\underline{13\,\Omega}}$ $R_{AC} = \underline{\underline{6.5\,\Omega}}$ $R_{BC} = \underline{\underline{8.6\,\Omega}}$

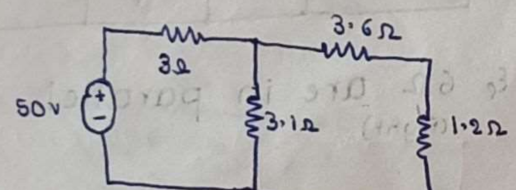


* In above circuit $6.5\Omega \,||\, 6\Omega = \frac{6 \times 6.5}{6 + 6.5} = 3.1\Omega$

also $5\Omega \,||\, 13\Omega = \frac{5 \times 13}{5+13} = 3.6\Omega$

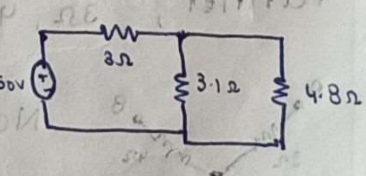
& $8.6\Omega \,||\, 1.5\Omega = \frac{8.6 \times 1.5}{8.6 + 1.5} = 1.27\Omega$

Now Redraw the circuit.



In above circuit 3.6Ω is in series with 1.2Ω

$= 1.2 + 3.6 = \underline{4.8\Omega}$, then



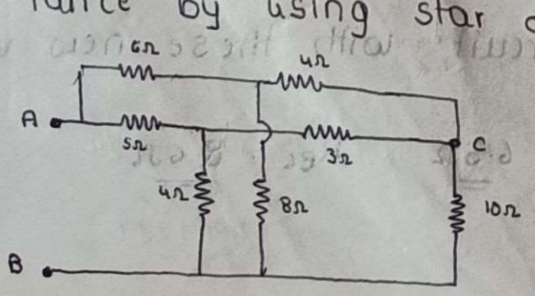
Now $R_T = 3 + \frac{4.8 \times 3.1}{4.8 + 3.1}$ {3.1 || 4.8 & in series with 3 }

$\boxed{R_T = 4.88\Omega}$

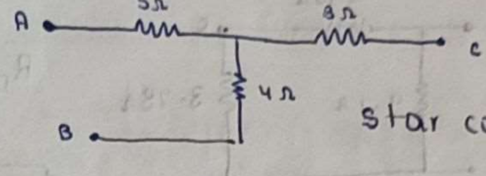
Now, $I = \frac{V}{R_T} = \frac{50}{4.88}$

$\boxed{I = 10.4 \text{ Amp}}$

40 In the figure, Determine the equivalent resistance by using star delta transformation.

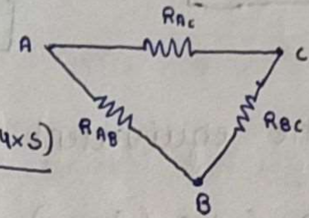


A In above circuit



convert it into star connection

Delta connection

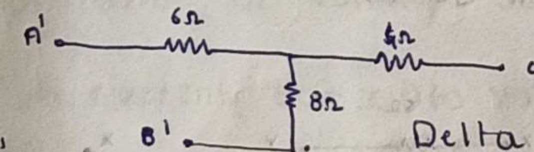


$$R_{AB} = \frac{(5\times3) + (3\times4) + (4\times5)}{3}$$ $R_{AB} = 15.6\,\Omega$

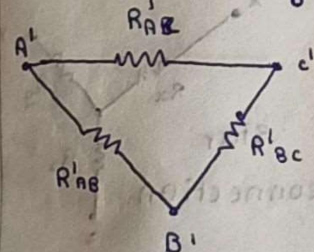
$$R_{BC} = \frac{(5\times3) + (3\times4) + (4\times5)}{5} = 9.4\,\Omega$$

$$R_{CA} = \frac{(5\times3) + (3\times4) + (4\times5)}{4} = 11.7\,\Omega$$

Also,



convert it into Delta connection.

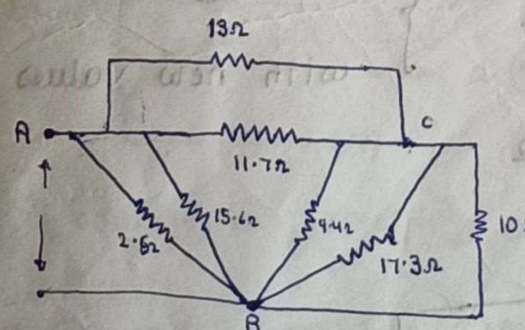


$R'_{AB} = 2.6\,\Omega$

$R'_{BC} = 17.3\,\Omega$

$R'_{AC} = 13\,\Omega$

Now Redraw the circuit.

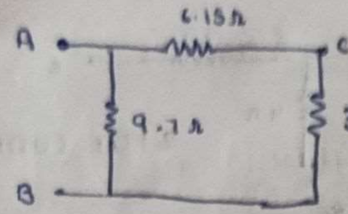


$9.4\,\Omega$, $17.3\,\Omega$ and $10\,\Omega$ are in parallel

Effective resistance = ~~44/8 Ω~~ $3.78\,\Omega$

In above circuit, $13\,\Omega \parallel 11.7\,\Omega = \frac{13\times11.7}{13+11.7} = 6.15\,\Omega$

Also, 2.5 & 15.6 in parallel $= \frac{2.5\times15.6}{2.5+15.6} = 9.7\,\Omega$

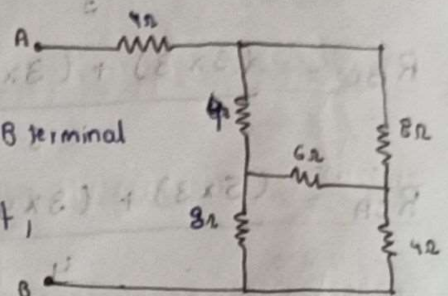


$$R_T = \frac{9.7(6.15+3.78)}{9.7+6.15+3.78}$$

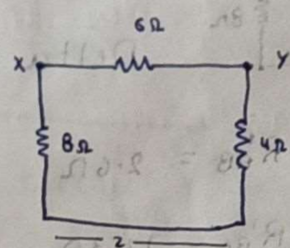
$$\boxed{R_T = 4.9\,\Omega}$$

5Q Find the equivalent resistance b/w A & B.

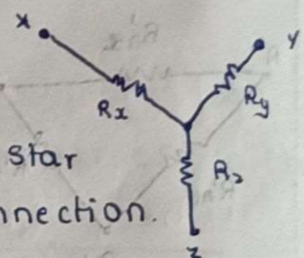
A Here 8Ω & 4Ω (down) are in parallel { because B terminal is present } If it is absent, they both will be in series.



consider Delta conn-ection



→



Star connection.

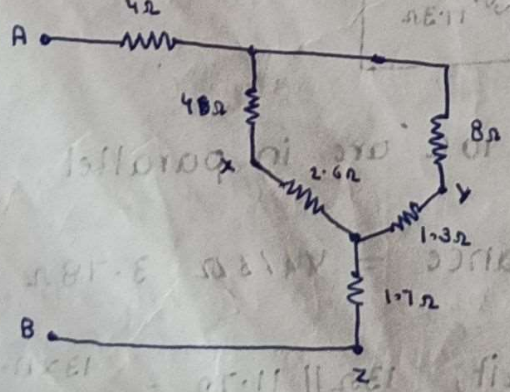
$$R_x = \frac{6\times 8}{6+8+4} = 2.6\,\Omega$$

$$R_y = \frac{6\times 4}{6+8+4} = 1.3\,\Omega$$

$$R_z = \frac{8\times 4}{6+8+4} = 1.7\,\Omega$$

} Redraw the circuit with new values

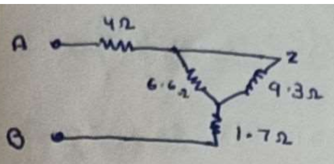
⇒



Now 48Ω & 2.6Ω also 8Ω & 1.3Ω are in series

$= 48\Omega + 2.6\Omega = 46.6\Omega$

$= 8\Omega + 1.3 = 9.3\Omega$



In above circuit, $6.6\Omega \parallel 9.3\Omega$

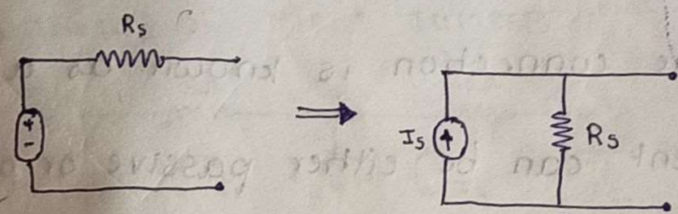
$$= \frac{6.6 \times 9.3}{6.6 + 9.3} = 3.86\Omega$$

Total resistance $= 3.86 + 4 + 1.7 = \boxed{9.56\Omega}$

{4Ω & 3.86 & 1.7 are in series}

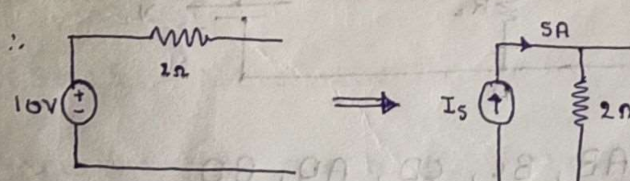
Source Transformation :-

* It is process which gives the idea of transformation of voltage source to current source & current source to voltage source.



For conversion, $I_S = \dfrac{V_S}{R_S}$ {voltage to current}

Ex :-

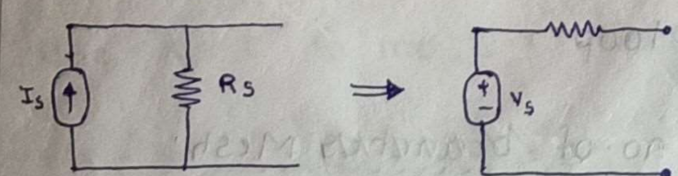


→ $I_S = \dfrac{10}{2} = 5A$

→ $I_S = 5A$

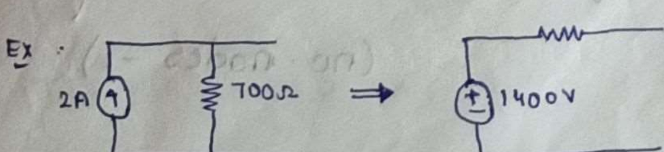
{voltage to current}

→ Current to voltage conversion :-



For conversion, $V_S = I_S R_S$

Ex :



$V_3 = 2 \times 700 = 1400\,\Omega$

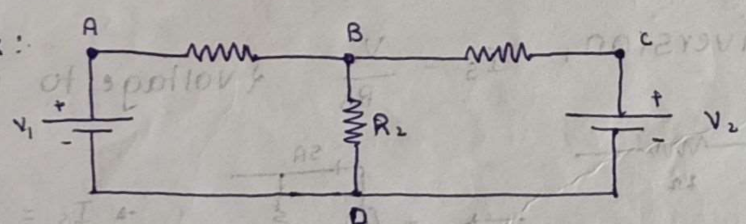
Mesh Analysis :-

* Mesh is a simple closed loop or simple closed path. Mesh don't contain any other mesh or loop inside it {no internal loops are there}

* Loop is a closed path, It can contain another loops inside it {internal loops are present}

* The element which is connected to any two points, the connection is known as a Branch. {The element can be either passive or active}.

Ex :-



Branches :- AB, BC, CD, AD, BD

ABDA is a mesh and loop

BCDB is a mesh and loop

ABCDA is a loop

Formula for no. of branches Mesh :

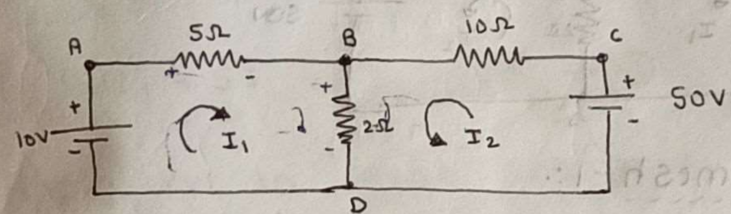
No. of Mesh equation = (no. of branches) - (no. nodes - 1)

* No. of mesh = $\boxed{B-(n-1)}$

Procedure:

1) Identify the number of meshes
2) Assume currents in each mesh
3) Write the current equations.
4) Solve the equations to find the current.

Q Write the mesh current equations in the circuit shown in figure also determine the values of Mesh currents



A In the above circuit, ABDA & BCDB are two meshes. Now consider I_1 current flowing clockwise in mesh-1. And consider current I_2 flowing anti-clockwise in mesh-2.

Apply Mesh analysis :-

Use K.V.L to mesh-1: ABDA {loop direction - ↷}

$+10 - 5I_1 - 2(I_1 + I_2) = 0$

$+10 - 7I_1 - 2I_2 = 0$

$7I_1 + 2I_2 = 10 \rightarrow$ (1)

Use KVL to mesh-2 : BCDB {loop direction ↻}

$10I_2 - 50 + 2(I_2 + I_1) = 0$

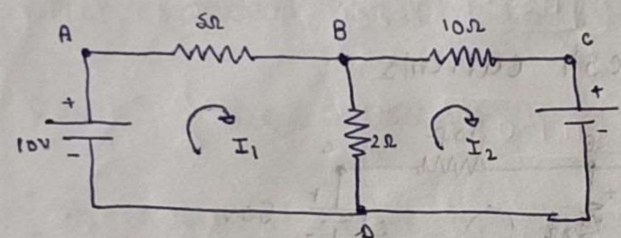
$= 2I_1 + 12I_2 = 50 \longrightarrow (2)$

By solving (1) & (2) equations

$\boxed{I_1 = 0.25\,A}$

$\boxed{I_2 = 4.125\,A}$ {Assumed current directions are true}

* Let us consider different current directions.



KVL for mesh-1 :-

$\rightarrow 10 - 5I_1 - 2(I_1 - I_2) = 0$

$\rightarrow 7I_1 - 2I_2 = 10 \rightarrow (1)$

KVL for mesh-2 :-

$\rightarrow +10I_2 - 50 + 2(I_2 - I_1) = 0$

$= 10I_2 + 2I_2 - 2I_1 = 50$

$= 12I_2 - 2I_1 = 50 \rightarrow (2)$

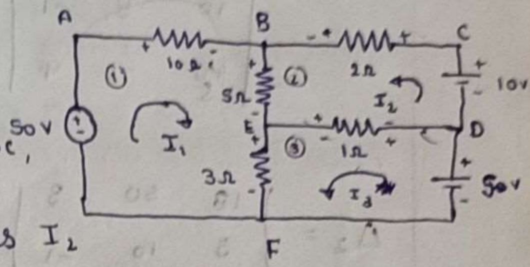
By solving (1) & (2), we get

$\boxed{I_1 = 0.25A}$

$\boxed{I_2 = -4.125\,A}$ {flowing reverse to the assumed direction}

Q. Determine the mesh current in given circuit.

A. Assume current in 1st mesh as I_1 in clockwise, & current in 2nd mesh as I_2 in anticlock wise & current in 3rd mesh as I_3 in anti-clock wise directions.



Apply KVL to Mesh ABEFA

$$-10I_1 - 5(I_1+I_2) - 3(I_1+I_3) + 50 = 0$$

$$-18I_1 - 5I_2 - 3I_3 = -50$$

$$18I_1 + 5I_2 + 3I_3 = 50 \rightarrow (1)$$

Apply KVL to Mesh BCDEB

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

$$-8I_2 - 5I_1 + I_3 = -10$$

$$5I_1 + 8I_2 - I_3 = 10 \rightarrow (2)$$

Apply KVL to mesh EDFE

$$+3(I_3+I_1) + 1(I_3-I_2) - 5 = 0$$

$$3I_1 - I_2 + 4I_3 = 5 \rightarrow (3)$$

$$\Delta = \begin{vmatrix} 18 & 5 & 3 \\ 5 & 8 & -1 \\ 3 & -1 & 4 \end{vmatrix} = 18(8(4) - (-1)(-1)) - 5(5\times4 - 3(-1)) + 3(5(-1) - 8(3))$$

$$= 356$$

$$\Delta_1 = \begin{vmatrix} 50 & 5 & 3 \\ 10 & 8 & -1 \\ \cancel{10}\,5 & -1 & 4 \end{vmatrix} = 50(8\times4 - (-1)(-1)) - 5(10(4) - (5)(-1)) + 3(10(-1) - 8(5)) = 1175$$

$$\Delta_2 = \begin{vmatrix} 18 & 50 & 3 \\ 5 & 10 & -1 \\ 3 & 5 & 4 \end{vmatrix} = 18(10(4) - (5)(-1)) - 50(5(4) - 3(-1)) + 3(5(5) - 3(10)) = -355$$

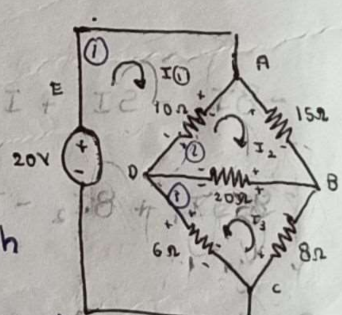
$$\Delta_3 = \begin{vmatrix} 18 & 5 & 50 \\ 5 & 8 & 10 \\ 3 & -1 & 5 \end{vmatrix} = 18(40+10) - 5(25-30) + 50(-5-24) = -525$$

$$I_1 = \frac{\Delta_1}{\Delta} = \frac{1175}{356} = \boxed{3.3A}$$

$$I_2 = \frac{\Delta_2}{\Delta} = \frac{-355}{356} = \boxed{-0.9A}$$

$$I_3 = \frac{\Delta_3}{\Delta} = \frac{-525}{356} = \boxed{-1.47A}$$

2Q Determine the values of mesh current in given circuit.



EADCE

ABDA

A: Assume current in mesh 1 as I_1 in clockwise & in mesh 2 as I_2 in clockwise & in mesh 3 as I_3 in anticlockwise directions.

Apply KVL to mesh-1 EADCE

$$+20V - 10(I_1 - I_2) - 6(I_1 + I_3) = 0$$

$$-16I_1 + 10I_2 - 6I_3 = -20$$

$16I_1 - 10I_2 + 6I_3 = 20 \rightarrow (1)$

Apply kvl to mesh (2) ABDA

$-10(I_2 - I_1) - 15I_2 - 20(I_2 + I_3) = 0$

$-45I_2 + 10I_1 - 20I_3 = 0$

$10I_1 - 45I_2 - 20I_3 = 0 \rightarrow (2)$

Apply kvl to mesh (3) DBCD

$6(I_3 + I_1) + 20(I_3 + I_2) + 8I_3 = 0$

$6I_1 + 20I_2 + 34I_3 = 0 \rightarrow (3)$

By cramers rule

$$\begin{vmatrix} 16 & -10 & 6 \\ 10 & -45 & -20 \\ 6 & 20 & 34 \end{vmatrix} \Delta = 16(-1530 + 400) + 10(340 + 120) + 6(200 + 270) = -10,660$$

$$\begin{vmatrix} 20 & -10 & 6 \\ 0 & -45 & -20 \\ 0 & 20 & 34 \end{vmatrix} \Delta_1 = 20(-1530 + 400) = -22,600$$

$$\begin{vmatrix} 16 & 20 & 6 \\ 10 & 0 & -20 \\ 6 & 0 & 34 \end{vmatrix} \Delta_2 = -20(340 + 120) = -9200$$

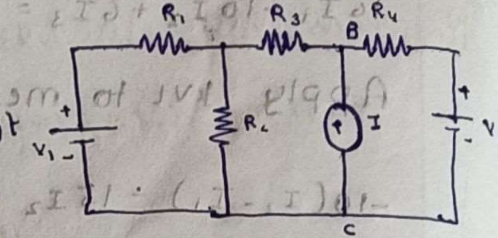
$$\begin{vmatrix} 16 & -10 & 20 \\ 10 & -45 & 0 \\ 6 & 20 & 0 \end{vmatrix} \Delta_3 = 20(200 + 270) = 9400$$

$$I_1 = \frac{\Delta_1}{\Delta} = \frac{-22600}{-10660} = \boxed{2.12 \text{ Amp}}$$

$$I_2 = \frac{\Delta_2}{\Delta} = \frac{-9200}{-10,660} = \boxed{0.86 \text{ Amp}}$$

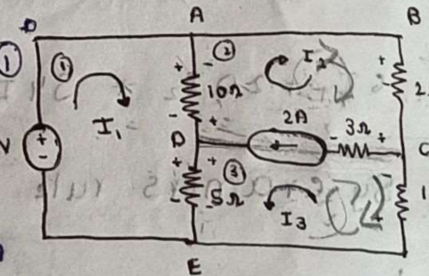
$$I_3 = \frac{\Delta_3}{\Delta} = \frac{+9400}{-10,660} = \boxed{-0.88 \text{ Amp}}$$

→ * Super mesh: A branch which is having a current source which is common for 2 or more meshes



BC is super mesh.

3Q Determine the current in the 5Ω resistor for the network shown in figure.



A Assume current in mesh ① as I_1 & in mesh ② as I_2 & in mesh ③ as I_3 in clock wise, ~~anti~~-clockwise, anti-clockwise directions respectively

Apply KVL to ADEA

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

$$3I_1 - 2I_2 + I_3 = 10 \rightarrow ①$$

Apply KVL to super mesh → 'ABCEDA'

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

$$15I_1 - 12I_2 + 6I_3 = 0$$

$$5I_1 - 4I_2 + 2I_3 = 0 \rightarrow ②$$

From common branch with current source

$0I_1 + I_2 + I_3 = 2\,Amp \rightarrow (3)$

By cramers rule,

$$\Delta = \begin{vmatrix} 3 & -2 & 1 \\ 5 & -4 & 2 \\ 0 & 1 & 1 \end{vmatrix} = 3(-4-2) + 2(5) + 1(5) = -3$$

$$\Delta_1 = \begin{vmatrix} 10 & -2 & 1 \\ 0 & -4 & 2 \\ 2 & 1 & 1 \end{vmatrix} \; 10(-4-2) + 2(-4) + 1(+8) = -60$$

$$\Delta_2 = \begin{vmatrix} 3 & 10 & 1 \\ 5 & 0 & 2 \\ 0 & 2 & 1 \end{vmatrix} \; 3(-4) - 10(+5) + 1(+10) = -52$$

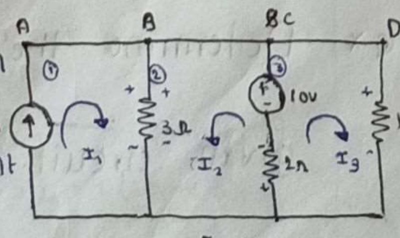
$$\Delta_3 = \begin{vmatrix} 3 & -2 & 10 \\ 5 & -4 & 0 \\ 0 & 1 & 2 \end{vmatrix} \; 3(-8) + 2(+10) + 10(+5) = 46$$

$$I_1 = \frac{\Delta_1}{\Delta} = \frac{-60}{-3} = \boxed{20\,Amp}$$

$$I_2 = \frac{\Delta_2}{\Delta} = \frac{-52}{-3} = \boxed{17.3\,Amp}$$

$$I_3 = \frac{\Delta_3}{\Delta} = \frac{46}{-3} = \boxed{-15.3\,Amp}$$

4Q Write the mesh equations for the circuit shown in figure and determine mesh currents.



A Assume current I_1 in mesh 1, current I_2 in mesh 2, current I_3 in mesh 3 in clock, anti-close, clock wise directions respectively.

Apply KVL to 'BCEB'

$-10 + 2(I_2 + I_3) + 3(I_2 + I_1) = 0$

$3I_1 + 5I_2 + 2I_3 = 10 \rightarrow (1)$

Apply KVL to 'CDEC'

$-(1)I_3 - 2(I_3 + I_2) + 10V = 0$

$-2I_2 - 3I_3 = -10$

$2I_2 + 3I_3 = 10 \rightarrow (2)$

From mesh 1, $I_1 = 10A \rightarrow (3)$

Substitute in (1)

$(5I_2 + 2I_3 = -20)\,3$

$(2I_2 + 3I_3 = 10)\,2$

$15I_2 + 6I_3 = -60$

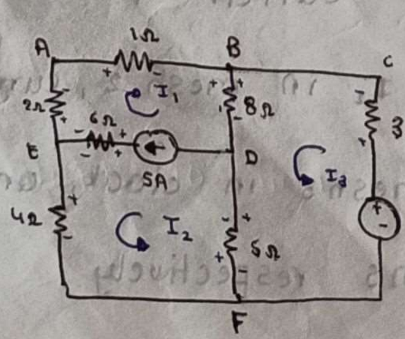
$\underline{4I_2 + 6I_3 = 20}$

$11I_2 = -80$

$I_2 = -80/11 = \boxed{-7.2A}$

Substitute in (2), then $\boxed{I_3 = 8.1A}$

5Q* Determine the values of mesh current in given circuit.



A Assume currents in each mesh as

shown figure.

Apply KVL to super mesh 'ABDFEA'

$-I_1 - 8(I_1 + I_3) + 5(I_2 - I_3) + 4I_2 - 2I_1 = 0$

$\cancel{-3I_1}\ -11I_1 + 9I_2 - 13I_3 = 0$

$11I_1 - 9I_2 + 13I_3 = 0 \rightarrow ①$

From common branch, with current source

$\boxed{I_1 + I_2 = 5\text{ Amp}} \rightarrow ②$

Apply KVL to mesh-3 BCFDB

$\cancel{5I_3}\ \cancel{+8}\quad 5(I_3 - I_2) + 8(I_3 + I_1) + 3I_3 - 10 = 0$

$8I_1 - 5I_2 + 16I_3 = 10 \rightarrow ③$

By cramers rule.

$\begin{vmatrix} 11 & -9 & 13 \\ 1 & 1 & 0 \\ 8 & -5 & 16 \end{vmatrix} = \Delta = 11(16-0) + 9(16-0) + 13(-5-8)$

$= \cancel{265}\ 151$

$\begin{vmatrix} 0 & -9 & 13 \\ 5 & 1 & 0 \\ 10 & -5 & 6 \end{vmatrix} = \Delta_1 = -9(30-0) + -13(-25-10)$

$= 265$

$\begin{vmatrix} 11 & 0 & 13 \\ 1 & 5 & 0 \\ 8 & 10 & 6 \end{vmatrix} = \Delta_2 = 11(30-0) + 13(10-40)$

$= 490$

$\begin{vmatrix} 11 & -9 & 0 \\ 1 & 1 & 5 \\ 8 & -5 & 10 \end{vmatrix} = \Delta_3 = 11(10+25) + 9(10-40)$

$= 150$

$$I_1 = \frac{\Delta_1}{\Delta} = \frac{265}{151} = \boxed{1.75\ A}$$

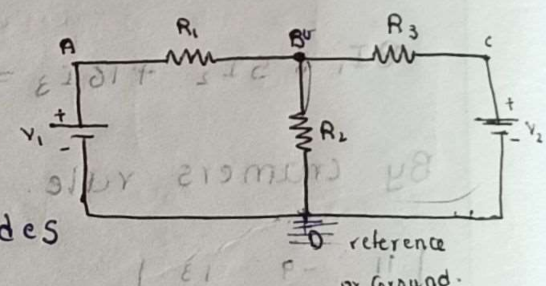
$$I_2 = \frac{\Delta_2}{\Delta} = \frac{490}{151} = \boxed{3.24\ A}$$

$$I_3 = \frac{\Delta_3}{\Delta} = \frac{115}{151} = \boxed{0.76\ A}$$

* Nodal Analysis :-

- Node :- Node is a common point which connects 2 or more elements {synonym - Junction}

* At every junction, current diversion takes place
* But at node, it is not compulsary to have a current diversion.



A, B, C, D → Nodes

B, D → Junctions, Nodes

* Solving by nodal Analysis

1) First identify the nodes where current diversion takes place (i.e Junctions) in the circuit.

2) No. of nodal equations = no. of main nodes. $= \{n-1$ {n = total no. of nodes {with reference}

3) Assume voltage at each node and write nodal equations

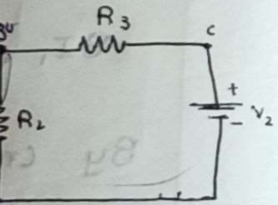
4) Solve the equations to find out the assumed voltage

which connects-

ction}

on takes place

to have a



reference or Ground.

urrent diversion

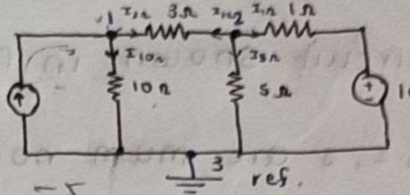
rcuit.

in nodes.

otal no. of nodes {with refrence}

the assumed.

Q. Write the nodal equations and determine the node vollage values.



A. Here 1, 2, 3 are nodes

& 1, 2 are main nodes.

Assume the voltage at each node as V_1, V_2 at 1 & 2 respectively

Apply KCL at node-1,

* Take unknown currents as outgoing currents
* Take currents (outgoing) as positive and incoming currents as negative.

$$5 = I_{10\Omega} + I_{3\Omega}$$

$$5 = \frac{V_1 - V_2}{3} + \frac{V_1 - 0}{10} \quad \{\text{resistance b/w } V_1 \text{ \& } V_2 \text{ is } 3\Omega\}$$

$$13V_1 - 10V_2 = 150 \rightarrow (1)$$

Apply KCL to node-2,

$$I_{3\Omega} + I_{5\Omega} + I_{1\Omega} = 0$$

$$\frac{V_2 - V_1}{3} + \frac{V_2 - 0}{5} + \frac{V_2 - 10}{1} = 0$$

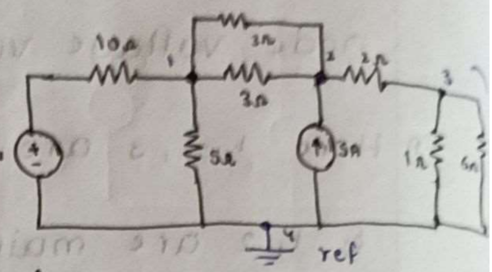
$$5V_2 - 5V_1 + 3V_2 + 15V_2 - 150 = 0$$

$$-5V_1 + 23V_2 = 150 \rightarrow (2)$$

By solving (1) & (2), we get $\boxed{V_1 = 19.87V}$

$\boxed{V_2 = 10.84}$

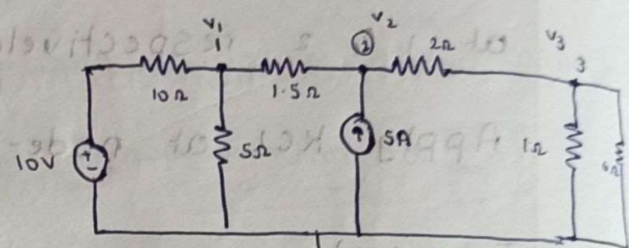
Q Determine the voltage at each node for the circuit shown in figure.



A 1, 2, 3 are main nodes.

In the above circuit, 3Ω & 3Ω are in parallel, effective resistance = 1.5Ω

Apply kcl to node-1



$I_{10\Omega} + I_{1.5\Omega} + I_{5\Omega} = 0$

$\frac{V_1 - 10}{10} + \frac{V_1 - V_2}{1.5} + \frac{V_1}{5} = 0$

{ v at node-1 - V_1

{ v at node-2, V_2

{ v at node-3, V_3

$3V_1 - 30 + 20V_1 - 20V_2 + 6V_1 = 0$

$29V_1 - 20V_2 = 30 \rightarrow$ (1)

Apply kcl to node-2

$-5 + I_{2\Omega} + I_{1.5} = 0$

$5 = I_{1.5\Omega} + I_{2\Omega}$

$5 = \frac{V_2 - V_1}{1.5} + \frac{V_2 - V_3}{2}$

$30 = 4V_2 - 4V_1 + 3V_2 - 3V_3$

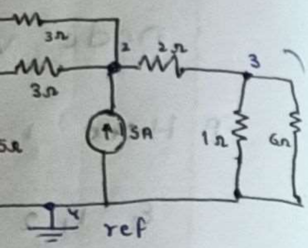
$-4V_1 + 7V_2 - 3V_3 = 30 \rightarrow$ (2)

Apply kcl to node-(3)

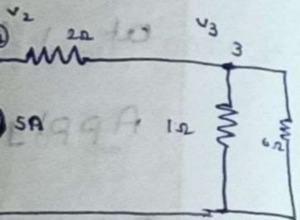
$I_{2\Omega} + I_{1\Omega} + I_{6\Omega} = 0$

$\frac{V_3 - V_2}{2} + \frac{V_3}{1} + \frac{V_3}{6} = 0$

de for the



$= 1.5\Omega$



V_1

$, V_2$

$- 3, V_3$

$$3V_3 - 3V_2 + 6V_3 + V_3 = 0$$

$$-3V_2 + 10V_3 = 0$$

$$= 3V_2 - 10V_3 = 0 \rightarrow (3)$$

By cramers method.

$$\begin{vmatrix} 29 & -20 & 0 \\ -4 & 7 & -3 \\ 0 & 3 & -10 \end{vmatrix} = \Delta = 29(-70+9)+20(40)$$

$$= -969$$

$$\begin{vmatrix} 30 & -20 & 0 \\ 30 & 7 & -3 \\ 0 & 3 & -10 \end{vmatrix} = \Delta_1 = 30(-70+9)+20(-300)$$

$$-7769$$

$$\begin{vmatrix} 29 & 30 & 0 \\ -4 & 30 & -3 \\ 0 & 0 & -10 \end{vmatrix} = \Delta_2 = 29(-300)-30(40)$$

$$= -9900.$$

$$\begin{vmatrix} 29 & -20 & 30 \\ -4 & 7 & 30 \\ 0 & 3 & 0 \end{vmatrix} = \Delta_3 = 29(-90)+\cancel{20}+30(-12)$$

$$= -2970$$

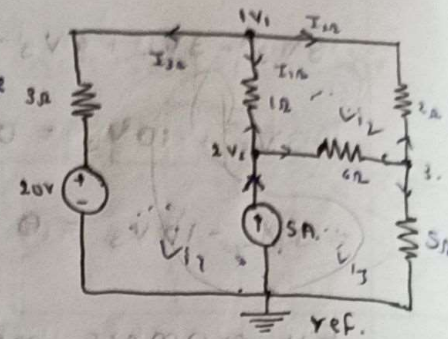
$$V_1\ \cancel{I_1} = \frac{\Delta_1}{\Delta} = \frac{-7769}{-969} = \boxed{8.01\ A}$$

$$V_2\ \cancel{I_2} = \frac{\Delta_2}{\Delta} = \frac{-9900}{-969} = \boxed{10.2\ A}$$

$$V_3\ \cancel{I_3} = \frac{\Delta_3}{\Delta} = \frac{-2970}{-969} = \boxed{3.01A}$$

Q Use the nodal analysis to find power disipated in 6Ω resistor for the circuit shown in figure.

A In circuit 3 mains nodes are present. voltage in them is V_1, V_2 & V_3



Apply KCl to node-1

$i_1 = 2.31$

$i_2 = 0.04$

$i_3 = 2.68$

$i_{6\Omega} = i_3 - i_2 = 2.64$

$P = i^2 R = (2.64)^2 6 = 41.8$

$I_{3\Omega} + I_{2\Omega} + I_{1\Omega} = 0$

$$\frac{V_1 - 20}{3} + \frac{V_1 - V_3}{2} + \frac{V_1 - V_2}{1} = 0$$

$$2V_1 - 40 + 3V_1 - 3V_3 + 6V_1 - 6V_2 = 0$$

$$11V_1 - 6V_2 - 3V_3 = 40 \rightarrow (1)$$

Apply kcl to node-2:

$$-5 + \frac{V_2 - V_1}{1} + \frac{V_2 - V_3}{6} = 0$$

$$-30 + 6V_2 - 6V_1 + V_2 - V_3 = 0$$

$$-6V_1 + 7V_2 - V_3 \boxed{= 30} \rightarrow (2)$$

Apply KCl to node-3:

$$I_{2\Omega} + I_{5\Omega} + I_{6\Omega} = 0$$

$$\frac{V_3 - V_1}{2} + \frac{V_3}{5} + \frac{V_3 - V_2}{6} = 0$$

$$\frac{15V_3 - 15V_1 + 6V_3 + 5V_3 - 5V_2}{30} = 0$$

$$-15V_1 - 5V_2 + 26V_3 = 0 \rightarrow (3)$$

$$15V_1 + 5V_2 - 26V_3 = 0$$

By cramers rule

$$\Delta = \begin{vmatrix} 11 & -6 & -3 \\ -6 & 7 & -1 \\ -15 & -5 & 26 \end{vmatrix} = 11(182-5)+6(-156-15)-3(30+105)$$
$$= 516$$

$$\Delta_1 = \begin{vmatrix} 40 & -6 & -3 \\ 30 & 7 & -1 \\ 0 & -5 & 26 \end{vmatrix} = 40(182-5)+6(780)-3(-150)$$

$$\Delta_2 = \begin{vmatrix} 11 & 40 & -3 \\ -6 & 30 & -1 \\ -15 & 0 & 26 \end{vmatrix} = 11(780)-40(-156-15)+3(+450)$$

$$\Delta_3 = \begin{vmatrix} 11 & -6 & 40 \\ -6 & 7 & 30 \\ -15 & -5 & 6 \end{vmatrix} =$$

$$V_1 = \frac{\Delta_1}{\Delta} = \boxed{23.6V}$$

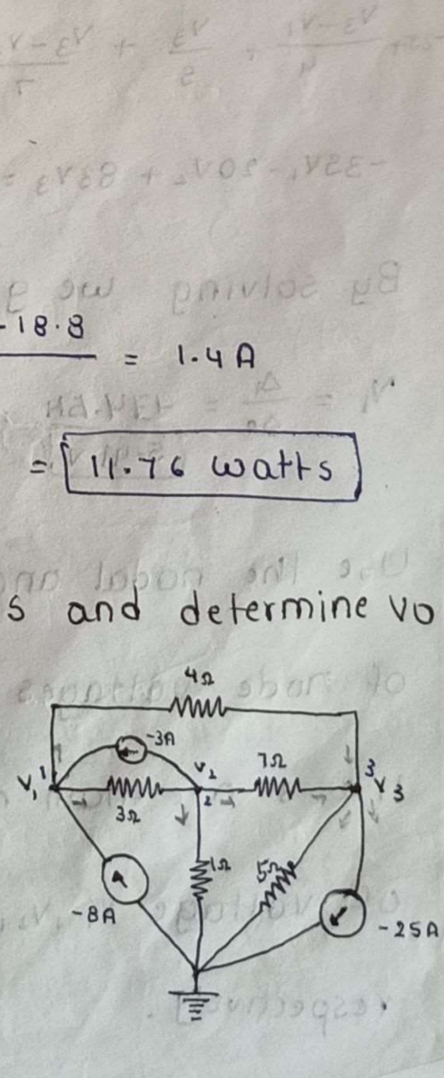
$$V_2 = \frac{\Delta_2}{\Delta} = \boxed{27.2V}$$

$$V_3 = \frac{\Delta_3}{\Delta} = \boxed{18.8V}$$

$$I_{6\Omega} = \frac{V_2 - V_3}{6} = \frac{27.26 - 18.8}{+6} = 1.4A$$

$$P_{6\Omega} = I_{6\Omega}^2 R = (1.4)^2 \times 6 = \boxed{11.76 \text{ watts}}$$

Q Use the nodal analysis and determine voltages at given circuit.



A 1, 2, 3 are main nodes with voltages V_1, V_2, V_3 respectively.

Apply kcl to node '1'.

$-8-3 = I_{4\Omega} + I_{3\Omega}$

$$-8-3 = \frac{V_1 - V_3}{4} + \frac{V_1 - V_2}{3}$$

$7V_1 - 4V_2 - 3V_3 = -132 \rightarrow (1)$

Apply kcl to node-'2'.

$$-3 + \frac{V_2}{1} + \frac{V_2 - V_3}{7} + \frac{V_2 - V_1}{3} = 0$$

$-7V_1 + 31V_2 - 3V_3 = 63 \rightarrow (2)$

Apply kcl to node-3.

$I_{4\Omega} + I_{5\Omega} + I_{7\Omega}$

$$-25 + \frac{V_3 - V_1}{4} + \frac{V_3}{5} + \frac{V_3 - V_2}{7} = \cancel{0}\ \cancel{25}\ 0$$

$-35V_1 - 20V_2 + 83V_3 = 3500 \rightarrow (3)$

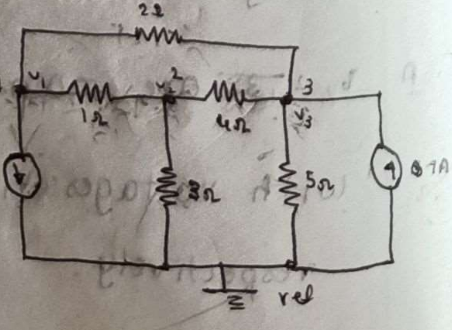
By solving we get

$V_1 = \frac{\Delta_1}{\Delta} = -434.5M$, $V_2 = \frac{\Delta_2}{\Delta} = -1812$, $V_3 = \frac{\Delta_3}{\Delta} = -4254.6$

$\boxed{5.41\ V}$ $\boxed{7.73V}$ $\boxed{46.31}$

Q Use the nodal analysis to determine the values of node voltages in given circuit.

A 1, 2, 3 are main nodes of voltage V_1, V_2, V_3 respectively.



A Apply kcl to node - 1

$I_{2\Omega} + I_{1\Omega} + 3 = 0$

$$3 + \frac{V_1 - V_3}{2} + \frac{V_1 - V_2}{1} = 0$$

$+3V_1 - 2V_2 - V_3 = -6 \rightarrow$ (1)

Apply kcl to node - 2

$I_{1\Omega} + I_{4\Omega} + I_{3\Omega} = 0$

$$\frac{V_2 - V_1}{1} + \frac{V_2 - V_3}{4} + \frac{V_2}{3} = 0$$

$12V_2 - 12V_1 + 3V_2 - 3V_3 + 4V_2 = 0$

$-12V_1 - 3V_3 + 19V_2 = 0$

$-12V_1 + 19V_2 - 3V_3 = 0 \rightarrow$ (2)

Apply kcl to node - 3

$I_{4\Omega} + I_{5\Omega} + I_{2\Omega} - 7 = 0$

$$\frac{V_3 - V_2}{4} + \frac{V_3}{5} + \frac{V_3 - V_1}{2} = 7$$

$5V_3 - 5V_2 + 4V_3 + 10V_3 - 10V_1 = 140$

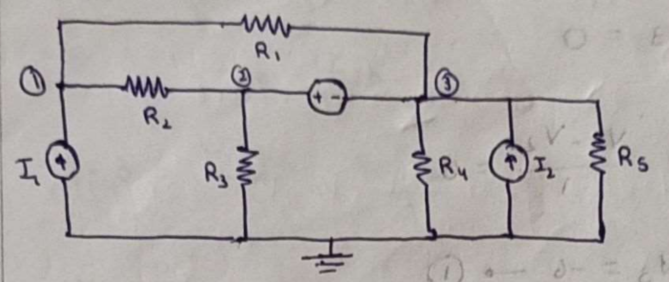
$-10V_1 - 5V_2 + 19V_3 = 140 \rightarrow$ (3)

By solving we get

$\boxed{V_1 = 5.2V}$ $\boxed{V_2 = 5.1V}$ $\boxed{V_3 = 11.4V}$

* <u>Super Node</u> : In a given circuit, If a common voltage source is present in between 2 or more

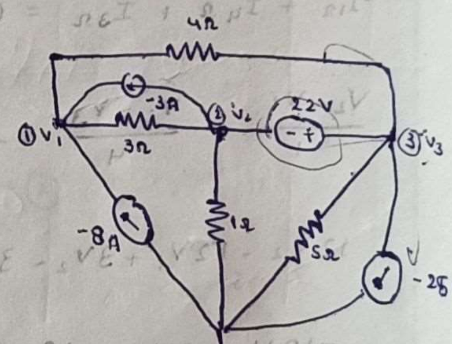
nodes, then it is a super node



Branch b/w node ② & node ③ is super node.

Q Determine the values of node voltages in the given circuit by nodal analysis.

A 1, 2, 3 are main nodes of voltages V_1, V_2 & V_3 respectively.



Apply kcl to node '1'

$$-(-8) - (-3) + I_{3\Omega} + I_{4\Omega} = 0$$

$$8 + 3 + \frac{V_1 - V_2}{3} + \frac{V_1 - V_3}{4} = 0$$

$$7V_1 - 4V_2 - 3V_3 = -132 \rightarrow ①$$

Apply kcl to super node (i.e. node 2 and node 3)

node-2 : $-3 + \frac{V_2}{1} + \frac{V_2 - V_1}{3}$ + (node-3) $(-25) + \frac{V_3}{5} + \frac{V_3 - V_1}{4} = 0$

$$\rightarrow -35V_1 + 80V_2 + 27V_3 = 1680 \rightarrow ②$$

From common voltage source b/w '2' & '3'

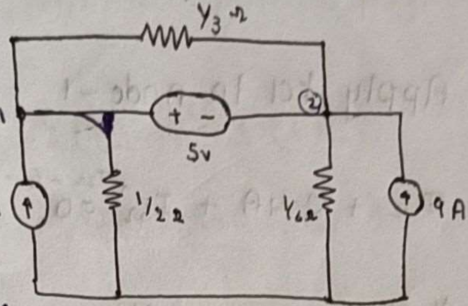
$$V_3 - V_2 = 22V \rightarrow ③$$

By solving equations, we get

$\boxed{V_1 = 1.07V}$ $\boxed{V_2 = 10.5V}$ $\boxed{V_3 = 32.5}$

In exam, we should solve by Cramers rule only....

Compute the voltages in given circuit by using nodal analysis.



1, 2, 3 are main nodes with voltages V_1 & V_2 respectively

Apply KCl to supernode (i.e node-1 & node-2)

$$-4 + \frac{V_1 - V_2}{1/3} + \frac{V_1}{1/2} + \frac{V_2}{1/6} + \frac{V_2 - V_1}{1/3} - 9 = 0$$

$2V_1 + 6V_2 = 13 \rightarrow (1)$

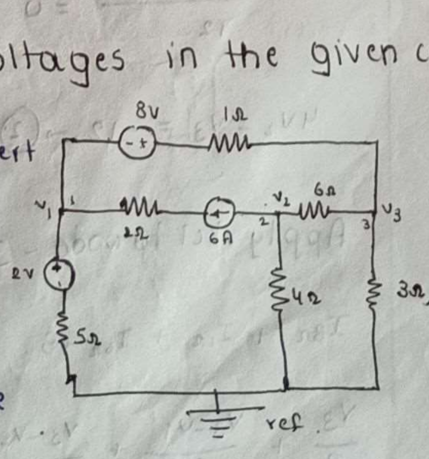
From voltage source b/w node-1 & node-2

$V_1 - V_2 = 5 \rightarrow (2)$

By solving (1) & (2), we get

$\boxed{V_1 = 5.37V}$ $\boxed{V_2 = 0.37V}$

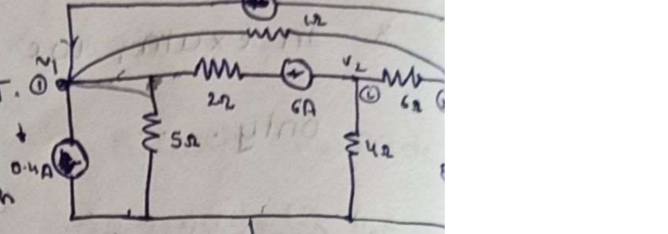
Q Determine the node voltages in the given circuit.



A In above circuit, convert 8v source in current source, $I_1 = V/1 = \underline{8A}$.

And also convert the 2V source to current source, $I_2 = 2/5 = \underline{0.4A}$

A. Now Redraw the circuit.



1, 2, 3 are main nodes with voltages V_1 V_2 V_3 respectively.

Apply kcl to node - 1

$$I_{1\Omega} + 0.4A + I_{5\Omega} \overset{+I_{2\Omega} - 6 - 8}{=} 0$$

$$\frac{V_1 - V_3}{1} + 0.4A + \frac{V_1}{5} + \frac{\cancel{V_1 - V_2}}{2\Omega} - 6 = 0$$
$$-8$$

$$\frac{V_1 - V_3}{1} + 0.4A + \frac{V_1}{5} - 6 = 0$$
$$-8$$

$$5V_1 - 5V_3 + V_1 = (16 - 0.4)5$$

$$6V_1 - 5V_3 = 5.16 \rightarrow (1)$$
$$68.$$

Apply kcl to node - 2

$$6 + I_{6\Omega} + I_{4\Omega} = 0$$

$$6 + \frac{V_2 - V_3}{6} + \frac{V_2}{4} = 0$$

$$\frac{12 + V_2 - V_3 + 3V_2}{12} = 0$$

$$4V_2 - V_3 = -12 \rightarrow (2)$$

Apply kcl to node - 3

$$I_{8\Omega} + I_{1\Omega} + I_{6\Omega} + 8$$

$$\frac{V_3}{8} + \frac{V_3 - V_1}{1} + \frac{V_3 - V_2}{6} = -8$$

$$\frac{3V_3 + 24V_3 - 24V_1 + 4V_3 - 4V_2}{24} = 8$$

$$\rightarrow -24V_1 - 4V_2 + 31V_3 = -8 \rightarrow (3)$$

By solving equations

$$\begin{vmatrix} 6 & 0 & -5 \\ 0 & 4 & -1 \\ -24 & -4 & 31 \end{vmatrix} \quad \Delta = 6(124-4) - 5(+96)$$

$$\cancel{-1352} = \underline{240}$$

$$\begin{vmatrix} 68 & 0 & -5 \\ -12 & 4 & -1 \\ -8 & -4 & 31 \end{vmatrix} \quad \Delta_1 = 68(\underset{120}{\cancel{-80}}) - 5(\cancel{-324}\ 48 + 32)$$

$$= \cancel{8320} = \underline{+7760}$$

$$\begin{vmatrix} 6 & 68 & -5 \\ 0 & -12 & -1 \\ -24 & -8 & 31 \end{vmatrix} \quad \Delta_2 = \cancel{6(-18)(-68(-24)\,6)}$$

$$\cancel{1584}\ 6(-372-8) + 68(-24)$$

$$-5(-288) = \underline{792}$$

$$\begin{vmatrix} 6 & 0 & 68 \\ 0 & 4 & -12 \\ -24 & -4 & -8 \end{vmatrix} \quad \Delta_3 = \cancel{6(-32) + 68(96)}$$

$$\cancel{6384} \quad 6(-32-48) + 68(96)$$

$$= \underline{6048}$$

$$V_1 = \frac{7760}{240} = \boxed{32.3\,V}$$

$$V_2 = \frac{792}{240} = \boxed{3.3\,V}$$

$$V_3 = \frac{6048}{240} = \boxed{25.2\,V}$$