19/09/22
Monday

② BEE ①

① Concept of linearity & linear elements :-

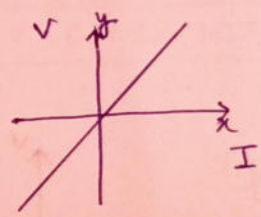
The elements of a ckt is said to be linear if it follows the principle of homogeneity and the principle of superposition.

Homogeneity :- $\boxed{f(a_1x_1 + a_2x_2) = a_1y_1 + a_2y_2}$

x = input
y = effect/output

$$x \rightarrow \boxed{\text{System}} \rightarrow y$$

$$ax \rightarrow \boxed{\text{System}} \rightarrow ay$$

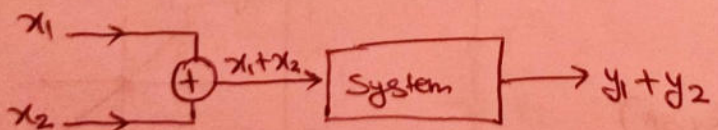


Superposition :- $\boxed{f(a_1x_1 + a_2x_2) = f(a_1x_1) + f(a_2x_2)}$

$$x_1 \rightarrow \boxed{\text{System}} \rightarrow y_1$$

$$x_2 \rightarrow \boxed{\text{System}} \rightarrow y_2$$

(⊕ Adder)



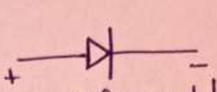
Eg: of linear elements :- Resistor, Inductor, Capacitor

② Unilateral And bilateral elements :-

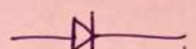
A network is said to be bilateral if it allows the current to flow in both the directions by providing the same impedence (to the current).

Eg: Register is bilateral, capacitor, Inductor. etc

eg of unilateral element → diode

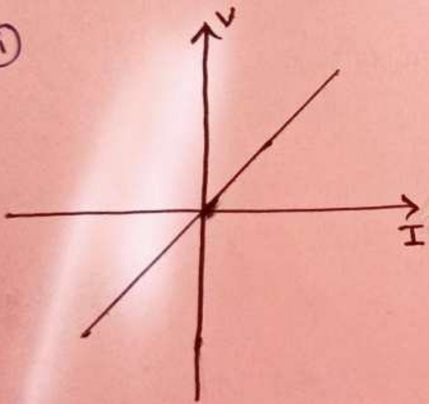


• forward biased
(less impedence)



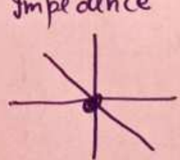
backward biased
(open ckt)

③ Eg ①



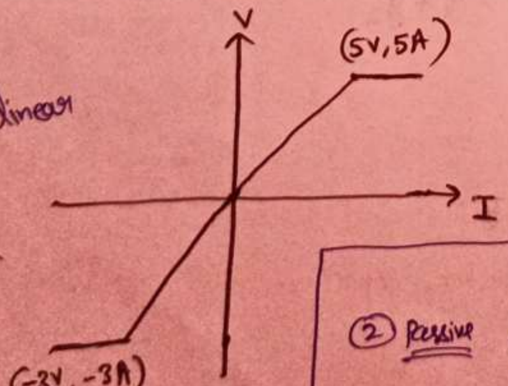
ⓐ Linear
ⓑ passive (+ve characteristic of impedence)
ⓒ bilateral

[for active there will -ve characteristic of Impedence


]

④ Eg ②

~~Non-linear~~ Non-linear
passive
~~bilateral~~
Unilateral



① Active elements → capable of delivering energy to ext. devices.

eg) voltage & current sources

② Passive elements :- capable of receiving energy or power.

eg) R, C, L etc

④ Basic Circuit Law :- (2 laws)

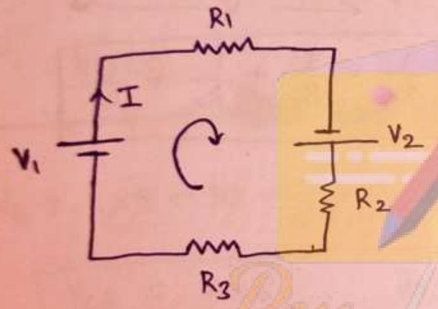
① Kirchhoff's current law (KCL)

② Kirchhoff's voltage law (KVL)

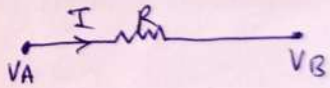
① **KCL** :- At any junction/Node the algebric sum of the currents is equal to zero. i.e. Current entering the node = Current leaving the node

② **KVL** :- The algebric sum of the voltage drawn across various elements along with the algebric sum of emf in any closed path is equal to zero.

★ $\boxed{\Sigma IR + \Sigma V = 0}$

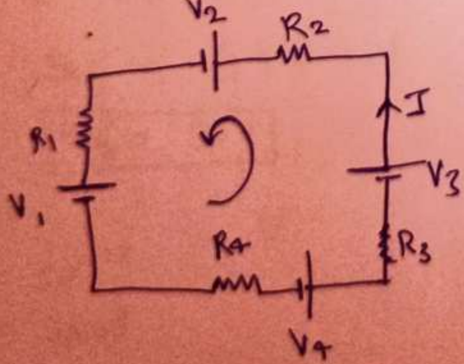


$\boxed{V_1 + V_2 = IR_1 + IR_2 + IR_3}$



$\boxed{V_A - IR - V_B = 0}$

eg)



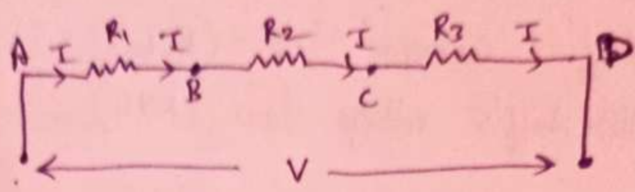
$V_3 - IR_2 - V_2 - IR_1 - V_1 - IR_4 + V_4 - IR_3 = 0$

$\boxed{V_3 + V_4 - V_1 - V_2 = I(R_2 + R_1 + R_3 + R_4)}$

(5) current division & voltage drop

(1) Series ckt :-

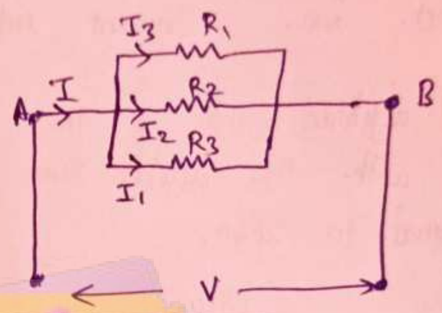
I = same in different elements, but have diff. voltage drop.



$$\boxed{R_{eq} = R_1 + R_2 + R_3}$$

(2) Parallel ckt :-

current division and voltage remains constant.



$$\boxed{\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

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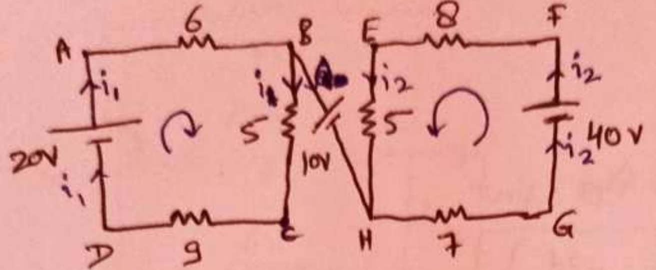
③ BEE

Q① :-



$V_{CE} = ?$

$V_{AG} = ?$

Sol^n)

$20 = 20 i_1$

$\boxed{i_1 = 1A}$

$40 = 20 i_2$

$\boxed{i_2 = 2A}$

Now by KVL .

~~$V_{CE} = V_C - V_E = i_1 \times 5 - 10 = -5V$~~

$V_C + i_1 \times 5 - 10 + i_2 \times 5 - V_E = 0$

$\boxed{V_{CE} = -5V}$ that means E has higher pot than C

by KVL

$V_A - 6i_1 - 10 - 7i_2 - V_G = 0$

$V_{AG} = 6 + 10 + 14$

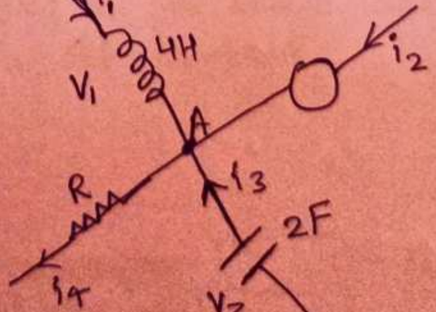
$\boxed{V_{AG} = 30V}$

② $i_2 = 5e^{-2t}$

$i_4 = 3\sin t$

$V_3 = 4e^{-2t}$

$V_1 = ?$



$i_3 = 4 \times 2 \times \left(-2e^{-2t}\right)$

$\boxed{i_3 = -16e^{-2t}}$

$q = CV_3$

$i_3 = \frac{dq}{dt} = C\frac{dV_3}{dt}$

using KCL

$\sum I_A = 0$

$i_1 + i_2 + i_3 = i_4$

$5e^{-2t} + i_1 - 16e^{-2t} = 3\sin t$

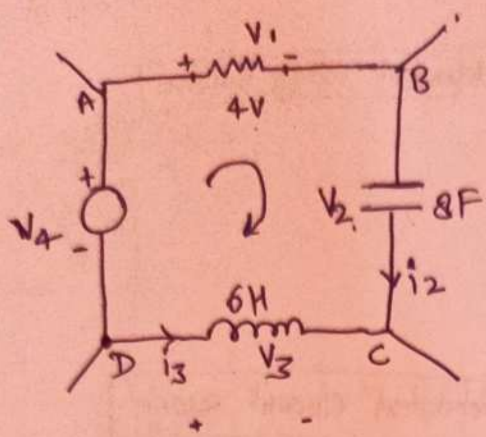
$$\boxed{i_1 = (3\sin t + 11e^{-2t})}$$

$\Phi = Li$

$e = \frac{-d\Phi}{dt} = +L\frac{di}{dt}$

$e = 4(3\cos t - 22e^{-2t})$ Ans

Q)



$i_2 = ?$

$v_1 = 4V$

$i_3 = 2e^{-t/3}$

$v_4 = 4\cos 2t$

Sol^n) using KVL

[− to + jaa rhaa
h to +ve V]

$$v_4 - v_1 - v_2 + v_3 = 0$$

$$4\cos 2t - 4 - v_2 + L\frac{di_3}{dt} = 0$$

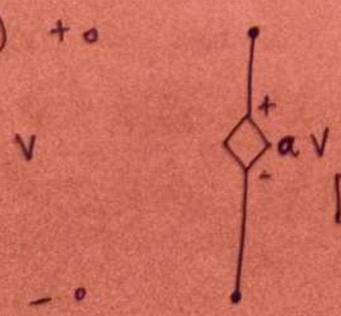
$$\boxed{4\cos 2t - 4 + 6\left(\frac{2}{3}e^{-t/3}\right) = v_2}$$

$$i_2 = C\frac{dv_2}{dt} = 8\left[\frac{d}{dt}\left(4\cos 2t - 4 + 4e^{-t/3}\right)\right]$$

$$\boxed{i_2 = 8\left[-8\sin 2t - \frac{4}{3}e^{-t/3}\right]}$$

Dependent Sources :- DS are defined as the source which depends upon the other parameters of a ckt or network.

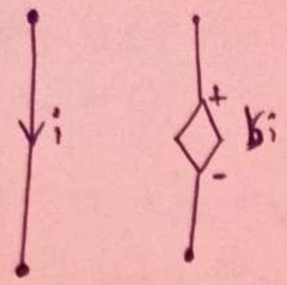
(a)



~~(dependent voltage source)~~

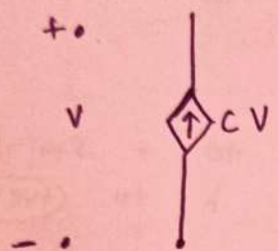
voltage dependent voltage source

(b)



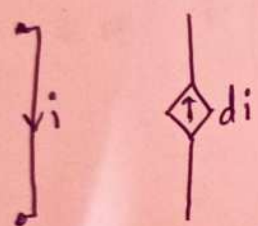
$\boxed{\text{Current dependent voltage source}}$

(c)



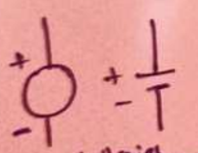
$\boxed{\text{Voltage dependent current source}}$

(d)



$\boxed{\text{Current dependent current source}}$

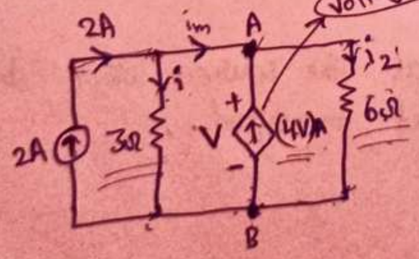
$\boxed{\text{dependent sources d.n.e}}$



(exist) ⇒ Independent Sources

batteries

Ques)



$V = ?$

$i = ?$

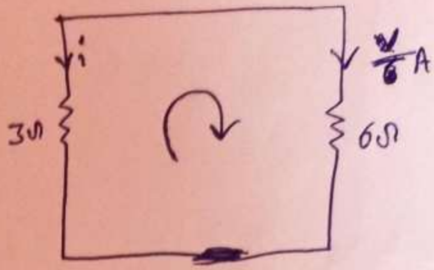
$i_2 = ?$

Sol^n)

$V_{AB} = V$

$i_2 = \frac{V_{AB}}{R_{AB}} = \frac{V}{6}$

by KVL



$3i = \frac{V}{6} \times 6$

$\boxed{i = \frac{V}{3} A}$

$i_m = i_2 - 4V$

$2 = i + i_m = \frac{V}{3} + \frac{V}{6} - 4V$

$i = 4V - i_2 + 2$

$\frac{V}{3} = 4V - \frac{V}{6} + 2$

$2 = \frac{V}{2} - 4V$

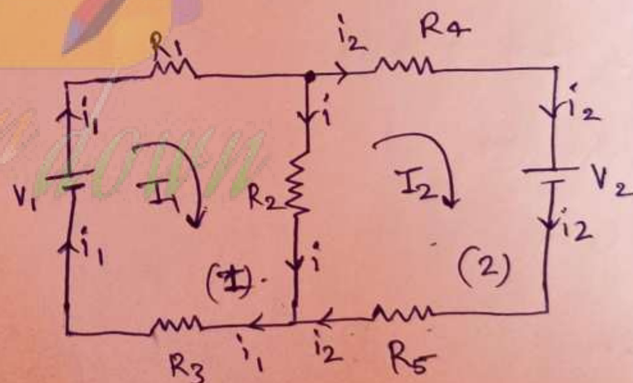
$4 = V - 8V$

$\boxed{V = -\frac{4}{7}}$

so $\boxed{4V = -\frac{16}{3} A}$

Mesh Analysis :-

~~KCL in mess 01~~



KCL

$\boxed{i + i_2 = i_1}$

KVL in mess 1

$V_1 - i_1R_1 - iR_2 - i_1R_3 = 0$

$\boxed{V_1 = i_1R_1 + i_1R_3 + iR_2}$

$V_1 = i_1R_1 + i_1R_3 + i_1R_2 - i_2R_2$

$\boxed{V_1 = i_1(R_1 + R_2 + R_3) - i_2R_2}$

KVL in mess 2

$-V_2 - i_2R_5 + iR_2 - i_2R_4 = 0$

$\boxed{V_2 = iR_2 - i_2R_5 - i_2R_4}$

$\boxed{V_2 = -I_2(R_4 + R_5 + R_2) + I_1R_2}$

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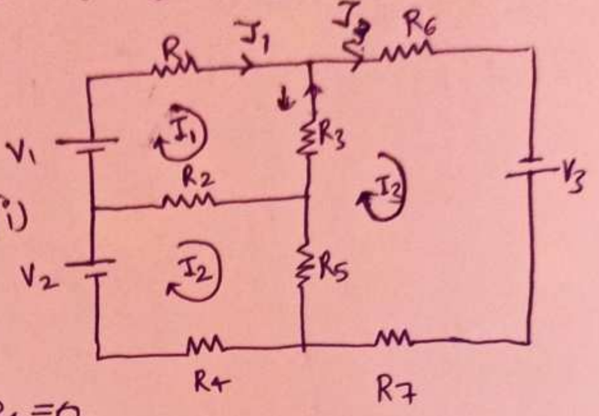
$\boxed{\text{BEE}}$

★ Mess analysis using Matrix form :- (Analog to KVL)



Mesh I:

$V_1 - I_1R_1 - (I_1-I_3)R_3 - (I_1-I_2)R_2 = 0$

$I_1(R_1+R_2+R_3) - I_2R_2 - I_3R_3 = V_1$ -(i)

Mesh II:

$V_2 - (I_2-I_1)R_2 - (I_2-I_3)R_5 - I_2R_4 = 0$

$-I_1(R_2) + I_2(R_2+R_5+R_4) - I_3R_5 = V_2$ --(ii)

Mesh III:

$V_3 - (I_3-I_2)R_5 - (I_3-I_1)R_3 - I_3R_7 - I_3R_6 = 0$

$-I_1R_3 - I_2R_5 + I_3(R_5+R_3+R_7+R_6) = V_3$ --(iii)

∴ in matrix form -

$$\begin{bmatrix} R_1+R_2+R_3 & -R_2 & -R_3 \\ -R_2 & R_2+R_4+R_5 & -R_5 \\ -R_3 & -I_2 & R_5+R_3+R_7+R_6 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix}$$

$$\begin{bmatrix} R_{11} & R_{12} & R_{13} \\ R_{21} & R_{22} & R_{23} \\ R_{31} & R_{32} & R_{33} \end{bmatrix}$$

(i) Calculate Δ

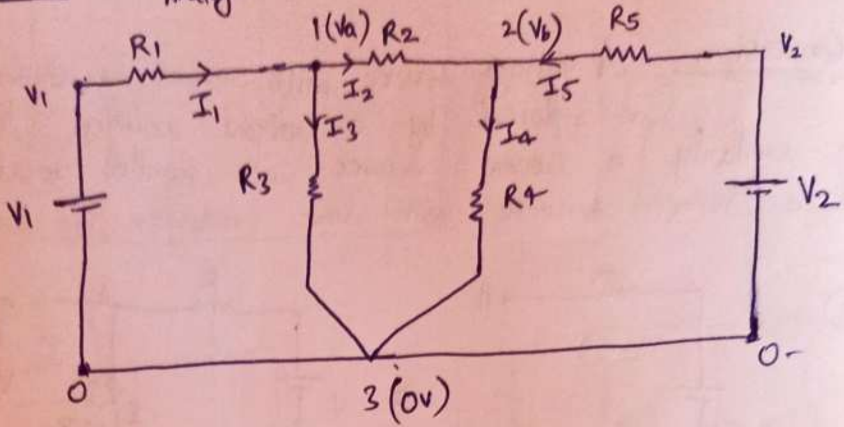
(ii) $\Delta_1 \begin{bmatrix} V_1 & R_{12} & R_{13} \\ V_2 & R_{22} & R_{23} \\ V_3 & R_{32} & R_{33} \end{bmatrix}$

(iii) Δ_2

(iv) Δ_3

$$\boxed{I_1 = \frac{\Delta_1}{\Delta} \quad I_2 = \frac{\Delta_2}{\Delta} \quad I_3 = \frac{\Delta_3}{\Delta}}$$

☆ Nodal Analysis :- (Analog to KCL)



KCL at Node 1: $I_3 = I_1 - I_2$

$$I_1 = I_2 + I_3$$

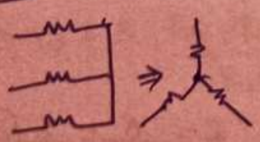
$$\frac{V_a - V_1}{R_1} = \frac{V_a - V_b}{R_2} + \frac{V_a - 0}{R_3}$$

At node 2:

$$I_4 = I_2 + I_5$$

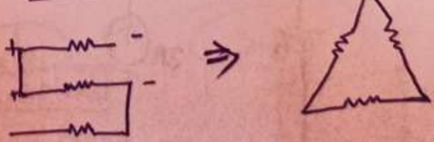
$$\frac{V_b - 0}{R_4} = \frac{V_a - V_b}{R_2} + \frac{V_2 - V_b}{R_5}$$

Star:



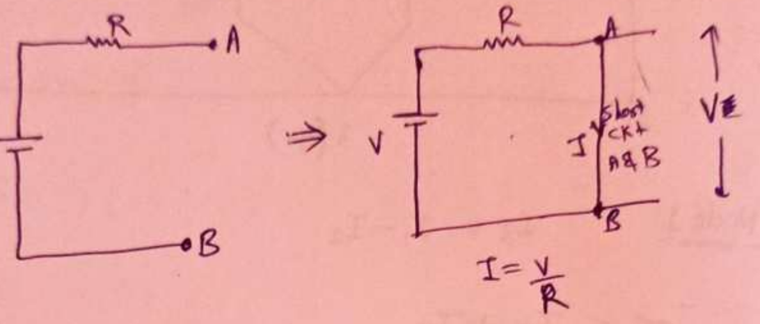
Short ckt
Same polarity connected

Delta:



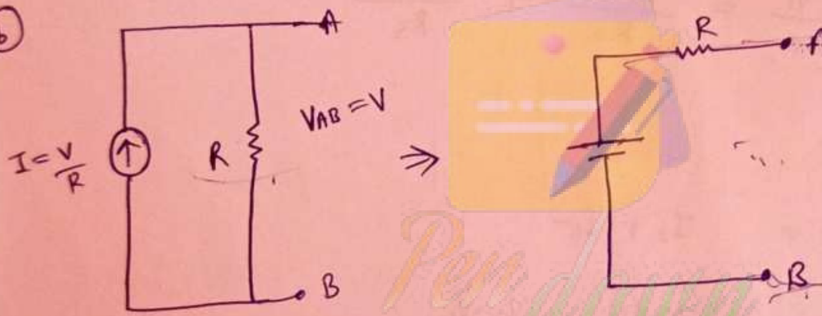
"Diff" polarity connected to 3 resistors, ① **Source Conversion**:- A voltage source with series resistance can be converted or replaced by a current source with same resistor in parallel. similarly a current source with parallel resistor can be converted a voltage source with same resistor in series

ⓐ

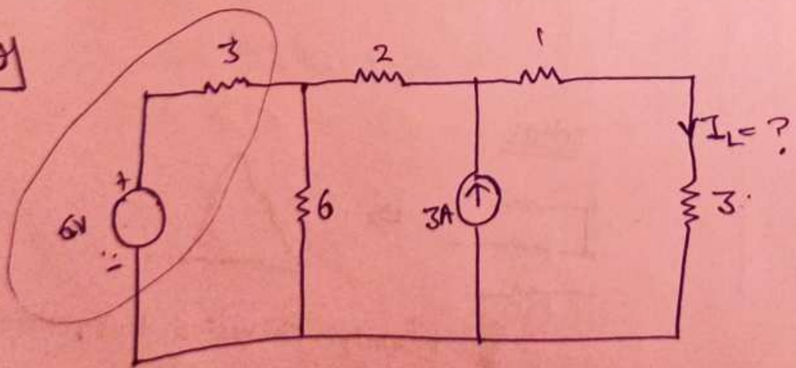


$I = \frac{V}{R}$

ⓑ



Q



Solⁿ

$I_1 = \frac{6}{9} = \frac{2}{3}$ A

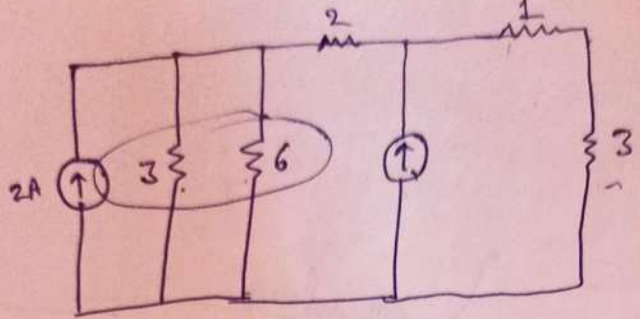
11Ω ⊕ $I = \frac{2}{3}$ A

+3

$\boxed{V = \frac{22}{3} V}$

$\frac{11}{3}$ A

Converted
esistor in



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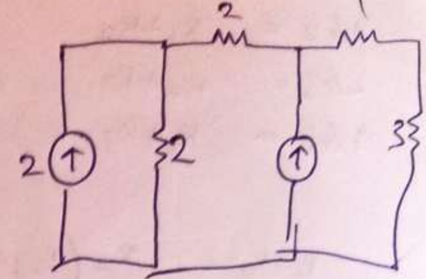

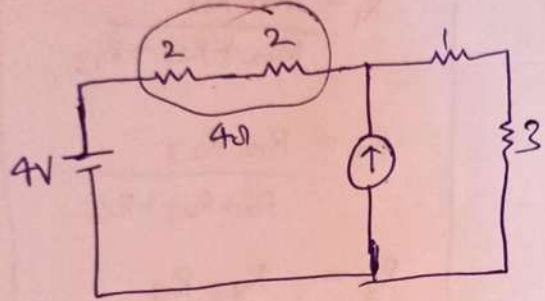

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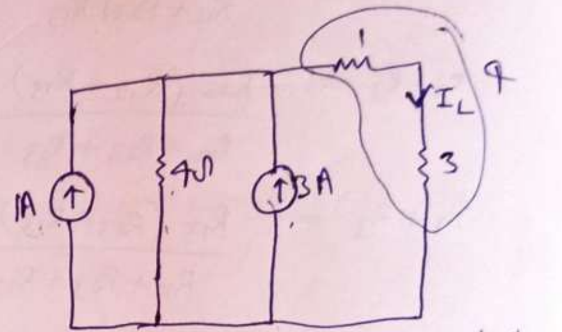
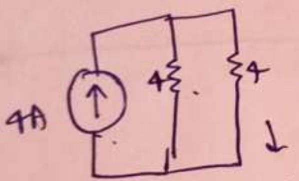


Since Resistance of both paths are equal so

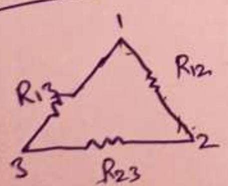
$\boxed{I_L = 2A}$ i.e $\left(\frac{3+1}{2}\right)A$



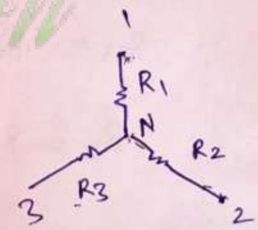
Current division rule

② Delta to Star Conversion:

(Δ, D/d)



⇒



(Y form), y

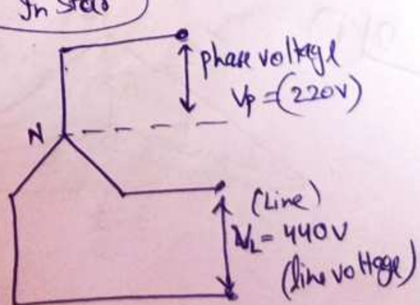
In Star

$$1\&2 = \frac{R_{12}(R_{23}+R_{13})}{R_{12}+R_{23}+R_{13}}$$

In delta both are same

$$2\&3 = \frac{R_{23}(R_{12}+R_{13})}{R_{12}+R_{23}+R_{13}}$$

$$3\&1 = \frac{R_{13}(R_{23}+R_{13})}{R_{12}+R_{23}+R_{13}}$$



$\boxed{V_L = \sqrt{3} V_p}$

$\frac{2}{3}$ A

= A
+3
$\frac{11}{3}$ A

1 & 2 = $R_1 + R_2$

2 & 3 = $R_2 + R_3$

1 & 3 = $R_1 + R_3$

$$R_1 + R_2 = \frac{R_{12}(R_{23} + R_{13})}{R_{12} + R_{23} + R_{13}}$$

$$R_2 + R_3 = \frac{R_{23}(R_{12} + R_{13})}{R_{12} + R_{23} + R_{13}}$$

$$R_1 + R_3 = \frac{R_{13}(R_{23} + R_{13})}{R_{12} + R_{23} + R_{13}}$$

On solving

$$\boxed{\begin{aligned} R_1 &= \frac{R_{12} R_{13}}{R_{12} + R_{23} + R_{13}} \\ R_2 &= \frac{R_{12} R_{23}}{R_{12} + R_{23} + R_{13}} \\ R_3 &= \frac{R_{23} R_{13}}{R_{12} + R_{23} + R_{13}} \end{aligned}}$$

Ans

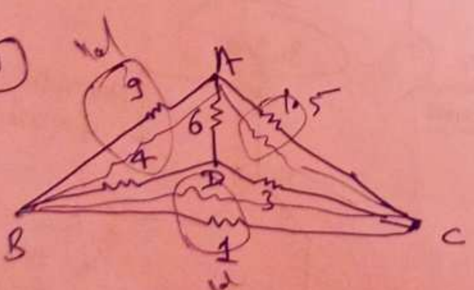
★ $\boxed{\text{Star} \rightarrow \text{Delta}}$:-

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

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

$$R_{13} = R_1 + R_3 + \frac{R_1 R_3}{R_2}$$

Q(1)



$R_{AB} = ?$

$R_{BC} = ?$

$R_{AC} = ?$