29/07/16

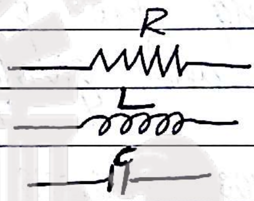
Network Analysis (Electrical Circuit Analysis)

Chapter - 1

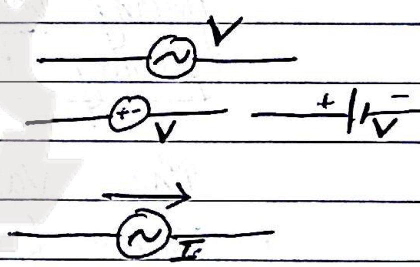
Basics About Network Analysis

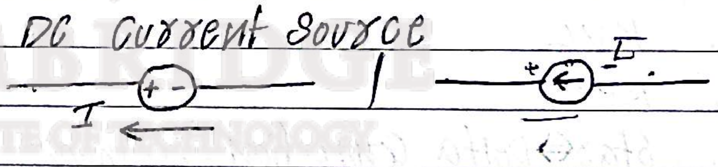
The various electrical elements are passive elements and active elements.

Passive elements are : i) Resistor
ii) Inductor
iii) Capacitor



Active elements are : i) Voltage source
a) AC voltage source
b) DC voltage source
ii) Current Source
a) AC current source
b) DC current source



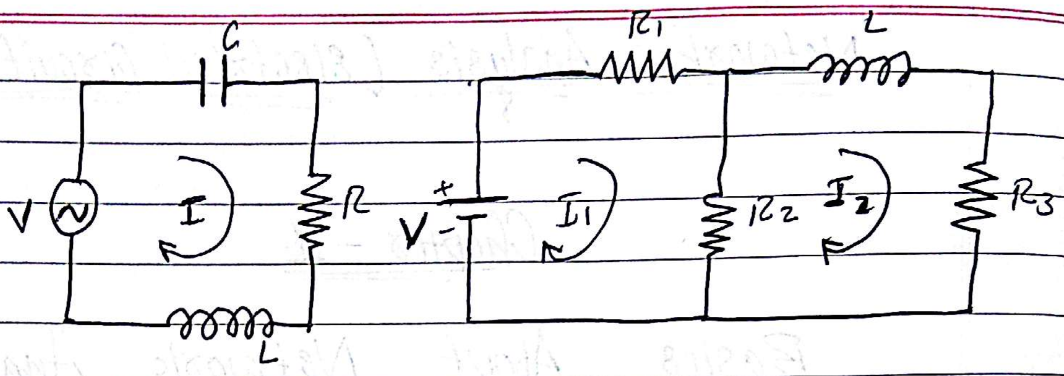


(Always current flows from positive polarity to negative polarity).

Electrical Circuit (or) Network :

A interconnection of various electrical elements (both passive and active) in the form of a closed path so that current flows through that is called electrical ckt / N/w.

Ex:



Network Analysis means studying about the given electrical network, understanding about its operation, rectifying the problems present in that (during failure) and giving a solution for the system.

NA gives various techniques or methods to solve the given electrical network, in the form of finding voltage across the N/w element or current flowing through the N/w via various elements.

The various ~~the~~ ~~are~~ NA techniques available are:

1. Ohm's Law
2. KVL
3. KCL
4. Star⇔Delta Connection / Technique.
5. Source Shifting
6. Loop Analysis.
7. Node Analysis

etc;

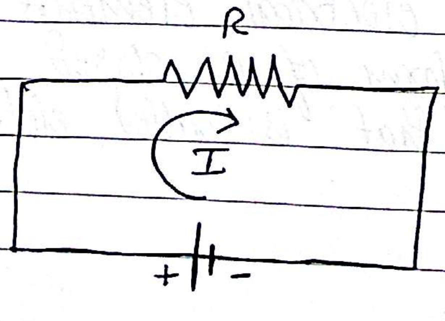
$P = VI$

$P = \frac{V^2}{R}$

$P = I^2 R$.

Passive Elements:

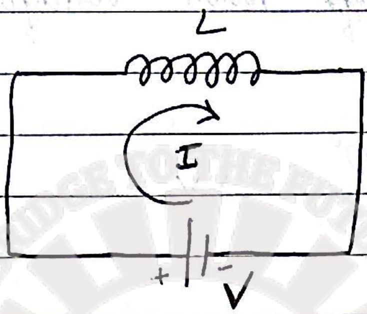
1. Resistor (R):



According to Ohm's Law, $\boxed{V = IR \quad I = \frac{V}{R}}$

In Resistor, V and I are in same phase.

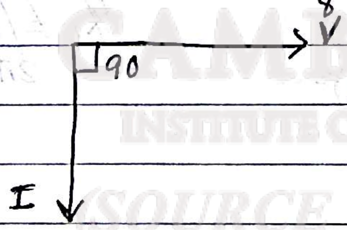
2. <u>Inductor:</u>



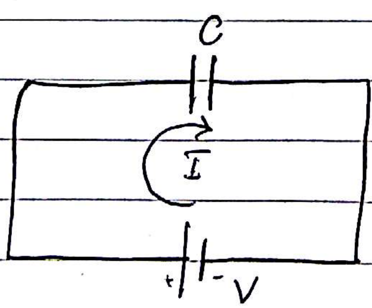
Voltage across the inductor, $V = I X_L$
where, X_L = inductive reactance
$X_L = 2\pi f L$

Also, voltage across inductor, $\boxed{V = L\frac{dI}{dt} \quad I = \frac{1}{L}\int V\,dt}$

In Inductor, current lags voltage by $90°$.



3) <u>Capacitor:</u>

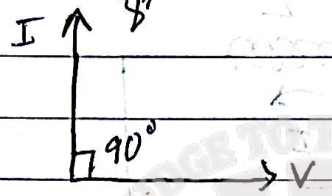


Voltage across the capacitor, $V = I X_C$
where, X_C = capacitive reactance
$X_C = \frac{1}{2\pi f C}$

Also, ~~v(t)~~ $I = C\frac{dv}{dt}$

$$V = \frac{1}{C}\int I \cdot dt$$

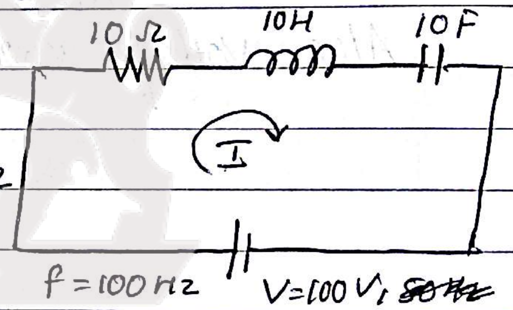
In capacitor current ~~voltage~~ leads voltage by 90°.



Impedance:

It is the total opposition made by the circuit if circuit consisting of R, L, C

Impedance $(Z) = R + jX_L - jX_C$



$Z = R + jX_L - jX_C$	$X_L = 6283.185\,\Omega$
$Z = 10 + j(X_L - X_C)$	$X_C = 1.591 \times 10^{-4}\,\Omega$
~~Z = 10 + j(3181.5)~~	

$Z = 10 + j(6283.18)$

$Z =$

~~$X_L = 2\pi f L = 1000\pi$~~

~~$X_C = \frac{1}{2\pi f C} = 3.1830 \times 10^{-4}\,\Omega$~~

Now, $|Z| = \sqrt{(10)^2 + (6283.1)^2}$

$= 6283.10\,\Omega$ #

$I = \frac{V}{|Z|} = \frac{100}{6283.10}$

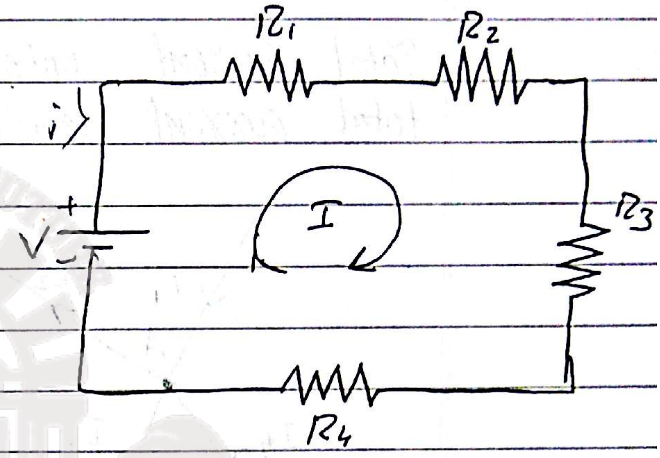
$I = 0.015$ Amp #

Admittance (Y):

It is the reciprocal of impedance,

i.e., $Y = \frac{1}{Z}$

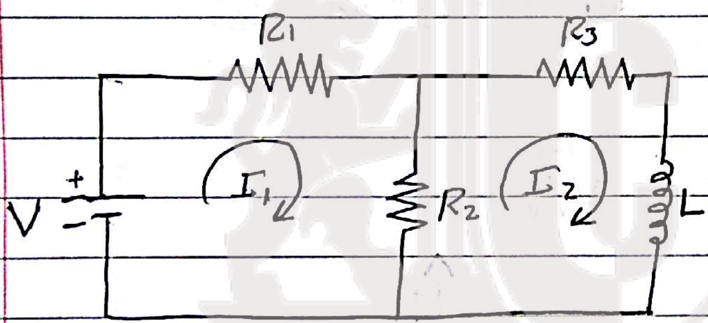
Kirchhoff's Voltage law:



$V = IR_1 + IR_2 + IR_3 + IR_4$

$V = I[R_1 + R_2 + R_3 + R_4]$

Total voltage = Sum of the voltage drops produced



KVL for Loop-I is,

$V = I_1 R_1 + I_1 R_2 - I_2 R_2$

$V = I_1 R_1 + R_2 (I_1 - I_2)$

KVL for Loop-II is,

$0 = I_2 R_3 + I_2 jX_L + I_2 R_2 - I_1 R_2$

$0 = I_2 R_3 + I_2 jX_L + R_2 (I_2 - I_1)$

Note:

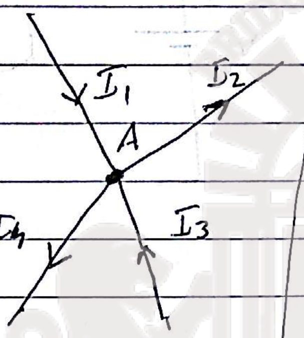
Series → Voltage
~~Current → B.~~ } → concept
Parallel → Current

Kirchhoff's Current Law:

Algebraic summation of all the currents at a node or junction is zero.

(or)

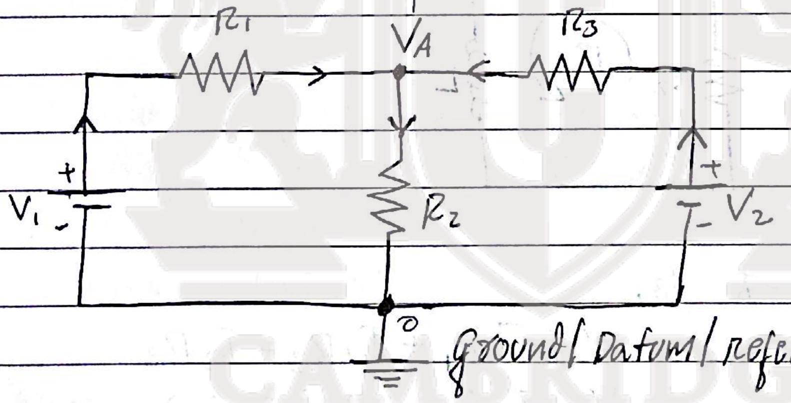
Total current entering into a node is equal to total current leaving away from the node.



According to KCL,

$$I_1 + I_3 = I_2 + I_4$$

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



ground/ Datum/ reference Node.

V_A – Node Voltage

According to KCL:

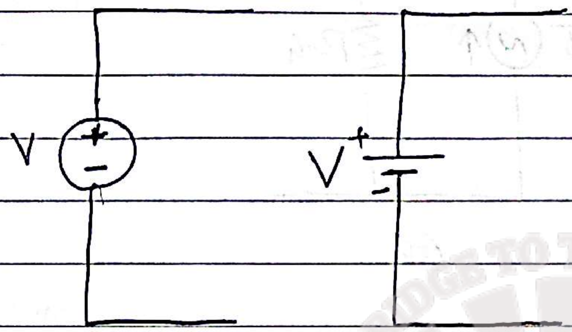
At Node V_A:

$$\frac{V_1 - V_A}{R_1} + \frac{V_2 - V_A}{R_3} = \frac{V_A - 0}{R_2}$$

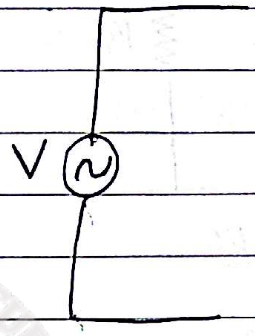
$$\frac{V_1}{R_1} + \frac{V_2}{R_3} - V_A\left(\frac{1}{R_1} + \frac{1}{R_3}\right) - \frac{V_A}{R_2} = 0$$

Voltage Sources

a. Ideal Voltage Source

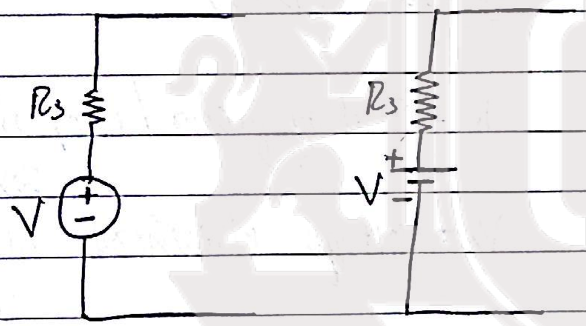


DC Voltage

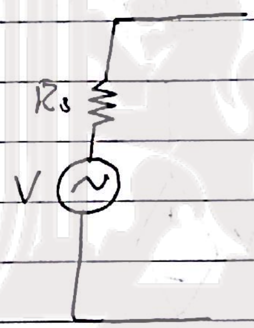


AC Voltage.

b. Practical Voltage Source



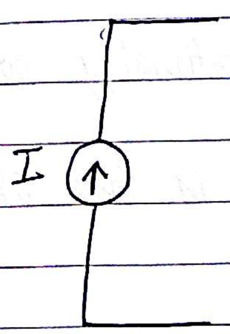
DC



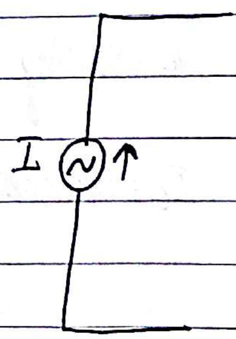
AC

Current Sources

a. Ideal Current Source



D.C



A.C

Date ____
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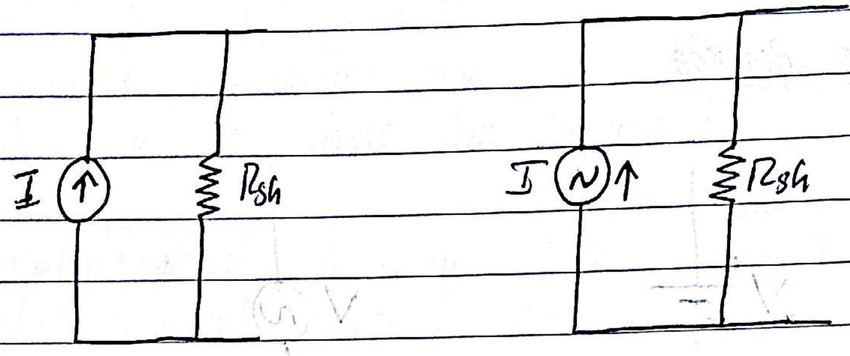
6. Practical Current sources

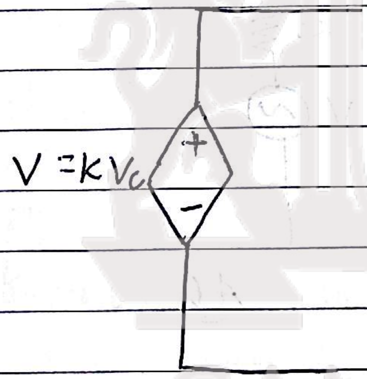


DC AC

Dependent sources

There are 4 types of dependent sources:

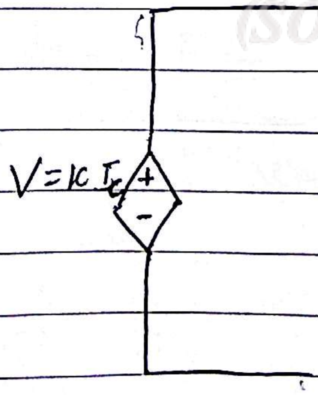
i. Voltage Dependent voltage source (VDVS):



K = Scaling factor / Proportionality constant.

V_c = Voltage elsewhere in the circuit.

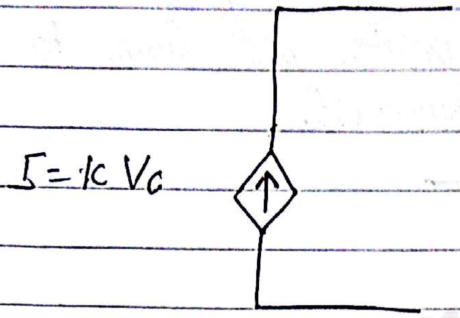
ii. Current Dependent Voltage Source (CDVS):



K = Scaling factor / Proportionality constant

I_c = Current elsewhere in the ckt.

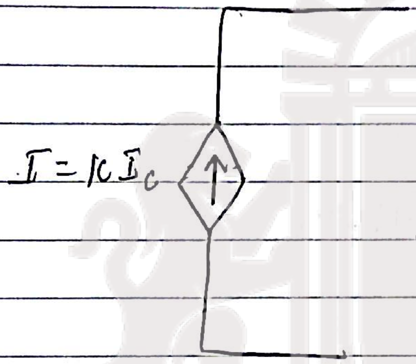
iii. Voltage Dependent Current Source (VDCS):



k = scaling factor / proportionality const.

V_c = Voltage elsewhere in the ckt.

iv. Current Dependent Current Source (CDCS):

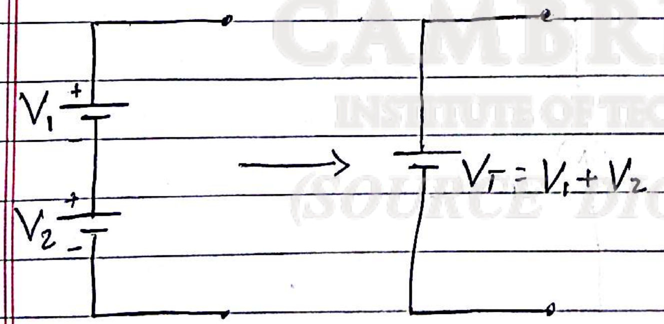


k = scaling factor / proportionality const.

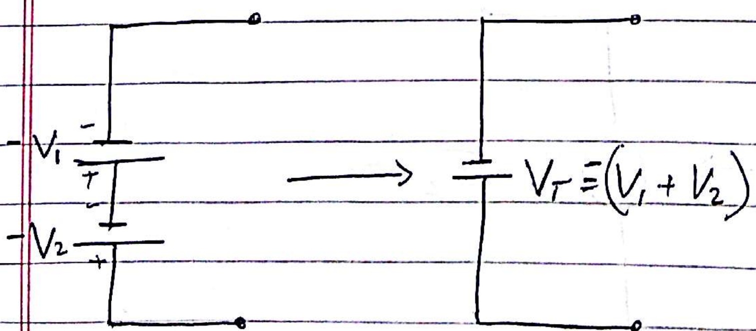
I_c = Current elsewhere in the ckt.

Addition & Subtraction of Voltage Sources:
(Combination of Voltage Sources)

1.



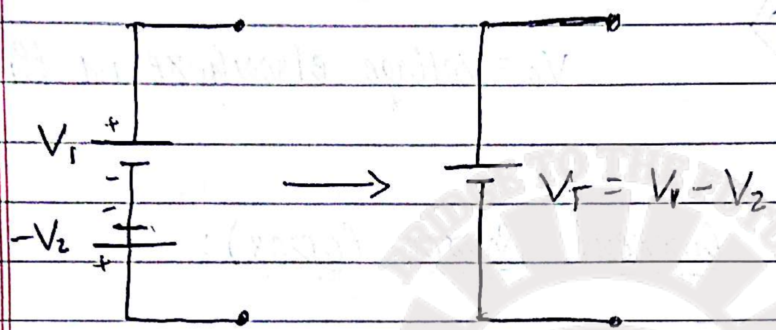
2.



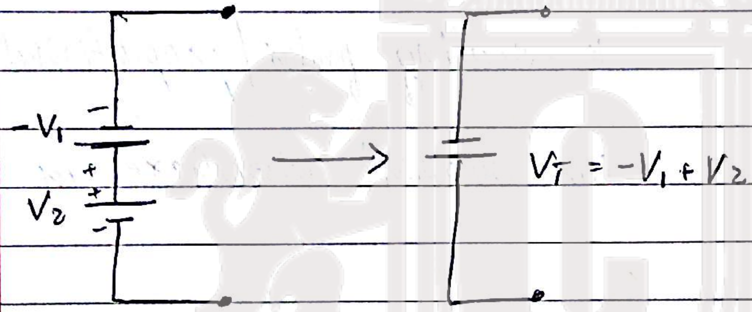
Note:

If the middle polarities of the two voltage sources are opposite, we have to add otherwise we have to subtract.

3.



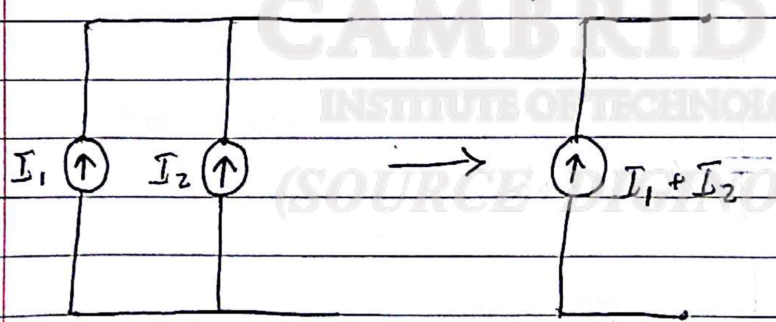
4.



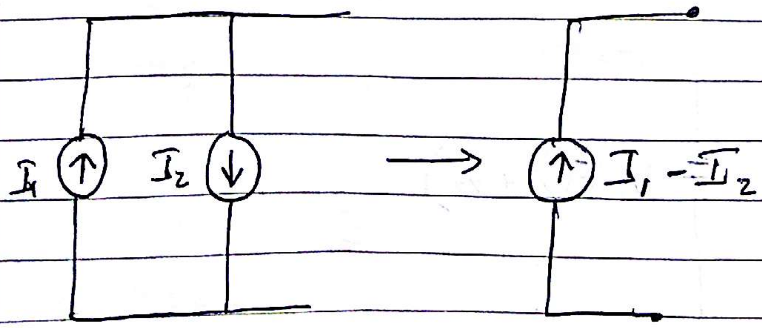
$(V_1 > V_2)$

Addition & subtraction of current sources:

1.



2.

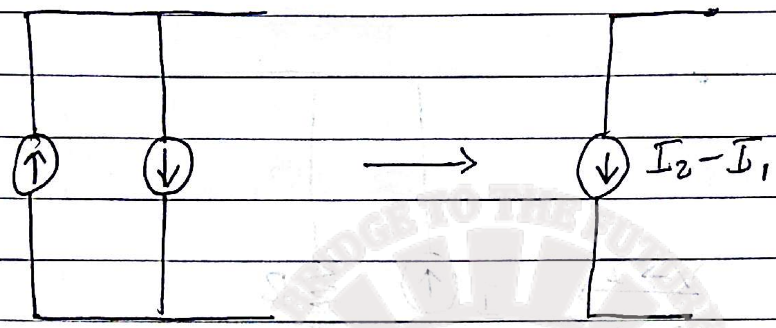


$I_1 > I_2$

Note:

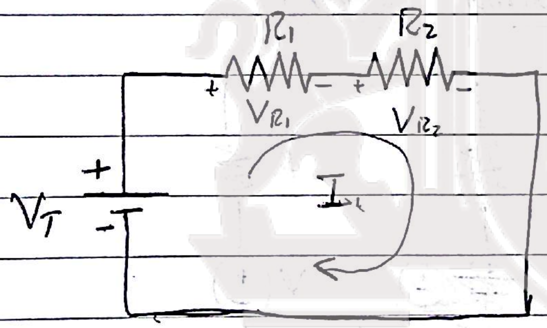
Current sources are added when they are in same direction otherwise subtracted.

3\.



$I_2 > I_1$

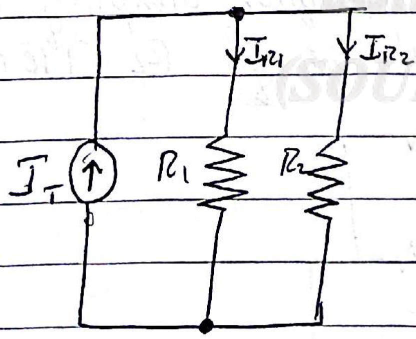
Voltage Divider Rule:



$$V_{R_1} = \frac{V_T \cdot R_1}{R_1 + R_2}$$

$$V_{R_2} = \frac{V_T \cdot R_2}{R_1 + R_2}$$

Current Divider Rule:

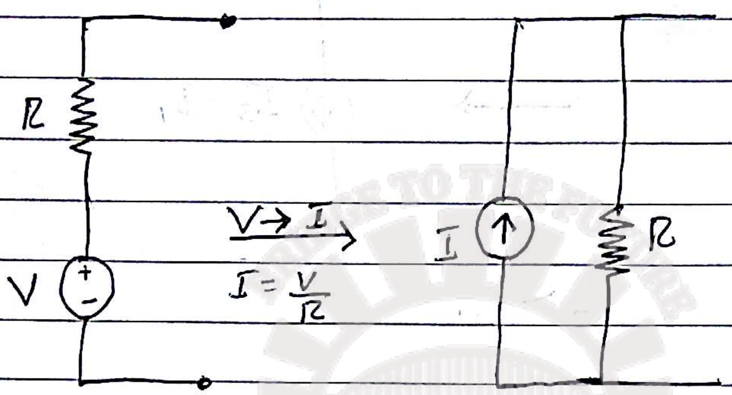


$$I_{R_1} = \frac{I_T \times R_2}{R_1 + R_2}$$

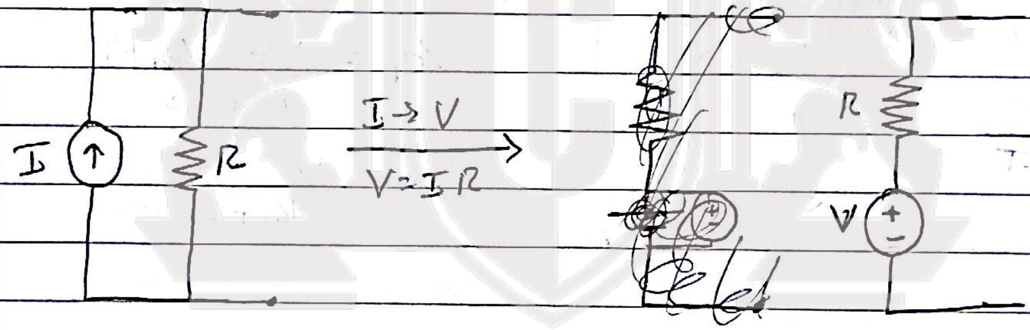
$$I_{R_2} = \frac{I_T \times R_1}{R_1 + R_2}$$

Source Transformation:

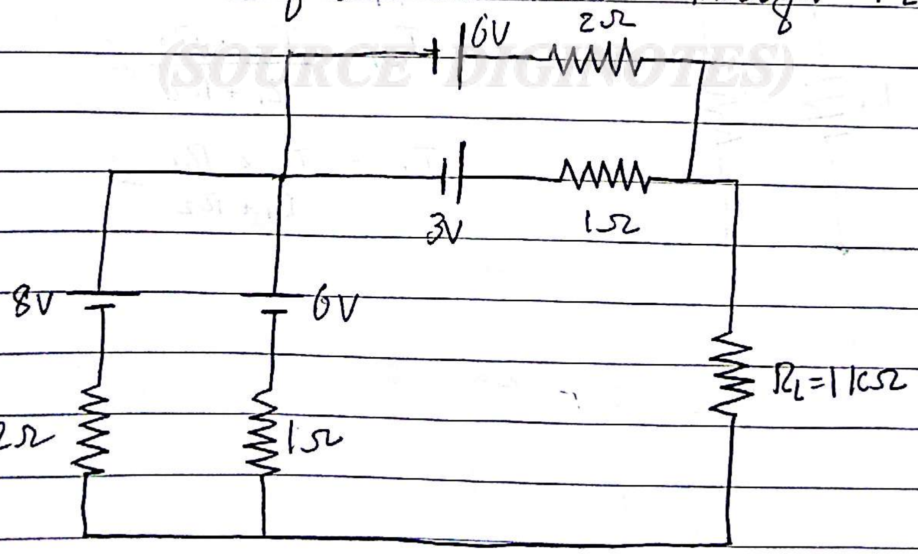
1. Voltage - Current Transformation ($V \rightarrow I$).



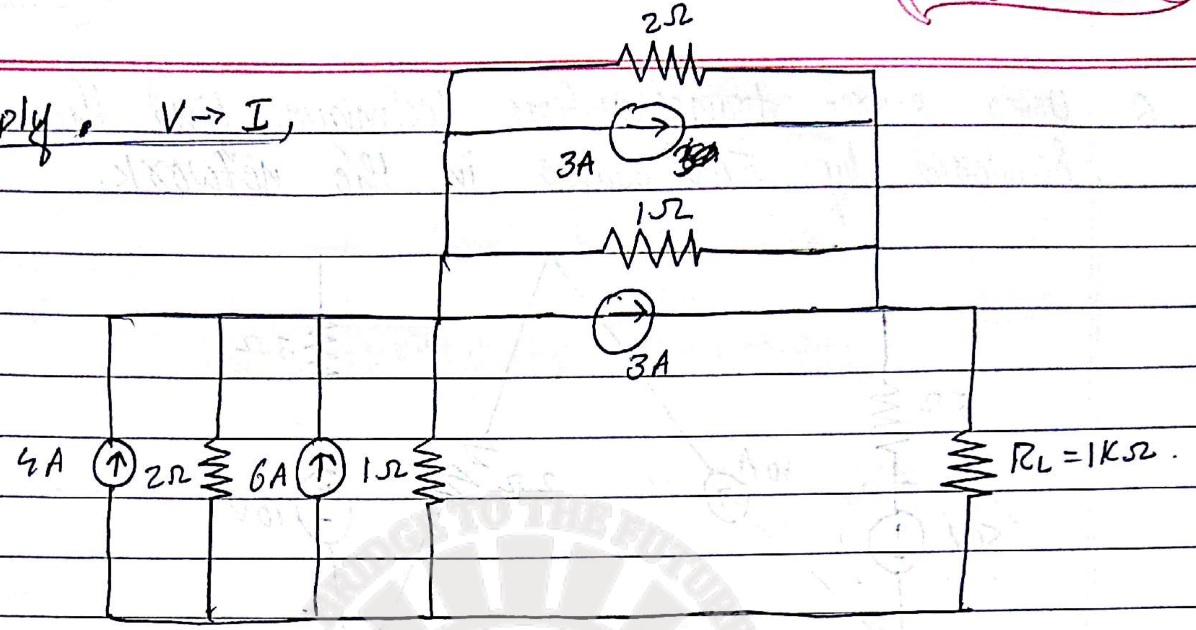
2. Current - Voltage Transformation ($I \rightarrow V$):

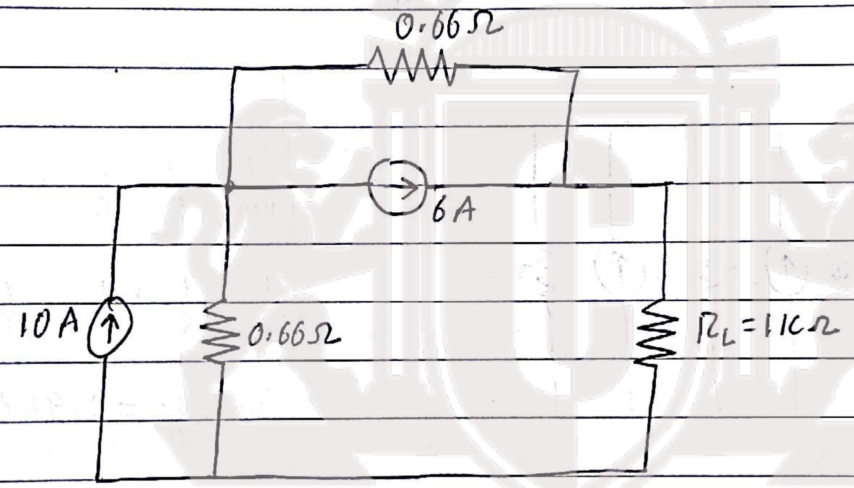


Q. Using current transformation technique, simplify the given N/w & find the current through $R_L = 1k\Omega$.

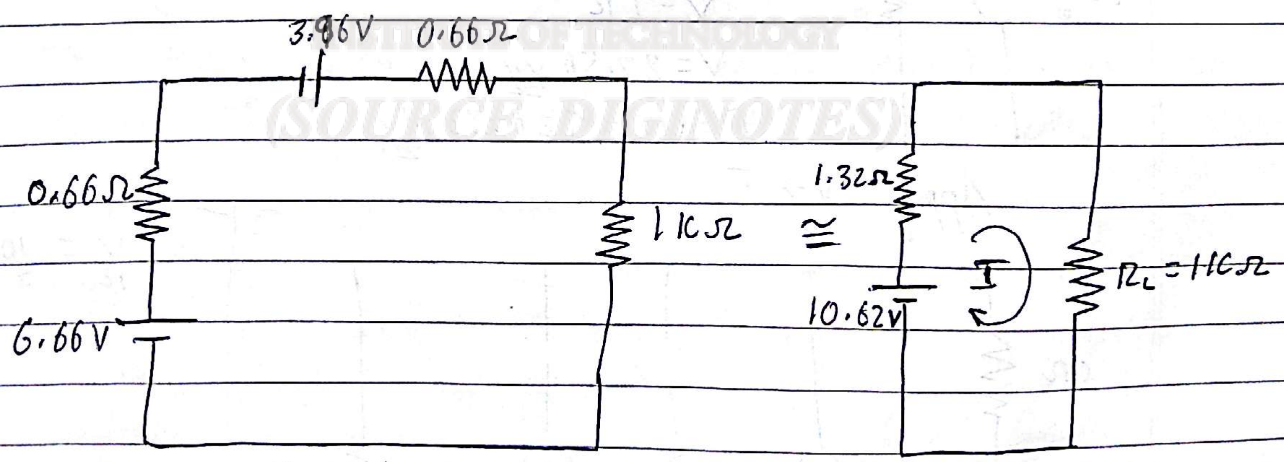


Apply, $V \to I$,





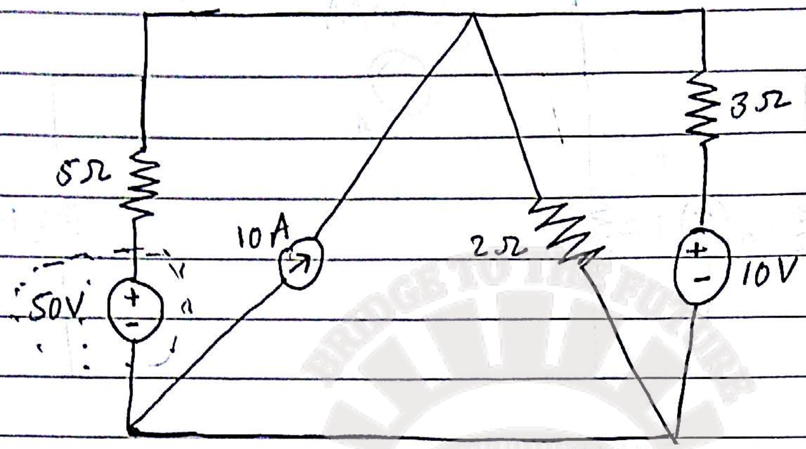
Apply $I \to V$,

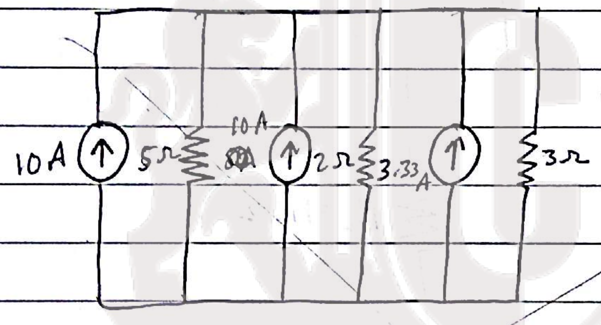


$\therefore$ Current through $R_L = I_{R_L} = \dfrac{10.62}{1000+1.32} = 0.0106\,A$

$= 10.6\,mA$

Q. Using source transformation technique, find the power delivered by 50V source in the network.

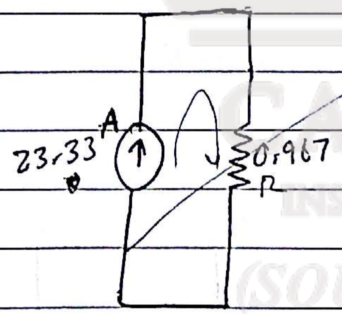




$$\frac{1}{R_{eqv}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\frac{1}{R_{eqv}} = \frac{1}{5} + \frac{1}{2} + \frac{1}{3} = \frac{31}{30}$$

$$R_{eqv} = \frac{30}{31} = 0.967$$

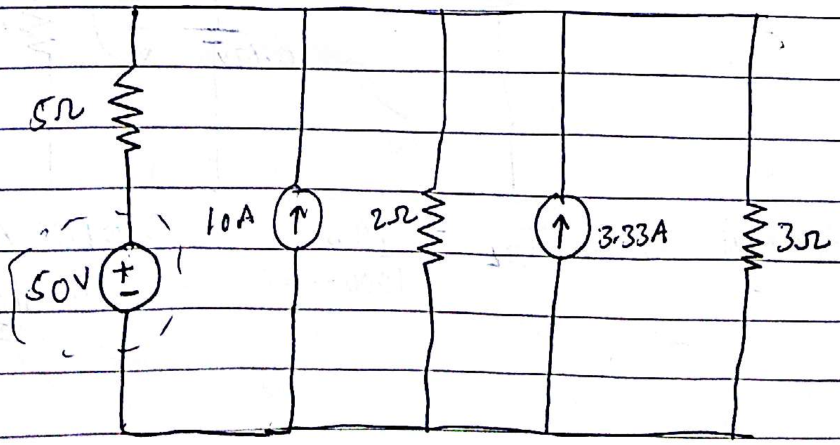


$V = IR$

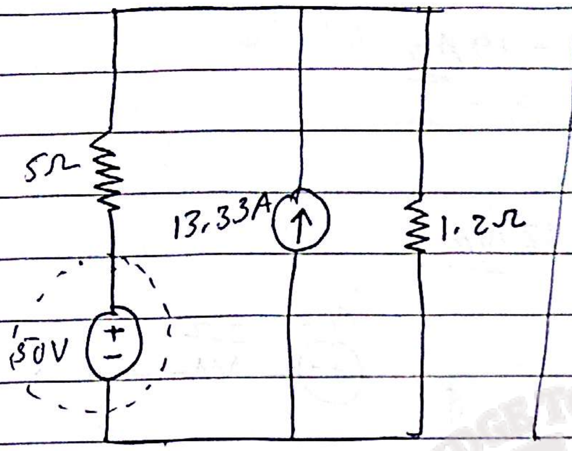
$V = 22.56\ V$

$P = VI = 526.132\ W$

Apply V -> I



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

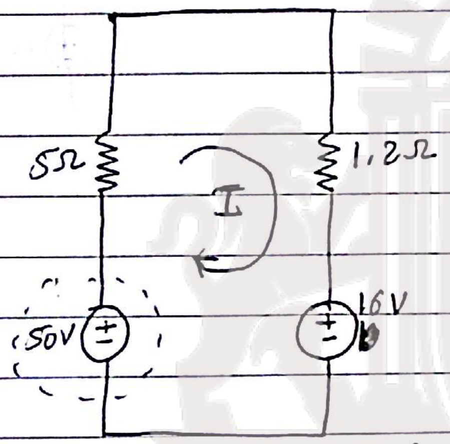


Apply I → V

$V = IR$

$V = 13.33 \times 1.2$

$V = 15.99\,V$



$I = \frac{V}{R} = \frac{50-16}{6.2} = \frac{34}{6.2}$

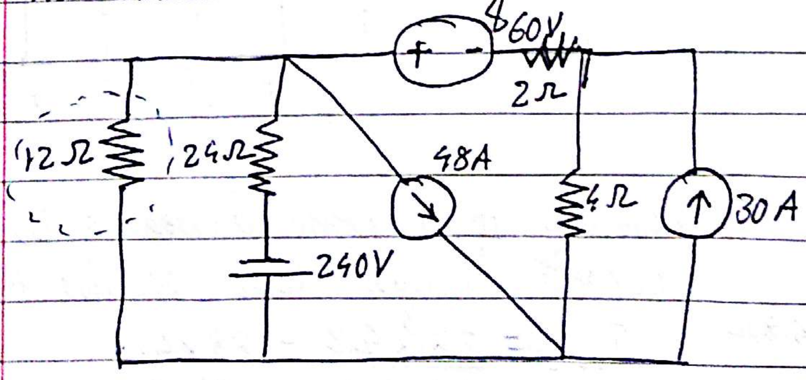
$I = 5.48\,A$

∴ Power delivered by 50V source is,

$P_{50V} = V \times I = 50 \times 5.48$

$P_{50V} = 274.2\,W$

Q. Find the current through 12Ω resistor in the network shown using the source transformation technique.

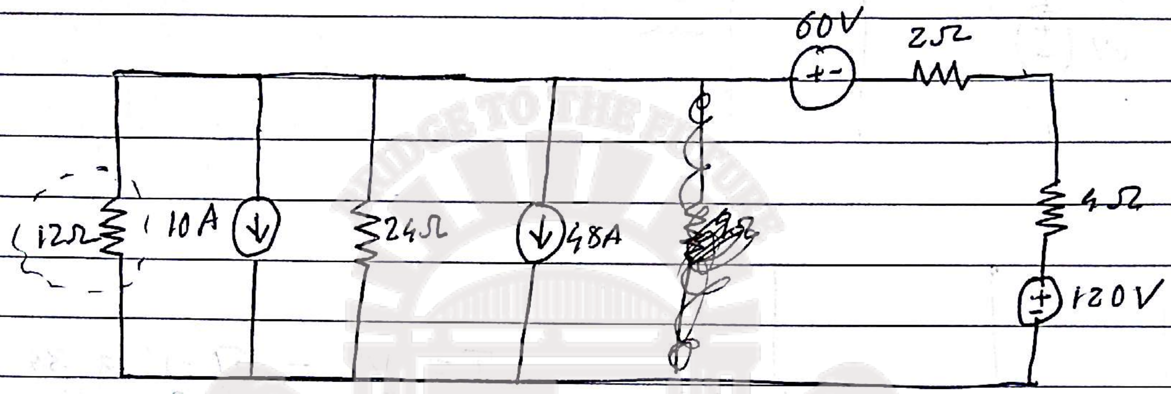


Apply V → I

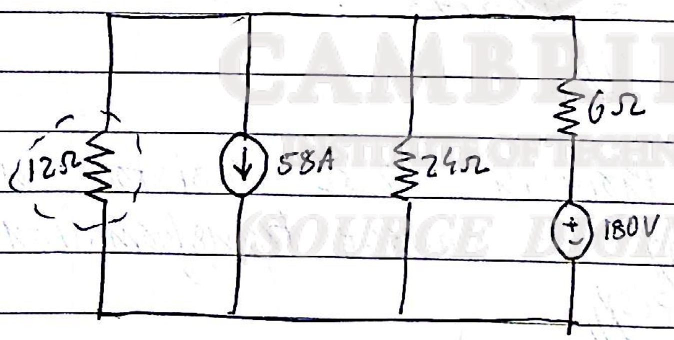
$$I = \frac{V}{R} = \frac{240}{24} = 10A$$

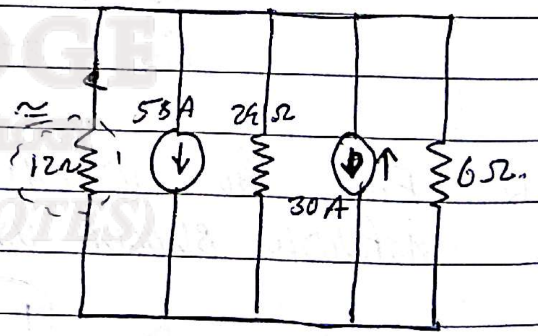
Apply I → V

$$V = IR = 30 \times 4 = 120V$$

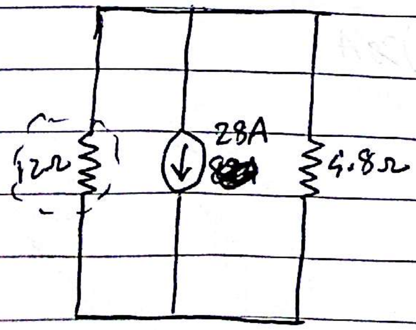


Apply V → I





$$I = \frac{V}{R} = \frac{180}{6} = 30A$$

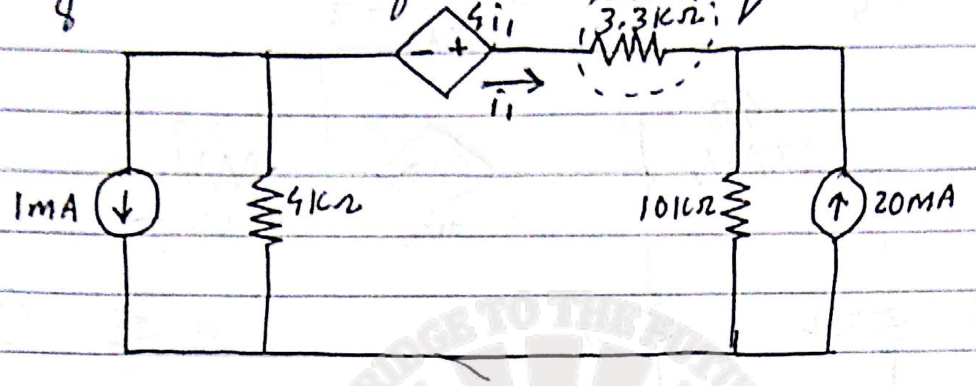


According to current divider rule, current through 12Ω resistor is,

$$I_{12\Omega} = \frac{28 \times 4.8}{12 + 4.8} = \frac{28 \times 4.8}{16.8}$$

$$I_{12\Omega} = 8A$$

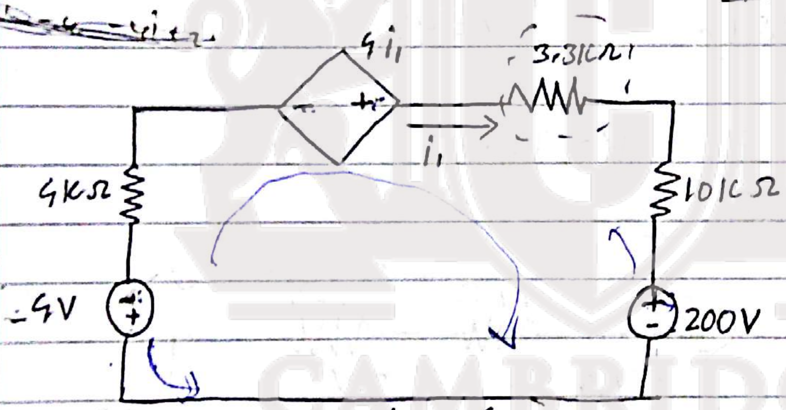
Q. Find the current i_1 in the network shown using source transformation technique.

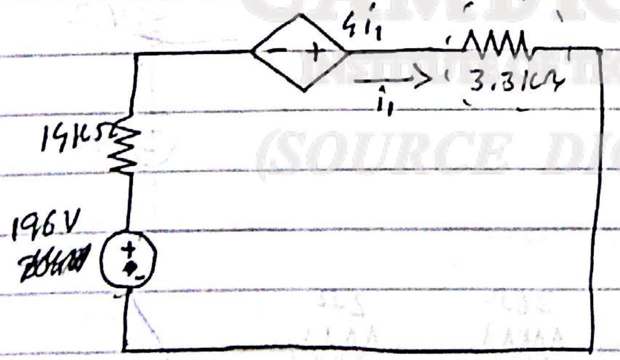


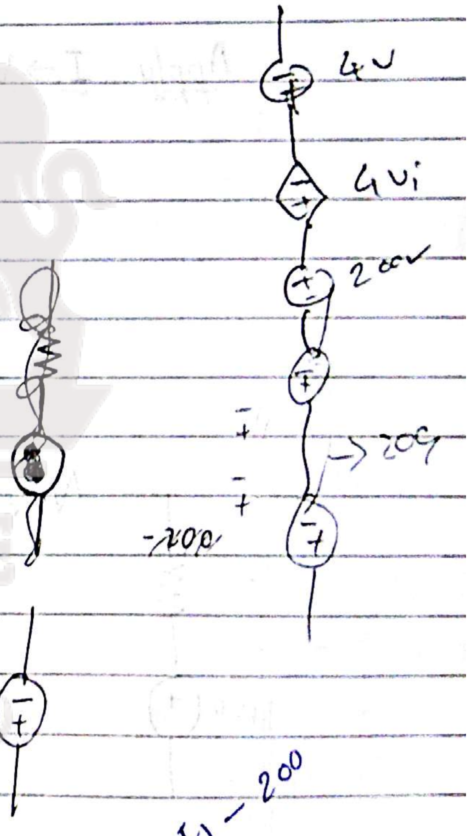
Apply $I \to V$:

$V = IR = 10^{-3} \times 4 \times 10^{3} = 4V$

$V = 20 \times 10^{-3} \times 10 \times 10^{3} = 200V$







$\ominus 4 - 4i_1 - 200$

Current $i_1 = \frac{V}{R} = \frac{196 - 4i_1}{17.3 \times 10^3}$

$17.3 \times 10^3 \times i_1 = 196 - 4i_1 \Rightarrow i_1 (4 + 17.3 \times 10^3) = 196$

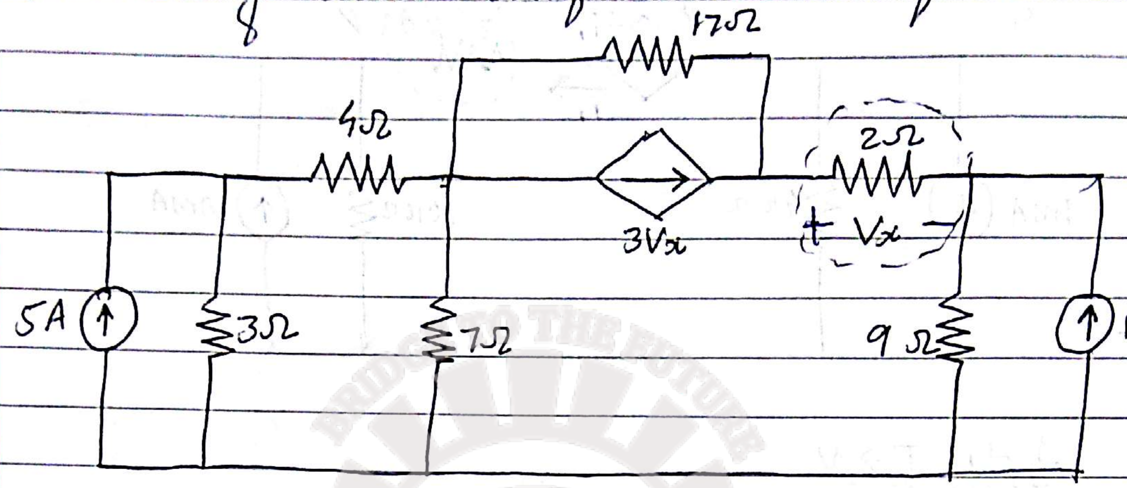
$i_1 = \frac{196}{17304} = 0.0113$

$-4 - 4i_1 + 200$

$200 = 4i_1 - 4$

$i_1 = 11.3 mA$

Q. Find the current through 2Ω resistor in the n/w shown using source transformation technique.



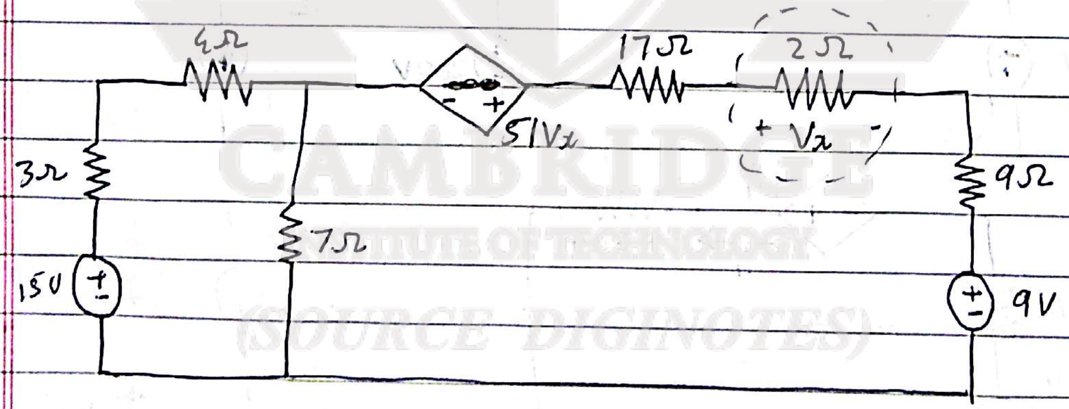
Apply $I \to V$

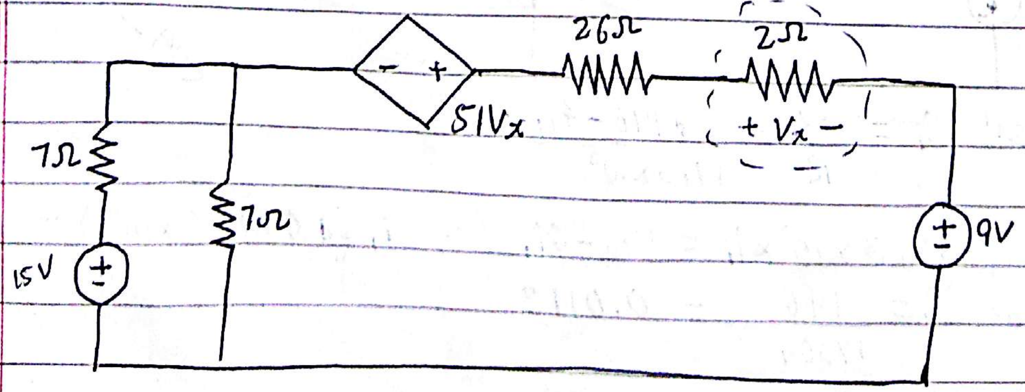
$V = IR = 5 \times 3$ | $V = IR = 1 \times 9$

$V = 15V$ | $V = 9V$

$V = IR \Rightarrow V = 3V_x \times 17$

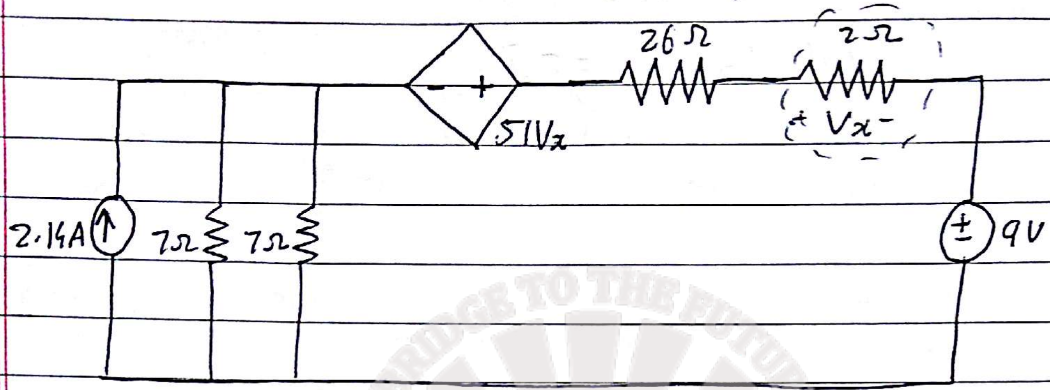
$V = 51V_x$



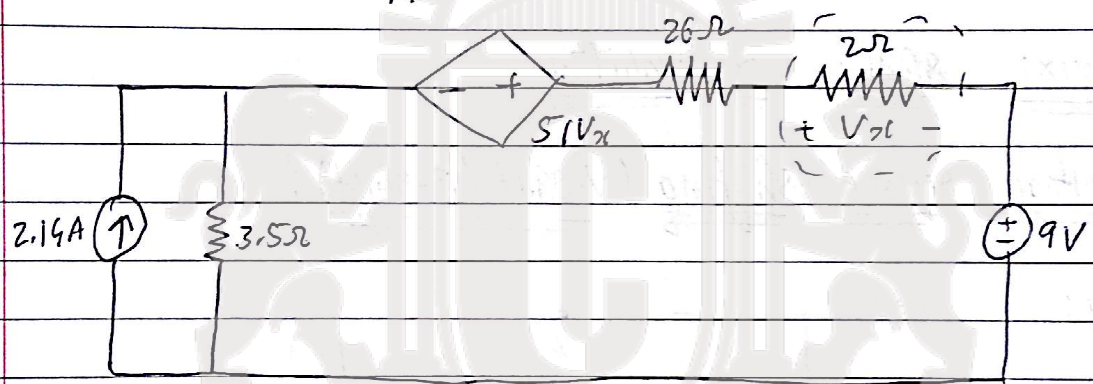


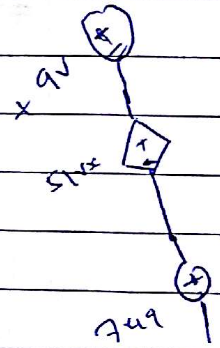
Apply V → I,

$$I = \frac{V}{R} = \frac{15}{7} = 2.14\,A$$



$$R_{equ} = \frac{7 \times 7}{14} = 3.5\Omega.$$

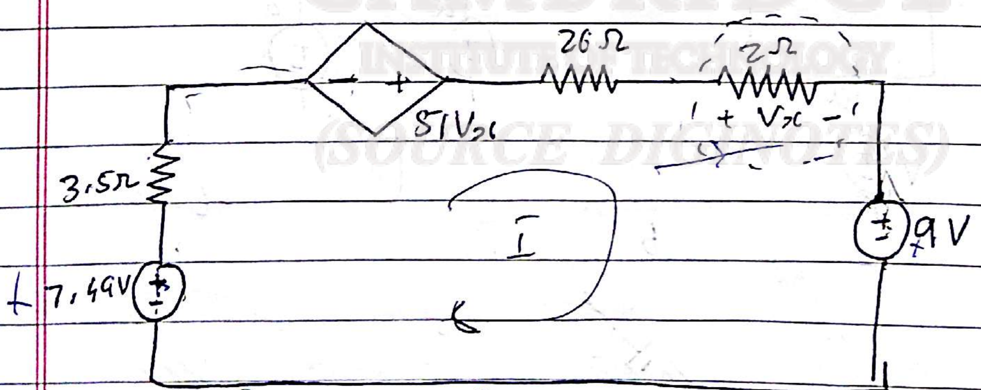


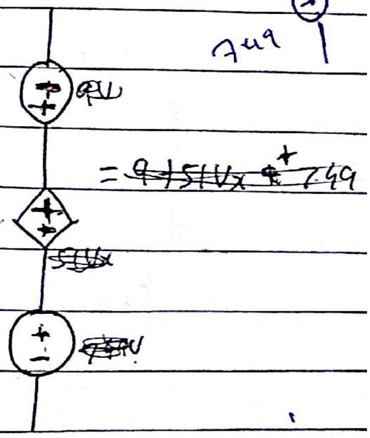


Apply: I → V.

$$V = IR$$

$$V = 2.14 \times 3.5 = 7.49V$$





∴ Current through 2Ω resistor,

$$I_{2\Omega} = \frac{V}{R} = \frac{-7.49 - 51V_x + 9}{31.5} \quad (V_x = I \times 2 = 2I).$$

$$31.5I = 1.51 - 51(2I) \Rightarrow 31.5I = 1.51 - 102I$$

$$133.5I = 1.51 \Rightarrow I =$$

+7.49 + 51Vx − 9V

∴ Current through 2Ω resistor,

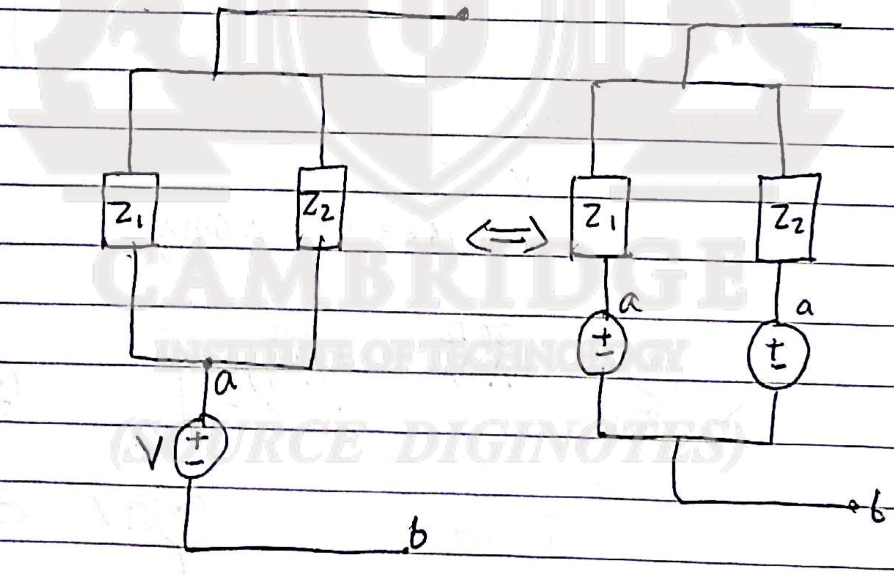
$$I = \frac{V}{R} = \frac{7.49 + 51V_x - 9}{31.5}$$

but $V_x = I2 = 2I$.

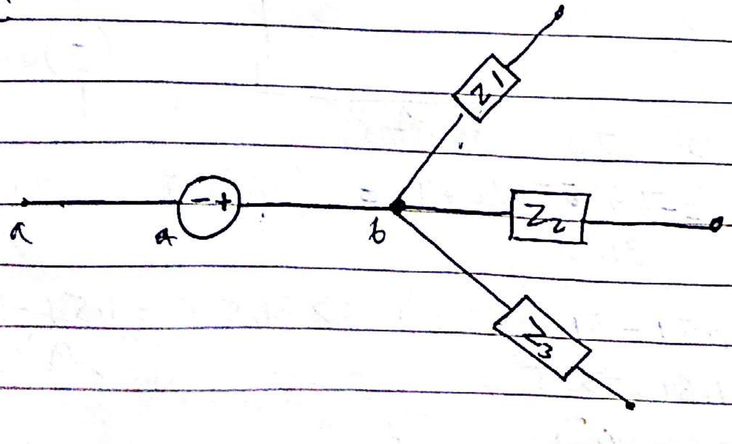
Source shifting or Mobility

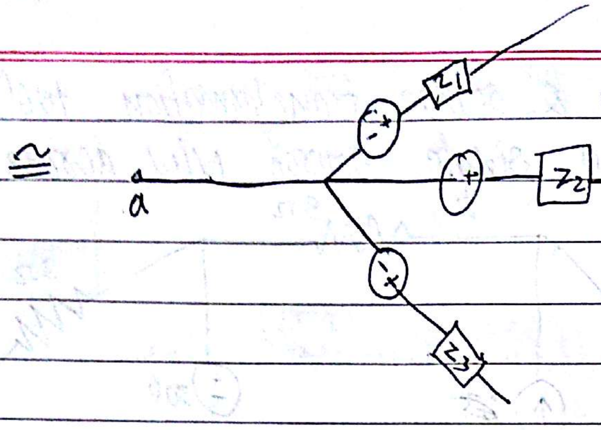
1. Voltage source shifting (V-shift / E-shift):

Ex:



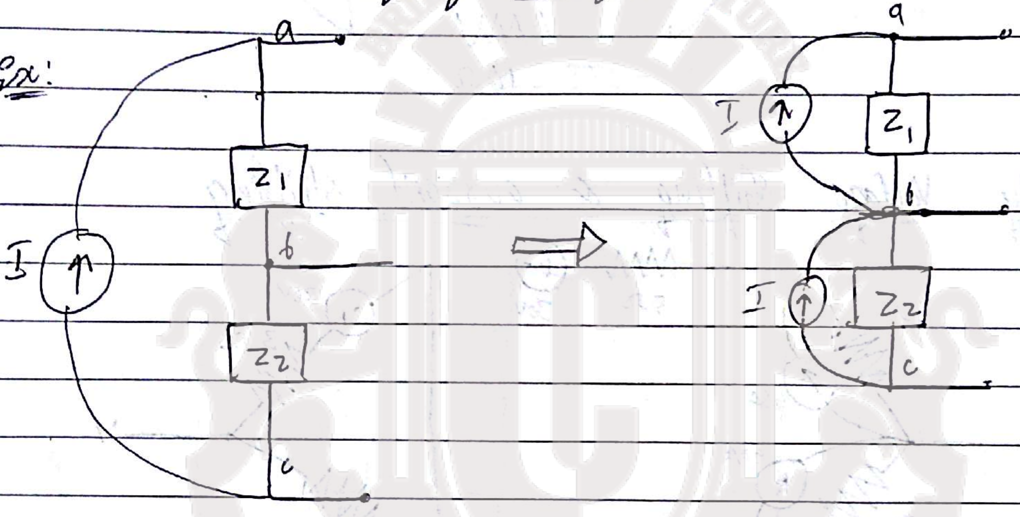
Ex:



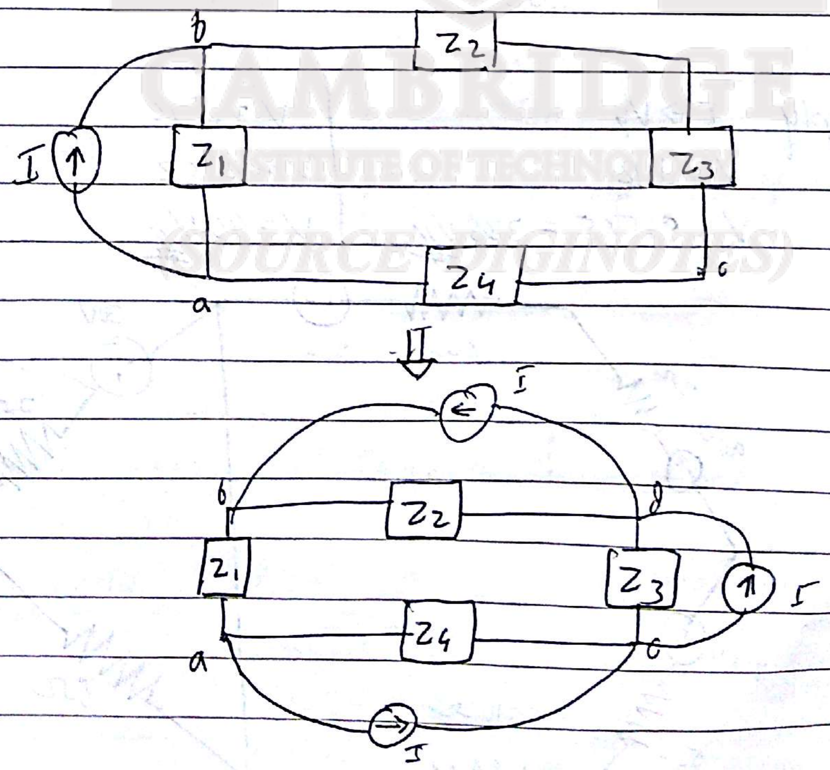


2. Current source shifting (I-shift):

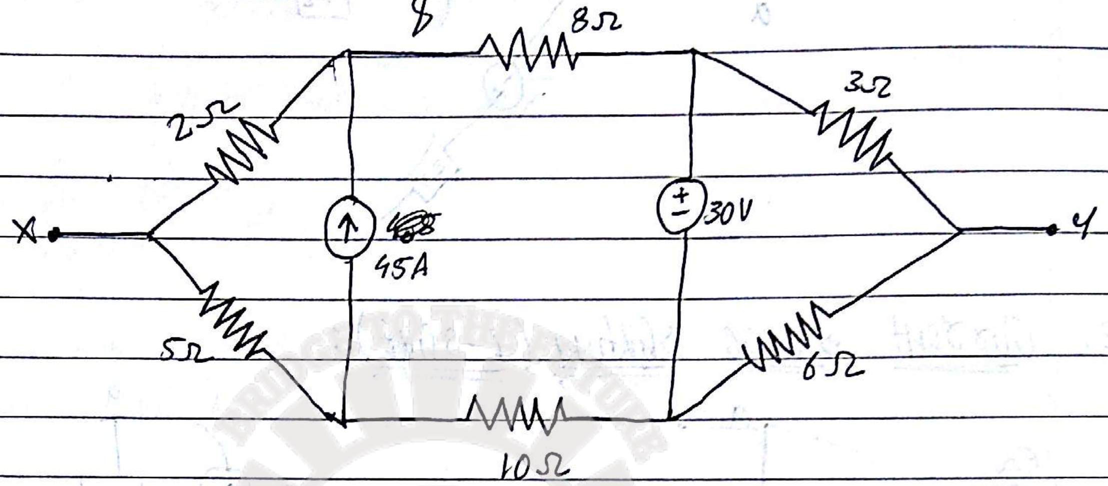
Ex:



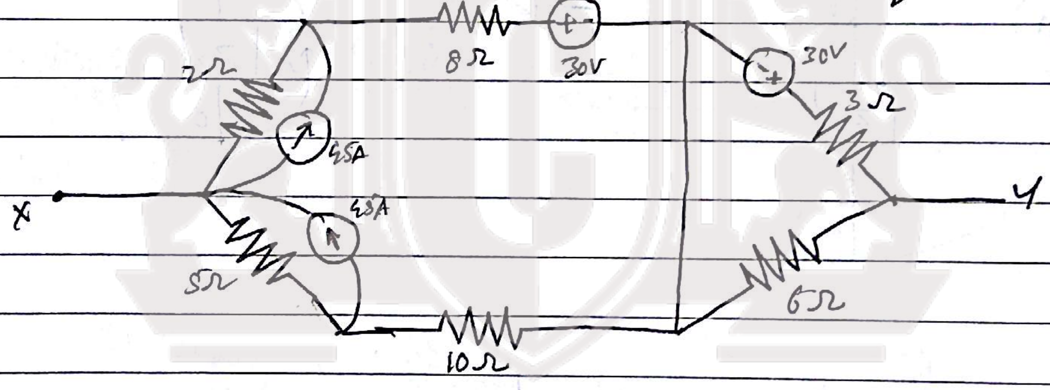
Ex:



Q. Using source shifting & source transformation technique the N/W into a single source N/W across X-Y.



Apply Voltage shifting & current shifting



Now Apply $I \rightarrow V$,

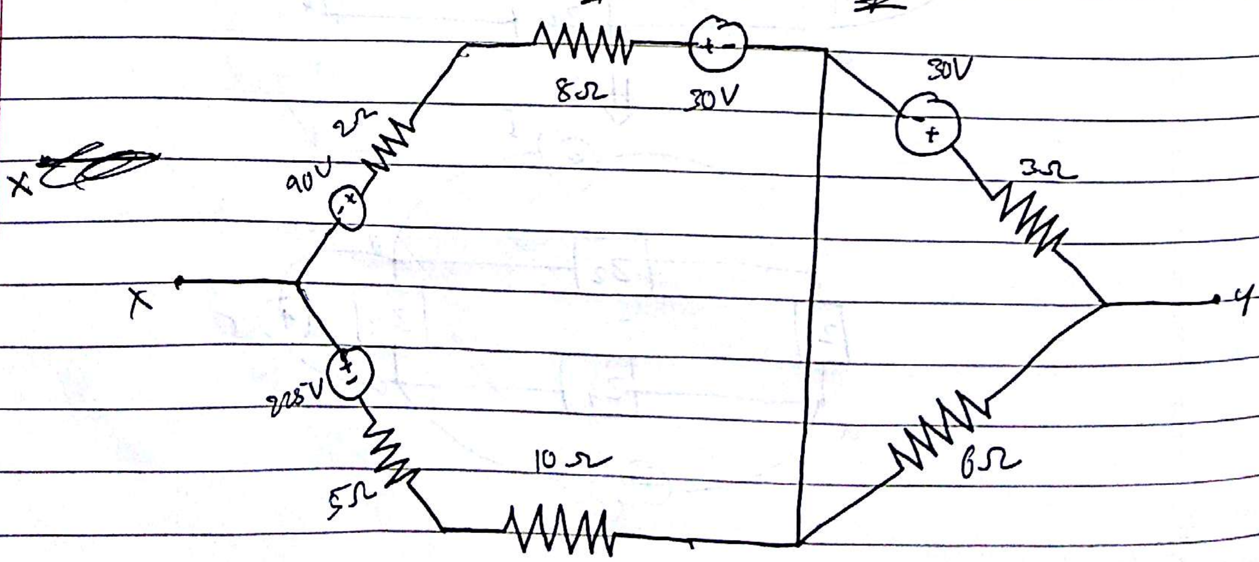
$V = IR$

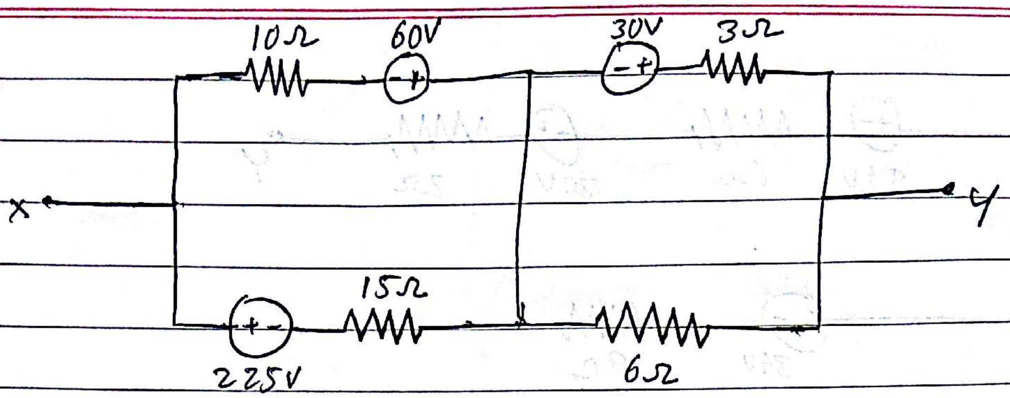
$V = 45 \times 5 = 225V$

$V = IR$

$V = 45 \times 2$

$V = 90V$

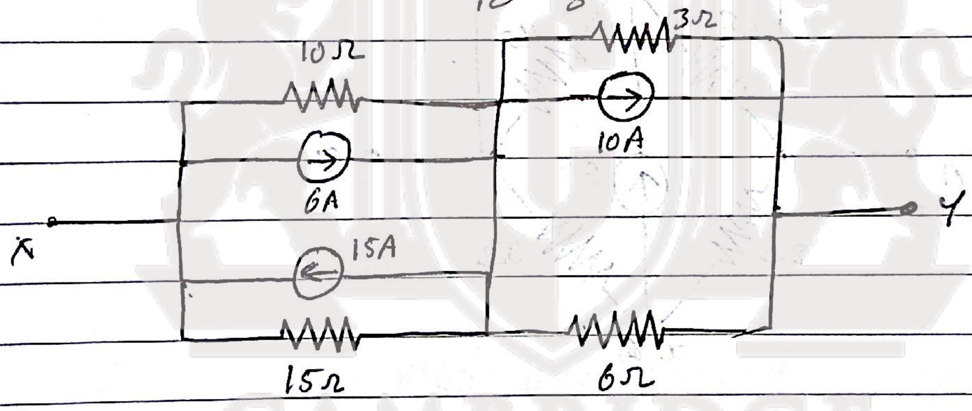


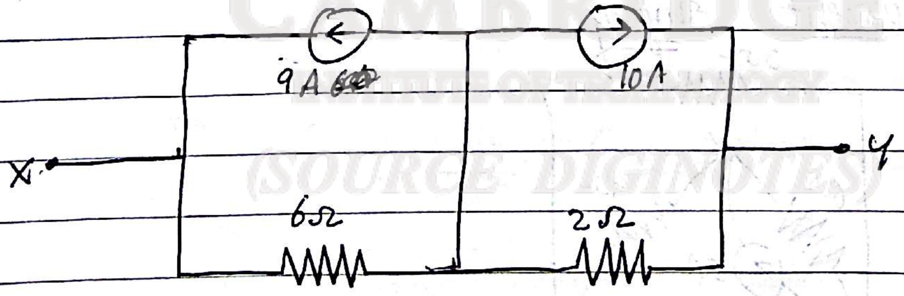


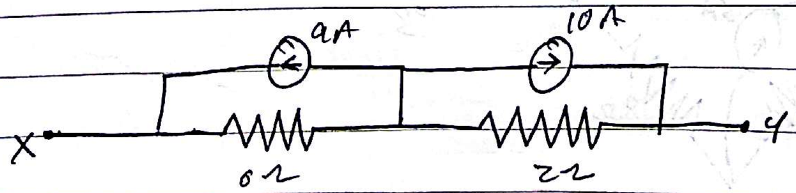
Apply V → I, $I = \frac{V}{R} = \frac{60}{10} = 6A$

$I = \frac{V}{R} = \frac{225}{15} = 15A$

$I = \frac{V}{R} = \frac{30}{3} = 10A$



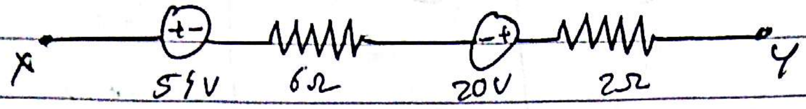


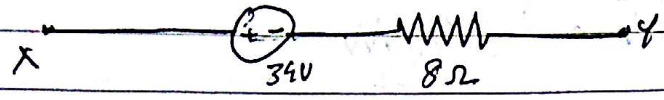


Now, apply I → V

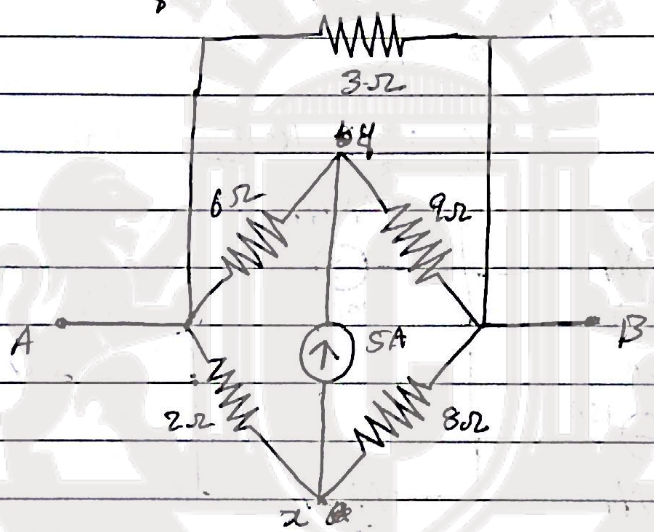
$V = IR = 9 \times 6 = 54\,V$

$V = IR = 10 \times 2 = 20\,V$

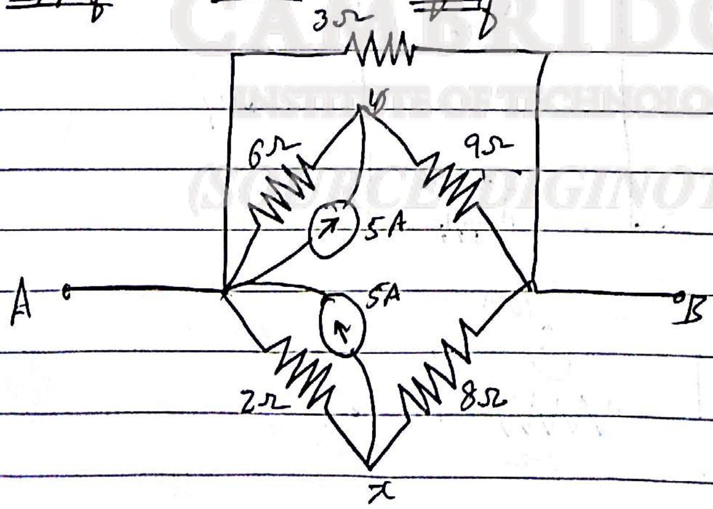




Q. Find the voltage b/w the points A & B using source mobility concept and source transformation.

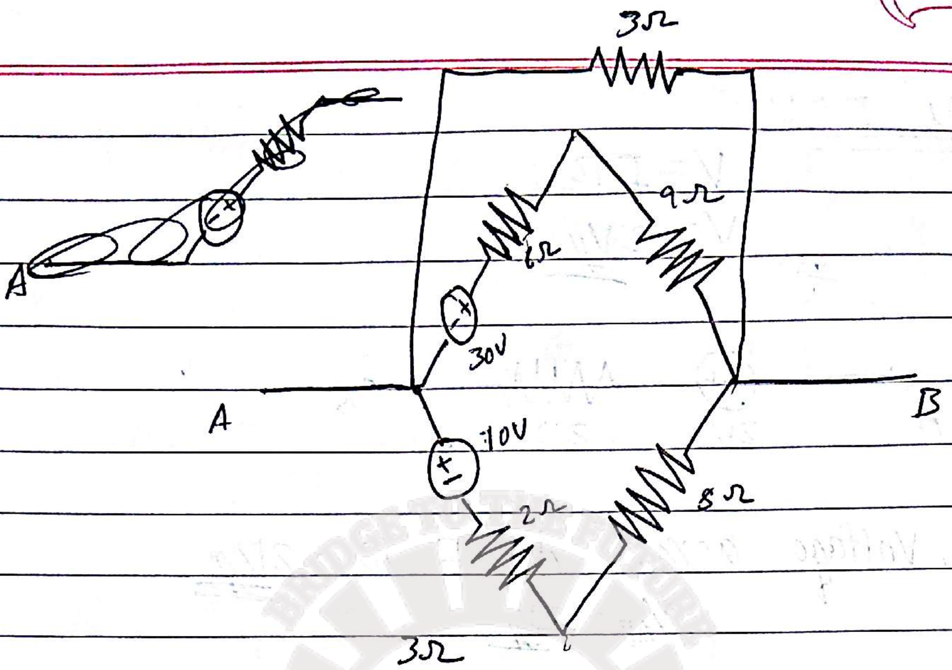


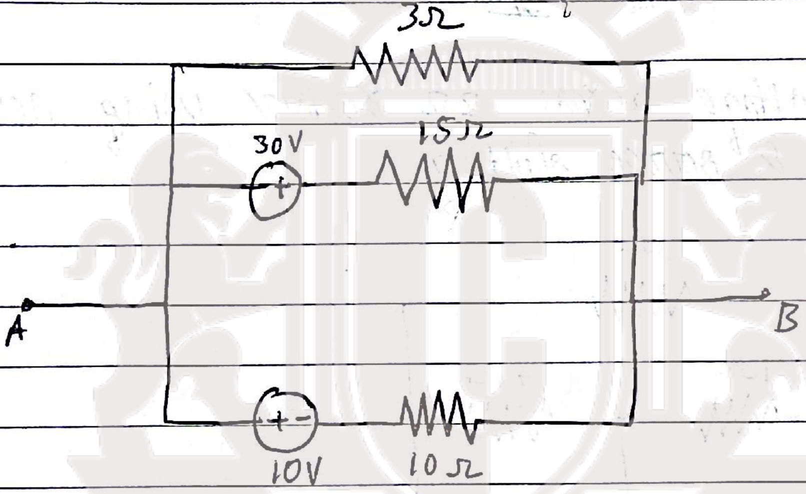
<u>Apply current shifting</u>



<u>Now apply, I → V :</u> $V = IR = 5 \times 6 = 30V$.

$V = IR = 5 \times 2 = 10V$





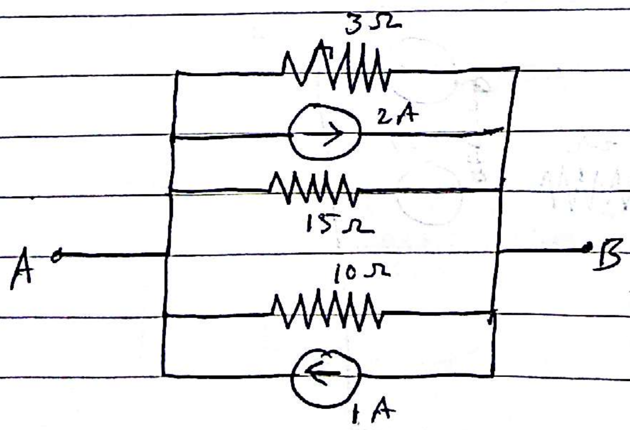
Apply voltage to current transformation:

$I = \frac{V}{R} = \frac{30}{15} = 2A$

$I = \frac{V}{R} = \frac{10}{10} = 1A$

$\frac{1}{R_{eqv}} = \frac{1}{3} + \frac{1}{15} + \frac{1}{10} = \frac{1}{2}$

$R_{eqv} = 2\Omega$



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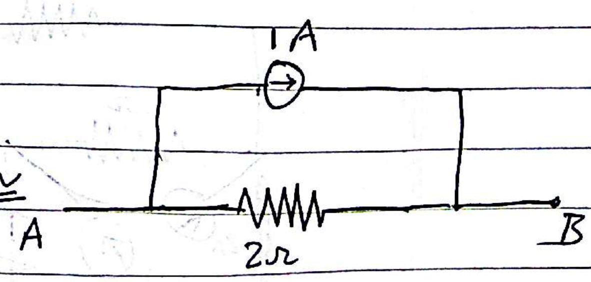
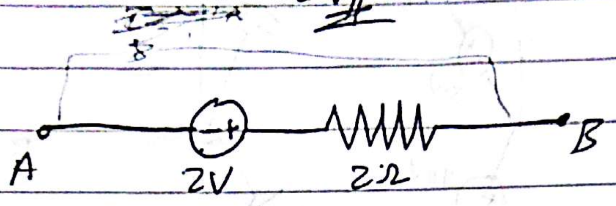


Apply $I \rightarrow V$

$$V = I R$$

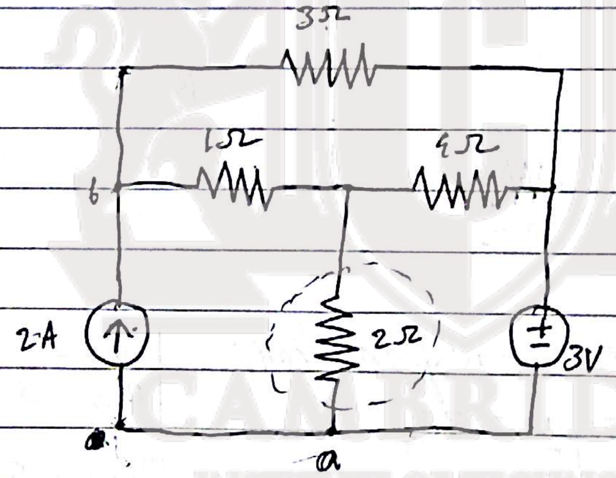
$$V = 2 V$$



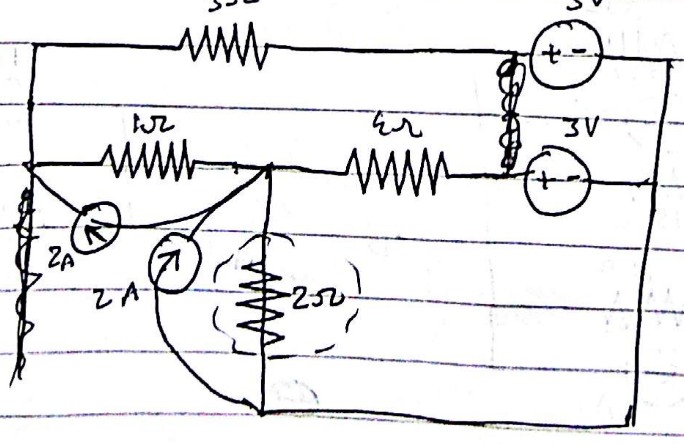
$\therefore$ Voltage across A & B is $2V$

$$V_{AB} = 2V$$

*** Q- Find the voltage across 2Ω resistor using source transformation & source shifting.

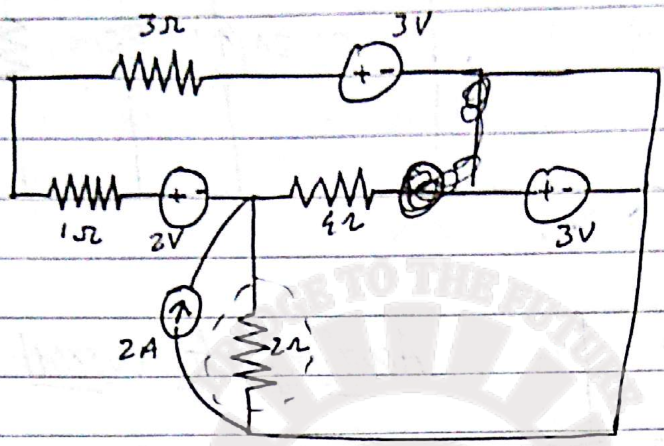


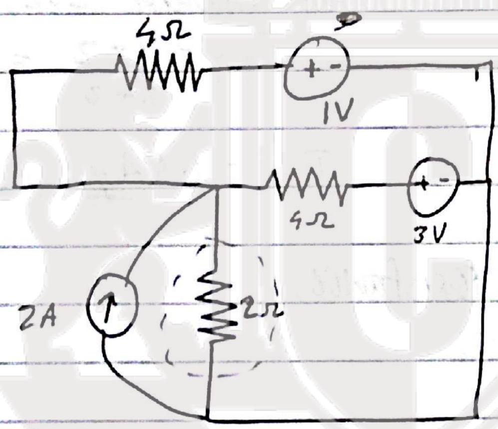
Apply current & voltage shifting



Now apply I → V:

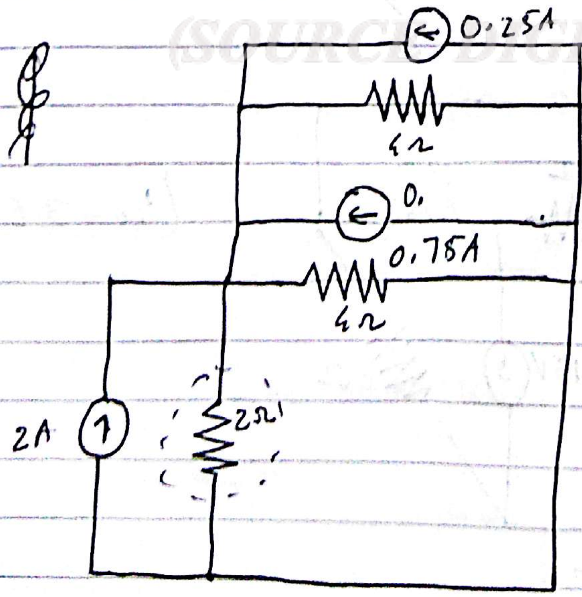
$$V = IR = 2 \times 1 = 2V$$





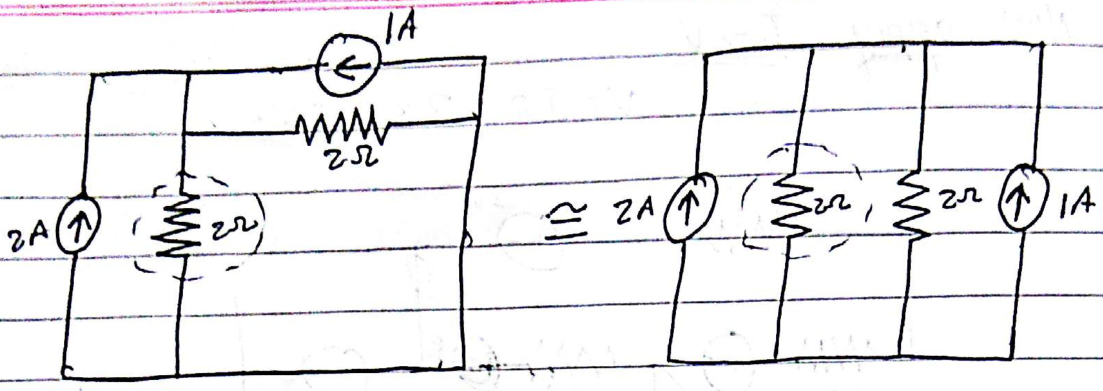
Now apply V → I: $I = \frac{V}{R} = \frac{3}{4} = 0.75A$

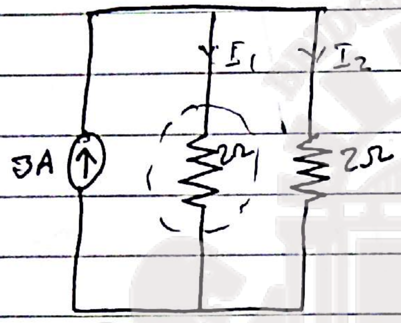
$$I = \frac{V}{R} = \frac{1}{4} = 0.25A$$



$I_{equ} = 1A.$

$R_{equ} = \frac{16}{8} = 2\Omega$





According to Current Division Rule

Current through 2Ω,

$$I_{2\Omega} = \frac{3 \times 2}{2+2} = \frac{\cancel{6}\,3}{\cancel{4}\,2}$$

$$I_{2\Omega} = 1.5A$$

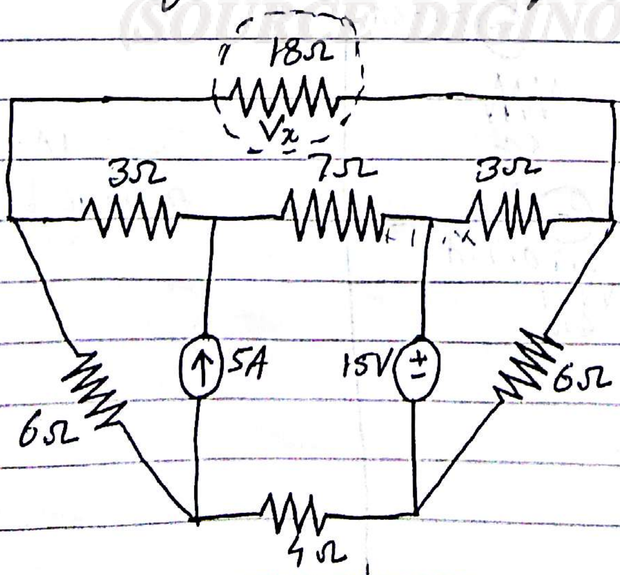
∴ Voltage across 2Ω resistance,

$$V_{2\Omega} = I_1 \times 2$$

$$V_{2\Omega} = 1.5 \times 2$$

$$V_{2\Omega} = 3V$$

Q. Find the voltage V_x using source shifting and source transformation techniques.



$\boxed{V_x = 3.6V}$

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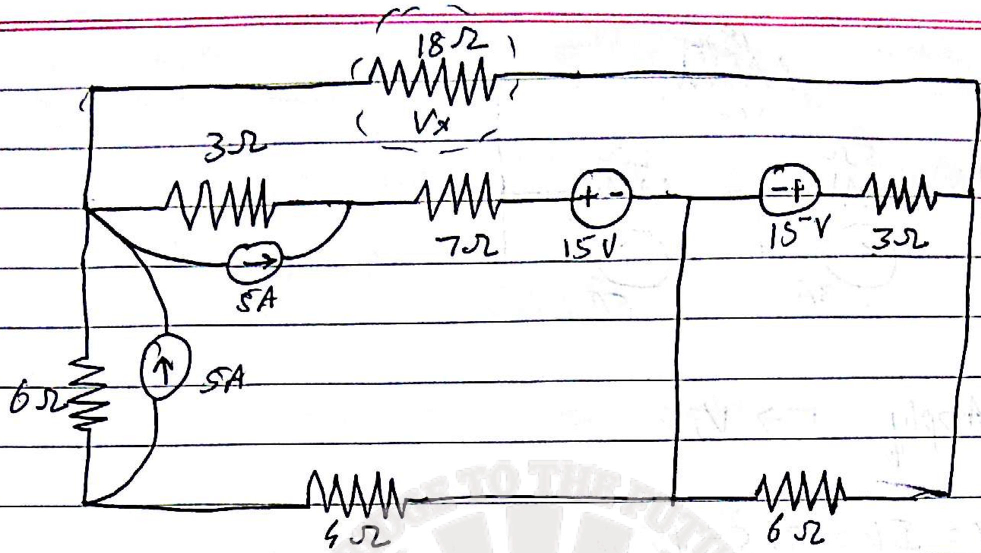
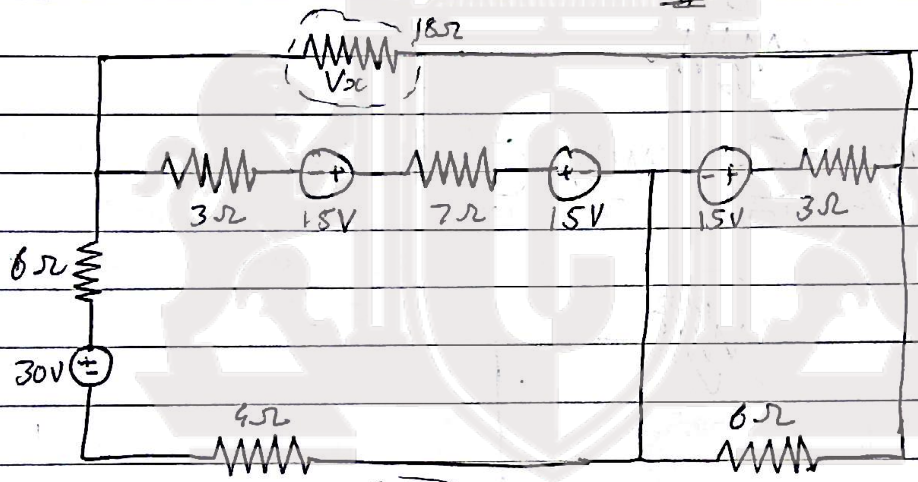
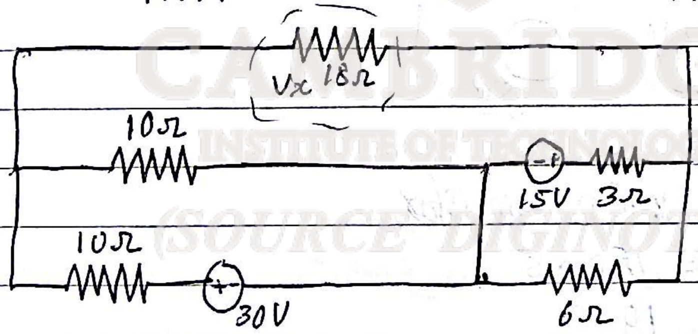


$V_x = 3.6V$

Apply I→V: $V = IR = V = 5 \times 6 = 30V$

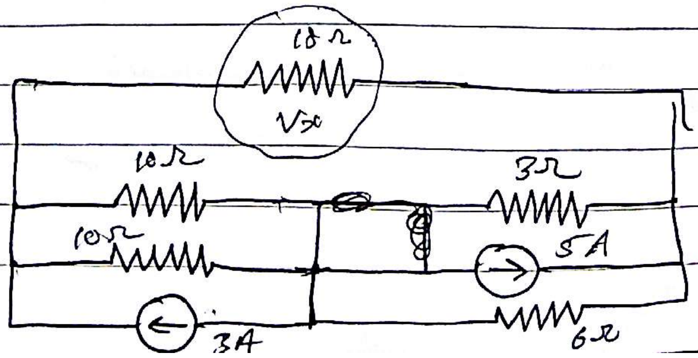
$V = IR = 3 \times 5 = 15V$





Apply V→I:

$I = \frac{V}{R} = \frac{30}{10} = 3A$ $I = \frac{15}{3} = 5A$



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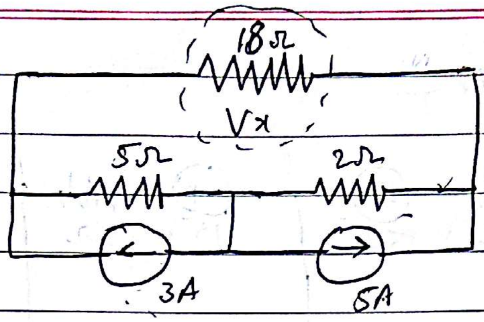
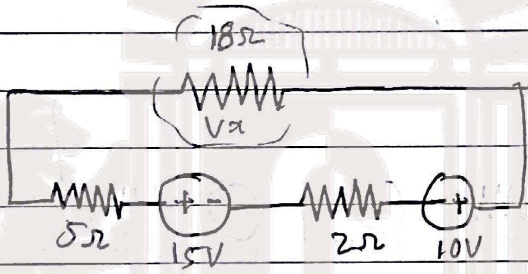
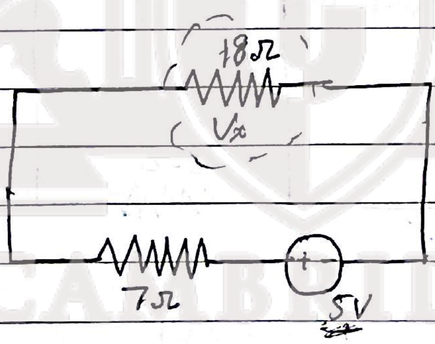


Apply I → V,

$V = IR = 3 \times 5 = 15\ V$

$V = IR = 5 \times 2 = 10\ V$





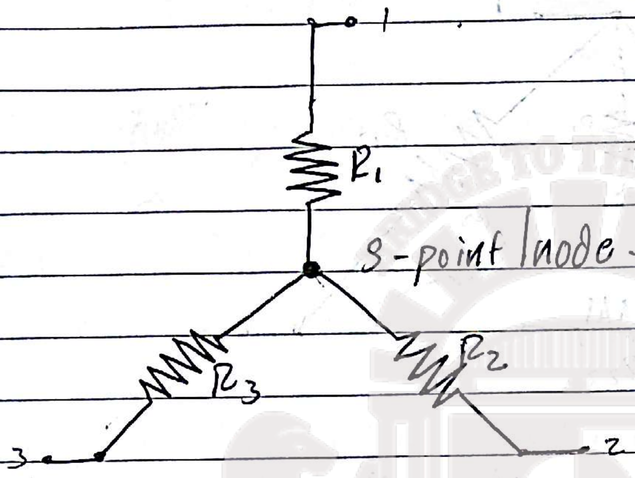
Voltage across 18Ω resistor,

$$V_x = \frac{18\Omega \times 5}{18+7}$$

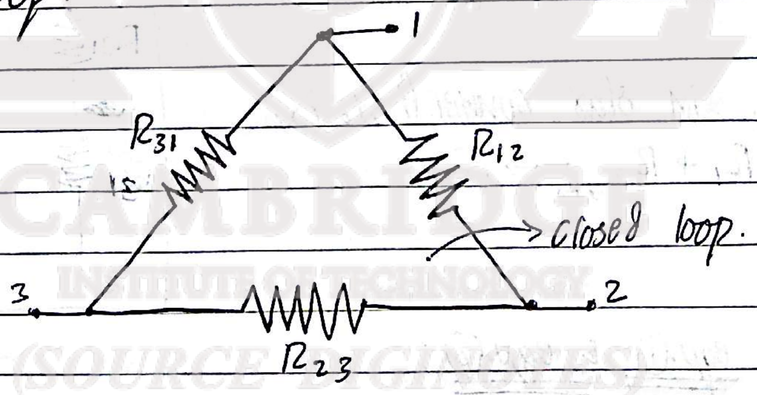
$V_x = 3.6\ V$

Star → Delta and Delta → Star transformation:

→ Three resistors are said to be connected in star connection when they form a node or junction.



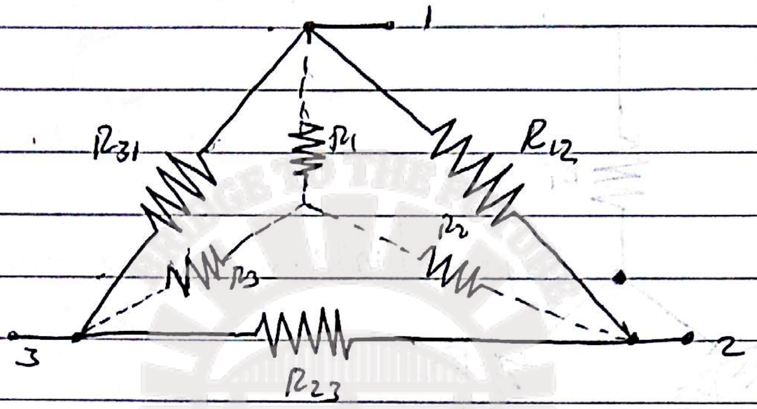
→ Three resistances or impedances are said to be connected in delta connection when they form a closed loop.



→ Star and Delta connections play a major role in NA. to find voltage across (or) current through the given element.

Star → Delta Conversion & Delta → Star Conversion

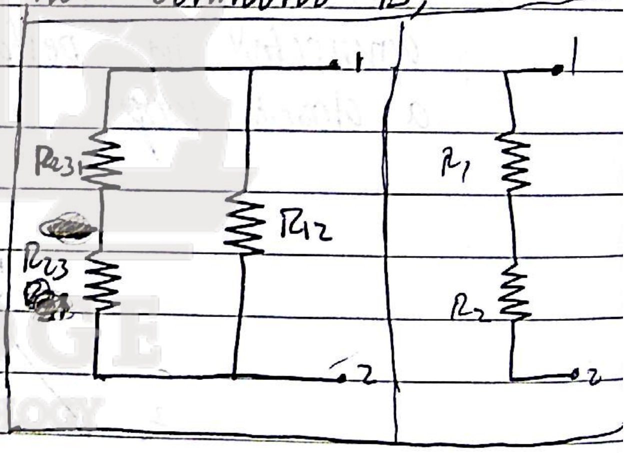
Consider the following N/w;



→ The equivalent resistance b/w the two terminals 1 & 2, when terminal 3 is absent or not connected is,

$$\frac{(R_{23}+R_{31})\times R_{12}}{R_{12}+R_{23}+R_{31}} \rightarrow (1).$$

(Delta connection).



Similarly, in star connection, is,

$$R_1 + R_2 \rightarrow (2).$$

Equate equ.(1) & equ.(2):

$$\frac{(R_{23}+R_{31})\times R_{12}}{R_{12}+R_{23}+R_{31}} = R_1 + R_2 \rightarrow (3).$$

Similarly, the equivalent resistance b/w the terminals 2 & 3 when terminal 1 is absent or not connected,

$$\frac{(R_{31}+R_{12})\times R_{23}}{R_{12}+R_{23}+R_{31}} = R_2 + R_3 \rightarrow (4).$$

III'y, the equivalent resistance b/w the terminals 1 & 3 when terminal 2 is not connected (or) absent,

$$\frac{(R_{12}+R_{23})\times R_{31}}{R_{12}+R_{23}+R_{31}} = R_1 + R_3 \quad \rightarrow (5).$$

Now add equations 3 and 5,

$$\frac{(R_{23}+R_{31})\times R_{12} + (R_{12}+R_{23})\times R_{31}}{R_{12}+R_{23}+R_{31}} = R_1+R_2+R_1+R_3$$
$$= 2R_1 + R_2 + R_3.$$

$$\frac{R_{12}R_{23} + R_{12}R_{31} + R_{31}R_{12} + R_{31}R_{23}}{R_{12}+R_{23}+R_{31}} = 2R_1 + R_2 + R_3$$

In place of $R_2 + R_3$, replace equ (4).

$$\Rightarrow \frac{R_{12}R_{23} + R_{12}R_{31} + R_{31}R_{12} + R_{31}R_{23}}{R_{12}+R_{23}+R_{31}} = 2R_1 + \frac{(R_{31}+R_{12})\times R_{23}}{R_{12}+R_{23}+R_{31}}$$

$$\frac{R_{12}R_{23} + R_{12}R_{31} + R_{31}R_{12} + R_{31}R_{23}}{R_{12}+R_{23}+R_{31}} = 2R_1 + \frac{R_{23}R_{31} + R_{23}R_{12}}{R_{12}+R_{23}+R_{31}}$$

$$\frac{\cancel{R_{12}R_{23}} + 2R_{12}R_{31} + \cancel{R_{31}R_{23}} - \cancel{R_{23}R_{31}} - \cancel{R_{23}R_{12}}}{R_{12}+R_{23}+R_{31}} = 2R_1$$

$$\frac{\cancel{2}R_{12}R_{31}}{R_{12}+R_{23}+R_{31}} = \cancel{2}R_1$$

$$\therefore \boxed{R_1 = \frac{R_{12}R_{31}}{R_{12}+R_{23}+R_{31}}} \rightarrow (6).$$

Similarly:

$$\boxed{R_2 = \frac{R_{23}R_{12}}{R_{12}+R_{23}+R_{31}}} \rightarrow (7)$$

$$\boxed{R_3 = \frac{R_{31}R_{23}}{R_{12}+R_{23}+R_{31}}} \rightarrow (8).$$

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Now multiply the equations, 6 & 7, 7 & 8 and 8 & 6.

$$R_1 \times R_2 = \frac{R_{12} R_{31}}{R_{12}+R_{23}+R_{31}} \times \frac{R_{23} \times R_{12}}{R_{12}+R_{23}+R_{31}} = \frac{R_{12}^2 R_{23} R_{31}}{(R_{12}+R_{23}+R_{31})^2} \rightarrow (9)$$

$$R_2 \times R_3 = \frac{R_{23} R_{12} \times R_{31} R_{23}}{(R_{12}+R_{23}+R_{31})^2} = \frac{R_{23}^2 R_{12} R_{31}}{(R_{12}+R_{23}+R_{31})^2} \rightarrow (10)$$

$$R_1 \times R_3 = \frac{R_{12} R_{31} \times R_{31} R_{23}}{(R_{12}+R_{23}+R_{31})^2} = \frac{R_{31}^2 R_{12} R_{23}}{(R_{12}+R_{23}+R_{31})^2} \rightarrow (11)$$

Add equs. 9, 10 & 11.

$$R_1 R_2 + R_2 R_3 + R_1 R_3 = \frac{R_{12}^2 R_{23} R_{31} + R_{23}^2 R_{12} R_{31} + R_{31}^2 R_{12} R_{23}}{(R_{12}+R_{23}+R_{31})^2}$$

$$R_1 R_2 + R_2 R_3 + R_1 R_3 = \frac{(R_{12} R_{23} R_{31})(R_{12}+R_{23}+R_{31})}{(R_{12}+R_{23}+R_{31})^2}$$

$$R_1 R_2 + R_2 R_3 + R_1 R_3 = \frac{R_{12} R_{23} R_{31}}{R_{12}+R_{23}+R_{31}}$$

But $R_3 = \dfrac{R_{31} R_{23}}{R_{12}+R_{23}+R_{31}}$

$$\therefore R_1 R_2 + R_2 R_3 + R_1 R_3 = R_{12} \cdot R_3$$

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

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

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

$|||^{ly}$,

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

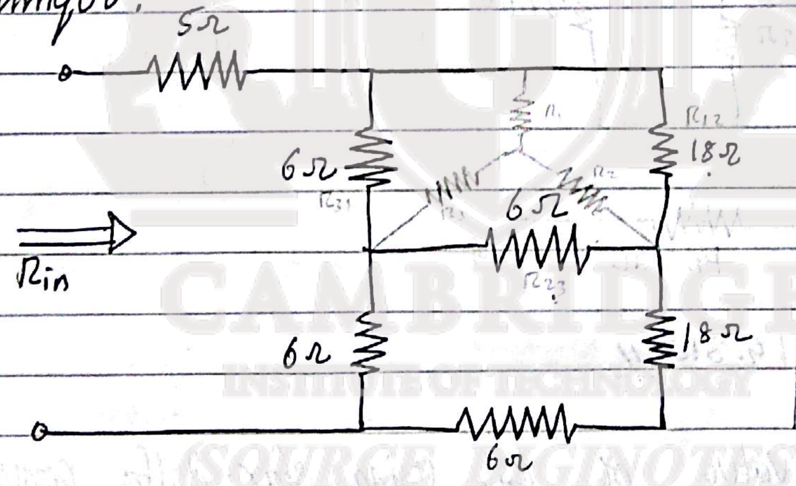
$$\cancel{R_{31} = R_3 + R_1 + R_3 R_1}$$

$|||^{ly}$,

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

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

Q. Find the value of Rin using star-Delta conversion technique:

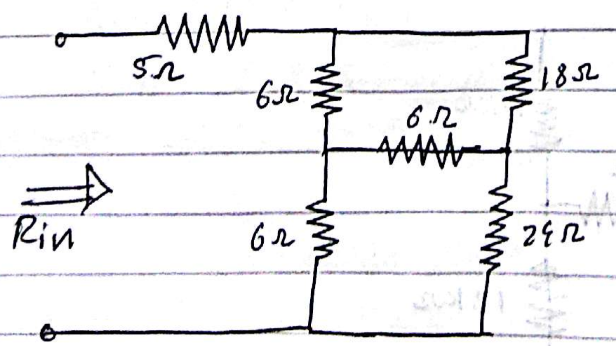


$R_1 = \frac{R_{12} R_{31}}{R_{12}+R_{23}+R_{31}} = 3.6\Omega$

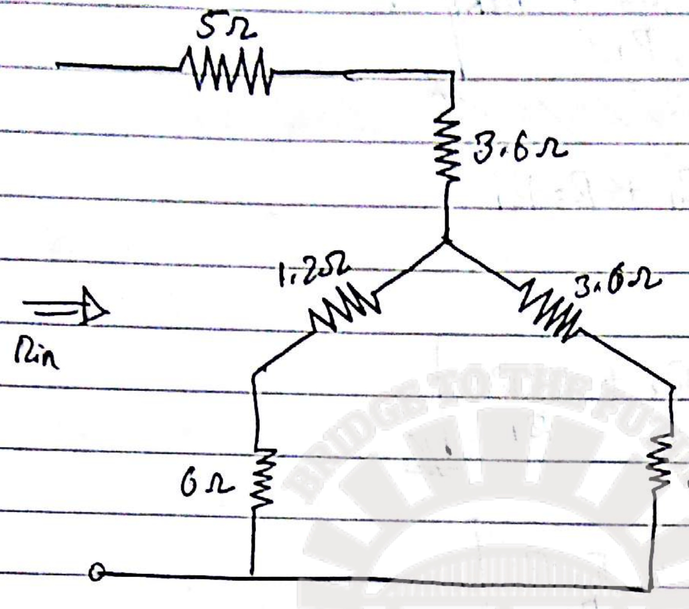
$R_2 = \frac{6 \times 18}{30} = 3.6\Omega$

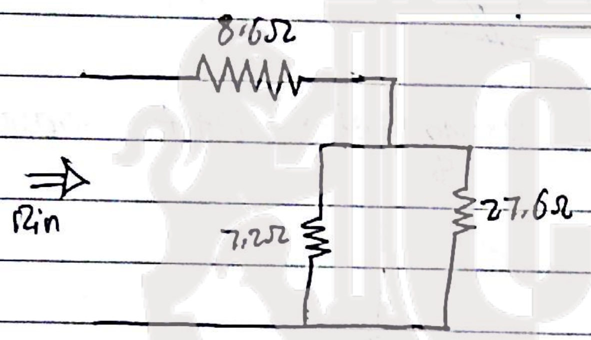
$R_3 = \frac{6 \times 6}{30} = 1.2\Omega.$

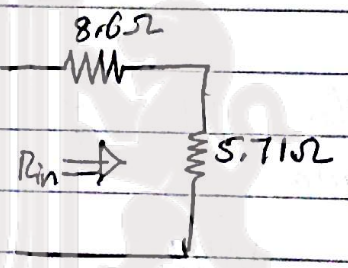
6Ω & 18Ω are in series.

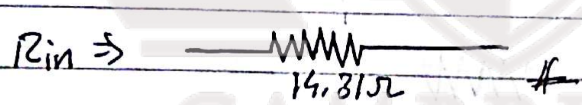


Apply $\Delta \rightarrow Y$



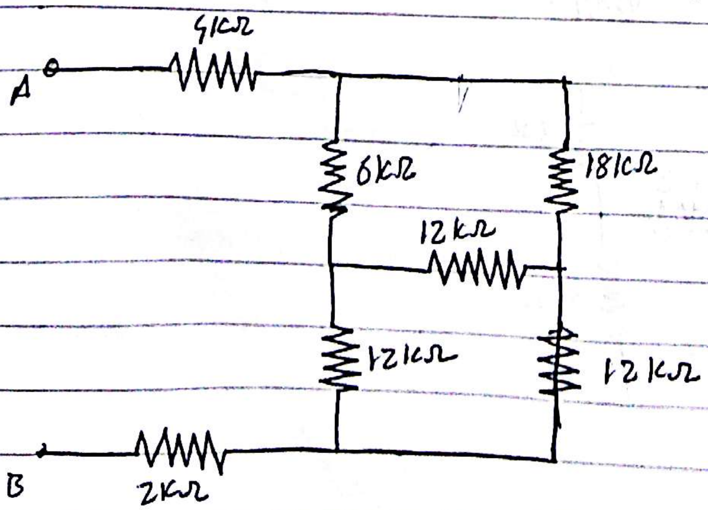


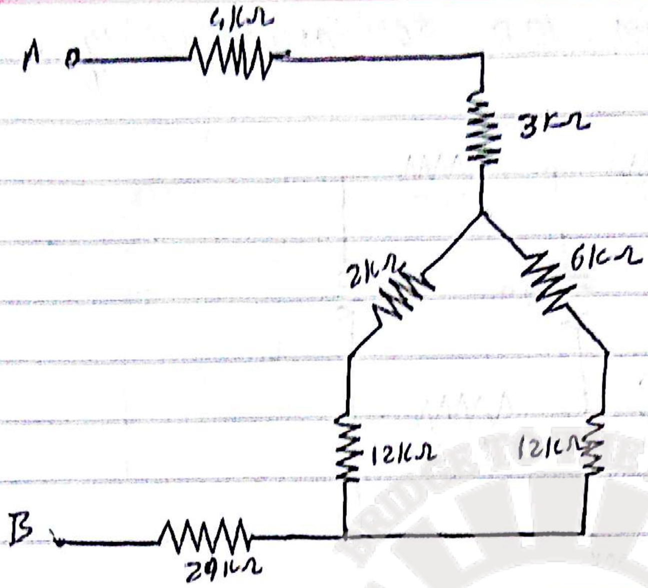


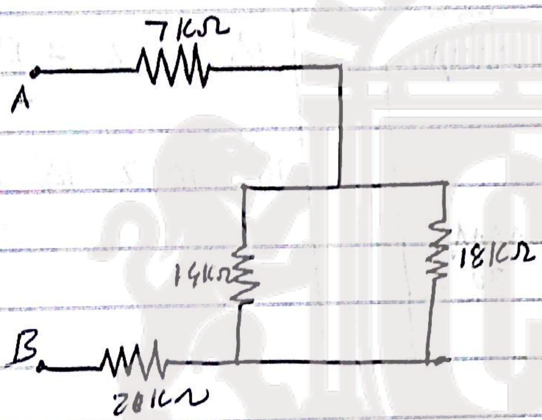


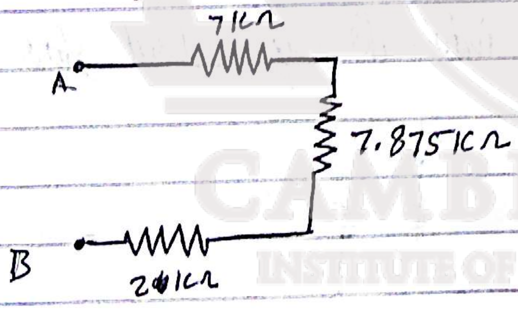
$\therefore R_{in} = 14.31\Omega$

HW.Q2. Find the value of R_{AB} using star-delta conversion.







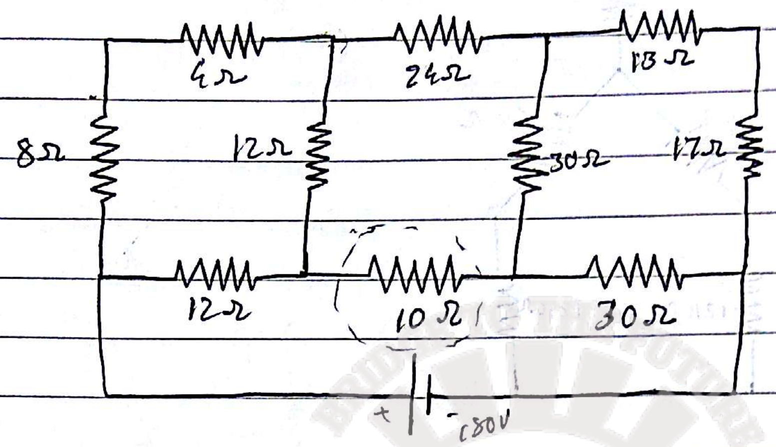


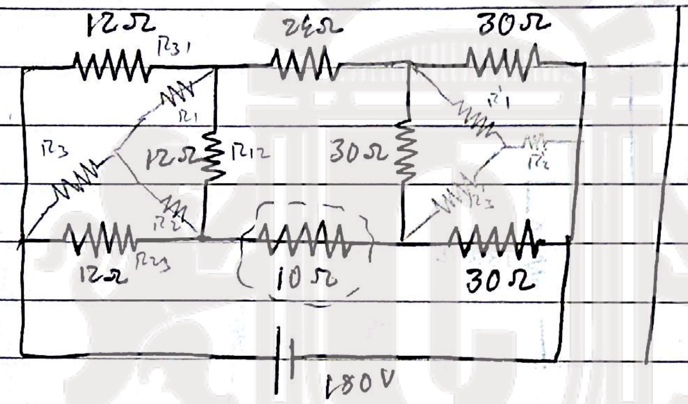
$R_{AB} = 7k + 7.875k + 2\cancel{0}k$

$R_{AB} = 14.875^{k} + 2k$

$R_{AB} = 16.875\,k\Omega$

Q. Find the current in 10Ω resistance using star-delta conversion.

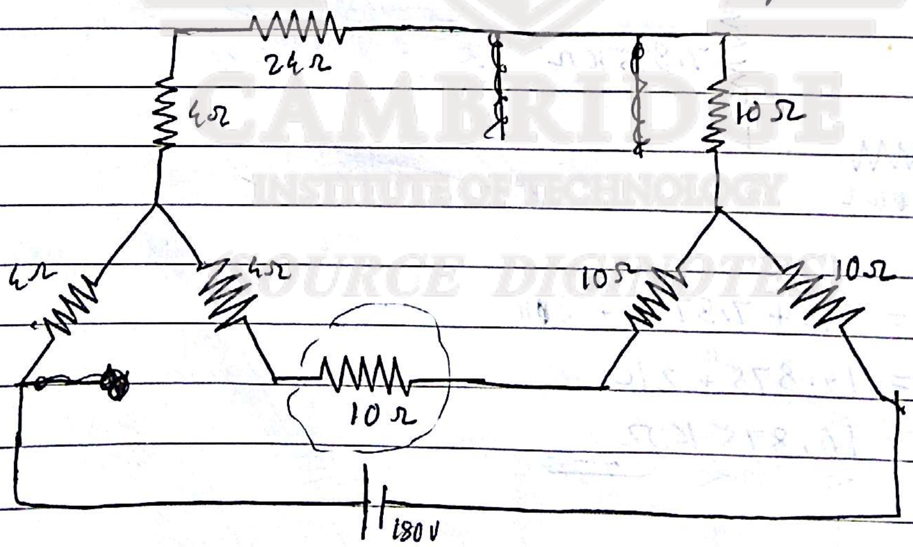


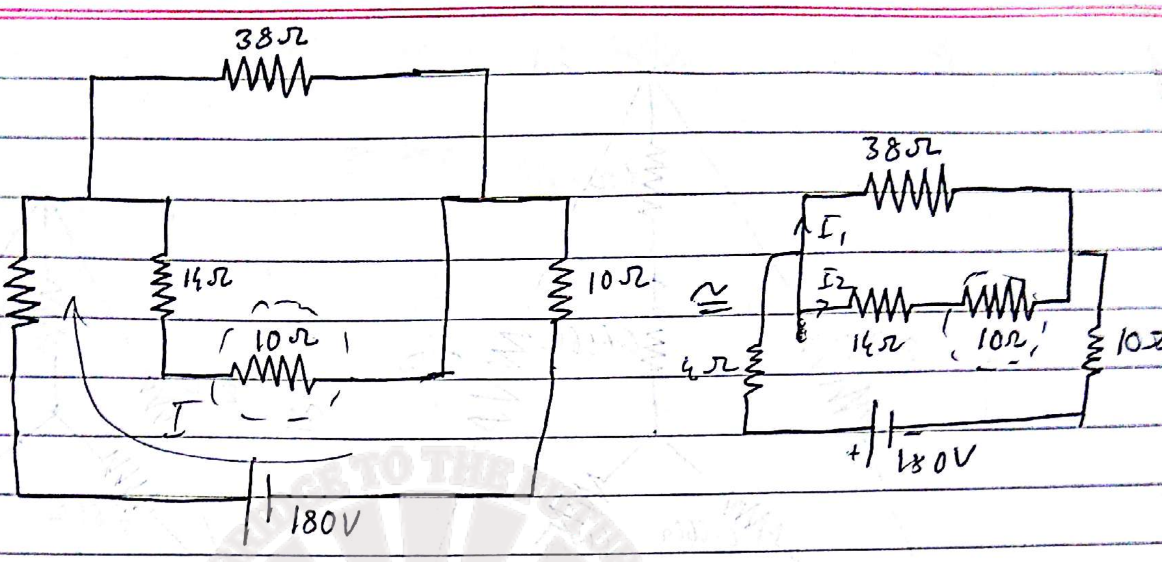


$R_1 = 4\Omega = R_2 = R_3$

$R_1' = 10\Omega = R_2' = R_3'$

Convert both the delta into its equivalent star connection.





$\cancel{I = \frac{V}{R}}$ Now, current, $I = \frac{V}{R} = \frac{180}{R_{equ}}$ #

$R_{equ} = 4 + 38 \| 24\Omega + 10$

$R_{equ} = 28.7\Omega$

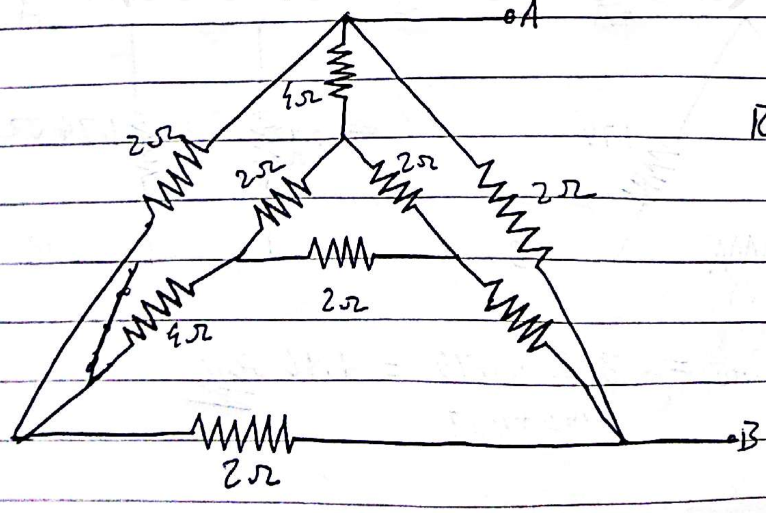
Current $I = \frac{180}{28.7} = 6.27A$

Current through 10Ω resistor,

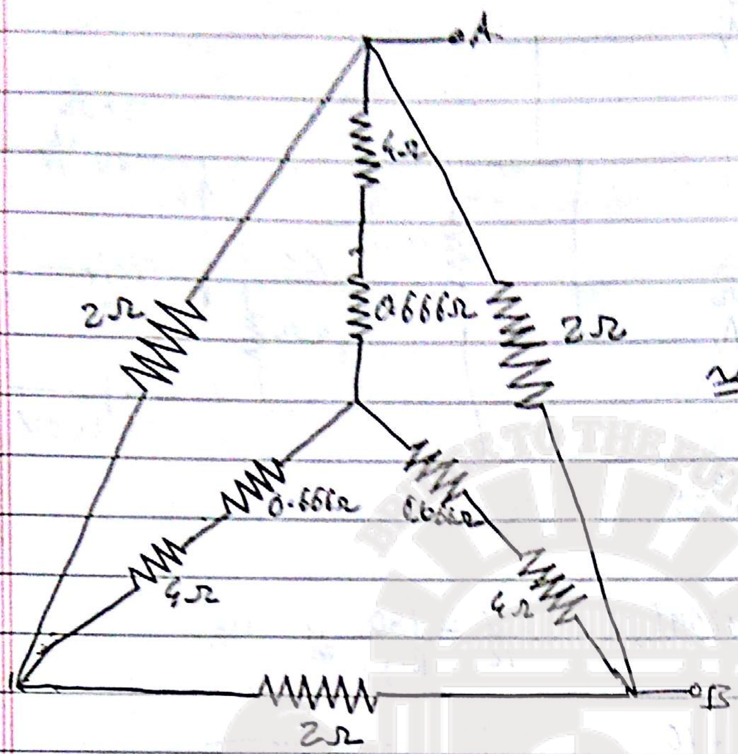
$I_2 = I_{10\Omega} = \cancel{\frac{10 \times 24\Omega}{24+38}}\ \frac{6.27 \times 38}{38 + 24}$

$I_2 = 3.84A$

Q. Find the value of R_{AB} in the N/w using Y-Δ conversion.



$R_1 = \frac{2 \times 2}{6} = 0.666\Omega = R_2 = R_3$



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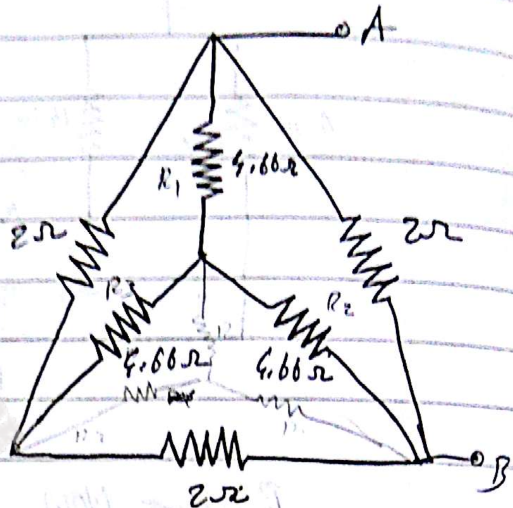
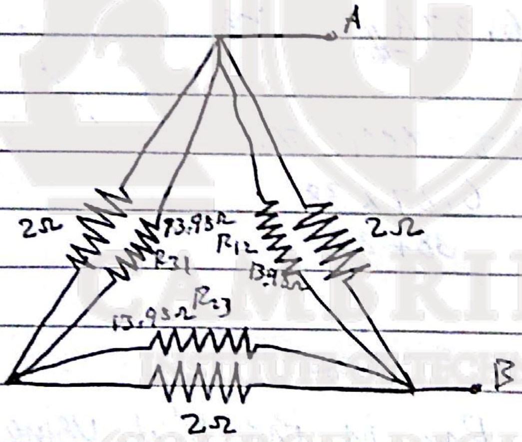


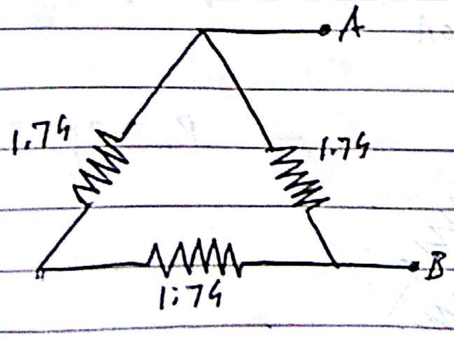


$$R_{12} = R_1 + R_2 + \frac{R_1 R_2}{R_3}$$

$$R_{12} = 4.66 + 4.66 + \frac{4.66 \times 4.66}{4.66}$$

$$R_{12} = 13.98\,\Omega$$

$$R_{equ} = \frac{2 \times 13.98}{2 + 13.98} = 1.74$$



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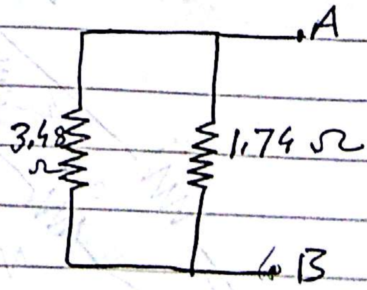
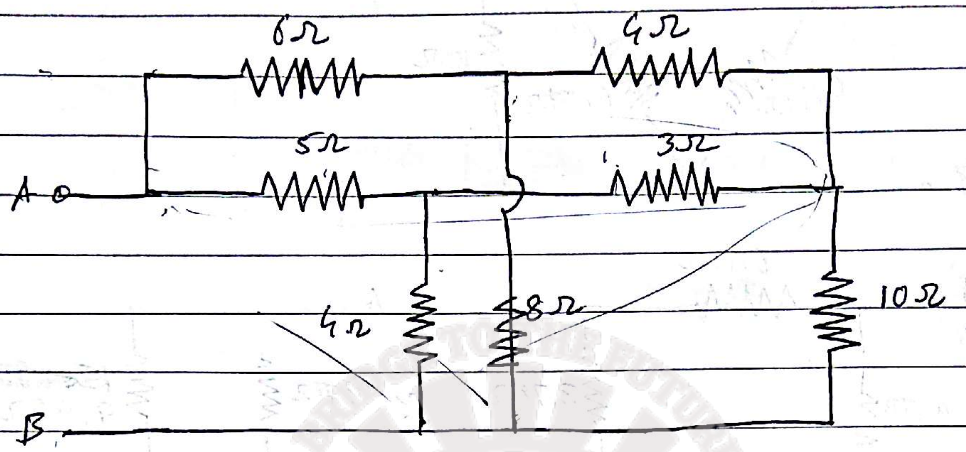
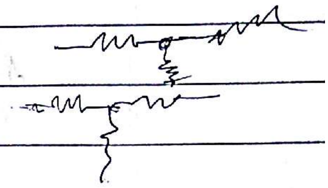


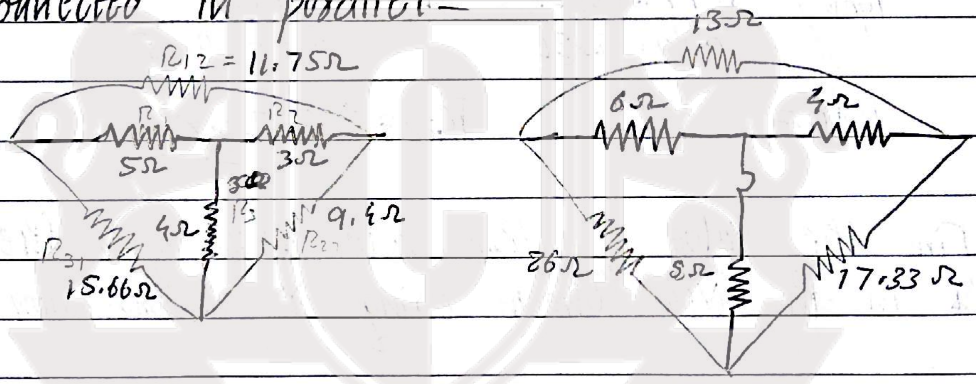
$$R_{AB} = \frac{3.48 \times 1.74}{3.48 + 1.74} = 1.16\,\Omega$$

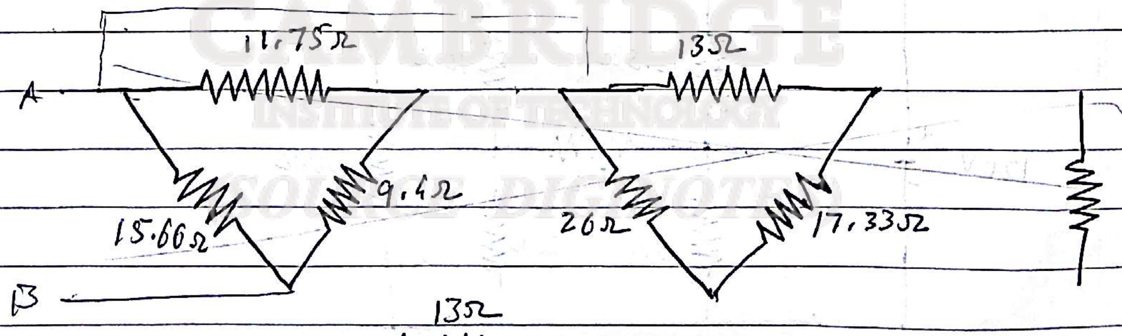
Q. Find the value of the resistance R_{AB} in the N/w shown.

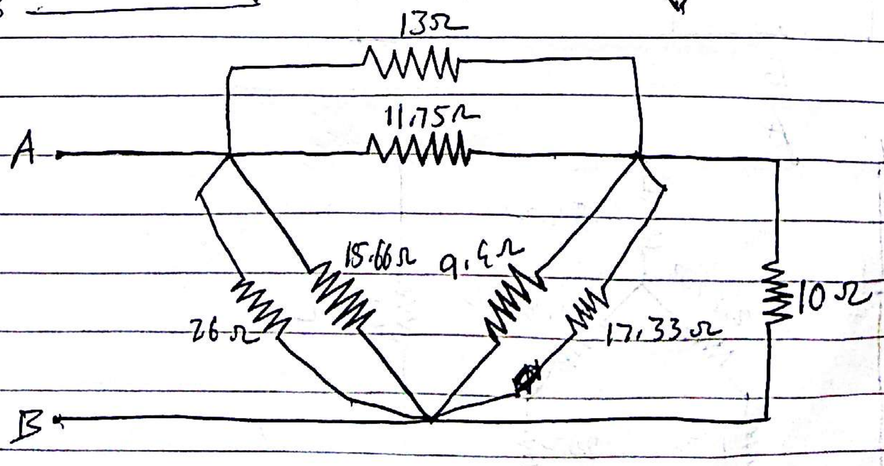


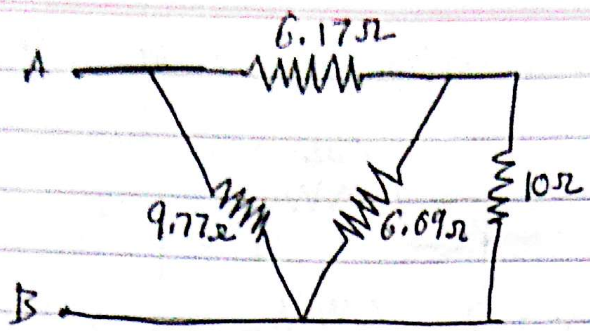


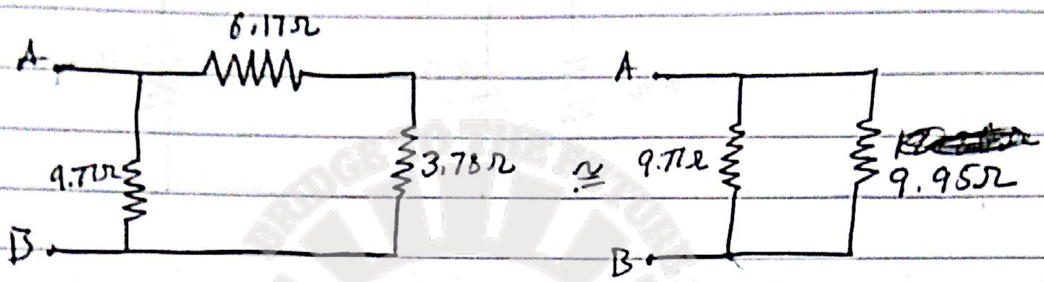
Convert both the stars into equivalent delta which are connected in parallel—











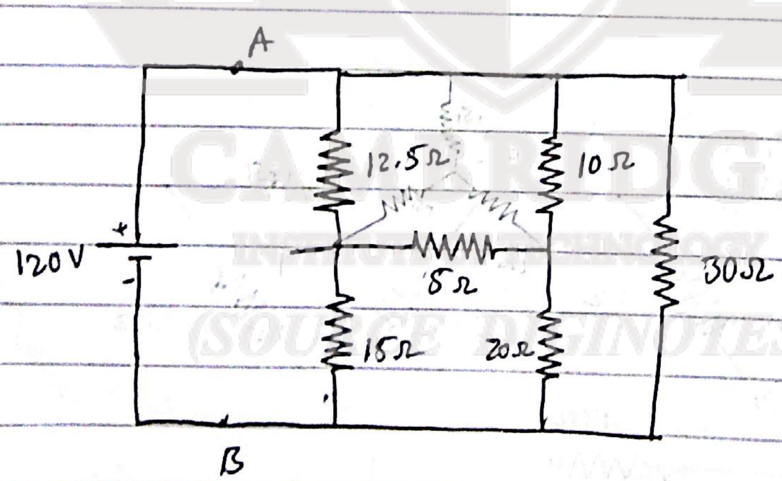
$R_{AB} = \cancel{\dfrac{9.77 \times 12.26}{9.77+12.26}}$

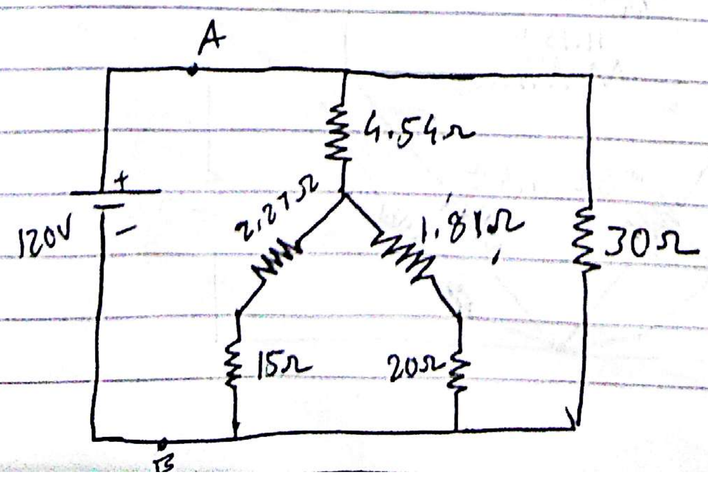
$\cancel{R_{AB}} =$

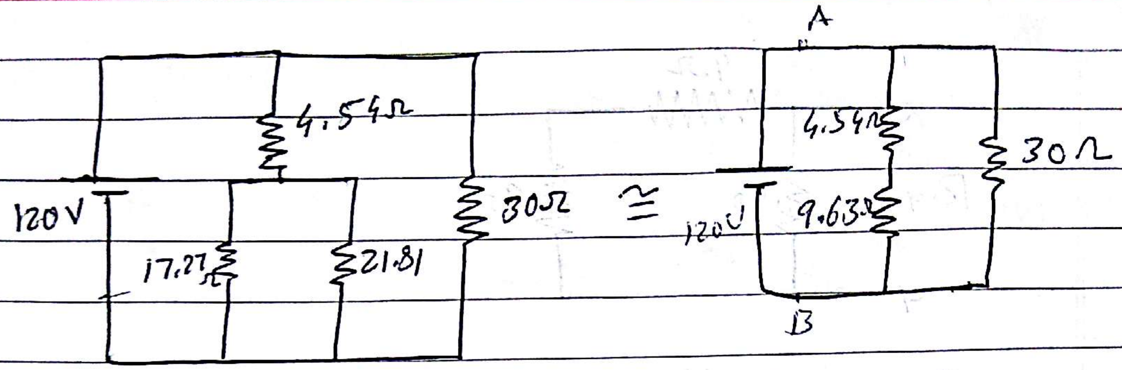
$$R_{AB} = \frac{9.77 \times 9.95}{9.77+9.95}$$

$$R_{AB} = 4.929\Omega$$

Q. Find the value of R_{AB} and hence find the current I in the N/w shown using Y-Δ conversion technique.





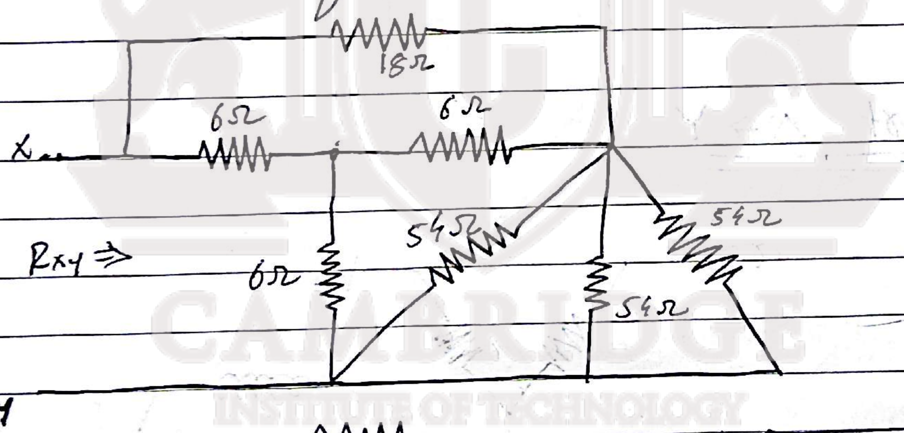


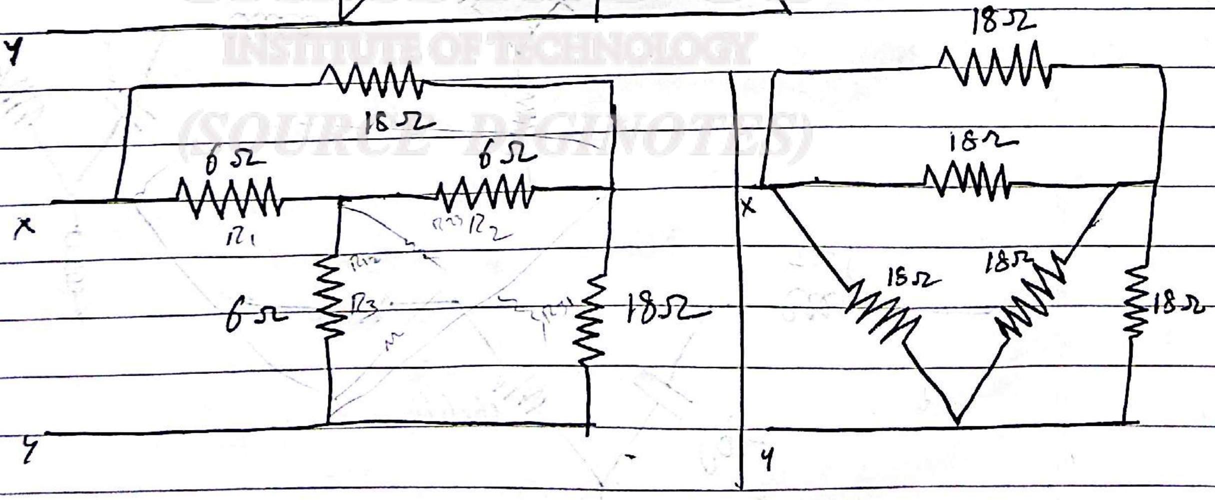
$R_{AB} = 14.17 \parallel 30$

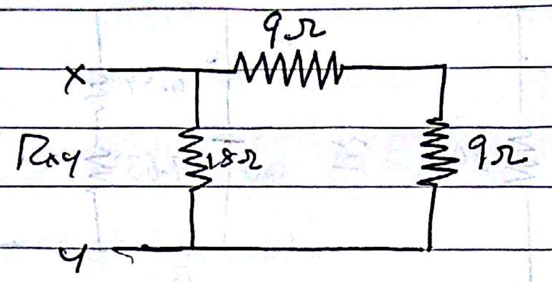
$R_{AB} = 9.62\,\Omega$

$I = \frac{V}{R} = \frac{120}{9.62} = 12.47\,A$

Q. Find the value of R_{xy}.



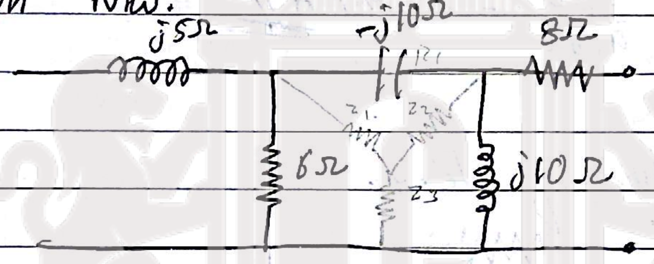




$R_{xy} = 18\Omega \,||\, 18\Omega$

$R_{xy} = 9\Omega$

Q. Convert the given N/w into single delta connection N/w.

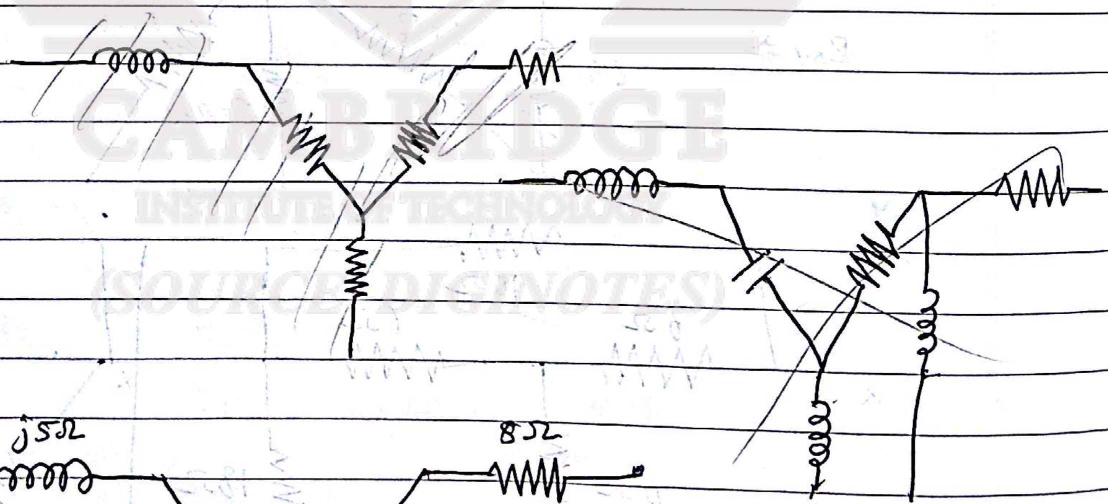


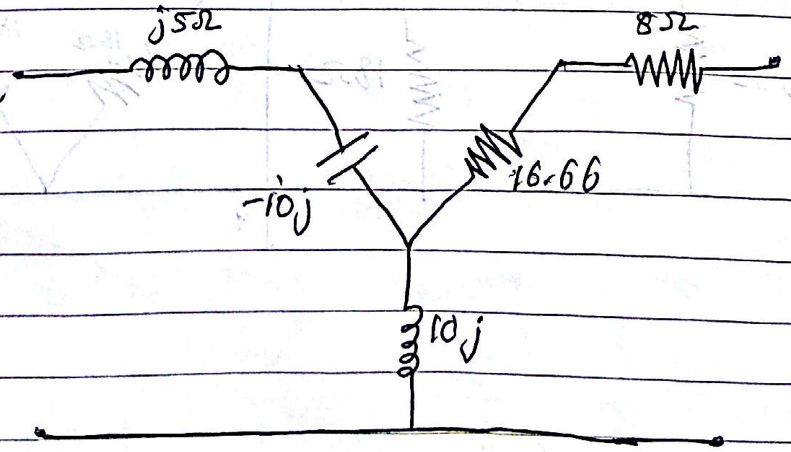
$Z_1 = -10j$

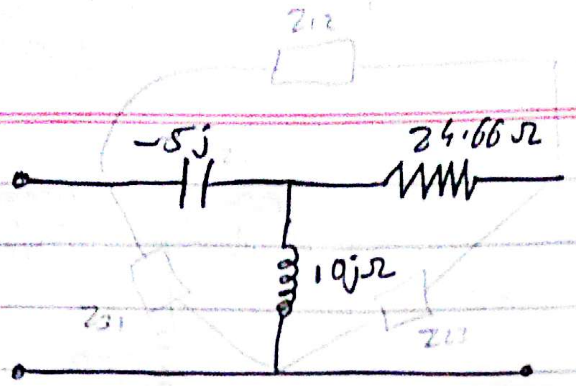
$Z_2 = 16.66$

$Z_3 = 10j$

Convert $\Delta \to Y$





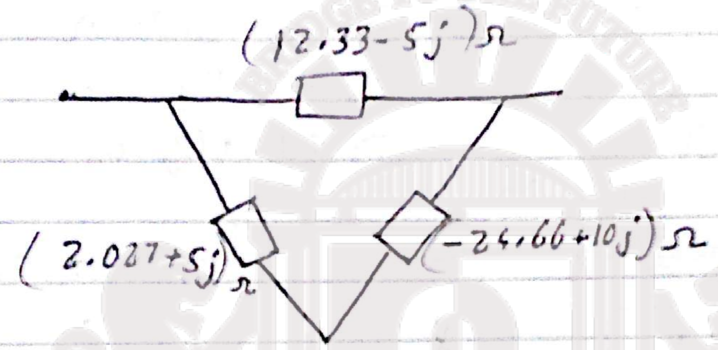


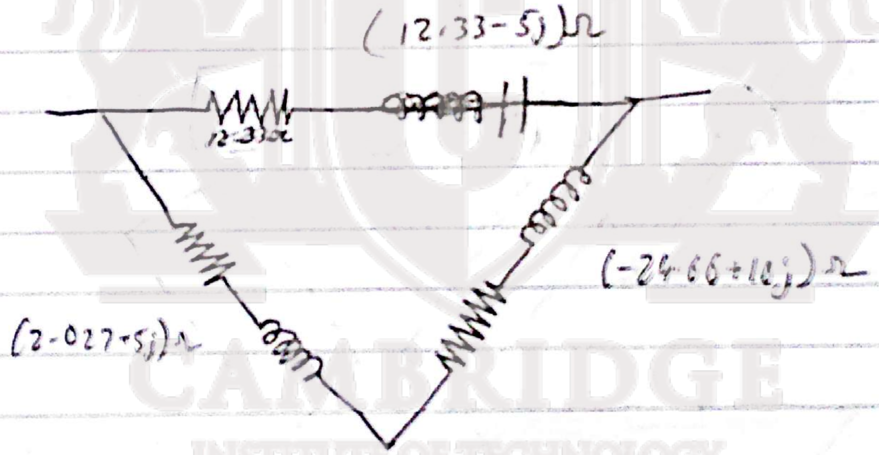
$Z_{12} = 12.33 - 5j$

$Z_{23} = -24.66 + 10j$

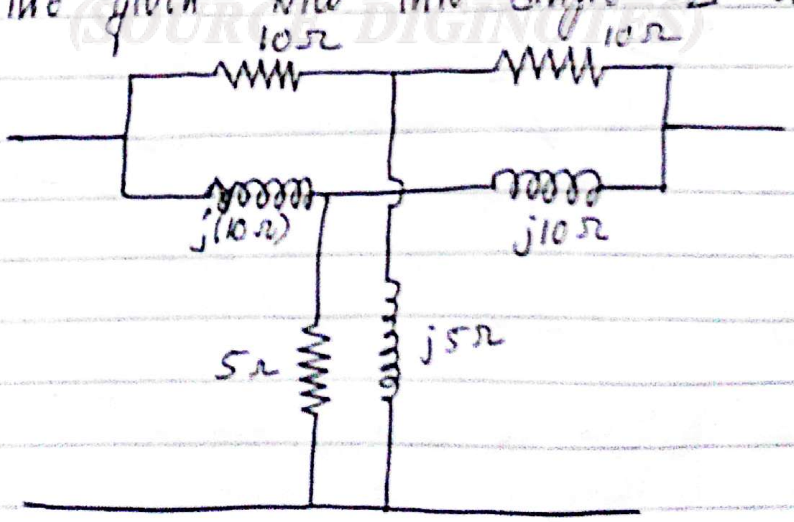
$Z_{31} = 2.027 + 5j$

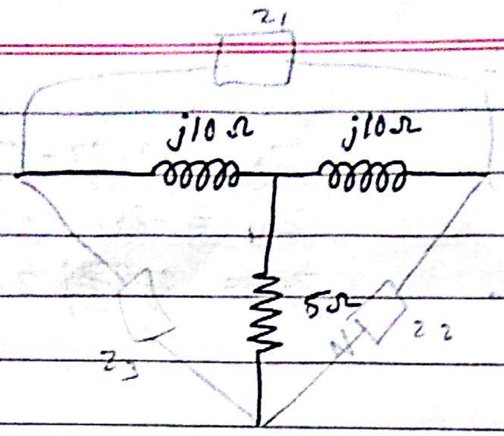
Convert $Y \rightarrow \Delta$:

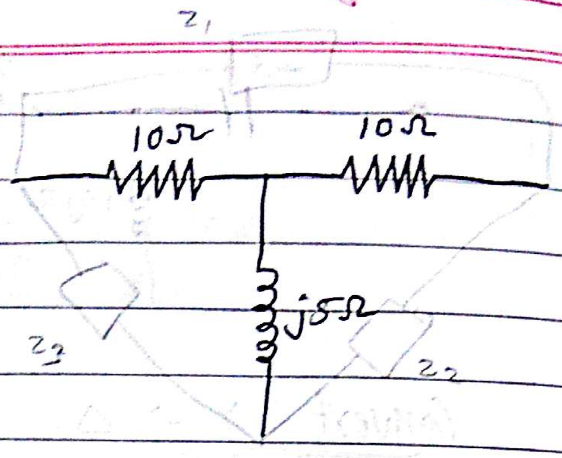




** Q. Convert the given N/w into single Δ connected N/w.







$Z_1 = -20+20j\ \Omega$

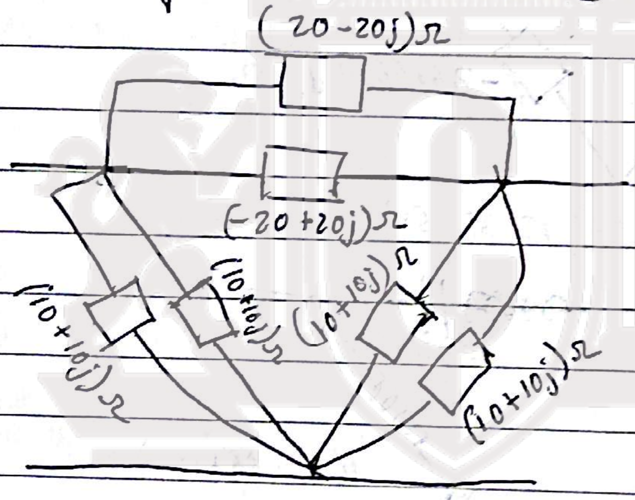
$Z_2 = 10+10j\ \Omega$

$Z_3 = 10+10j\ \Omega$

$Z_1 = 20-20j\ \Omega$

$Z_2 = 10+10j\ \Omega$

$Z_3 = 10+10j\ \Omega$

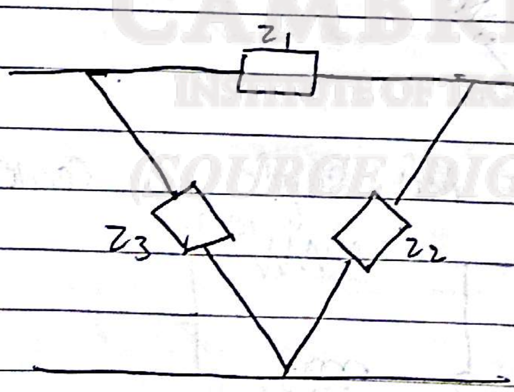


$\therefore Z_1 = (20-20j) \,||\, (-20+20j)$

$Z_1 = 0.$

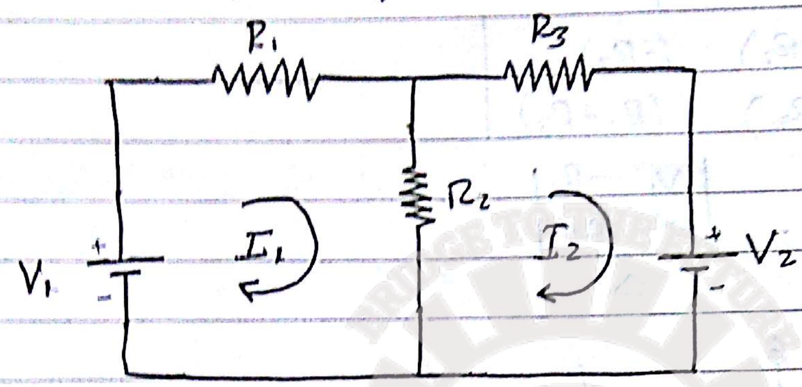
$Z_2 = 5+5i.$

$Z_3 = 5+5i$



Loop or Mesh Analysis

Consider following circuit,



In the given N/w, there are two loops.
Name the loop currents as I_1, I_2.
Assume the loop current directions in clockwise direction.

Now Apply KVL to loop no. 1,

$$V_1 = I_1 R_1 + (I_1 - I_2) R_2 \rightarrow (1)$$

Now Apply KVL to loop no. 2,

$$-V_2 = (I_2 - I_1) R_2 + I_2 R_3 \rightarrow (2)$$

$$[V] = [I][R].$$

$$\begin{bmatrix} V_1 \\ -V_2 \end{bmatrix} = \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} \begin{bmatrix} R_1 + R_2 & -R_2 \\ -R_2 & R_2 + R_3 \end{bmatrix}$$

$V_1 = I_1(R_1 + R_2) - I_2 R_2$

$-V_2 = -I_1(R_2) + I_2(R_2 + R_3)$

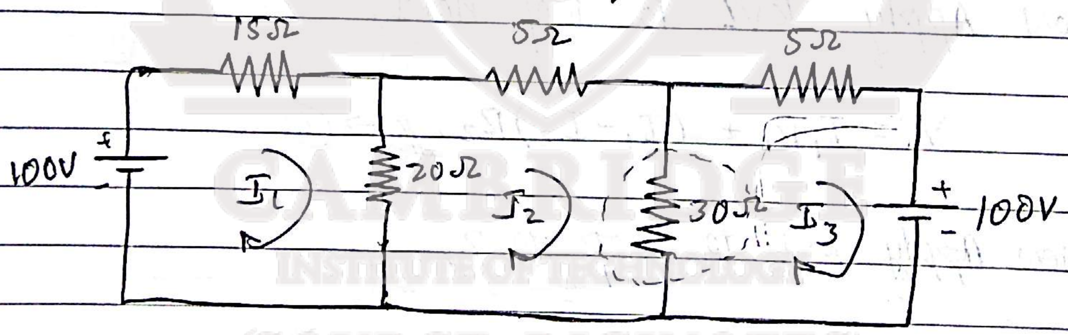
In loop analysis, to find the loop currents I_1 & I_2, we have to apply Cramer's Rule. According to this rule,

$$\Delta = \begin{vmatrix} (R_1+R_2) & (-R_2) \\ (-R_2) & (R_2+R_3) \end{vmatrix}$$

$$I_1 = \frac{\Delta_1}{\Delta} = \frac{\begin{vmatrix} V_1 & -R_2 \\ -V_2 & (R_2+R_3) \end{vmatrix}}{\Delta}$$

$$I_2 = \frac{\Delta_2}{\Delta} = \frac{\begin{vmatrix} (R_1+R_2) & V_1 \\ -R_2 & -V_2 \end{vmatrix}}{\Delta}$$

Q. Find the current through 30Ω resistance in the N/w shown using loop analysis.



Assume three loop currents I_1, I_2 & I_3 in clockwise direction.

Apply KVL to Loop No: 1

$$100 = 15I_1 + 20(I_1 - I_2) + 0I_3$$

$$100 = I_1(15+20) - I_2(20) + 0I_3$$

$$100 = 35I_1 - 20I_2 + 0I_3 \rightarrow (1)$$

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Apply KVL to loop No. 2:

$$0 = 20(I_2 - I_1) + 5I_2 + (I_2 - I_3)30.$$

$$0 = I_2(20+5+30) - I_1(20) - I_3(30).$$

$$0 = -20I_1 + 55I_2 - 30I_3 \rightarrow (2)$$

Apply KVL to loop No. 3:

$$-100 = I_3(30+5) - I_2(30) + 0I_1$$

$$-100 = 0I_1 - 30I_2 + 35I_3 \rightarrow (3)$$

Now write all the 3 equation in matrix form.

$[V] = [I][R]$

$$\begin{bmatrix} 100 \\ 0 \\ -100 \end{bmatrix} = \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} \begin{bmatrix} 35 & -20 & 0 \\ -20 & 55 & -30 \\ 0 & -30 & 35 \end{bmatrix}.$$

Apply Cramer's Rule,

$$\Delta = \begin{vmatrix} 35 & -20 & 0 \\ -20 & 55 & -30 \\ 0 & -30 & 35 \end{vmatrix} = 35(55\times35 - 30\times30) + 20(-20\times35) + 0.$$

$$\Delta = 21875$$

$$I_1 = \frac{\Delta_1}{\Delta} = \frac{\begin{vmatrix} 100 & -20 & 0 \\ 0 & 55 & -30 \\ -100 & -30 & 35 \end{vmatrix}}{21875}$$

$$I_1 = \frac{100(55\times35 - 30\times30) + 20(0 - 30\times100)}{21875} = \frac{42500}{21875} = 1.94A$$

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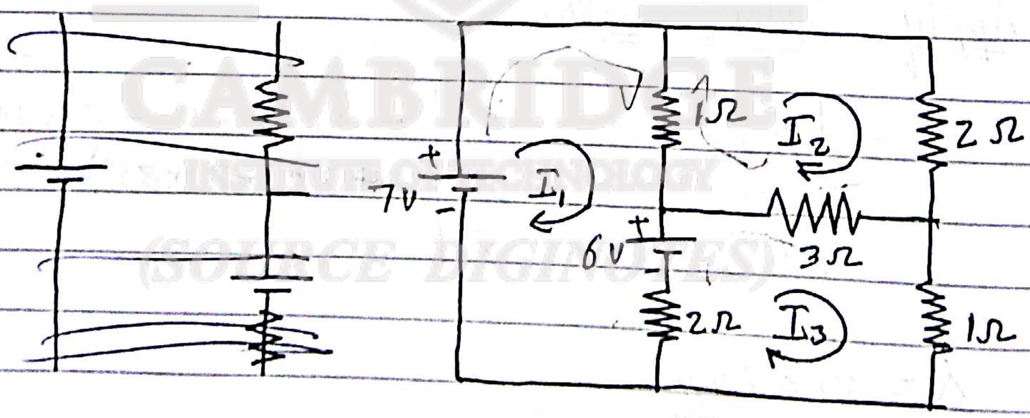
$$I_2 = \frac{\begin{vmatrix} 35 & 100 & 0 \\ -20 & 0 & -30 \\ 0 & -100 & 35 \end{vmatrix}}{21875} = \frac{-35000}{21875} = -1.6\,A$$

$$I_3 = \frac{\begin{vmatrix} 35 & -20 & 100 \\ -20 & 55 & 0 \\ 0 & -30 & -100 \end{vmatrix}}{21875} = \frac{-92500}{21875} = -4.22\,A$$

Current flowing through 30Ω resisitance,

$$I_{30\Omega} = I_2 - I_3$$
$$I_{30\Omega} = -1.6 - (-4.22)$$
$$I_{30\Omega} = 2.62\,A$$

Q. Find all the loop currents using loop analysis for the N/w shown.



Apply KVL to loop-1:

$$3I_1 - I_2 - 2I_3 = 7 - 6$$
$$3I_1 - I_2 - 2I_3 = 1 \rightarrow (1)$$

Apply KVL to loop-2:

$$-I_1 + 6I_2 - 3I_3 = 0 \rightarrow (2).$$

Apply KVL to loop-3:

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

$$[V] = [I][R]$$

$$\begin{bmatrix} 1 \\ 0 \\ 6 \end{bmatrix} = \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} \begin{bmatrix} 3 & -1 & -2 \\ -1 & 6 & -3 \\ -2 & -3 & 6 \end{bmatrix}$$

Apply Cramer's Rule:

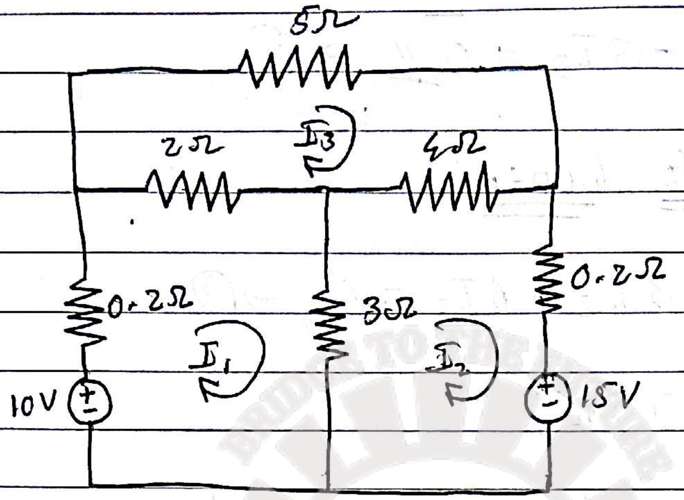
$$\Delta = \begin{vmatrix} 3 & -1 & -2 \\ -1 & 6 & -3 \\ -2 & -3 & 6 \end{vmatrix} = 39$$

$$I_1 = \frac{\Delta_1}{\Delta} = \frac{\begin{vmatrix} 1 & -1 & -2 \\ 0 & 6 & -3 \\ 6 & -3 & 6 \end{vmatrix}}{39} = \frac{117}{39} = 3A$$

$$I_2 = \frac{\Delta_2}{\Delta} = \frac{\begin{vmatrix} 3 & 1 & -2 \\ -1 & 0 & -3 \\ -2 & 6 & 6 \end{vmatrix}}{39} = \frac{78}{39} = 2A$$

$$I_3 = \frac{\Delta_3}{\Delta} = \frac{\begin{vmatrix} 3 & -1 & 1 \\ -1 & 6 & 0 \\ -2 & -3 & 6 \end{vmatrix}}{39} = \frac{117}{39} = 3A$$

Q. Find the loop currents.



Apply KVL for loop-1:

$$5.2I_1 - 3I_2 - 2I_3 = 10 \rightarrow (1).$$

Apply KVL for loop-2:

$$-3I_1 + 7.2I_2 - 4I_3 = -15 \rightarrow (2).$$

Apply KVL for loop-3:

$$-2I_1 - 4I_2 + 11I_3 = 0 \rightarrow (3).$$

[V] = [I] [R]

$$\begin{bmatrix} 10 \\ -15 \\ 0 \end{bmatrix} = \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} \begin{bmatrix} 5.2 & -3 & -2 \\ -3 & 7.2 & -4 \\ -2 & -4 & 11 \end{bmatrix}$$

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Apply Cramer's Rule:

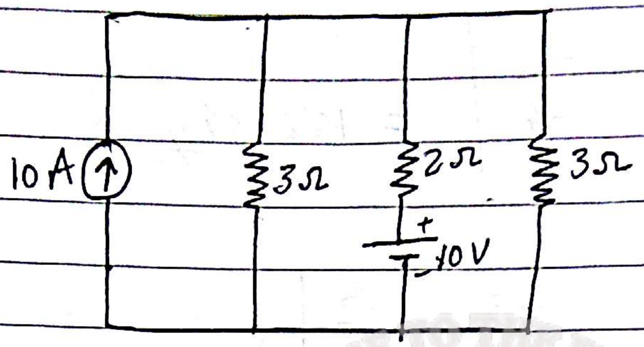
$$\Delta = \begin{vmatrix} 5.2 & -3 & -2 \\ -3 & 7.2 & -4 \\ -2 & -4 & 11 \end{vmatrix} = 152.84$$

$$I_1 = \frac{\Delta_1}{\Delta} = \frac{\begin{vmatrix} 10 & -3 & -2 \\ -15 & 7.2 & -4 \\ 0 & -4 & 11 \end{vmatrix}}{152.84} = \frac{17}{152.84} = 0.111A$$

$$I_2 = \frac{\Delta_2}{\Delta} = \frac{\begin{vmatrix} 5.2 & 10 & -2 \\ -3 & -15 & -4 \\ -2 & 0 & 11 \end{vmatrix}}{152.84} = \frac{-388}{152.84} = -2.53A$$

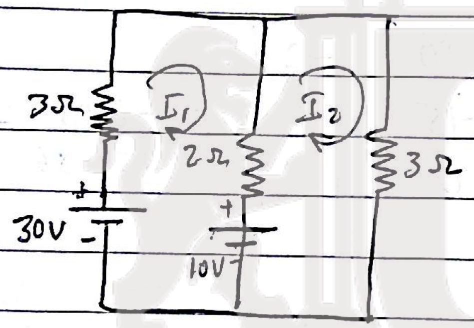
$$I_3 = \frac{\Delta_3}{\Delta} = \frac{\begin{vmatrix} 5.2 & -3 & 10 \\ -3 & 7.2 & -15 \\ -2 & -4 & 0 \end{vmatrix}}{152.84} = \frac{-138}{152.84} = -0.9024A$$

Q- Find the mesh currents in the given ckt.



Apply I → V:

$$V = IR = 30V$$



Apply KVL to loop-1:

$$5I_1 - 2I_2 = 20V \rightarrow (1).$$

Apply KVL to loop-2:

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

$$[V] = [I][R]$$

$$\begin{bmatrix} 20 \\ 10 \end{bmatrix} = \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} \begin{bmatrix} 5 & -2 \\ -2 & 5 \end{bmatrix}$$

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Apply Cramer's Rule:

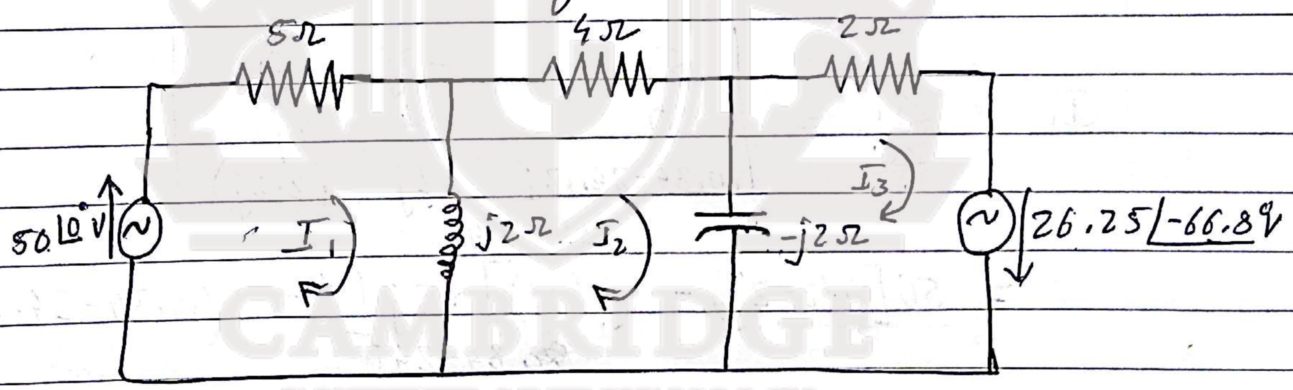
$$\Delta = \begin{vmatrix} 5 & -2 \\ -2 & 5 \end{vmatrix} = 25 - 4 = 21$$

0.11
-2.53
-0.4

$$I_1 = \frac{\Delta_1}{\Delta} = \frac{\begin{vmatrix} 20 & -2 \\ 10 & 5 \end{vmatrix}}{21} = \frac{100+20}{21} = 5.714\,A$$

$$I_2 = \frac{\Delta_2}{\Delta} = \frac{\begin{vmatrix} 5 & 20 \\ -2 & 10 \end{vmatrix}}{21} = \frac{50+40}{21} = 4.285\,A$$

Q. Find the current through 4Ω resistance in the N/w shown using loop analysis.



Apply KVL to loop-1:

$$50\angle 0^\circ = (5+j2)I_1 - j2 I_2 + 0 I_3 \rightarrow (1)$$
$$(50)$$

KVL to loop-2:

$$0 = -j2 I_1 + (4+j2-j2)I_2 - (-j2)I_3$$
$$0 = -j2 I_1 + 4I_2 + j2 I_3 \rightarrow (2)$$

KVL to loop-3:

$$26.25\angle -66.8^\circ V = 0 I_1 + 2j I_2 + (2-2j)I_3 = 0 \rightarrow (3)$$
$$(10.3409 - 24.12j)$$

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$[V] = [I][R]$

$$\begin{bmatrix} 50 \\ 0 \\ 10.34-24.12j \end{bmatrix} = \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} \begin{bmatrix} 5+2j & -2j & 0 \\ -2j & 4 & 2j \\ 0 & 2j & (2-2j) \end{bmatrix}$$

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

$$\Delta = (5+2j)\left[4(2-2j)-(2j)(2j)\right] + 2j\left[-2j(2-2j)-0\right] + 0.$$

$\Delta = 84-24j.$

$\Delta = 87.36 \angle -15.94$

$$I_1 = \frac{\Delta_1}{\Delta} = \frac{\begin{vmatrix} 50 & -2j & 0 \\ 0 & 4 & 2j \\ 10.34-24.12j & 2j & (2-2j) \end{vmatrix}}{84-24j}$$

$$= \frac{50\left[4(2-2j)-(2j)(2j)\right] + 2j\left[0-2j(10.34-24.12j)\right]}{84-24j}$$

$$= \frac{641.36-496.48j}{84-24j}$$

$$= 8.62-3.44j \text{ A}$$

$$I_2 = \frac{\Delta_2}{\Delta} = \frac{\begin{vmatrix} 5+2j & 50 & 0 \\ -2j & 0 & 2j \\ 0 & 10.34-24.12j & (2-2j) \end{vmatrix}}{84-24j}$$

$$I_2 = \frac{(5+2j)\left[0 - 2j\,(10.34 - 24.12j)\right] - 50\left[-2j\,(2-2j)\right]}{84-24j}$$

$$I_2 = \frac{0.16 + 0.12j}{84 - 24j}$$

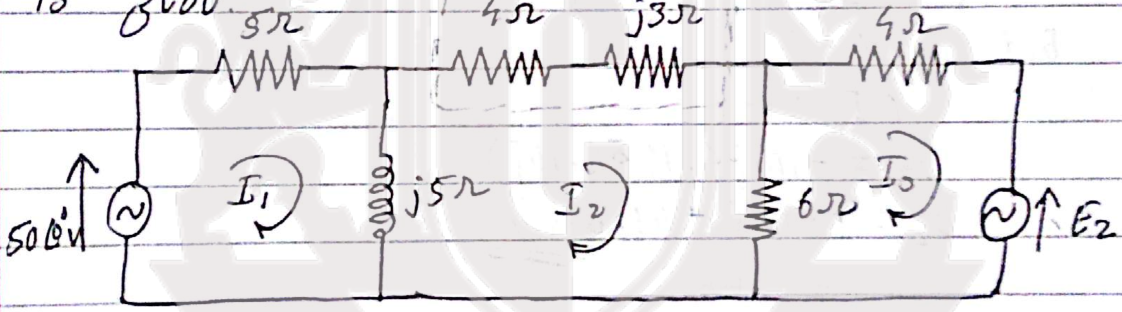
$I_2 = 1.383\times10^{-3} + 1.823\times10^{-3}j$ A

$I_2 = 2.289\times10^{-3} \angle 52.81^\circ$ A

$I_2 = 0.00228$ A ≈ 0 A

I_2 = current through 4Ω resistance.

Q. Find the value of the voltage source, $V_2(E_2)$ in the N/w shown such that current through $(4+j3)\Omega$ is zero.



According to the given data, current flowing through $(4+j3)\Omega$ is zero.

$\therefore \boxed{I_2 = 0}$

Apply KVL to loop-1,

$(5+5j)I_1 - 5j\,I_2 + 0\,I_3 = 50 + 0j$.

~~But $I_2 = 0$, $(5+5j)I_1 = 50+0j$~~

~~Apply KVL to loop-2;~~

But $I_2 = 0$, $\quad (5+5j)\,I_1 = 50$

$$I_1 = \frac{50}{5+j5} = 5 - 5j \text{ A}$$

Apply KVL to loop-2,

$$-j5(I_1) + (10+j8)I_2 - 6I_3 = 0$$

But $I_2 = 0$,

$$\Rightarrow -j5(I_1) - 6I_3 = 0 \quad \rightarrow (1)$$

$$-6I_3 = +j5(I_1)$$

$$-6I_3 = +j5(5-5j)$$

$$-6I_3 = +25 - 25j$$

$$I_3 = -4.16 \mp 4.16j \text{ A}$$

Apply KVL to loop-3,

$$10I_3 - 6I_2 + 0I_1 = -E_2$$

But $I_2 = 0$

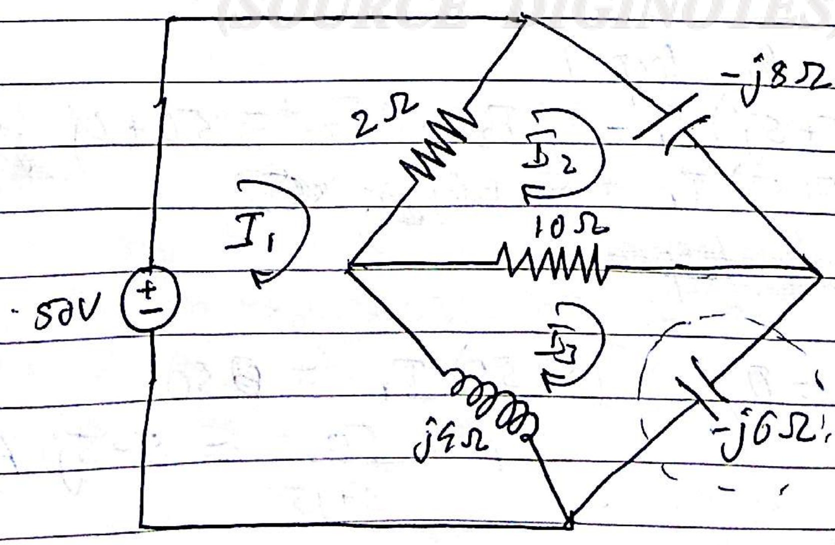
$$10I_3 = -E_2$$

$$E_2 = -10(-4.16 \mp 4.16j)$$

$$E_2 = +41.6 + 41.6j \text{ V}$$

$$E_2 = 58.83\angle 45^\circ \text{ V}$$

Q. Find the current through $-j6\Omega$ in the N/w shown.



Apply KVL to loop-1:

$$(2+j4)I_1 - 2I_2 - j4(I_3) = 50 \rightarrow (1).$$

Apply KVL to loop-2:

$$-2I_1 + (12-j8)I_2 - 10I_3 = 0 \rightarrow (2).$$

Apply KVL to loop-3:

$$-j4 I_1 - 10 I_2 + (10-j2)I_3 = 0 \rightarrow (3).$$

$$[V] = [I][R]$$

$$\begin{bmatrix} 50 \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} \begin{bmatrix} 2+j4 & -2 & -j4 \\ -2 & (12-j8) & -10 \\ -j4 & -10 & (10-j2) \end{bmatrix}$$

Current through $-j6\Omega$ is I_3.

$\therefore$ To find I_3,

$$\Delta = \begin{vmatrix} 2+j4 & -2 & -j4 \\ -2 & (12-j8) & -10 \\ -j4 & -10 & (10-j2) \end{vmatrix}$$

$$\Delta = (2+j4)\left[(12-j8)(10-j2) - 100\right]$$

$$+2\left[-2(10-j2) - 10(j4)\right] - j4\left[20 + (j4)(12-j8)\right]$$

$$\Delta = (424-192j) + (-40-72j) + (192-208j)$$

$$\Delta = 576-472j$$

$$I_3 = \frac{\Delta_3}{\Delta} = \frac{\begin{vmatrix} 2+j4 & -2 & 50 \\ -2 & (12-j8) & 0 \\ -j4 & -10 & 0 \end{vmatrix}}{576 - 472j}$$

$$= \frac{50(+20 + 4j(12-8j)) - \alpha + 0(\,)}{576-472j}$$

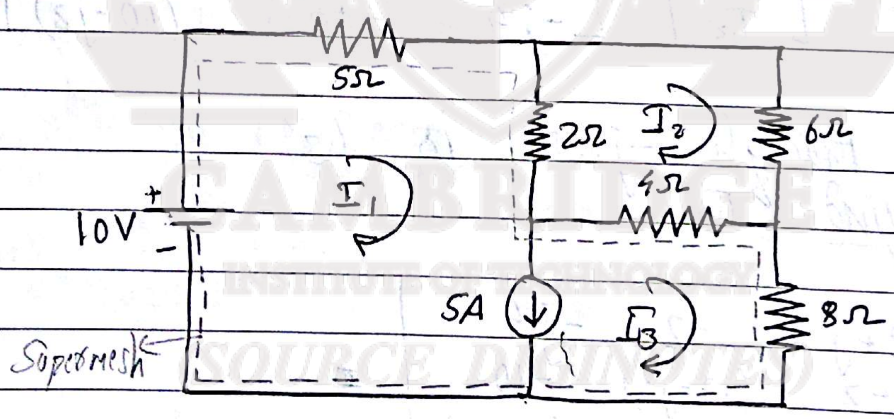
$$= \frac{2600+2400j}{576-472j}$$

$$I_3 = 0.6578 + 4.7057j \text{ A}$$

$$I_3 = 4.75 \angle 82.04^\circ \text{ A}$$

Super-Mesh Analysis:

1. Using mesh analysis find the values of loop currents in the N/w shown.



Super mesh concept appears when their is a ideal current source in b/w any two loops.

In the given N/w, their is a ideal current source 5A b/w loop 1 & loop-3.

$\therefore \quad I_1 - I_3 = 5A \rightarrow (1)$

$\therefore$ Loops 1 and 3 becomes super mesh.

Apply KVL to supermesh:

$$7I_1 - 2I_2 + 12I_3 - 4I_2 = 10$$
$$7I_1 - 6I_2 + 12I_3 = 10 \rightarrow (2)$$

Apply KVL to loop-2:

$$-2I_1 + 12I_2 - 4I_3 = 0 \rightarrow (3)$$

$$[V] = [I][R]$$

$$\begin{bmatrix} 5 \\ 10 \\ 0 \end{bmatrix} = \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} \begin{bmatrix} 1 & 0 & -1 \\ 7 & -6 & 12 \\ -2 & 12 & -4 \end{bmatrix}$$

Apply Cramer's Rule:

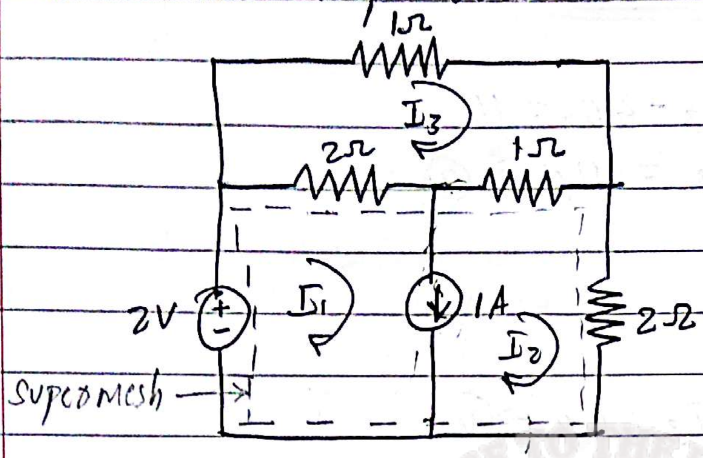
$$\Delta = \begin{vmatrix} 1 & 0 & -1 \\ 7 & -6 & 12 \\ -2 & 12 & -4 \end{vmatrix} = -192$$

$$I_1 = \frac{\Delta_1}{\Delta} = \frac{\begin{vmatrix} 5 & 0 & -1 \\ 10 & -6 & 12 \\ 0 & 12 & -4 \end{vmatrix}}{-192} = \frac{-720}{-192} = 3.75\,A$$

$$I_2 = \frac{\Delta_2}{\Delta} = \frac{\begin{vmatrix} 1 & 5 & -1 \\ 7 & 10 & 12 \\ -2 & 0 & -4 \end{vmatrix}}{-192} = \frac{-40}{-192} = 0.2083\,A$$

$$I_3 = \frac{\Delta_3}{\Delta} = \frac{\begin{vmatrix} 1 & 0 & 5 \\ 7 & -6 & 10 \\ -2 & 12 & 0 \end{vmatrix}}{-192} = \frac{240}{-192} = -1.25\,A$$

Q. Find the loop currents.



This problem is under supermesh concept because there is a ideal current source 1A b/w the loops 1 & 2.

$$\therefore \quad I_1 - I_2 = 1 \rightarrow (1)$$

Apply KVL to supermesh,

$$2I_1 + 3I_2 - 3I_3 = 2 \rightarrow (2)$$

Apply KVL to loop-3,

$$-2I_1 - I_2 + 4I_3 = 0 \rightarrow (3)$$

$$[V] = [I][R]$$

$$\begin{bmatrix} 1 \\ 2 \\ 0 \end{bmatrix} = \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} \begin{bmatrix} 1 & -1 & 0 \\ 2 & 3 & -3 \\ -2 & -1 & 4 \end{bmatrix}_{\substack{m \times n \\ 3 \times 3}}$$

Apply Cramer's Rule,

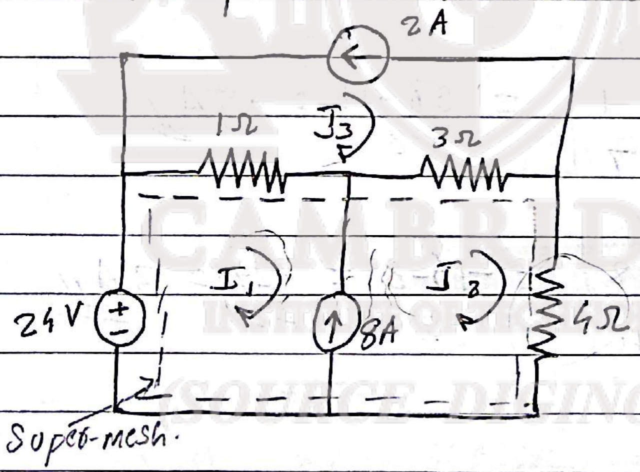
$$\Delta = \begin{vmatrix} 1 & -1 & 0 \\ 2 & 3 & -3 \\ -2 & -1 & 4 \end{vmatrix} = 11$$

$$I_1 = \frac{\Delta_1}{\Delta} = \frac{\begin{vmatrix} 1 & -1 & 0 \\ 2 & 3 & -3 \\ 0 & -1 & 4 \end{vmatrix}}{11} = \frac{17}{11} = 1.54\,A$$

$$I_2 = \frac{\Delta_2}{\Delta} = \frac{\begin{vmatrix} 1 & 1 & 0 \\ 2 & 2 & -3 \\ -2 & 0 & 4 \end{vmatrix}}{11} = \frac{6}{11} = 0.5454\,A$$

$$I_3 = \frac{\Delta_3}{\Delta} = \frac{\begin{vmatrix} 1 & -1 & 1 \\ 2 & 3 & 2 \\ -2 & -1 & 0 \end{vmatrix}}{11} = \frac{10}{11} = 0.909\,A$$

Q. Find the power in 4Ω resistance in the N/w shown.



There is a ideal current source 8A b/w loops 1 & 2.

$\therefore \quad -I_1 + I_2 = 8 \rightarrow (1)$.

2A current source is at the perimeter (boundary) of the N/w,

$\therefore \quad 0 - I_3 = 2A$

$I_3 = -2A$

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Apply KVL to super-mesh.

$$I_1 + 7I_2 - 4I_3 = 24$$
$$I_1 + 7I_2 - 4(-2) = 24$$
$$I_1 + 7I_2 = 24 - 8$$
$$I_1 + 7I_2 = 16 \rightarrow (2).$$

$$[V] = [I][R]$$

$$\begin{bmatrix} 8 \\ 16 \end{bmatrix} = \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} \begin{bmatrix} -1 & 1 \\ 1 & 7 \end{bmatrix}$$

Apply Cramer's Rule,

$$\Delta = \begin{vmatrix} -1 & 1 \\ 1 & 7 \end{vmatrix} = -7 - 1 = -8$$

$$I_1 = \frac{\Delta_1}{\Delta} = \frac{\begin{vmatrix} 8 & 1 \\ 16 & 7 \end{vmatrix}}{-8} = \frac{56 - 16}{-8} = -5A$$

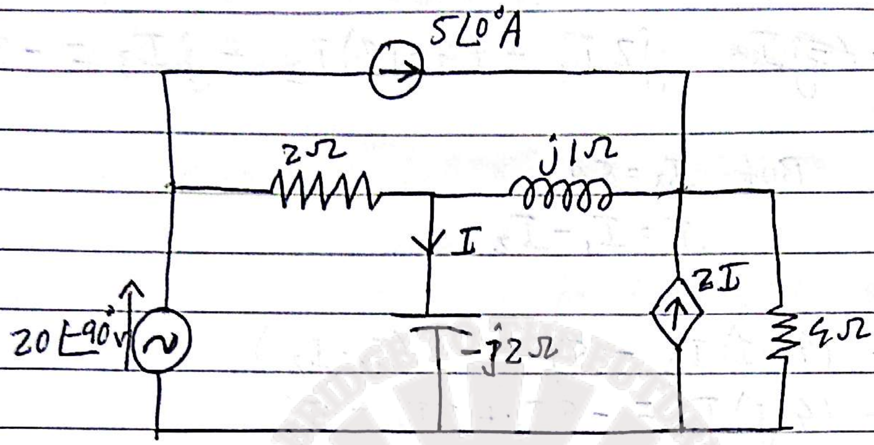
$$I_2 = \frac{\Delta_2}{\Delta} = \frac{\begin{vmatrix} -1 & 8 \\ 1 & 16 \end{vmatrix}}{-8} = \frac{-16 - 8}{-8} = \frac{+24}{+8} = 3A$$

$$I_3 = -2A$$

Now, power in 4Ω resistance,

$$P_{4\Omega} = I^2 R$$
$$P_{4\Omega} = I_2^2 \times 4$$
$$P_{4\Omega} = (3)^2 \times 4$$
$$P_{4\Omega} = 9 \times 4$$
$$P_{4\Omega} = 36 \text{ Watts}$$

Q. Find the value of current I in the N/w shown.

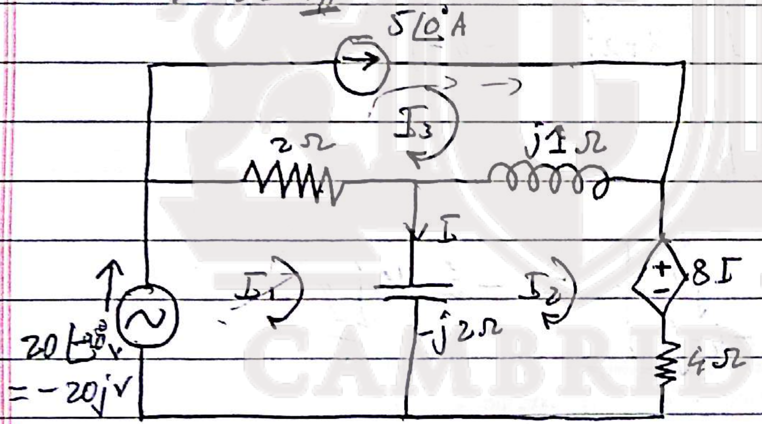


Convert current source into voltage source.

$V = IR$

$V = 2I \times 4$

$V = 8I\ V$



~~There is a ideal current source b/w~~

There is a 5∠0° current at the perimeter of the N/w.

$0 + I_3 = 5\angle 0°$

$I_3 = 5\angle 0°$

$I_3 = 5A$

Apply KVL to loop no. 1

$(2-2j)I_1 + j2I_2 - 2I_3 = 20\angle -90°$

$(2-j2)I_1 + j2I_2 - 10 = -20j$

$(2-j2)I_1 + j2I_2 = 10 - 20j \rightarrow (1)$

Apply KVL to loop no. 2.

$j2I_1 + (4-j1)I_2 - jI_3 = -8I$

But $I_3 = 5A$

$I = I_1 - I_2$

$j2I_1 + (4-j1)I_2 - 5j = -8(I_1 - I_2)$

$j2I_1 + (4-j)I_2 = -8I_1 + 8I_2 + 5j$

$(8+2j)I_1 + (-4-j)I_2 = 5j \rightarrow (2)$

$[V] = [I][R]$

$$\begin{bmatrix} 10-20j \\ 5j \end{bmatrix} = \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} \begin{bmatrix} 2-2j & j2 \\ 8+2j & -4-j \end{bmatrix}$$

Apply Cramer's Rule,

$$\Delta = \begin{vmatrix} 2-2j & j2 \\ 8+2j & -4-j \end{vmatrix} = -6-10j$$

$$I_1 = \frac{\Delta_1}{\Delta} = \frac{\begin{vmatrix} 10-20j & j2 \\ 5j & -4-j \end{vmatrix}}{-6-10j} = \frac{-50+70j}{-6-10j}$$

$I_1 = -2.9411 - 6.7647j$

$I_1 = 7.3763 \angle -113.49°$

$$I_2 = \frac{\Delta_2}{\Delta} = \frac{\begin{vmatrix} 2-2j & 10-20j \\ 8+2j & 5j \end{vmatrix}}{-6-10j} = \frac{-110+150j}{-6-10j}$$

$I_2 = -6.176 - 14.705j$ A

$I_2 = 15.95 \angle -112.78°$ A

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$I = I_1 - I_2$

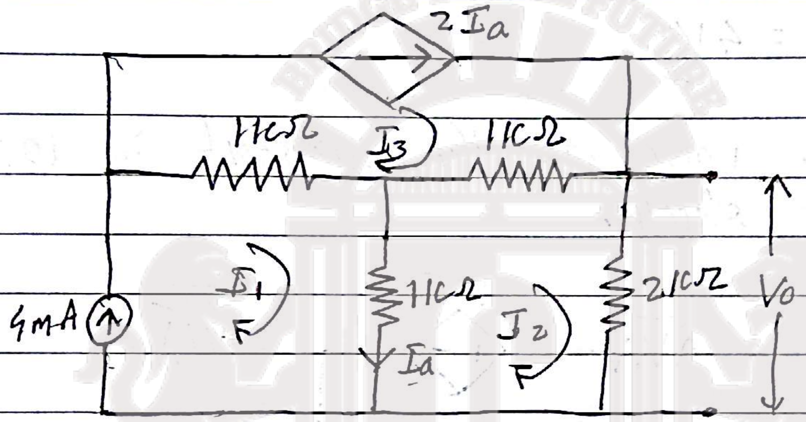
$I = -2.9411 - 6.764j - (-6.176 - 14.705j)$

$I = 3.2349 + 7.941j\,A$

(or)

$I = 8.574\angle 67.83^\circ$

Q. Find the value of Vo in the N/w shown.



4mA is at the perimeter.

$\therefore I_1 = 4mA$

III^ly, $2I_a$ current source is at the perimeter of loop-3.

$\therefore I_3 = 2I_a\,A$

But $I_a = I_1 - I_2$

$I_3 = 2(I_1 - I_2)$

$I_3 = 2I_1 - 2I_2$

Apply KVL to loop no-2:

$-1k\,I_1 + 4k\,I_2 - 1k\,I_3 = 0$

$-1k \times 4m + 4k\,I_2 - 1k(2I_1 - 2I_2) = 0$

$-4 + 4k\,I_2 - 2k\,I_1 + 2k\,I_2 = 0$

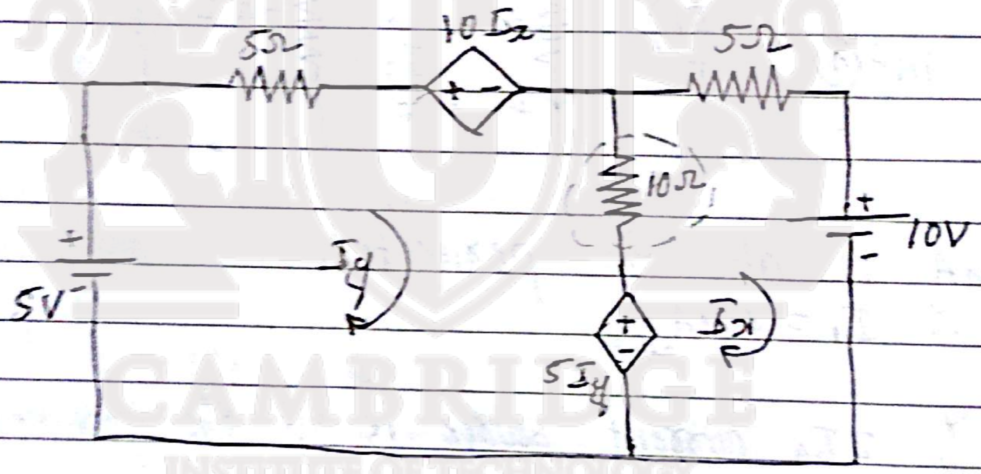
$-4 + 6k\,I_2 - 2k \times 4m = 0$

$6k\,I_2 = 4 + 8$
$6k\,I_2 = 12$
$I_2 = 2mA$

Voltage across V_0 is given by,

$V_0 = I_2 \times R_{2k\Omega}$
$V_0 = 2m \times 2k$
$V_0 = 4V$

Q- Find the value of the current in 10Ω in the N/w shown.



Apply KVL to loop no-1:

$I_y(5+10) - I_x(10) = 5 - 10I_x - 5I_y$
$15I_y - \cancel{10I_x} = 5 - \cancel{10I_x} - 5I_y$
$20I_y = 5$
$I_y = \frac{5}{20}\ \frac{1}{4}$

$I_y = 0.25A$

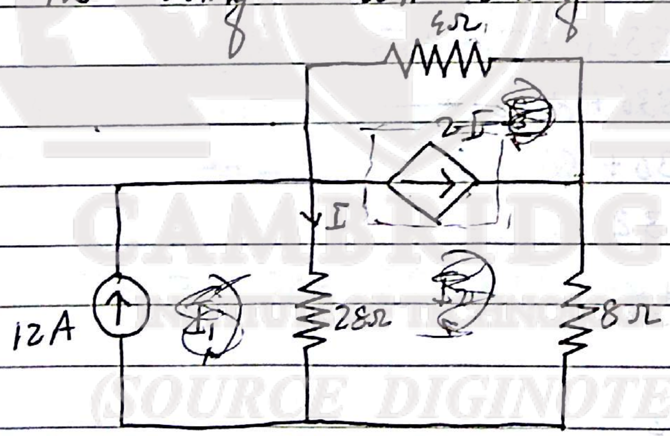
Apply KVL to loop No-2:

$$15I_x - 10I_y = -10 + 5I_y$$
$$15I_x - 15I_y = -10$$
$$15I_x = -10 + 15(0.25)$$
$$15I_x = -10 + 3.75$$
$$15I_x = -6.25$$
$$I_x = -0.416\,A$$

Current in 10Ω resistance is,

$$I_{10\Omega} = I_y - I_x$$
$$= 0.25 - (-0.416)$$
$$= 0.666\,A$$

Q. Find the value of the dependent source in the given N/w using mesh analysis.



$$I_1 = 12A$$

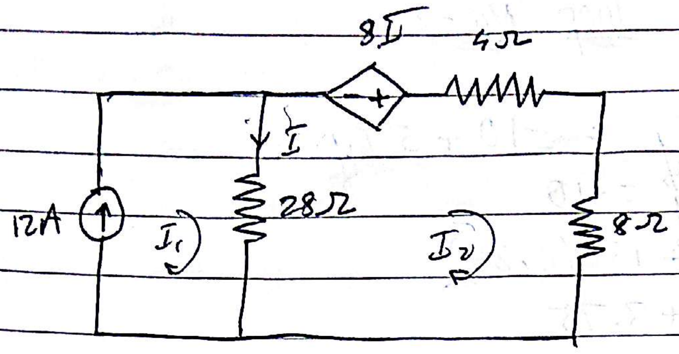
Apply $I \to V$.
$V = IR = 2I \times 4$
$V = 8I$

~~Apply KVL to loop-2.~~

$-28I_1$

12A is at the perimeter.

$$I_1 = 12A$$



Apply KVL to loop-2

$-28I_1 + 40I_2 = +8I$

$-28(12) + 40I_2 = 8I$

$-336 + 40I_2 = 8I$

But $I = I_1 - I_2$

$+40I_2 = 336 + 8(I_1 - I_2)$

$40I_2 = 336 + 8I_1 - 8I_2$

$8I_2 + 40I_2 = 336 + 8(12)$

$48I_2 = 336 + 96$

$48I_2 = 432$

$I_2 = 9A$

$I = I_1 - I_2$

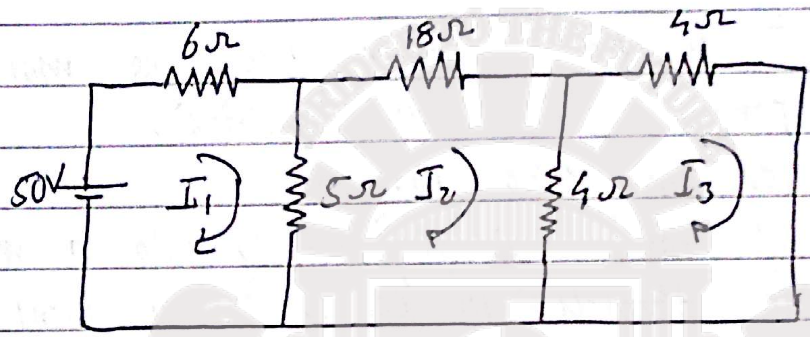
$I = 12 - 9$

$I = 3A$

Dependent source, $2I = 6A$

Q. For the following mesh equations construct the circuit diagram.

$$11 I_1 - 5 I_2 = 50$$
$$-5 I_1 + 27 I_2 - 4 I_3 = 0.$$
$$-4 I_2 + 8 I_3 = 0.$$

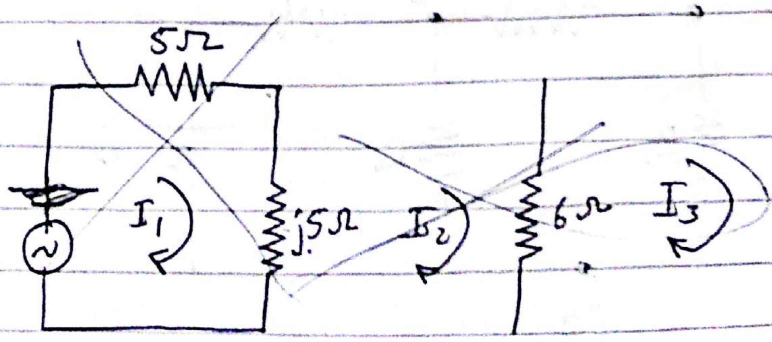


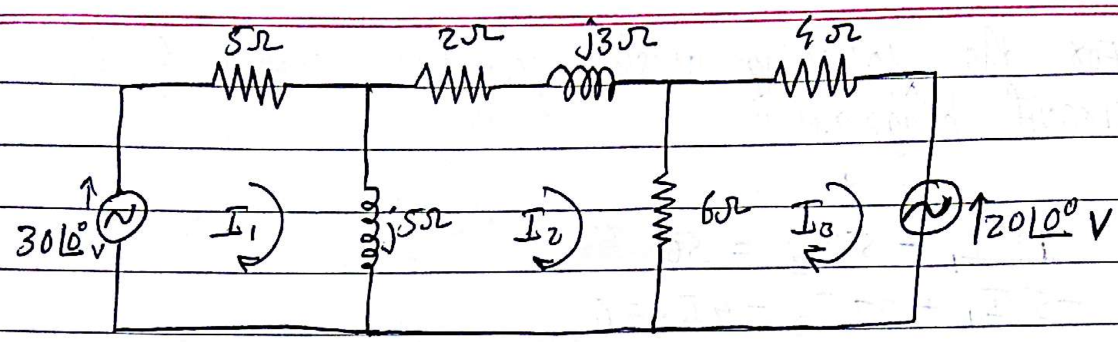
Q. For the following matrix arrangement in loop analysis, construct the circuit.

$$\begin{bmatrix} 5+j5 & -j5 & 0 \\ -j5 & 8+j8 & -6 \\ 0 & -6 & 10 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} 30\angle 0^\circ \\ 0 \\ -20\angle 0^\circ \end{bmatrix}$$

The loop equations are; $(5+j5) I_1 - j5 I_2 = 30\angle 0^\circ$

$$(-j5) I_1 + (8+j8) I_2 - 6 I_3 = 0.$$
$$0\ I_1 - 6 I_2 + 10 I_3 = -20\angle 0^\circ$$



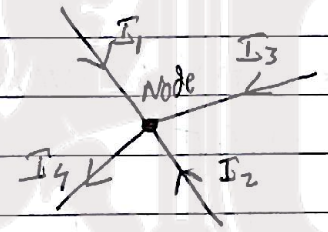


Node Analysis:

→ If two or more branches meeting at a common point is called node (junction).

→ KCL is applied for node analysis.

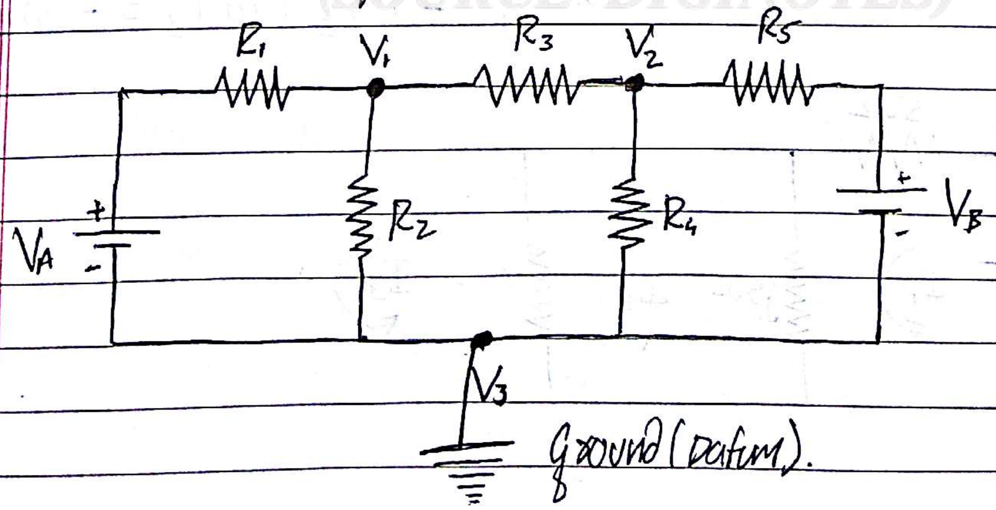
→ According to KCL, total current entering into a node is equal to total ~~feau~~ current leaving away from the node.



According to KCL,

$$\boxed{I_1 + I_2 + I_3 = I_4}$$

→ Consider the following circuit.



Apply KCL to node V_1:

$$V_1\left(\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}\right)-\frac{V_2}{R_3}=\frac{V_A}{R_1} \rightarrow (1)$$

Apply KCL to node-2 (V_2):

$$V_2\left(\frac{1}{R_3}+\frac{1}{R_4}+\frac{1}{R_5}\right)-\frac{V_1}{R_3}=\frac{V_B}{R_5}$$

$$-V_1\left(\frac{1}{R_3}\right)+V_2\left(\frac{1}{R_3}+\frac{1}{R_4}+\frac{1}{R_5}\right)=\frac{V_B}{R_5} \rightarrow (2)$$

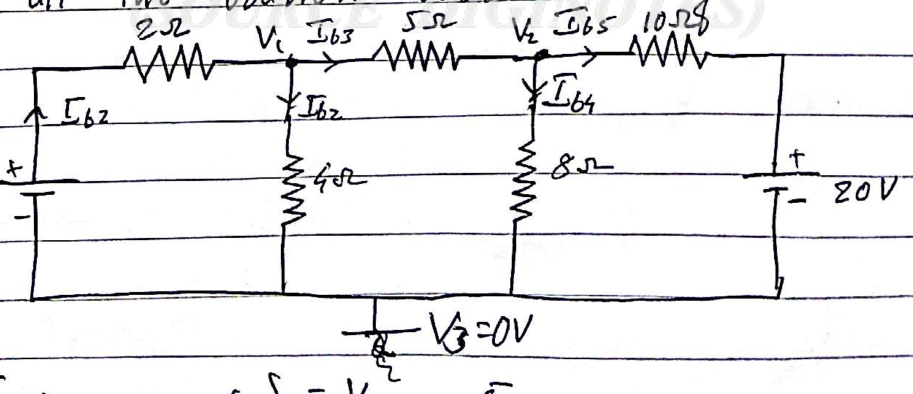
Represent equ. (1) & (2) in matrix form,

$$\begin{bmatrix} \frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3} & -\frac{1}{R_3} \\ -\frac{1}{R_3} & \frac{1}{R_3}+\frac{1}{R_4}+\frac{1}{R_5} \end{bmatrix}\begin{bmatrix} V_1 \\ V_2 \end{bmatrix}=\begin{bmatrix} V_A/R_1 \\ V_B/R_5 \end{bmatrix}$$

Note:

In node analysis, no. of equations are 1 less than no. of equations in loop analysis.

Q. Find all the branch currents using ~~load~~ node analysis.



$$V_1\left(\frac{1}{2}+\frac{1}{5}+\frac{1}{4}\right)=\frac{V_2}{5}=5$$

$$V_1(0.5+0.25+0.2)-V_2(0.2)=5$$

$$V_1(0.95)-V_2(0.2)=5 \rightarrow (1)$$

$$-\frac{V_1}{5} + V_2\left(\frac{1}{10} + \frac{1}{5} + \frac{1}{8}\right) = \frac{20}{10} = 2.$$

$$-0.2V_1 + V_2(0.425) = 2 \rightarrow (2).$$

$V_1 = 6.941V$

$V_2 = 7.972V$

$$\begin{bmatrix} 0.95 & -0.2 \\ -0.2 & 0.425 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} 5 \\ 2 \end{bmatrix}$$

$\Delta = 0.363$

$$V_1 = \frac{\begin{vmatrix} 5 & -0.2 \\ 2 & 0.425 \end{vmatrix}}{\Delta} =$$

The branch currents are,

$$I_{b1} = \frac{10 - V_1}{2} = \frac{10 - 6.94}{2} = 1.53\,A$$

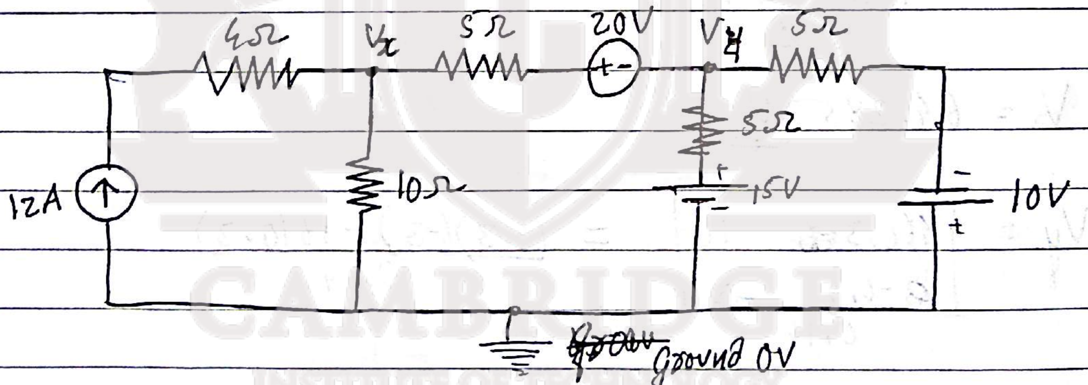
$$I_{b2} = \frac{V_1 - V_3}{4} = \frac{6.94 - 0}{4} = 1.735\,A$$

$$I_{b3} = \frac{V_1 - V_2}{5} = \frac{6.94 - 7.97}{5} = -0.206\,A \quad (\xleftarrow[\text{opp.}]{})$$

$$I_{b4} = \frac{V_2 - V_3}{8} = \frac{7.97 - 0}{8} = 0.996\,A$$

$$I_{b5} = \frac{V_2 - 20}{10} = \frac{7.97 - 20}{10} = -1.203\,A \quad (\xleftarrow[\text{opp.}]{})$$

Q. Find the node voltages V_x and V_y in the N/w shown.



Apply KCL to node V_x,

Note: (Since, 4Ω is in series with 12A current source, it has no significance.
∴ 4Ω is neglected.)

$$V_x\left[\frac{1}{10} + \frac{1}{5}\right] - V_y\left[\frac{1}{5}\right] = 12 + \frac{20}{5}$$

$$0.3V_x - 0.2V_y = 16 \rightarrow (1).$$

Apply KCL to node V_y:

$$V_y\left[\frac{1}{5}+\frac{1}{5}+\frac{1}{5}\right]-V_x\left[\frac{1}{5}\right]=\frac{-20}{5}+\frac{15}{5}-\frac{10}{5}$$

$$-0.2V_x+0.6V_y=-3 \rightarrow (2)$$

$$\begin{bmatrix}0.3 & -0.2\\ -0.2 & 0.6\end{bmatrix}\begin{bmatrix}V_x\\ V_y\end{bmatrix}=\begin{bmatrix}16\\ -3\end{bmatrix}$$

$$\Delta=\begin{vmatrix}0.3 & -0.2\\ -0.2 & 0.6\end{vmatrix}$$

$\Delta = 0.14$

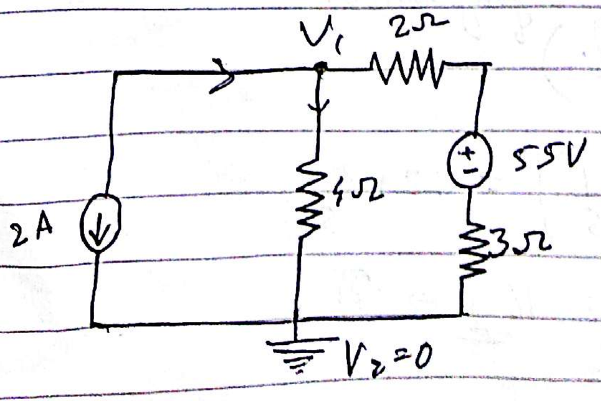
$$V_x=\frac{\begin{vmatrix}16 & -0.2\\ -3 & 0.6\end{vmatrix}}{\Delta}=\frac{16(0.6)-(0.2)(3)}{0.14}$$

$V_x = 64.2857\,V$

$$V_y=\frac{\begin{vmatrix}0.3 & 16\\ -0.2 & -3\end{vmatrix}}{0.14}=\frac{(0.3)(-3)+16(0.2)}{0.14}$$

$V_y = 16.42\,V$

Q. Find the power delivered by 2A current source in the N/w shown.



Apply KCL to node V_1:

$$V_1\left[\frac{1}{4}+\frac{1}{5}\right] = -2 + \frac{55}{5}$$

$$0.45V_1 = 9$$

$$V_1 = 20V$$

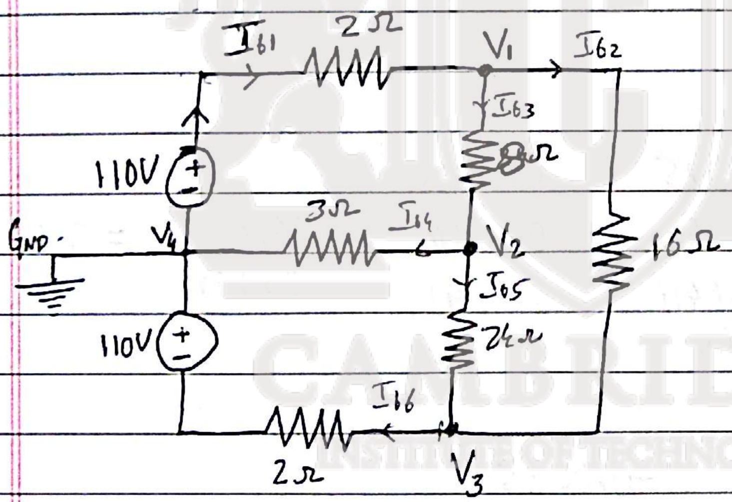
∴ Power delivered by 2A current source,

$$P_{2A} = V_1 I$$

$$P_{2A} = 20\times 2$$

$$P_{2A} = 40 \text{ Watts}$$

Q. Find all the branch currents in the N/w shown.



Apply KCL to node V_1:

$$V_1\left[\frac{1}{2}+\frac{1}{8}+\frac{1}{16}\right] - V_2\left[\frac{1}{8}\right] - V_3\left[\frac{1}{16}\right] = \frac{110}{2}$$

$$0.6875V_1 - 0.125V_2 - 0.0625V_3 = 55 \rightarrow (1)$$

Apply KCL to node V_2:

$$V_2\left[\frac{1}{8}+\frac{1}{3}+\frac{1}{24}\right] - V_1\left[\frac{1}{8}\right] - V_3\left[\frac{1}{24}\right] = 0$$

$$-0.125V_1 + 0.5V_2 - 0.0416V_3 = 0 \rightarrow (2)$$

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Apply KCL to node V_3:

$$V_3\left[\frac{1}{2}+\frac{1}{16}+\frac{1}{24}\right]-V_2\left[\frac{1}{24}\right]-V_1\left[\frac{1}{16}\right]=\frac{-110}{2}$$

$$-0.0625V_1-0.0416V_2+0.6041V_3=-55 \rightarrow (3)$$

$$\begin{bmatrix}V_1\\V_2\\V_3\end{bmatrix}\begin{bmatrix}0.6875 & -0.125 & -0.0625\\-0.125 & 0.5 & -0.0416\\-0.0625 & -0.0416 & 0.6041\end{bmatrix}=\begin{bmatrix}55\\0\\-55\end{bmatrix}$$

$$\Delta=\begin{vmatrix}0.6875 & -0.125 & -0.0625\\-0.125 & 0.5 & -0.0416\\-0.0625 & -0.0416 & 0.6041\end{vmatrix}$$

$$\Delta=0.1944$$

$$V_1=\frac{\begin{vmatrix}55 & -0.125 & -0.0625\\0 & 0.5 & -0.0416\\-55 & -0.0416 & 0.6041\end{vmatrix}}{0.1944}=\frac{14.5128}{0.1944}=74.6544V$$

$$V_2=\frac{\begin{vmatrix}0.6875 & 55 & -0.0625\\-0.125 & 0 & -0.0416\\-0.0625 & -55 & 0.6041\end{vmatrix}}{0.1944}=\frac{2.2935}{0.1944}=11.7978V$$

$$V_3=\frac{\begin{vmatrix}0.6875 & -0.125 & 55\\-0.125 & 0.5 & 0\\-0.0625 & -0.0416 & -55\end{vmatrix}}{0.1944}=-\frac{16.0421}{0.1944}=-82.5212V$$

$$I_{b1} = \frac{110 - V_1}{2} = \frac{110 - 74.6544}{2} = 17.67A$$

$$I_{12} = \frac{V_1 - V_3}{16} = \frac{74.65 + 82.521}{16} = 9.823A$$

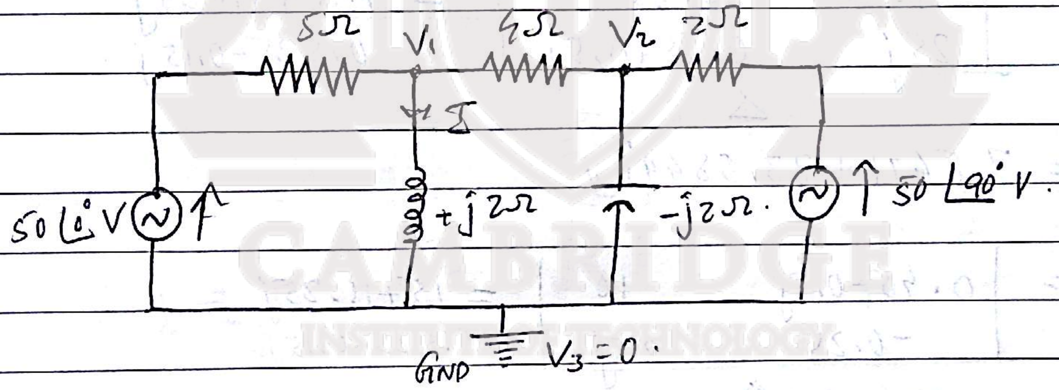
$$I_{b3} = \frac{V_1 - V_2}{8} = \frac{74.65 - 11.79}{8} = 7.8575A$$

$$I_{b4} = \frac{V_2 - V_4}{8} = \frac{11.7978}{3} = 3.9326A$$

$$I_{b5} = \frac{V_2 - V_3}{24} = 3.929A$$

$$I_{b6} = \frac{V_3 - (-110)}{2} = \frac{-82.5212 + 110}{2} = 13.7394A$$

Q. Find the value of current I in the N/W shown using node analysis.



Apply KCL to node V_1:

$$V_1\left[\frac{1}{5} + \frac{1}{4} + \frac{1}{j2}\right] - V_2\left[\frac{1}{4}\right] = \frac{50\angle 0^\circ}{5} = \frac{50 + 0j}{5}$$

$$V_1[0.45 - 0.5j] - 0.25V_2 = 10$$

Apply KCL to node V_2:

$$V_2\left[\frac{1}{4}+\frac{1}{2}-\frac{1}{j2}\right]-V_1\left[\frac{1}{4}\right]=\frac{50\angle 90^\circ}{2}$$

$$-0.25V_1+V_2[0.75+0.5j]=25j$$

$$\begin{bmatrix}V_1\\V_2\end{bmatrix}\begin{bmatrix}0.45-0.5j & -0.25\\-0.25 & 0.75+0.5j\end{bmatrix}=\begin{bmatrix}10\\25j\end{bmatrix}$$

$$\Delta=\begin{vmatrix}0.45-0.5j & -0.25\\-0.25 & 0.75+0.5j\end{vmatrix}$$

$$\Delta=0.525-0.15j$$

$$V_1=\frac{\begin{vmatrix}10 & -0.25\\25j & 0.75+0.5j\end{vmatrix}}{\Delta}=\frac{7.5+11.25j}{0.525-0.15j}$$

$$V_1=7.5471+23.5849j$$

$$V_2=\frac{\begin{vmatrix}0.45-0.5j & 10\\-0.25 & 25j\end{vmatrix}}{\Delta}=\frac{15+11.25j}{0.525-0.15j}=$$

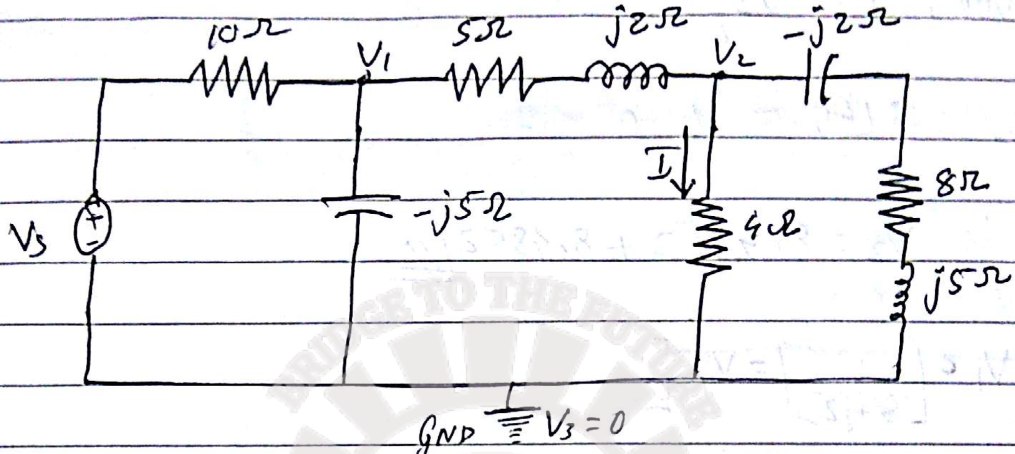
$$V_2=20.754+27.358j$$

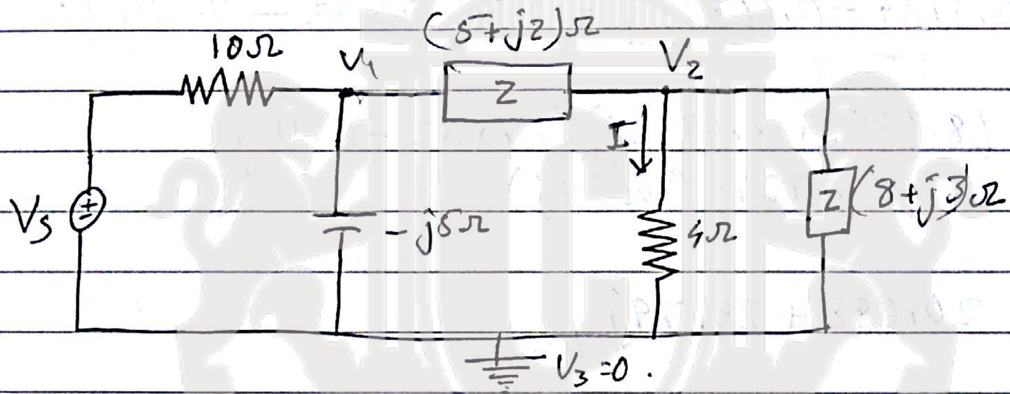
$$I=\frac{V_1-V_3}{j2}=\frac{(7.5471+23.5849j)-0}{j2}$$

$$I=11.7924-3.7735j\ A$$

$$I=12.3815\angle -17.74^\circ\ A$$

Q. Find the value of V_s in the N/w shown such that current $I = 3\angle 45^\circ A$ Using node analysis.





Apply KCL to node V_1:

$$V_1\left[\frac{1}{10} - \frac{1}{j5} + \frac{1}{5+j2}\right] - V_2\left[\frac{1}{5+j2}\right] = \frac{V_s}{10}$$

$$[0.2724 + 0.1310j]\,V_1 - (0.1724 - 0.0689j)\,V_2 = \frac{V_s}{10} = 0.1V_s \rightarrow ①.$$

Apply KCL to node V_2:

$$V_2\left[\frac{1}{5+j2} + \frac{1}{4} + \frac{1}{8+j3}\right] - V_1\left[\frac{1}{5+j2}\right] = 0.$$

$$[0.532 - 0.110j]\,V_2 - (0.1724 - 0.0689j)\,V_1 = 0 \rightarrow ②.$$

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~~$I_{4\Omega} = \frac{V_2 - V_3}{4\Omega}$~~

Now, $I = \frac{V_2 - V_3}{4}$

$$3\angle 45^\circ = \frac{V_2 - 0}{4}$$

$$V_2 = 8.4852 + 8.4852j$$

~~$V_1 \left[\frac{1}{5+j2}\right] = V_2 [$~~

From ②

$$V_1 [0.1724 - 0.0689j] = V_2 [0.532 - 0.110j]$$

$$V_1 = \frac{(8.4852 + 8.4852j)(0.532 - 0.110j)}{(0.1724 - 0.0689j)}$$

$$V_1 = 20.088 + 28.79j$$

$$[0.2724 + 0.1310j] V_1 - (0.1724 - 0.0689j) V_2 = 0.1 V_s$$

$$(0.1) V_s = [0.2724 + 0.1310j][20.088 + 28.79j] - [0.1724 - 0.0689j][8.4852 + 8.4852j]$$

~~$0.1 V_s = -3674.9245 + 7650.4729j$~~

~~$V_s = -36749.245 + 76504.729j$~~

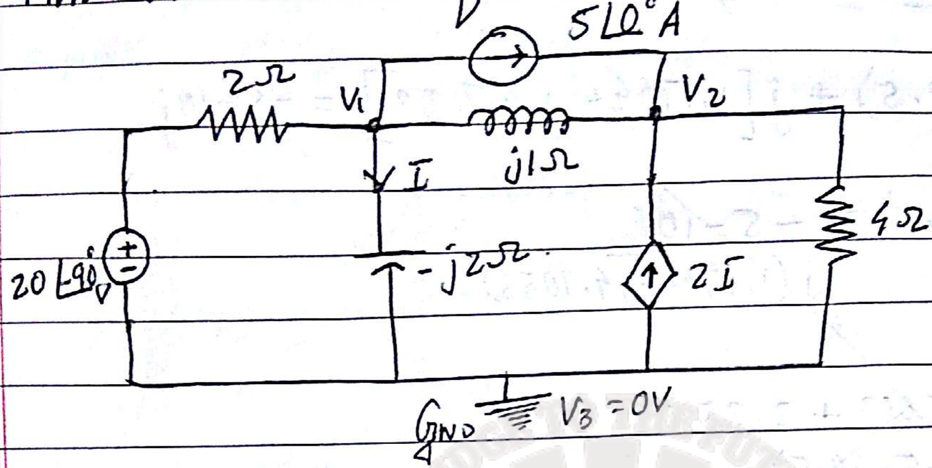
~~$V_s = 84873.320 \angle 115.65^\circ$~~

$$0.1 V_s = -0.3469 + 9.59j$$

$$V_s = -3.469 + 95.9j \quad (\text{or})$$

$$V_s = 96.0197 \angle 92.071$$

Q. Find the value of current I using node analysis.



Apply KCL to node V_1:

$$V_1\left[\frac{1}{2}+\frac{1}{-2j}+\frac{1}{j\Omega}\right]-V_2\left[\frac{1}{j1\Omega}\right]=\frac{20\angle-90^\circ}{2}-5\angle0^\circ A$$

$$(0.5-0.5j)V_1-V_2(-j)=-5-10j$$

$$(0.5-0.5j)V_1+jV_2=-5-10j \rightarrow (1)$$

Apply KCL to node V_2:

$$V_2\left[\frac{1}{j}+\frac{1}{4}\right]-V_1\left[\frac{1}{j}\right]=5\angle0^\circ+2I$$

But $I=\frac{V_1-V_3}{-j2}=\frac{V_1}{-j2}$

$$\therefore V_1(\cancel{j})+(0.25-j)V_2=5+2\left(\frac{V_1}{-j2}\right)=5+\cancel{V_1j}$$

$$(0.25-j)V_2=5$$

$$V_2=\frac{5}{0.25-j}$$

$$V_2=1.1764+4.7058j\ V$$

$$V_2=4.85\angle75.96^\circ\ V$$

Substitute V_2 in equ ①,

$$V_1(0.5 - j0.5) + j[1.1764 + j\,4.7058] = -5 - 10j$$

$$V_1(0.5 - j0.5) = \frac{-5 - 10j}{j(1.1764 + j\,4.7058)}$$

$$V_1 = \frac{0.50003 + 2.25004j}{(0.5 - j0.5)}$$

$$V_1 = -1.750 + 2.750j \text{ V}$$

$$V_1 = -3.259 \angle 122.47^\circ \text{ V}$$

$$V_1(0.5 - j0.5) = -0.2942 - 11.1764j$$

$$V_1 = 10.8822 - 11.4706j \text{ V}$$

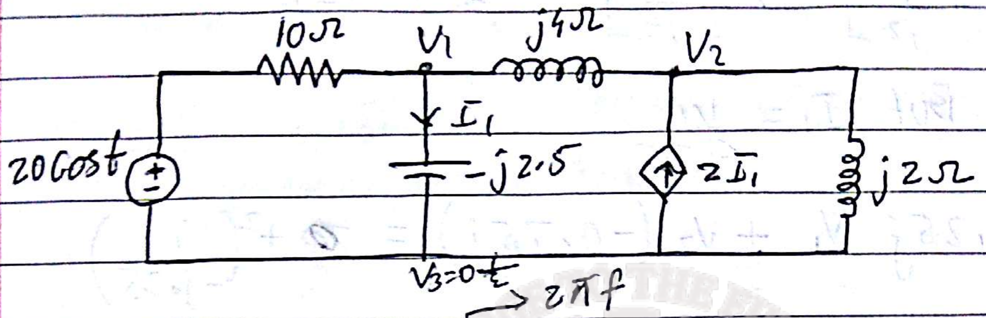
$$V_1 = 15.811 \angle -46.50 \text{ V}$$

$$I_1 = \frac{V_1}{-j2} = +5.7353 + 5.4411j \text{ A}$$

$$\cancel{I = 7.9056 \angle 136.50^\circ \text{ A}}$$

$$I = 7.9056 \angle 43.5 \text{ A}$$

Q. Find the value of the current I_1 in the N/w shown using Node analysis.



$$V(t) = A \sin(\omega t + \phi)$$

$\omega \rightarrow 2\pi f$; A → Amplitude; ϕ → Phase Angle

$\Downarrow$ $A\angle\phi$

$20\cos t \Rightarrow A = 20;\ \omega = 1;\ \phi = 0.$

$20\cos t = 20\angle 0$

Apply KCL to V_1:

$$V_1\left[\frac{1}{10} + \frac{1}{j4} - \frac{1}{2.5j}\right] - V_2\left[\frac{1}{4}\right] = \frac{20}{10}$$

$$(0.35 + 0.4j)V_1 - (0.25)V_2 = 20 \rightarrow (1)$$

Apply KCL to V_2:

$V_2\left[\frac{1}{\;}\right.$

Apply KCL to V_1:

$$V_1\left[\frac{1}{10} + \frac{1}{j4} - \frac{1}{j2.5}\right] - V_2\left[\frac{1}{j4}\right] = \frac{20}{10}$$

$$(0.1 + 0.15j)V_1 + (0.25j)V_2 = 2$$

Apply KCL to node V_2:

$$V_2\left[\frac{1}{j4}+\frac{1}{j2}\right]-V_1\left[\frac{1}{j4}\right]=\cancel{0}+2I_1$$

But $I_1=\dfrac{V_1}{-j\cdot 2.5}$

$$0.25j\,V_1+V_2(-0.75j)=\cancel{0}+2\left(\frac{V_1}{-j\cdot 2.5}\right)$$

$$0.25j\,V_1-0.75j\,V_2=\cancel{0}+\frac{2V_1}{-j\cdot 2.5}$$

$$\left(0.25j+\frac{2}{j\cdot 2.5}\right)V_1-0.75j\,V_2=0.$$

$$-0.55j\,V_1-0.75j\,V_2=0.$$

$$\begin{bmatrix}V_1\\V_2\end{bmatrix}\begin{bmatrix}0.1+0.15j & 0.25j\\ -7.75j & -0.75j\end{bmatrix}=\begin{bmatrix}2\\0\end{bmatrix}$$

$$\Delta=\begin{vmatrix}0.1+0.15j & 0.25j\\ -7.75j & -0.75j\end{vmatrix}$$

$$\Delta=-1.825-0.075j$$

$$V_1=\frac{\begin{vmatrix}2 & 0.25j\\ 0 & -0.75j\end{vmatrix}}{\Delta}=\frac{-1.5j}{-1.825-(0.075j)}$$

$$V_1=18.97\angle 18.43^\circ$$

$$I_1=7.59\angle 108.4^\circ$$

$$(0.1 + 0.15j)V_1 + (0.25j)V_2 = 2$$

$$(-0.55j)V_1 - 0.75j\,V_2 = 0.$$

$$\Delta = \begin{vmatrix} 0.1+0.15j & 0.25j \\ -0.55j & -0.75j \end{vmatrix}$$

$$\Delta = -0.025 - 0.075j$$

$$V_1 = \frac{\begin{vmatrix} 2 & 0.25j \\ 0 & -0.75j \end{vmatrix}}{\Delta}$$

$$V_1 = \frac{-1.5j}{-0.025-0.075j}$$

$$V_1 = 18+6i \text{ V}$$

$$V_1 = 18.973 \angle 18.43^\circ \text{ V}$$

$$\therefore I_1 = \frac{V_1}{-j2.5} = \frac{18+6i}{-j2.5}$$

$$I_1 = -2.4+7.2j$$

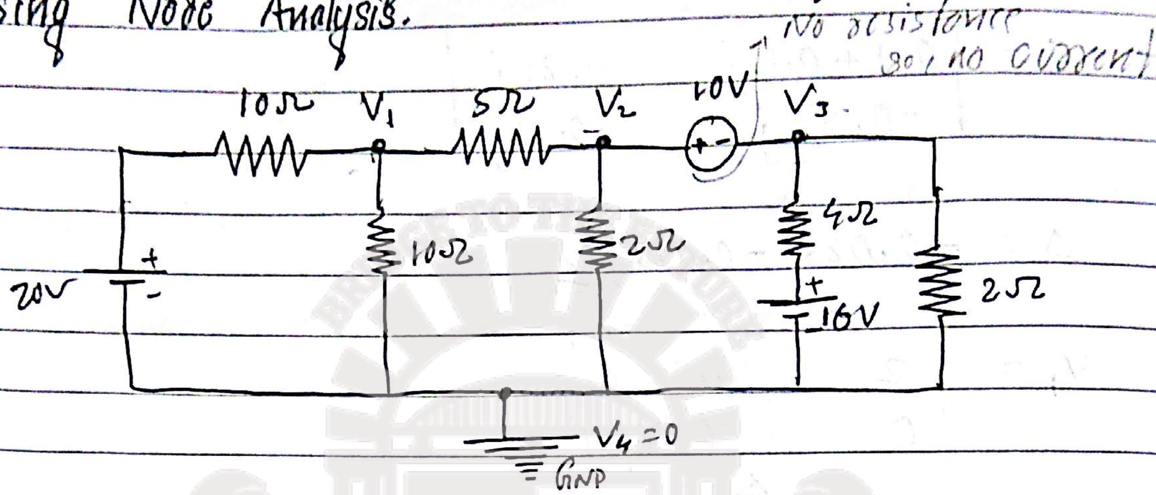
$$I_1 = 7.58 \angle 108.4^\circ \text{ A}$$

$\therefore$ Current I_1 in time domain ~~is~~ is I_1,

$$I_1 = 7.58 \cos(t + 108.4^\circ)$$

Super-node Analysis:

Q. Find the value of $I_{4\Omega}$ in the given N/W using Node Analysis.



10 V voltage source is connected b/w the nodes V_2 and V_3. Therefore, $V_2 - V_3$ forms a super node.

Therefore, $V_2 - V_3 = 10 \rightarrow (1)$.

Apply KCL to node V_1:

$$V_1\left[\frac{1}{10}+\frac{1}{10}+\frac{1}{5}\right] - V_2\left[\frac{1}{5}\right] = \frac{20}{10}$$

$$0.4V_1 - 0.2V_2 = 2 \Rightarrow (2)$$

Now apply KCL to supernode $V_2 - V_3$,

$$V_2\left[\frac{1}{5}+\frac{1}{2}\right] + V_3\left[\frac{1}{4}+\frac{1}{2}\right] - V_1\left[\frac{1}{5}\right] = \frac{16}{4}$$

$$-0.2V_1 + 0.7V_2 + 0.75V_3 = 4 \rightarrow (3)$$

$$P\begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix}\begin{bmatrix} 0 & 1 & -1 \\ 0.4 & -0.2 & 0 \\ -0.2 & 0.7 & 0.75 \end{bmatrix} = \begin{bmatrix} 10 \\ 2 \\ 4 \end{bmatrix}$$

$$\Delta = \begin{vmatrix} 0 & 1 & -1 \\ 0.4 & -0.2 & 0 \\ -0.2 & 0.7 & 0.75 \end{vmatrix} = -0.54$$

$$V_3 = \frac{\begin{vmatrix} 0 & 1 & 10 \\ 0.4 & -0.2 & 2 \\ -0.2 & 0.7 & 4 \end{vmatrix}}{-0.54} = \frac{0.4}{-0.54}$$

$$V_3 = -0.740\ V$$

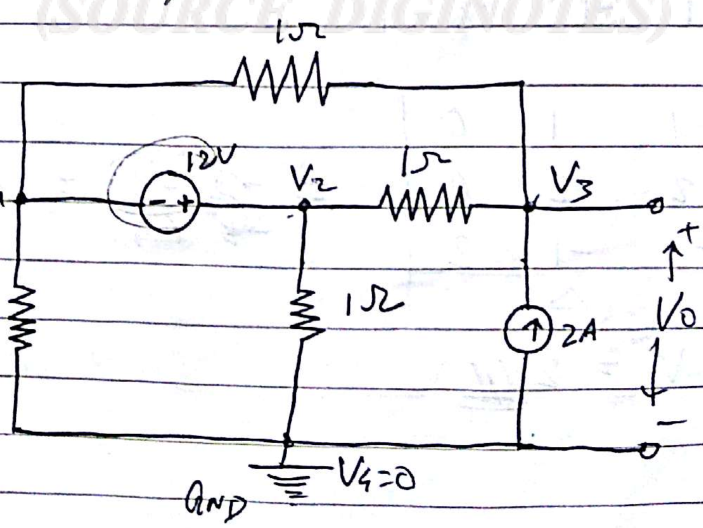
Current across 4Ω resistance,

$$\cancel{I_{4\Omega} = \frac{V_3 - 16}{4} = \frac{-0.740 - 16}{4}}$$

$$\cancel{I_{4\Omega} = -4.185A} \quad \text{current }(\uparrow)\ I_{4\Omega} = \frac{16 - V_3}{4} = \frac{16-(-0.740)}{4}$$

$$I_{4\Omega} = 4.185A$$

Q- Find the value of V_0 in the n/w shown:



12 V voltage source is connected b/w the 2 nodes V_1 & V_2

$$V_2 - V_1 = 12\,V \rightarrow (1)$$

Apply KCL to node $V_1 - V_2$:

$$V_1\left[\frac{1}{1}+\frac{1}{1}\right] + V_2\left[\frac{1}{1}+\frac{1}{1}\right] - V_3\left[\frac{1}{1}\right] - V_3\left[\frac{1}{1}\right] = 0$$

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

Apply KCL to node V_3:

$$V_3\left[\frac{1}{1}+\frac{1}{1}\right] - V_1\left[\frac{1}{1}\right] - V_2\left[\frac{1}{1}\right] = 2$$

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

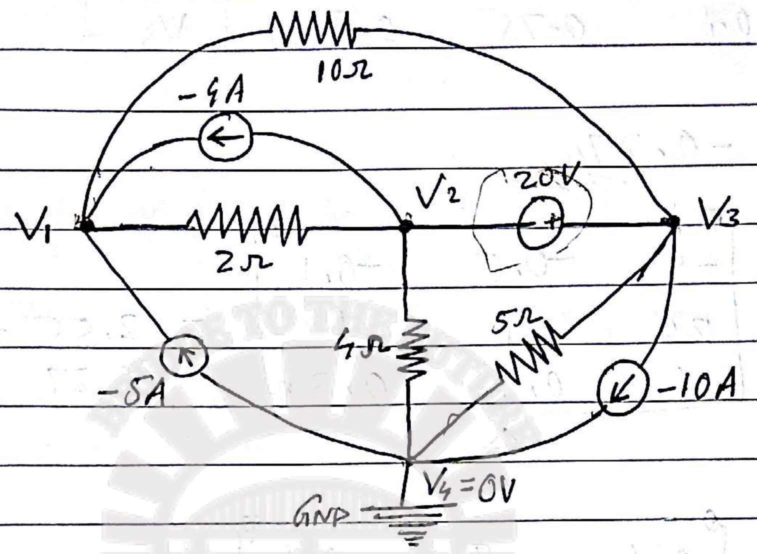
$$\begin{bmatrix} -1 & 1 & 0 \\ 2 & 2 & -2 \\ -1 & -1 & 2 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 2 \end{bmatrix}$$

$$\Delta = \begin{vmatrix} -1 & 1 & 0 \\ 2 & 2 & -2 \\ -1 & -1 & 2 \end{vmatrix} = -4$$

$$V_3 = \frac{\begin{vmatrix} -1 & 1 & 0 \\ 2 & 2 & 0 \\ -1 & -1 & 2 \end{vmatrix}}{\Delta} = \frac{-8}{-4} = 2\,V$$

$$\therefore V_0 = V_3 = 2\,V$$

Q. Find all the node voltages V_1, V_2 and V_3 using
*** node analysis.



Apply KCL to node V_1:

$$V_1\left[\frac{1}{2}+\frac{1}{10}\right] - V_2\left[\frac{1}{2}\right] - V_3\left[\frac{1}{10}\right] = -5-4.$$

$$0.6V_1 - 0.5V_2 - 0.1V_3 = -9 \rightarrow (1)$$

There is a 20V voltage source b/w the nodes V_2 and V_3.

$\therefore\ V_3 - V_2 = 20 \rightarrow (2)$

((+ − (−)))

$V_2 - V_3$ forms a super node.

Apply KCL to this super-node,

$$V_2\left[\frac{1}{2}+\frac{1}{4}\right] + V_3\left[\frac{1}{5}+\frac{1}{10}\right] - V_1\left[\frac{1}{2}\right] - V_1\left[\frac{1}{10}\right] = 4+10$$

$$-0.6V_1 + 0.75V_2 + 0.3V_3 = 14 \rightarrow (3)$$

$$\begin{bmatrix} 0.6 & -0.5 & -0.1 \\ 0 & -1 & 1 \\ -0.6 & 0.75 & 0.3 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} -9 \\ 20 \\ 14 \end{bmatrix}$$

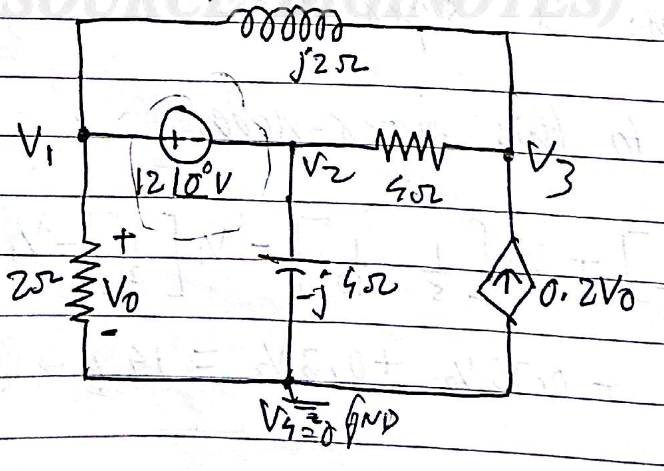
$\Delta = -0.27$

$$V_1 = \frac{\begin{vmatrix} -9 & -0.5 & -0.1 \\ 20 & -1 & 1 \\ 14 & 0.75 & 0.3 \end{vmatrix}}{\Delta} = \frac{2.55}{-0.27} = -9.44\,V$$

$$V_2 = \frac{\begin{vmatrix} 0.6 & -9 & -0.1 \\ 0 & 20 & 1 \\ -0.6 & 14 & 0.3 \end{vmatrix}}{\Delta} = \frac{-0.6}{-0.27} = 2.22\,V$$

$$V_3 = \frac{\begin{vmatrix} 0.6 & -0.5 & -9 \\ 0 & -1 & 20 \\ -0.6 & 0.75 & 14 \end{vmatrix}}{\Delta} = \frac{-6}{-0.27} = 22.22\,V$$

Q. Find the value of V_0 in the n/w shown.



$12\angle 0^\circ V$ voltage source is b/w the nodes V_1 and V_2.
$\therefore$ $V_1 - V_2$ forms the super-node.

Apply KCL to this super-node:

$$V_1\left[\frac{1}{2}+\frac{1}{j2}\right] + V_2\left[\frac{1}{4}+\frac{1}{-j4}\right] - V_3\left[\frac{1}{4}\right] - V_3\left[\frac{1}{j2}\right] = 0.$$

$$[0.5 - 0.5j]V_1 + [0.25 + 0.25j]V_2 - [0.25 - 0.5j]V_3 = 0.$$

$$[0.5 - 0.5j]V_1 + [0.25 + 0.25j]V_2 + [-0.25 + 0.5j]V_3 = 0 \rightarrow (1)$$

$V_1 - V_2 = 12\angle 0^\circ$

$V_1 - V_2 = 12 \rightarrow (2)$.

Apply KCL to node V_3:

$$V_3\left[\frac{1}{4}+\frac{1}{j2}\right] - V_2\left[\frac{1}{4}\right] - V_1\left[\frac{1}{j2}\right] = 0.2V_0$$

$$0.5j\,V_1 - 0.25V_2 + [0.25 - 0.5j]V_3 = 0.2V_0.$$

According to the given problem $V_0 = V_1$

$$\therefore 0.5j\,V_1 - 0.25V_2 + [0.25 - 0.5j]V_3 = 0.2V_1$$

$$0.5j\,V_1 - 0.2V_1 - 0.25V_2 + [0.25 - 0.5j]V_3 = 0.$$

$$[0.5j - 0.2]V_1 - 0.25V_2 + [0.25 - 0.5j]V_3 = 0.$$

$$[-0.2 + 0.5j]V_1 - 0.25V_2 + [0.25 - 0.5j]V_3 = 0 \rightarrow (3)$$

$$\begin{bmatrix} 0.5-0.5j & 0.25+0.25j & -0.25+0.5j \\ 1 & -1 & 0 \\ -0.2+0.5j & -0.25 & 0.25-0.5j \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 0 \\ 12 \\ 0 \end{bmatrix}$$

$$\Delta = \begin{vmatrix} 0.5-0.5j & 0.25+0.25j & -0.25+0.5j \\ 1 & -1 & 0 \\ -0.2+0.5j & -0.25 & 0.25-0.5j \end{vmatrix}$$

$$\Delta = (-0.25+0.5j)\left[(-0.25)-(-1)(-0.2+0.5j)\right]$$
$$+(0.25-0.5j)\left[(0.5-0.5j)(-1)-(0.25+0.25j)\right]$$

$\cancel{\Delta = -0.1375 - 0.35j}$

$\Delta = -0.2+0.0875j$

$$V_1 = \frac{\begin{vmatrix} 0 & 0.25+0.25j & -0.25+0.5j \\ 12 & -1 & 0 \\ 0 & -0.25 & 0.25-0.5j \end{vmatrix}}{\Delta}$$

$$V_1 = \frac{-12\left[(0.25+0.25j)(0.25-0.5j)-(-0.25)(-0.25+0.5j)\right]}{\Delta}$$

$$V_1 = \frac{-1.5-0.75j}{-0.2+0.0875j}$$

$V_1 = 4.918+5.901j \; V$

$V_1 = 7.6822 \angle 50.19^\circ \; V$

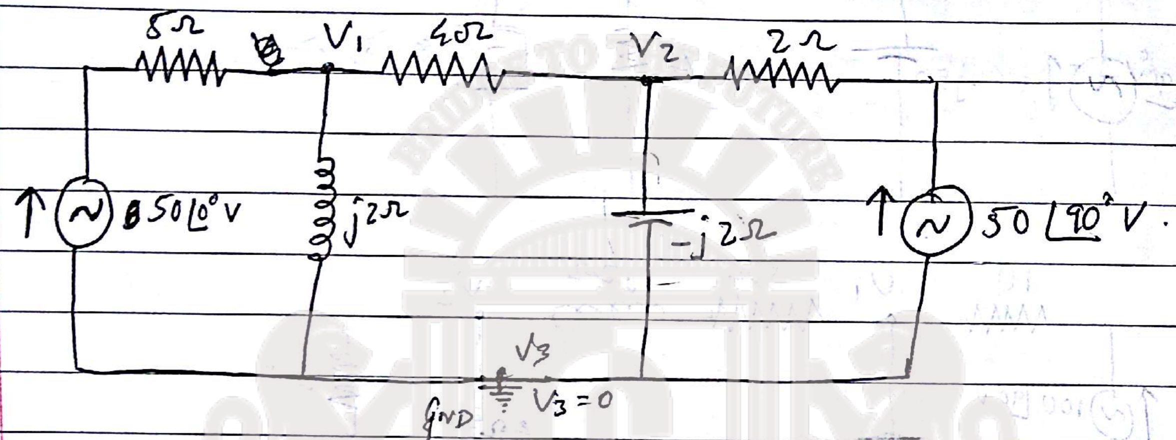
$\therefore V_0 = 4.918+5.901j \; V$ (or)

$V_0 = 7.6822 \angle 50.19^\circ \; V$

Q. For the following nodal equations construct the N/w.

$$V_1\left[\frac{1}{5}+\frac{1}{j2}+\frac{1}{4}\right]-V_2\left[\frac{1}{4}\right]=\frac{50\angle 0^\circ}{5} \rightarrow (1).$$

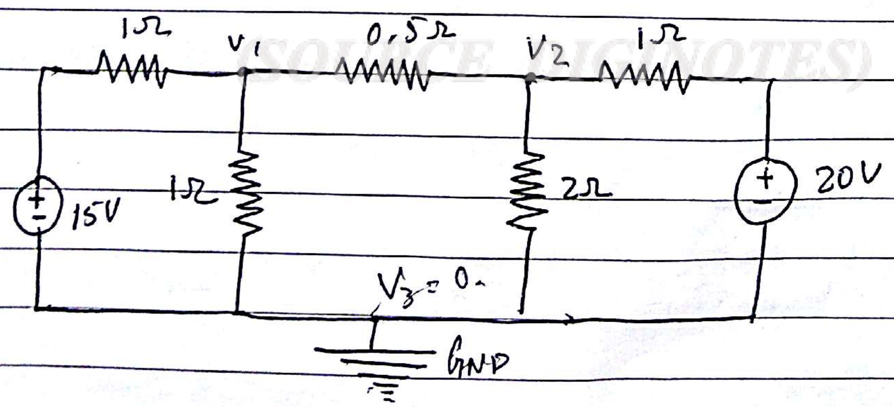
$$-V_1\left[\frac{1}{4}\right]+V_2\left[\frac{1}{4}+\frac{1}{2}+\frac{1}{-j2}\right]=\frac{50\angle 90^\circ}{2} \rightarrow (2).$$



Q. For the following nodal equations, develop the ckt.

$$V_1\left[\frac{1}{1}+\frac{1}{1}+\frac{1}{0.5}\right]-V_2\left[\frac{1}{0.5}\right]=\frac{15}{1} \rightarrow (1).$$

$$-V_1\left[\frac{1}{0.5}\right]+V_2\left[\frac{1}{0.5}+\frac{1}{2}+\frac{1}{1}\right]=\frac{20}{1} \rightarrow (2).$$



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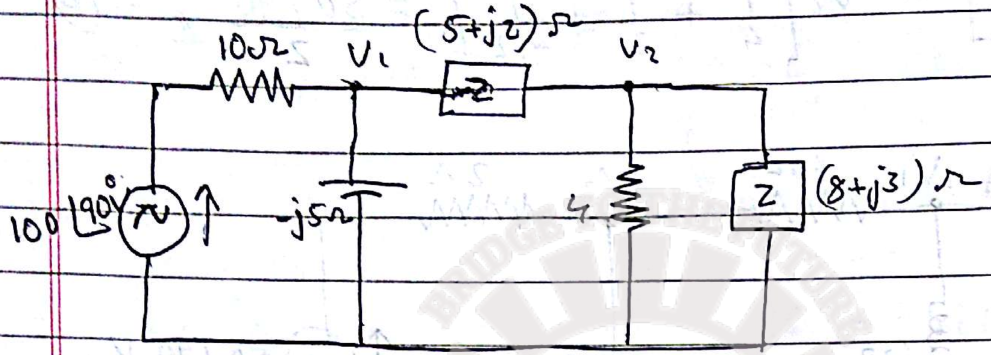
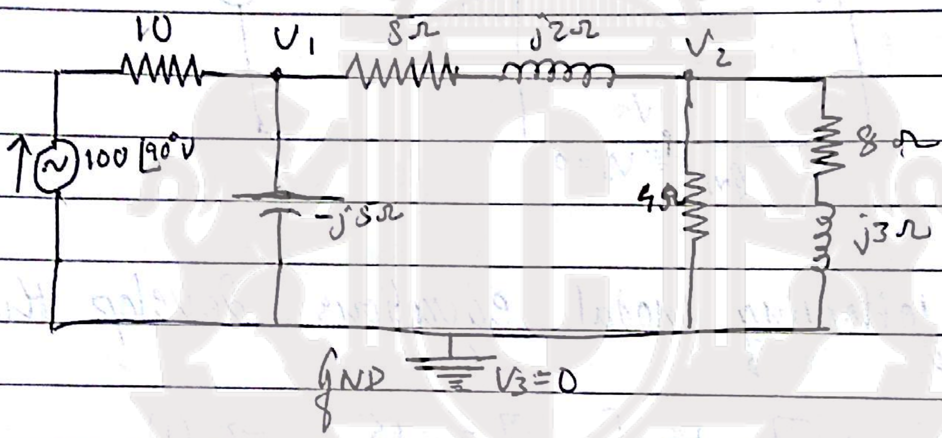
Q. $V_1\left[\frac{1}{10}+\frac{1}{-j5}+\frac{1}{5+j2}\right]-V_2\left[\frac{1}{5+j2}\right]=\frac{100\angle 90^\circ}{10} \rightarrow (1)$

$-V_1\left[\frac{1}{(5+j2)}\right]+V_2\left[\frac{1}{5+j2}+\frac{1}{4}+\frac{1}{8+j3}\right]=0 \rightarrow (2)$





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