Module - 2

-Mohd. Irfan.

1) State Kirchoff's Law.

There are basically two ~~all~~ laws under Kirchoff's Law.

→ Kirchoff's Current Law (Kirchoff's Ist law):-

KCL states that the total current in a closed circuit, the entering current at a node is equal to the current leaving at the node or the algebraic sum of current at node ~~is~~ in an ~~ele~~ electronic circuit is equal to zero.

→ Kirchoff's Voltage Law (Kirchoff's 2nd Law):-

KVL states that, the algebraic sum of the voltage in a closed circuit is equal to zero or the ~~algo~~ algebraic sum of voltage at node is equal to zero. Hence the sum of the voltage difference across all the elements in a circuit is always zero.

2) Calculate eq ~~resits~~ resistance of circuit if applied voltage is 23V and current flowing through circuit is 4A, receiving power of 92W.

Given power = 92W

Voltage = 23V

current = 4A.

So to find out resistance we need to apply ohm's law.

Power = Voltage x Current.

$92 = 23 \times 4$

$92 = 92$

Ohm's law states that the current through a conductor between two points is directly proportional to the potential diff across those two points. Introducing the concept of proportionality, the resistance, one arrives at the mathematical equation $I = V/R$.

According to Ohm's law:- $I = \frac{V}{R}$ ⟶ ①

substituting the value of I & V in ①.

$4 = \frac{23}{R}$ so $R = \frac{23}{4} = 5.75\,\Omega$

3) If charge developed between two plates is 2C and capacitance is 4.5µF, determine the voltage applied to the plates.

Given, $Q = 2C$

Charge

C [capacitance] $= 4.5 \times 10^{-6}$ F. $[\because \mu = 10^{-6}]$.

We know that charge stored & supply voltage in a capacitor.

$Q \propto V$

$Q = CV$ ⟶ ①

substitute value of Q & C in ①.

$2 = 4.5 \times 10^{-6} \times V$.

$V = \frac{2}{4.5 \times 10^{-6}}$ volts.

$V = \frac{2 \times 10^{6} \times 10}{45}$ volts

$\Rightarrow \frac{2 \times 10^{7}}{45}$ volts $= 0.044 \times 10^{7}$ volts.

22.5

$= 4.4 \times 10^{5}$ volts.

4) If three capacitors are connected in series which ~~are~~ are 2F, 3F and 6F. Calculate eq capacitance.

When the capacitors are connected in series.

The expression to equivalence capacitance is given as follows.

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots \frac{1}{C_n} \longrightarrow ①$$

Here, $n = 3$ so

$$eq \Rightarrow \frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \rightarrow ①$$

Here, given $C_1 = 2F$

$C_2 = 3F$

$C_3 = 6F$

So, substitute value of $C_1, C_2 \& C_3$ in eq ①.

$$\frac{1}{C_{eq}} = \left[\frac{1}{2} + \frac{1}{3} + \frac{1}{6}\right]\frac{1}{F}$$

$$\frac{1}{C_{eq}} = \frac{3+2+1}{6} = \frac{6}{6} = 1.$$

$$\boxed{C_{eq} = 1F}$$

5) If three inductor are in parallel with 20mH, 25mH and 50mH, then determine the equivalent inductance.

When the inductors are connected in parallel.

The expression to equivalence inductance is given as follows.

$$\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \cdots \frac{1}{L_n}.$$

Here, $n = 3$ so the eq^n is

$$\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} \longrightarrow ①.$$

The given inductances are:

$L_1 = 20mH.$

$L_2 = 25mH.$

$L_3 = 30mH.$

So substitute the values of L_1, L_2, L_3 in eq ①

$$\frac{1}{L_{eq}} = \left[\frac{1}{20} + \frac{1}{25} + \frac{1}{30}\right]\frac{1}{mH}.$$

$$\frac{1}{L_{eq}} = \left[\frac{15+12+10}{300}\right]\frac{1}{mH}.$$

$$\frac{1}{L_{eq}} = \left[\frac{37}{300}\right]\frac{1}{mH}.$$

$$L_{eq} = \frac{300}{37} mH = 8.1mH.$$

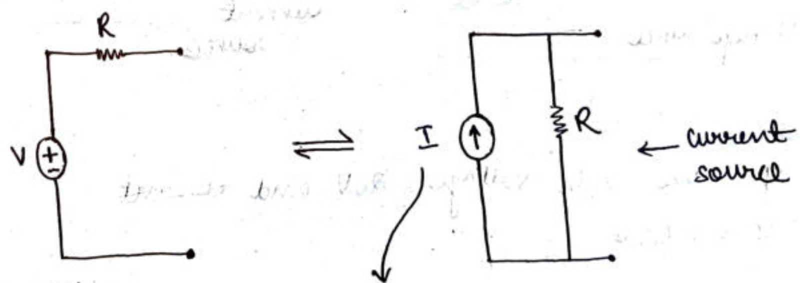
5	20, 25, 30
2	4, 5, 6
	2, 5, 3

$5 \times 5 \times 2 \times 2 \times 3$

$= 300.$

6) Deduce current source from voltage source using source transformation.

Source transformation for deducing current source from voltage source is given below.



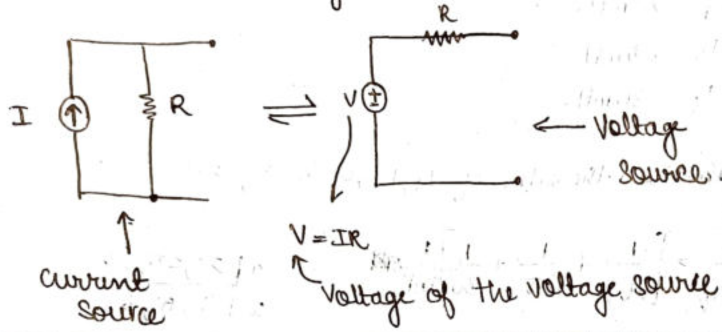
Voltage Source.

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

I ↑ current flowing through current source

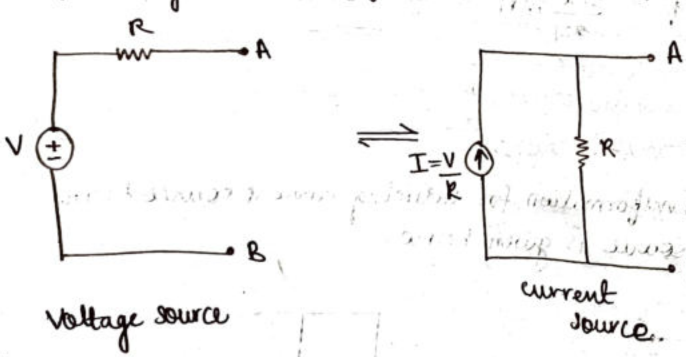
7) Deduce voltage source from current source using Source transformation.

Source transformation for deducing ~~current~~ voltage source from current source can be given as follows.



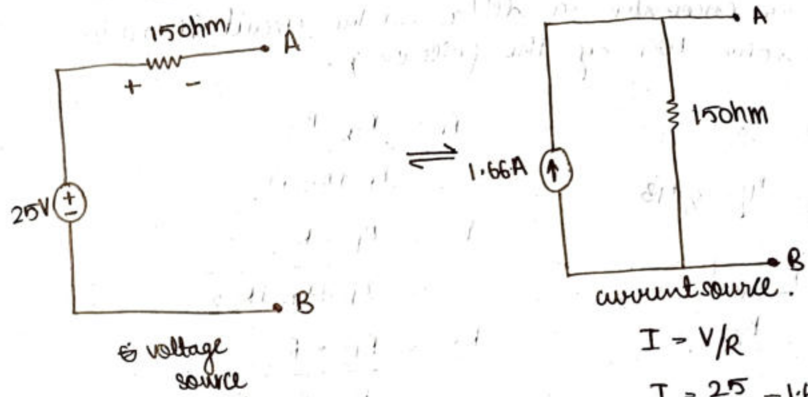
8) Across AB terminal a voltage source of 25V is in series with resistance of 15 ohm resistor, apply source transformation and redraw the circuit diagram across AB terminal.

Ans:- To convert voltage source to current source, the following source transformation should be done.



Given,

Voltage source with voltage = 25V and ~~current~~ resistor = 15ohms

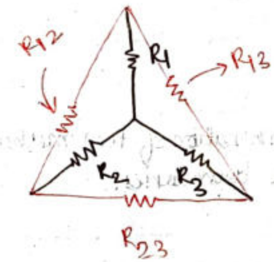


$I = V/R$

$I = \frac{25}{15} = 1.66A$

9) Write expression for star delta formation.

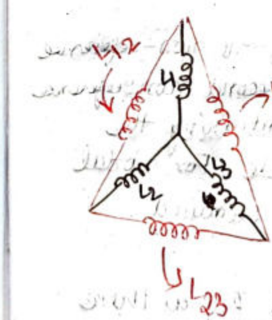
Ans:- When ever we encounter a star formation in the circuit we can do the following transformation



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

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

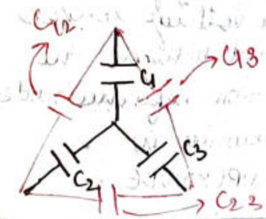
$R_{23} = R_2 + R_3 + \frac{R_2 R_3}{R_1}$.



$L_{12} = L_1 + L_2 + \frac{L_1 L_2}{L_3}$

$L_{13} = L_1 + L_3 + \frac{L_1 L_3}{L_2}$

$L_{23} = L_2 + L_3 + \frac{L_2 L_3}{L_1}$

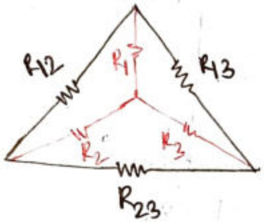


$\frac{1}{C_{12}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{\frac{1}{C_1} \cdot \frac{1}{C_2}}{1/C_3}$

$\frac{1}{C_{13}} =$ ||ly

$\frac{1}{C_{23}} \rightarrow$ ||ly..

(Q10) If we encounter a delta in the circuit it can be ~~we~~ solve ~~like~~ by the following.



$$R_1 = \frac{R_{12} \cdot R_{13}}{R_{12}+R_{13}+R_{23}}$$

$$R_2 = \frac{R_{12} \cdot R_{23}}{R_{12}+R_{13}+R_{23}}$$

$$R_3 = \frac{R_{13} \cdot R_{23}}{R_{12}+R_{13}+R_{23}}$$

* For inductance also its similar to resistor

For conductance in place of R_1, R_2, R_3 we should write $\frac{1}{R_1}, \frac{1}{R_2}, \frac{1}{R_3}$.

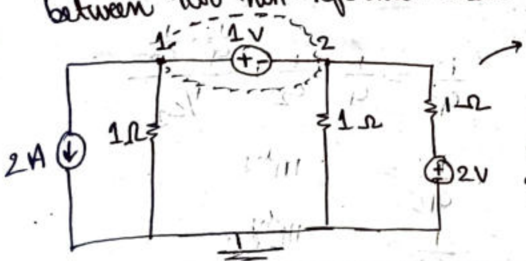
Plz write down the expression for inductor & conductor also in the exam.

Q11) Define super mesh.

Ans:- Supermesh is defined as the combination of two meshes which have current source on their boundaries.

Q12) Give the condition for super node.

Ans:- Each supernode contains two nodes, one non-reference node and another node that may be a second non reference node or the reference node. Super node containing the reference node have one node voltage variable. For nodal analysis, the supernode construct is only required between two non-reference nodes.



→ In the fig as there is a voltage source present between the two non-reference nodes it becomes a SUPERNODE.

Q13) Limitation of Mesh Analysis.

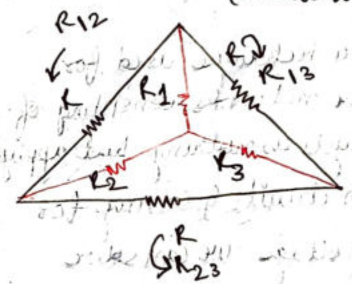
- We can use this method only when the circuit is planar, otherwise the method is not fully useful.
- If network is large then no. of meshes will be large, hence the no of equations will be more & it will be inconvenient to use in that case.

Q14) Limitation of Nodal analysis.

- Only used for analysis of linear elements such as resistors, capacitors and inductors.
- The other limitation is that they assume reference 0 volts that is constantly zero. However, constant zero volts doesnot always occur especially in long distance transmission line.

Q15). If three equivalent values of resistors are in delta, determine their equivalent values in star connection

(Delta to star).



$$R_1 = \frac{R_{12} \cdot R_{13}}{R_{12}+R_{13}+R_{23}}$$

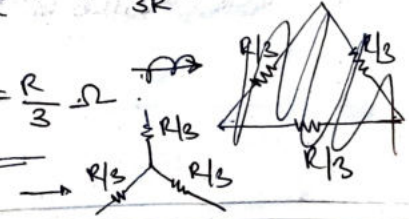
$$R_2 = \frac{R_{12} \cdot R_{23}}{R_{12}+R_{13}+R_{23}}$$

$$R_3 = \frac{R_{13} \cdot R_{23}}{R_{12}+R_{13}+R_{23}}.$$

Since $R_{12} = R_{13} = R_{23} = R$

So $R_1 = \frac{R^2}{3R}$; $R_2 = \frac{R^2}{3R}$; $R_3 = \frac{R^2}{3R}$.

So, $R_1 = R_2 = R_3 = \frac{R}{3}\ \Omega$.



Q16) Define reference node.

Ans:- A reference node is a node created, that is also called as the ground ~~node~~ and ~~it~~ helps in defining other node voltages with respect to this point. The reference node has a potential of zero. The following symbol indicates the reference node.

 } Reference node symbol.

Q17) Give Difference between nodal analysis & mesh analysis.

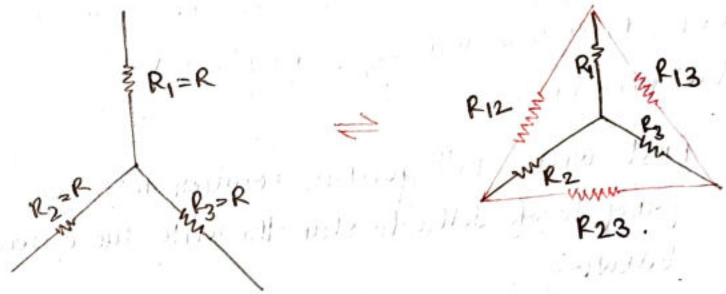
Mesh Analysis:- Technique used to solve the complex networks of more no. of meshes. Mesh analysis is nothing but apply KVL to each an every loop in the circuit & solving for mesh currents. By finding the mesh current we can solve any required data of networks.

Nodal Analysis:- Nodal analysis is a technique used for solving ~~a~~ complex networks consisting of more number of nodes. Node analysis is nothing but applying KCL to each and every node in circuit & solving for node voltages. By find node voltage we can solve any required data of the network.

Q18) If three equivalent resistors are in star then calculate their equivalent values in Delta connection.

PTO →

(Star to delta)



$$R_{12} = R_1 + R_2 + \frac{R_1 R_2}{R_3} \longrightarrow ①$$

$$R_{13} = R_1 + R_3 + \frac{R_1 R_3}{R_2} \longrightarrow ②$$

$$R_{23} = R_2 + R_3 + \frac{R_2 R_3}{R_1} \longrightarrow ③$$

But we know that $R_1 = R_2 = R_3 = R \longrightarrow ④$

sub ④ in eq ①.

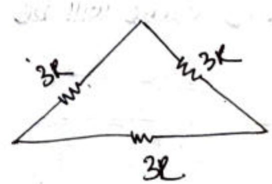
$$R_{12} = R + R + \frac{R^2}{\cancel{R}} = 3R$$

$$R_{13} = R + R + \frac{R^2}{R} = 3R$$

$$R_{23} = R + R + \frac{R^2}{R} = 3R$$

therefore,

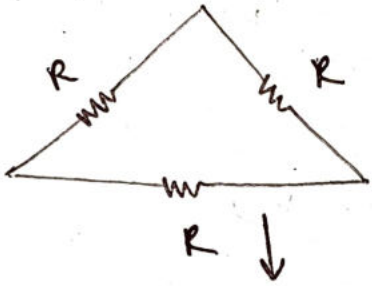
$R_{12} = R_{13} = R_{23} = 3R.$

⟹ 

19) If three equal values resistors with R = 3 ohm are in delta ; Determine their ~~equo~~ equivalent value in Star connection.

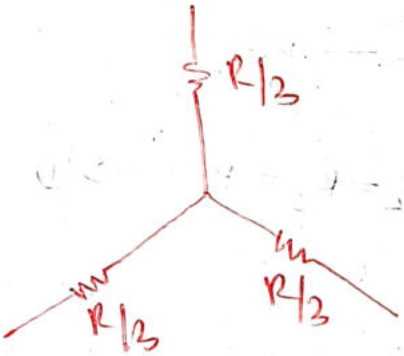
Ans:- First write 15th question solution i.e., the proof ~~to~~ of delta to star the write the anwer below:-

Given

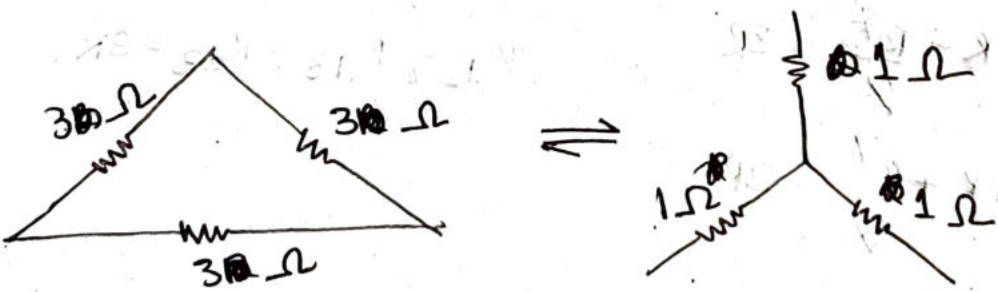


$R = 3\,\Omega$.

then,



so



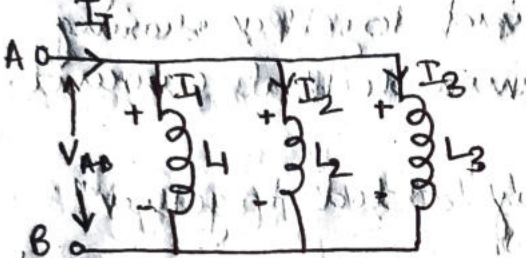
so the equivalence value will be $1\,\Omega$ each.

PART - B :-

– Mohd Irfan
E.C.E B.

2) Predict in detail the equivalence of inductance of series & parallel circuits respectively & explain with neat example.

Inductors in Parallel :-



Inductors are said to be in parallel when both of their terminals are respectively connected to each other terminal of another inductor or inductors.

The voltage drop across all the inductors in parallel will be the same. Then, inductors in parallel have a common voltage across them, & in ~~other~~ the example below

$$V_{L1} = V_{L2} = V_{L3} = V_{AB} \text{ ... etc.}$$

The sum of individual current flowing through each inductor can be found using KCL where $I_T = I_1 + I_2 + I_3$ and self induced emf across an inductor is given as

$$V = L \frac{di}{dt}$$

~~sub~~ substituting the current $i_1 + i_2 + i_3$ the voltage across the parallel combination is given as -

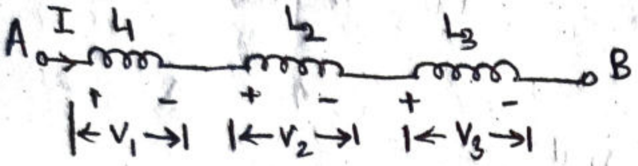
$$V_{AB} = L_T \frac{d}{dt}(i_1 + i_2 + i_3) = L_T \left[\frac{di_1}{dt} + \frac{di_2}{dt} + \frac{di_3}{dt}\right]$$

Sub $\frac{di}{dt} = \frac{V}{L}$ we get,

$$V_{AB} = L_T \left[\frac{V}{L_1} + \frac{V}{L_2} + \frac{V}{L_3}\right].$$

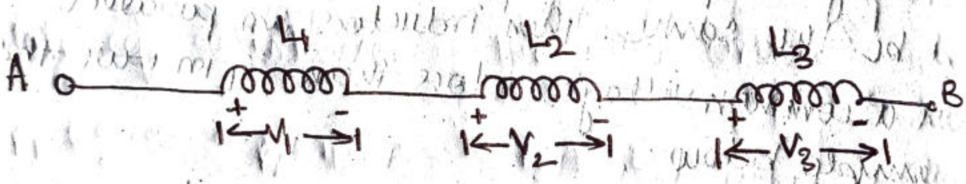
So the parallel inductor eq^n can be given as

$$\boxed{\frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \text{---} + \frac{1}{L_n}}$$



Inductors can be connected together in series when they are chained together sharing common electrical current.

Inductors in series are simply "added together", because the no of coils turns is effectively increased, with total current inductance L_T being equal to the sum all individual inductances added together.



Series inductor have common current flowing through them

$$I_{L1} = I_{L2} = I_{L3} = I_{AB} \text{----} etc.$$

The sum of individual voltage drop ~~ass~~ across each inductor is given as ~~$V = L\frac{di}{dt}$~~ $V_T = V_1 + V_2 + V_3$ by the use of KVL.

The ~~seff~~ self inductance emf across an inductor is given by $V = L\frac{di}{dt}$.

$$L_T\frac{di}{dt} = L_1\frac{di}{dt} + L_2\frac{di}{dt} + L_3\frac{di}{dt}$$

The eq^n for series connection can be given as

$$L_T = L_1 + L_2 + L_3 + \text{---} + L_n$$

3) Estimate the equivalence capacitance of series and parallel connection of resistors capacitors element.

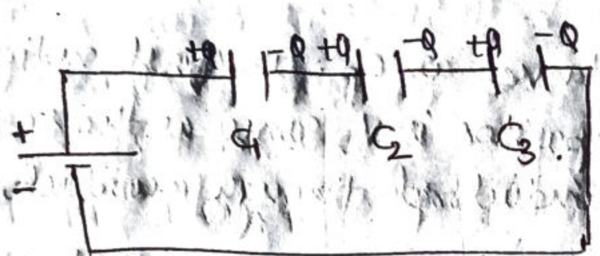
→ SERIES CONNECTION:-

The capacitance of a capacitor is given by the relationship of charge and voltage i.e., $Q = CV$ or $C = \frac{Q}{V}$.

for calculation of V we can write $V = \frac{Q}{C}$.

The voltage across individual capacitors will be

$$V_1 = \frac{Q}{C_1},\ V_2 = \frac{Q}{C_2},\ V_3 = \frac{Q}{C_3}, \text{ — so on.}$$



Thus the total is the sum of individual voltages

$$V = V_1 + V_2 + V_3;$$

Taking total capacitance as C_s for series capacitance consider $V = \frac{Q}{C_s} = V_1 + V_2 + V_3$.

$$V = V_1 + V_2 + V_3. \qquad \left[\because V = \frac{Q}{C_s} \text{ and } V_1 = \frac{Q}{C_1}, V_2 = \frac{Q}{C_2}, V_3 = \frac{Q}{C_3}\right]$$

$$\frac{Q}{C_s} = \frac{Q}{C_1} + \frac{Q}{C_2} + \frac{Q}{C_3}$$

taking Q as common on both sides.

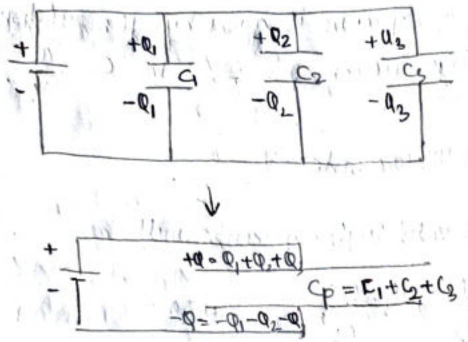
$$\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}.$$

} Formula for calculating eq capacitance for capacitors connected in series.

For n capacitors the total capacitance will be:-

$$\cancel{\frac{1}{C_n}}\ \frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \text{——} \frac{1}{C_n}.$$

→ Parallel Combination :-



Taking equivalence capacitance as C_p. We first notice that the voltage across each capacitor is V, same as the source since they are directly conductored through a conductor.

Thus capacitors have ~~a~~ same charge on them as they ~~have~~ would be connected individually to voltage source.

The total charge Q is the sum of individual charges

$Q = Q_1 + Q_2 + Q_3 \dots$

Using the ~~reo~~ relationship $Q = CV$; we use total charge $Q = C_pV$, where $Q_1 = C_1V$; $Q_2 = C_2V$; $Q_3 = C_3V$.

so $C_pV = C_1V + C_2V + C_3V$.

taking V common & cancelling on both sides,

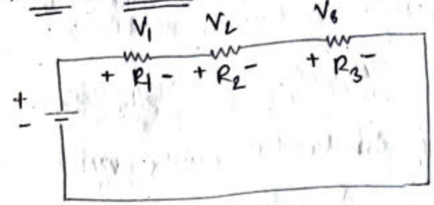
$\boxed{C_p = C_1 + C_2 + C_3}$ } Formula for capacitance for capacitors connected in the parallel combination.

For n no. of capacitor connected in series the formula is given by:-

$\boxed{C_p = C_1 + C_2 + C_3 + \text{———} + C_n}$

4) Estimate the equivalence ~~capacitance~~ resistance of series and parallel combination of resistors.

→ ~~Parallel~~ Series Connection :-



According to ohms law, $V = IR$, since energy is conserved the voltage is equal to the potential energy per ~~chamo~~ charge, The sum of voltage applied to the circuit by the source and potential drops across individual resistors across the loop should be equal to zero.

We get $V = IR$.

$V = IR_1 + IR_2 + IR_3$. [$\because V = IR$]

$IR_{eq} = IR_1 + R_2I + IR_3$.

$\cancel{I}R_{eq} = \cancel{I}[R_1 + R_2 + R_3]$

$\boxed{R_{eq} = R_1 + R_2 + R_3}$ } Formula for eq resistance of resistors connected in parallel combination

For n no. of resistors connected in series.

$\boxed{R_{eq} = R_1 + R_2 + R_3 + \text{———} R_n}$.

→ Parallel Combination :-

For each resistor there is the same voltage supply.
According to ohm's law, $V = IR$.
For each resistor $I_1 = \frac{V}{R_1}$, $I_2 = \frac{V}{R_2}$, $I_3 = \frac{V}{R_3}$

So.

$$I = I_1 + I_2 + I_3.$$

$$\frac{V}{R} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

taking V common on both sides.

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

} Formula for eq resistance of resistor connected in parallel combination.

for n no of resistors the formula will be :

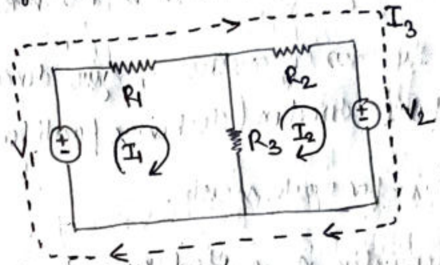
$$\boxed{\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots \frac{1}{R_n}}$$

Q) Discuss the method used to determine loop current for multiple loop networks with neat diagram.

Loop Current method :-

The loop current method is a small variation on the Mesh current method. The changes are highlighted in the list below.

- Identify the meshes (open windows of the circuit) and loops (other closed paths).
- Assign current variable to each mesh or loop, using a consistent direction (clockwise or anticlockwise).
- Write Kirchoff's voltage law equation around each mesh and loop.
- Solve the resulting system of equations for all mesh & loop currents.
- Solve for any element currents and voltages you want using ohm's law.



Q) Summarise the procedure to calculate node voltage of electrical network using nodal analysis.

Ans:- Node voltage can be calculate by using Nodal Analysis.

This type of analysis can be used for both Planar & Non-planar networks.

→ Firstly identify the no of nodes and take one node as the reference node (grounded).

→ Assign voltages ($V_1, V_2 \ldots V_{n-1}$) [∵ no of nodes-n] excluding the reference node.

→ Write KCL equation at each node except to that of the refrence node.

→ Use ohms law to calculate the value of current or resistance.

Q) Discuss the method used to determine the loop currents for multiple loop network with ideal current source b/w any two meshes.

Ans:- The process of analysis is known as Mesh Analysis.

→ Firstly identify the no of meshes & give direction of current in a stable direction (clockwise / anticlockwise).

→ Write KVL equation for each mesh.

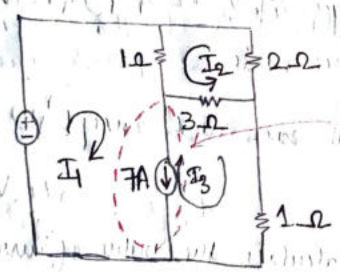
• But when we encounter a ideal current source between two meshes, it is said to be a "Supermesh".

→ The supermesh equation is given by the sum of current flowing through the current source equal to current.

→ Then the super mesh would be excluded & the equation would be written simultaneously.

→ The other mesh equations would be written the normal way only.

Eg:-

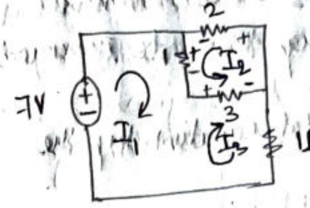


$I_1 + (-I_3) = 7$

$\boxed{I_1 - I_3 = 7}$ → Supermesh Eqⁿ.

Now eqⁿ is written excluding the super mesh.

→



All the equations are written with the help of KVL.

$7 - I_1 + I_2 - 3(I_3 + I_2) - I_3 = 0$

And then mesh ② eqⁿ is written

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

So this is the process if we encounter a super mesh.

Q) Summarise the procedure to calculate node voltage of an electrical network with ideal voltage source b/w any two nodes.

The process of analysis used is known as Nodal Analysis.

→ Identify the nodes and take a reference node (grounded).

→ Assign voltages ($V_1, V_2 \cdots V_{n-1}$) [n = no. of nodes] excluding reference node.

→ Write KCL equation at each node, except to that of reference node.

• When we encounter an ideal voltage source between two nodes then it is told to be a "SUPERNODE."

→ Supernode eq is the potential difference b/w those two nodes equal to the voltage of voltage source.

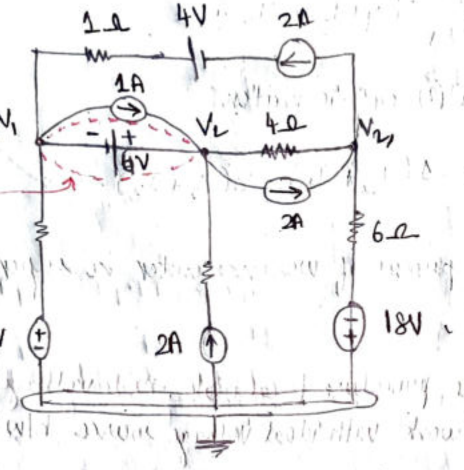
~~Supernode eq is written~~

→ Now apply Nodal analysis @ those two nodes simultaneously by excluding the ~~nodes~~ supernode.

→ Now we can write the other nodal equation by the normal method itself.

Eg:-

Supernode.



Supernode eqⁿ → $\boxed{V_2 - V_1 = 6 \text{ volts}}$.

outgoing current = Incoming current.

Now write eqⁿ including the supernode.

$$\frac{V_1 - 8}{8} + 1 + \frac{V_2 - V_3}{4} + 2 = 2 + 2 + 1.$$

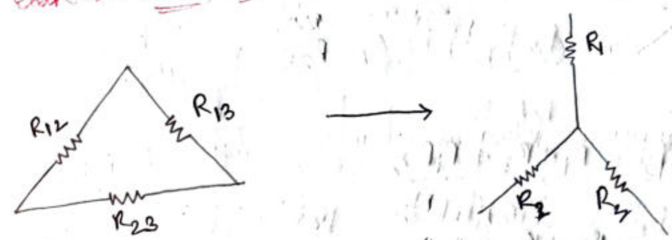
Other node eqⁿ

$$\frac{V_3 - V_2}{4} + \frac{V_3 + 18}{6} - 2 = 2.$$

11) Derive the expression of star delta transformation to derive the equivalence resistance of complex network.

Ans:- Star delta transformation can be applied to the following circuits.

• Delta to Star Transformation:-



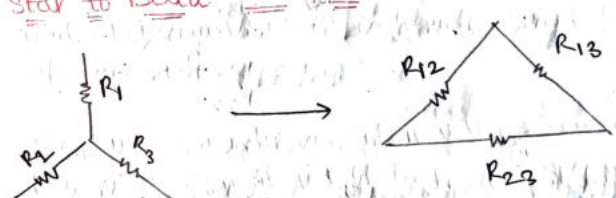
(Delta)

Here the following formulae can be used.

$$R_1 = \frac{R_{12} \cdot R_{13}}{R_{12} + R_{23} + R_{13}} ; \quad R_2 = \frac{R_{12} \cdot R_{23}}{R_{12} + R_{13} + R_{23}}.$$

$$R_3 = \frac{R_{13} \cdot R_{23}}{R_{12} + R_{13} + R_{23}}.$$

• Star to Delta Transform:-



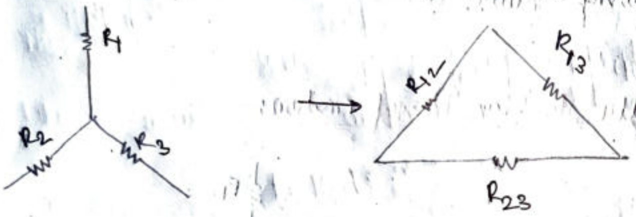
Here the following formulae can be used.

$$R_{13} = R_1 + R_3 + \frac{R_1 R_3}{R_2} ; \quad R_{23} = R_2 + R_3 + \frac{R_2 R_3}{R_1}$$

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

12) If three equal resistors with R = 3ohm are in star, determine their equivalence resistance of its delta connection

Star to Delta formation :-

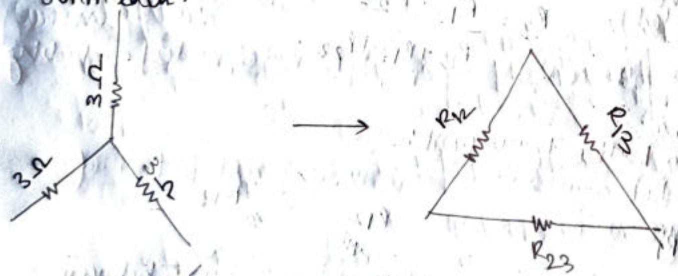


$$R_{13} = R_1 + R_3 + \frac{R_1 R_2}{R_2}$$

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

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

Here in the given it is ~~eq~~ given as eq^n resistance of 3ohm each.



$$R_{12} = R_1 + R_2 + \frac{R_1 R_2}{R_3} = 3 + 3 + \frac{\cancel{9}^3}{\cancel{3}} = 3R = 3(3) = 9\,\Omega$$

$$R_{23} = R_2 + R_3 + \frac{R_2 R_3}{R_1} = 3 + 3 + \frac{\cancel{9}^3}{\cancel{3}} = 3R = 3(3) = 9\,\Omega$$

$$R_{13} = R_1 + R_3 + \frac{R_1 R_2}{R_2} = 3 + 3 + \frac{\cancel{9}^3}{\cancel{3}} = 3R = 3(3) = 9\,\Omega.$$

13) Three capacitors are 10F, 12F & 5F. calculate eq capacitance in series & parallel connection.

Series Connection of Capacitors :-

The formulae is given by :-

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots \frac{1}{C_n}$$

Here, $n = 3$

$C_1 = 10F$

$C_2 = 12F$

$C_3 = 5F$

So,

$$\frac{1}{C_{eq}} = \frac{1}{10} + \frac{1}{12} + \frac{1}{5}.$$

$$\frac{1}{C_{eq}} = \frac{27}{600} \qquad C_{eq} = \frac{600}{27} = 22.22F.$$

Parallel Connection of Capacitors :-

The formula is given by →

$$C_{eq} = C_1 + C_2 + \cdots C_n$$

$n \to$ ~~no~~ 3

$C_1 = 10F$

$C_2 = 12F$

$C_3 = 5F$

So,

$$C_{eq} = 10 + 12 + 5$$

$$C_{eq} = 27F.$$

14) Consider a coil allowing a current of $i(t) = 4t^2$ for 1ms. derive ~~tot~~ voltage ~~incude~~ induced, power absorbed & energy stored by inductor if the inductance is 5H

Ans:- Voltage ~~inducted~~ induced $(V) = L\frac{di}{dt} = 5\frac{d}{dt}(4t^2)$

$$= 5(8t)$$

$$= 40t.$$

Power absorbed

$$P = vi = \left[L\frac{di}{dt}\right] * i = \frac{1}{2}L\frac{di^2}{dt} = \frac{d}{dt}\left[\frac{1}{2}Li^2\right].$$

$$P = \frac{d}{dt}\left[\frac{1}{2}Li^2\right] = \frac{d}{dt}\left[\frac{1}{2}(5)(4t^2)^2\right]$$

$$= \frac{d}{dt}\left[\frac{5}{2} \times 16t^4\right] = \frac{d}{dt}\left[40t^4\right].$$

$$P = 160t^3.$$

Energy stored:-

$$E = \frac{1}{2}Li_{(t)}^2 = \frac{1}{2}(5)(4t^2) = 10t^2.$$

Q) Consider a capacitor allowing a current of $V(t) = 4t^2 + 2t + 1$, derive the expression for current flowing, power absorbed and energy stored by capacitor, if capacitance is 5F.

Current flow:-

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

$$i = 5\left[\frac{d}{dt}[4t^2+2t+1]\right]$$

$$i = 5[8t+2]$$

$$i = 40t+10.$$

power absorbed:-

Energy stored

$$W_C(t) = \frac{1}{(2)}C\left[4t^2+2t+1\right]^2.$$

$$= \frac{1}{2}CV_{(t)}^2.$$

Q) If three inductors are placed in parallel having 100mH, 25mH and 35mH inductance respectively. then calculate equivalent inductance.

For inductors connected in parallel combination the formula is given by:-

$$\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2} + \cdots + \frac{1}{L_n}.$$

Here $n=3$

$n_1 = 100mH$

$n_2 = 25mH$

$n_3 = 35mH$.

$$\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3}.$$

$$\frac{1}{L_{eq}} = \frac{1}{100} + \frac{1}{25} + \frac{1}{35}.$$

$$\frac{1}{L_{eq}} = \frac{100+25+35}{100 \times 25 \times 35} = \frac{160}{87500}$$

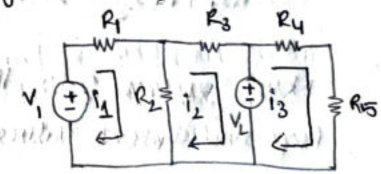
$$L_{eq} = \frac{87500}{160} = 546.87\,mH.$$

$$= 546.87 \times 10^{-3} H.$$

$$= 0.54 H.$$

Q) Explain inspection method to write mesh equation for a network.

The mesh equations for general planar network can be written by inspection without going through detailed steps.



The loop eq^n are:-

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

$$R_2(I_2 - I_1) + I_2R_3 = -V_2$$

$$R_4I_3 + R_5I_3 = V_2.$$

Reorder the eq^n

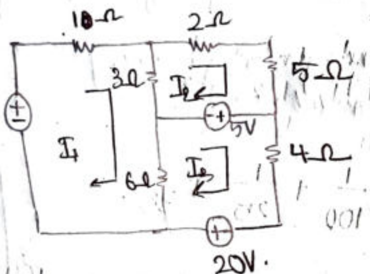
$$(R_1+R_2)I_1 - R_2 I_2 = V_1$$

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

$$(R_4+R_5) I_3 = V_2.$$

This is how we write eq^n of mesh in general.

Take a circuit:-



Take the resistors which are not in common with any other loop as positive and the other resistors that are common with other loops take them as "±" and take the sum of them and equate it to the sum of voltage in the loop.

$$R_{11}I_1 \pm R_{12}I_2 \pm R_{13}I_3 = V_1$$

$$\pm R_{21}I_1 \pm R_{22}I_2 \pm R_{23}I_3 = V_2.$$

$$\pm R_{31}I_1 \pm R_{32}I_2 + R_{33}I_3 = V_3$$

Here,

$$19I_1 - 3I_2 - 6I_3 = 10V$$

$$-3I_1 + 10I_2 = -5V$$

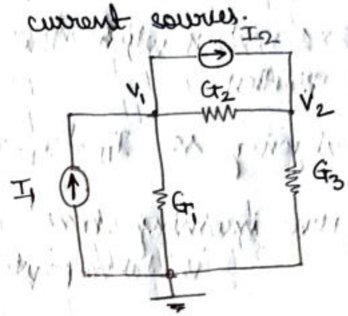
$$-6I_1 + 10I_3 = 25V$$

Now you can solve the eq to find out Respective current values.

10) Explain Nodal equation writing using inspection method.

Ans:- The analysis equations can be obtained by direct inspection.

- For circuits with only resistors and independent current sources.



→ Convert all resistances to conductance.

$$R \to \frac{1}{R} \quad G = \frac{1}{R}.$$

→ take $AX = B$ matrix. → the size of A depends on no of current sources. Here it's 2 so it's a 2×2 matrix.

$A \to$ conductance matrix.

→ fill the 11 elements like 1st row 1st column, 2nd row 2nd column, 3rd row 3rd column etc.

→ The 11 position is the sum of conductances connected to node 1.

Here its $\begin{bmatrix} G_1+G_2 & \\ & G_2+G_3 \end{bmatrix}$ Fill the diagonal element.

→ The half diagonal elements are filled with the conductance common between the nodes. Always taken as -ve.

$$\begin{bmatrix} G_1+G_2 & -G_2 \\ -G_2 & G_2+G_3 \end{bmatrix}$$

And always write and remember $G_{mn} = G_{nm}$.

→ The X matrix is a 2×1 matrix where the respe nodes voltages are written.

Here its $\begin{bmatrix} V_1 \\ V_2 \end{bmatrix}$

→ The B matrix is also a 2×1 matrix where the current source value is written.

I_1 is incoming & I_2 outgoing so $I_{11} = I_1 - I_2$

$I_{21} = I_2$ [Here incoming current is taken positive.

So $B = \begin{bmatrix} I_1 - I_2 \\ I_2 \end{bmatrix}$

Take the whole eqn of matrix we get

$$\begin{bmatrix} G_1+G_2 & -G_2 \\ -G_2 & G_2+G_3 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} I_1 - I_2 \\ I_2 \end{bmatrix}$$

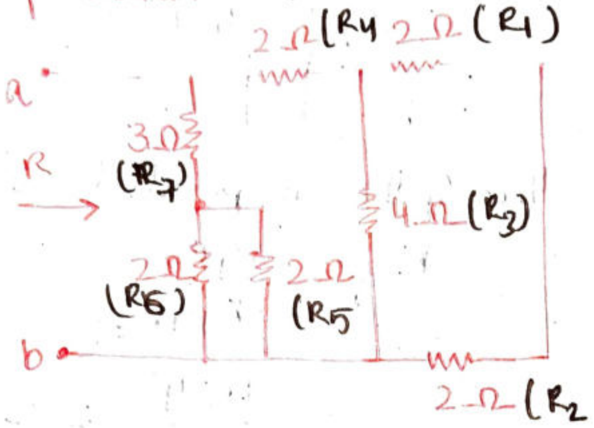
$(G_1+G_2)\cancel{(G_2+G_3)} V_1 - G_2 V_2 = I_1 - I_2 \longrightarrow (1)$

$-G_2 V_1 + (G_2+G_3) V_2 = I_2 \longrightarrow (2)$

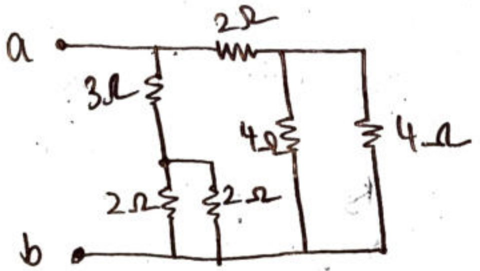
Solve for required values.

PART - C

1) Calculate eq resistance showing step by step explaination.



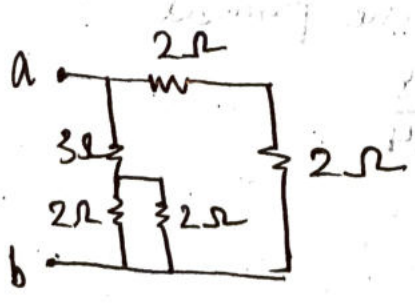
Step 1 :- The last two resistors (R_1) & (R_2) are in series so they can be written as $R_1 + R_2$ i.e., $2+2 = 4\Omega$



Step 2 :-

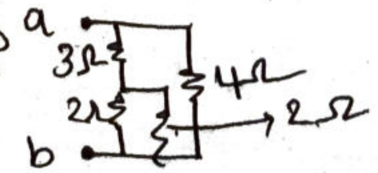
Now 4Ω & 4Ω are in parallel so the eq Resistance will be $\frac{R_1 R_2}{R_1+R_2}$ ie.

$$\frac{4 \times 4}{4+4} = 2\Omega$$



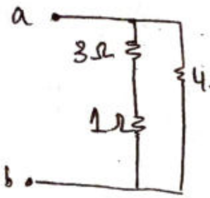
Step 3 :- 2Ω & 2Ω are in series so $R_1 + R_2$ ie.,

$2+2 = 4\Omega$



Step 4 :- 2Ω & 2Ω in parallel so

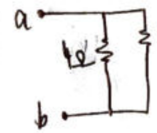
$$\frac{R_1 R_2}{R_1+R_2} = 1\Omega$$



Step 5 3Ω & 1Ω in series so

$R_1 + R_2$; $3 + 1 = 4\,\Omega$

Step 6 :-



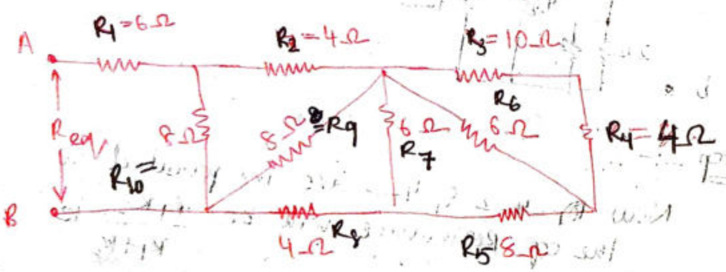
4Ω & 4Ω in parallel so then

$$R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$$

$$= \frac{4 \times 4}{4+4} = 2\,\Omega.$$

So the final Req is equal to 2Ω.

2) Calculate eq resistance of the given circuit.

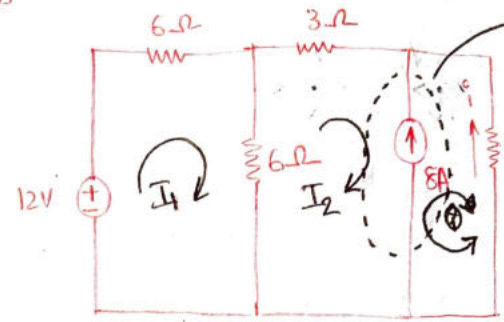


1) R_3, R_4 in series $R_3 + R_4 = 14\,\Omega$

2) 14Ω & 6Ω (R_6) are parallel

$$R_{eq} = \frac{18 \times 6}{18+6} = \frac{108}{24}$$

3)

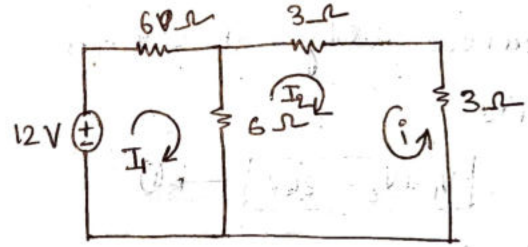


ideal current source b/w two loops the its a super mesh

So super mesh equation;

$$-I_2 - i = 8A$$

$$\boxed{I_2 + i = -8A.} \longrightarrow ①$$



WKT $V = IR$

$12 = I(6)$

$I = 2A$

$$12 - \cancel{6I_1} - \cancel{6I_2}_{1} + 6I_2 - 3I_2 - 3i = 0.$$

$$12 - \underset{2A}{12I_1} - 3I_2 - 3i = 0.$$

$$12 - 24 - 3I_2 - 3i = 0.$$

$$3I_2 - 3i = 12$$

$$I_2 - i = 4 \longrightarrow ②$$

solve eq ① & ②.

$$\cancel{I_2} + i = -8A.$$

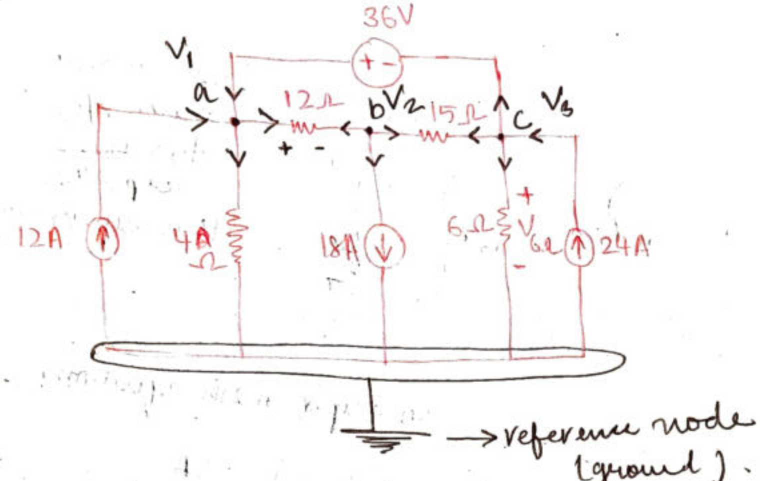
$$-\cancel{I_2} + i = -4A.$$

$$2i = -12A.$$

$$i = -6A.$$

$$\boxed{i = -6A}$$

4)



~~Apply KCL @ a~~.

Apply supernode analysis at 36V ie., between V_1 & V_3

V_1 —|— V_3 $\boxed{V_1 - V_3 = 36V} \to ①$

Apply nodal analysis at V_1 & V_3 simultaneously excluding the supernode.

Then we get,

Incoming = Outgoing

$$12 + 24 = \frac{V_1 - V_2}{12} + \frac{V_1}{4} + \frac{V_3 - V_2}{15} + \frac{V_3}{6}$$

$$36 = \frac{V_1 - V_2}{12} + \frac{V_1}{4} + \frac{V_3 - V_2}{15} + \frac{V_3}{6}$$

$$36 = \frac{V_1 - V_2 + 3V_1 + 2V_3}{12} + \frac{V_3 - V_2}{15}$$

$$36 = \frac{4V_1 + 2V_3 - V_2}{12} + \frac{V_3 - V_2}{15}$$

$$36 = \frac{2V_1 + 72 - V_2}{12} + \frac{V_3 - V_2}{15}$$

$$36 - 6 = \frac{2V_1 - V_2}{12} + \frac{V_3 - V_2}{15}$$

$$30 = \frac{10V_1 - 5V_2 + 4V_3 - V_2}{60}$$

$$1800 = 10V_1 - 6V_2 + 4V_3$$

$$1800 = 6V_1 - 6V_2 + (4V_1 + 4V_3) \quad 36 \times 4 = 144$$

$$1800 - 144 = 6(V_1 - V_2)$$

$$\frac{1656}{6} = V_1 - V_2$$

$$276 = V_1 - V_2 \longrightarrow ①$$

Nodal analysis @ V_2.

Incoming = Outgoing

$$0 = \frac{V_2 - V_1}{12} + \frac{V_2 - V_3}{15} + 18$$

$$\frac{V_2 - V_1}{12} + \frac{V_2 - V_3}{15} + 18 = 0$$

$$5V_2 - 5V_1 + 4V_2 - 4V_3 + \cancel{270}\ 1080 = 0$$

$$9V_2 - 5V_1 - 4V_3 + 180 = 0$$

$$4V_2 + 5V_2 - 5V_1 - 4V_3 = -1080$$

$$4V_2 - 1370 - 4V_3 = -1080 \Rightarrow 4V_2 - 4V_3 = 290 \to ③$$

eq^n ① $\rightarrow$ $V_1 - V_3 = 36V$

eq^n ② $\rightarrow$ $V_1 - V_2 = 276V$

eq^n ③ $\rightarrow$ $4V_2 - 4V_3 = 290V$.

~~From eq^n ② $V_1 - V_2 = 276V$~~

$V_1 = 276V + \cancel{V_2} \rightarrow$ ④

~~put eq^n ④ in ①.~~

$\cancel{276 + V_2 - V_3 = 36V}$

$\cancel{V_3 - V_2 = 240V} \rightarrow$ ⑤

~~solve eq ⑤ & ⑥~~

$\cancel{4V_3 - 4V_2 = 960}$

$\cancel{4V_2 - 4V_3}$

Use cramer's rule to find out the value of V_1, V_2, V_3.

$$\begin{bmatrix} 1 & 0 & -1 \\ 1 & 1 & 0 \\ 4 & -4 & 0 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 36 \\ 276 \\ 290 \end{bmatrix}.$$

$\Delta = 8$

$\Delta_1 = 1394$

$\Delta_2 = 814$

$\Delta_3 = 1106$

$V_1 = 174.25$

$V_2 = 101.75$

$V_3 = 138.25$.

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

Current through

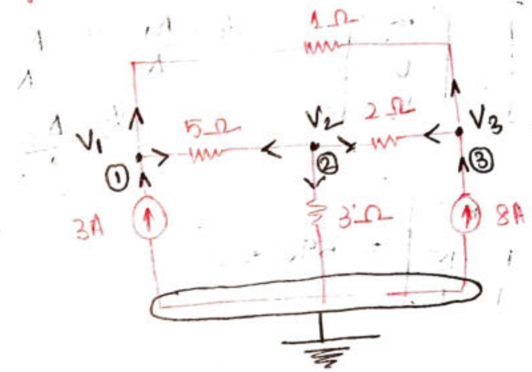
$12\Omega = \frac{72.5}{12\Omega} = 6.04$ Amp.

$15\Omega = \frac{36.5}{15} = 2.43$ Amp

$4\Omega = \frac{174.25}{4} = 43.5$ Amp

$6\Omega = \frac{138.25}{6} = 23.04$ Amp.

⑤ Determine node voltage and power absorbed by ohmic resistor for the network shown.



Nodal analysis @ V_1.

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

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

$6V_1 - V_2 + 5V_3 = 15 \longrightarrow$ ①.

nodal analysis at V_2

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

$6V_2 - 6V_1 + 15V_2 - 15V_3 + 10V_2 = 0.$

$-6V_1 + 31V_2 - 15V_3 = 0 \longrightarrow$ ②

Nodal analysis @ V_3.

$$\frac{V_3 - V_1}{1} + \frac{V_3 - V_2}{2} = 8$$

$2V_3 - 2V_1 + V_3 - V_2 = 16.$

$-2V_1 - V_2 + V_3 = 16 \longrightarrow$ ③.

For calculation of node voltage.
We should apply cramer's rule.

$$\begin{bmatrix} 6 & -1 & 5 \\ -6 & 31 & -15 \\ -2 & -1 & 1 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 15 \\ 0 \\ 16 \end{bmatrix}$$

$V_1 = \frac{\Delta_1}{\Delta}$, $V_2 = \frac{\Delta_2}{\Delta}$, $V_3 = \frac{\Delta_3}{\Delta}$.

$$\Delta = \begin{bmatrix} 6 & -1 & 5 \\ -6 & 31 & -15 \\ -2 & -1 & 1 \end{bmatrix} = \cancel{640}\,400,$$

$$\Delta_1 = \begin{bmatrix} 15 & -1 & 5 \\ 0 & 31 & -15 \\ 16 & -1 & 1 \end{bmatrix} = -2000$$

$$\Delta_2 = \begin{bmatrix} 6 & 15 & 5 \\ -6 & 0 & -15 \\ -2 & 16 & 1 \end{bmatrix} = 1500$$

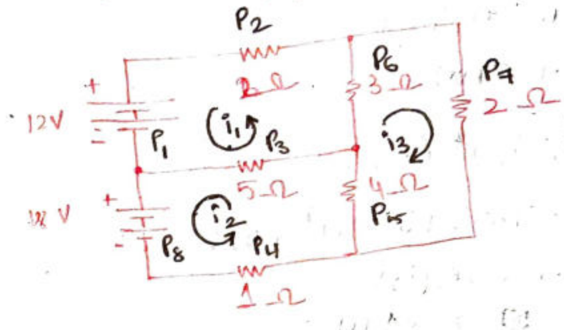
$$\Delta_3 = \begin{bmatrix} 6 & -1 & 15 \\ -6 & 31 & 0 \\ -2 & -1 & 16 \end{bmatrix} = 3900$$

$$\left.\begin{aligned} V_1 &= \frac{\Delta_1}{\Delta} = \frac{-2000}{400} = -5V \\ V_2 &= \frac{\Delta_2}{\Delta} = \frac{1500}{400} = 3.75V \\ V_3 &= \frac{\Delta_3}{\Delta} = \frac{3900}{400} = 9.75V \end{aligned}\right\} \text{Node voltages}$$

$\cancel{Power = I^2R}$ Power $= \frac{V^2}{R}$ Here V = Voltage across 5ohm resistor

$$= \frac{V_2 - V_1}{5} = \frac{3.75+5}{5} = 1.75W$$

6) Using inspection method, calculate the current in each mesh & power loss in each element for network shown in figure?



Mesh analysis by inspection can only be applied if there is a circuit with only resistors & independent voltage sources.

we will 3x3 matrix.

$$\begin{bmatrix} 10 & -5 & -3 \\ -5 & 10 & -4 \\ -3 & -4 & 9 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix} = \begin{bmatrix} -12 \\ -18 \\ 0 \end{bmatrix}$$

$$\left.\begin{aligned} 10i - 5i_2 - 3i_3 &= -12 \\ -5i + 10i_2 - 4i_3 &= -18 \\ -3i_1 - 4i_2 + 9i_3 &= 0 \end{aligned}\right\} eq^n s.$$

$\Delta = 305$.

apply cramer's rule.

$i_1 = \frac{\Delta_1}{\Delta}$; $i_2 = \frac{\Delta_2}{\Delta}$; $i_3 = \frac{\Delta_3}{\Delta}$

$i_1 = -6.27A$
$i_2 = -7.02A$.
$i_3 = -5.21A$.

$$\Delta_1 = \begin{bmatrix} -12 & -5 & -3 \\ -18 & 10 & -4 \\ 0 & -4 & 9 \end{bmatrix} = -1914$$

$$\Delta_2 = \begin{bmatrix} 10 & -12 & -3 \\ -5 & -18 & -4 \\ -3 & 0 & 9 \end{bmatrix} = \cancel{-1276}\ -2142$$

$$\Delta_3 = \begin{bmatrix} 10 & -5 & -12 \\ -5 & 10 & -18 \\ -3 & -4 & 0 \end{bmatrix} = -1590$$

- **Power Loss:-**

Power loss is given by I^2R.

Power loss at $P_2 = (-6.27)^2(2)$

$= 39.31W$.

Power loss at $P_3 = (i_2 - i_1)^2(5)$.

$= (-7.02+6.27)^2(5)$.

$= 0.5625(5)$

$= 2.81W$.

Power loss at $P_4 = (i_2)^2 \times 1$

$= 49.28W$.

Power loss at $P_5 = (i_2+i_3)^2 \times 4$

$= (-7.02-5.21)^2 \times 4$.

$= 598.29W$

Power loss at $P_6 = (i_3+i_1)^2 \times 3$.

$= (-5.21 - 6.27)^2(3)$

$= (-11.48)^2(3)$

$= 395.37W$.

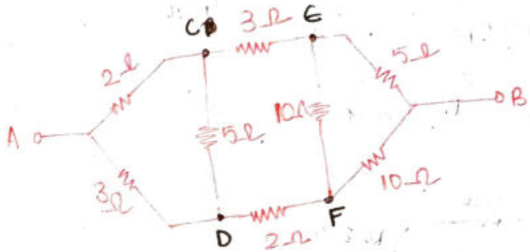
Power loss at $P_7 = (i_3)^2 \times 2$

$= (-5.21)^2 \times 2$

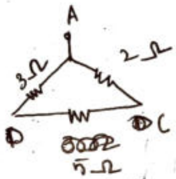
$= 27.14 \times 2$

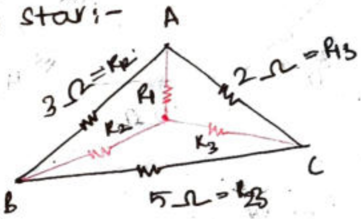
$= 54.28W$.

8) Calculate the voltage to be applied across AB in order to drive current of 5A. In the circuit using star delta transformation for the network shown in fig?



Convert Delta to star:-

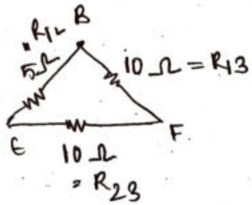


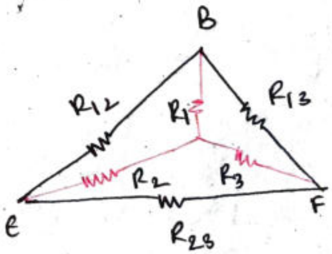


$R_1 = \frac{R_{12} \cdot R_{13}}{R_{12}+R_{13}+R_{23}} = \frac{2\times3}{10} = \frac{6}{10} = \frac{3}{5}\Omega$

$R_2 = \frac{R_{12} \cdot R_{23}}{R_{12}+R_{13}+R_{23}} = \frac{2\times5}{10} = \frac{3}{2}\Omega$

$R_3 = \frac{R_{13} \cdot R_{23}}{R_{13}+R_{12}+R_{23}} = \frac{2\times5}{10} = 1\Omega$.



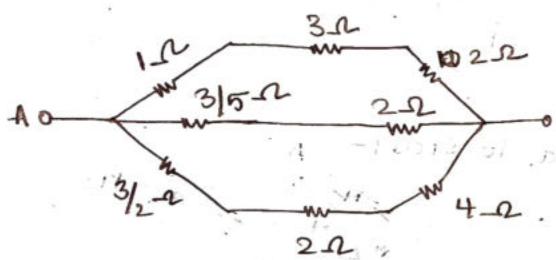


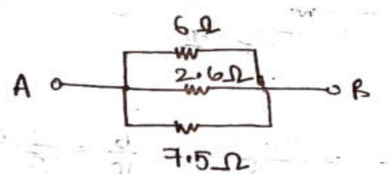
$R_1 = \frac{R_{12} \cdot R_{13}}{R_{12}+R_{23}+R_{31}} = \frac{10\times5}{25} = 2\Omega$

$$R_2 = \frac{R_{12} \cdot R_{23}}{R_{12}+R_{23}+R_{13}} = \frac{5\times10}{25} = 2\,\Omega$$

$$R_3 = \frac{R_{13} \cdot R_{23}}{R_{12}+R_{23}+R_{13}} = \frac{10\times10}{25} = 4\,\Omega.$$

The circuit can be redrawn as:-





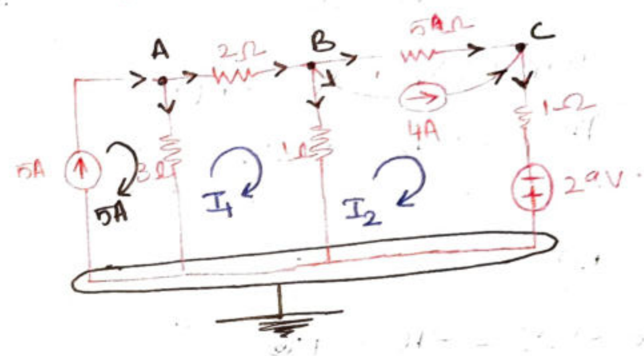
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}.$$

$$\frac{1}{R_{eq}} = \frac{1}{6} + \frac{5}{13} + \cancel{\frac{15}{24}}\ \frac{2}{15}.$$

$$\frac{1}{R_{eq}} = \frac{195+\cancel{90}\,450+156}{1170}$$

$$R_{eq} = \frac{1170}{801} = \underline{\underline{1.46\,\Omega}}.$$

9) Determine the node voltage using nodal analysis for given circuit.



~~Nodal analysis @ A.~~

Nodal Analysis @ A.

$$5 = \frac{V_A}{3} + \frac{V_A - V_B}{2} \longrightarrow (1)$$

Nodal Analysis @ B.

$$\frac{V_A - V_B}{2} = \frac{V_B - V_C}{5} + 4 + \frac{V_B}{1} \longrightarrow (2)$$

Nodal analysis @ C.

$$\frac{V_B - V_C}{5} + 4 = \frac{V_C + 29}{1} \longrightarrow (3).$$

simplify (1), (2) & (3)

eq^n (1) :- $30 = 5V_A - 3V_B$.

eq^n (2) ;- $40 = 5V_A - 17V_B + 2V_C$.

eq^n (3) :- $V_B - V_C + 20 = 5V_C + 145$

$V_B - 6V_C = 125$.

use eq ① ② ③ to find V_A, V_B, V_C.

eq② $\rightarrow (\cancel{5V_A - 3V_B})^{30} - 14V_B + 2V_C = 40$

$\cancel{30}$ $-14V_B + 2V_C = 10 \rightarrow$ ⑤.

$14V_B - 2V_C = -10$.

eq③ $V_B - 6V_C = 125$.

$V_B - 6V_C - 135 = -10 \rightarrow$ ⑥.

eq ⑤ & eq ⑥ to be equated.

$14V_B - 2V_C = V_B - 6V_C - 135$.

$13V_B + 4V_C = -135$.

So the equations are:-

$5V_A - 3V_B + 0V_C = 30$

$5V_A - 17V_B + 2V_C = 40$

$0V_A + V_B - 6V_C = 125$.

Apply cramer's rule.

$V_A = \frac{\Delta_1}{\Delta}$, $V_B = \frac{\Delta_2}{\Delta}$, $V_C = \frac{\Delta_3}{\Delta}$.

$$\begin{bmatrix} 5 & -3 & 0 \\ 5 & -17 & 2 \\ 0 & 1 & -6 \end{bmatrix} \begin{bmatrix} V_A \\ V_B \\ V_C \end{bmatrix} = \begin{bmatrix} 30 \\ 40 \\ 125 \end{bmatrix}$$

$$\Delta = \begin{bmatrix} 5 & -3 & 0 \\ 5 & -17 & 2 \\ 0 & 1 & -6 \end{bmatrix} = 410.$$

$$\Delta_1 = \begin{bmatrix} 30 & -3 & 0 \\ 40 & -17 & 2 \\ 125 & 1 & -6 \end{bmatrix} = 1530.$$

$$\Delta_2 = \begin{bmatrix} 5 & 30 & 0 \\ 5 & 40 & 2 \\ 0 & 125 & -6 \end{bmatrix} = -1550.$$

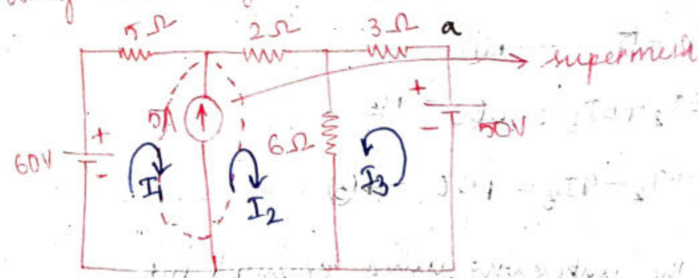
$$\Delta_3 = \begin{bmatrix} 5 & -3 & 30 \\ 5 & -17 & 40 \\ 0 & 1 & 125 \end{bmatrix} = -8800.$$

$V_1 = \frac{\Delta_1}{\Delta} = \frac{1530}{410} = 3.73V$

$V_2 = \frac{\Delta_2}{\Delta} = \frac{-1550}{410} = -3.78V$

$V_3 = \frac{\Delta_3}{\Delta} = \frac{-8800}{410} = -21.4V$.

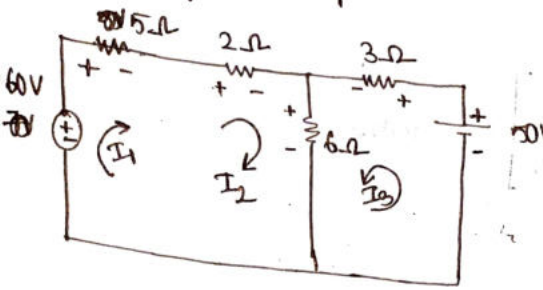
= 10) Determine the current through branch a-b using mesh analysis shown in figure.



There is independent current source in between 2 meshes so it is a super mesh.

The eq^n of supermesh is: $\boxed{I_2 - I_1 = 5} \rightarrow$ ①.

Write the eq^n of mesh ① & ② simultaneously including the supermesh.



$$60 - 5I_1 - 2I_2 - 6(I_2 + I_3) = 0 \longrightarrow ②$$

$$60 - 5I_1 - 2I_2 - 6I_2 - 6I_3 = 0$$

$$60 - 5I_1 - 8I_2 - 6I_3 = 0 \longrightarrow ②$$

Mesh analysis @ mesh 3.

$$-50 - 3I_3 - 6(I_3 + I_2) = 0$$

$$-50 - 3I_3 - 6I_3 - 6I_2 = 0$$

$$-50 - 6I_2 - 9I_3 = 0 \longrightarrow ③$$

$$I_2 - I_1 = 5 \longrightarrow ①$$

$$5I_1 + 8I_2 + 6I_3 = 60 \longrightarrow ②$$

$$0I_1 - 6I_2 - 9I_3 = +50 \longrightarrow ③$$

Find the unknowns using cramer's rule.

$$\begin{bmatrix} -1 & 1 & 0 \\ 5 & 8 & 6 \\ 0 & -6 & -9 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} 5 \\ 60 \\ +50 \end{bmatrix}$$

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

$\Delta = 81$

$\Delta_1 = 660$.

$\Delta_2 = 1065$.

$\Delta_3 = -1160$

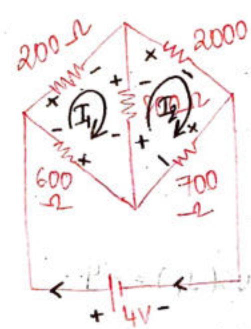
$I_1 = 8.14A$.

$I_2 = 13.14A$.

$I_3 = -14.32A$.

The current flowing through the branch a-b is I_3 i.e., $-14.32A$.

Q11) Determine current through 800ohm resistor in the network shown.



Apply mesh analysis @ mesh ①.

$$\cancel{4 - 200I_1 - 800(I_1 - I_2)}$$

$$\cancel{4 - 200I_1 - 800I_1 + 800I_2 - 600I_1 = 0}$$

$$\cancel{4 = 800I_1} \quad \cancel{I_1 = \frac{4}{800}} = 0.005A = 5mA.$$

$$4 - 200I_1 - 800I_1 + 800I_2 - 600I_1 = 0$$

$$800I_2 - 1600I_1 = -4 \longrightarrow ①$$

Apply mesh analysis @ Mesh ②.

$+4 - 2000I_2 - 700I_2 - 800I_2 + 800I_1 = 0$.

$800I_1 - 3500I_2 = -4 \longrightarrow$ ②.

→ solve eq ① & eq ② for current values.

$800I_2 - 1600I_1 = -4$

$800I_1 - 3500I_2 = -4$ .... ×2.

$800I_2 - \cancel{1600I_1} = -4$

$\cancel{1600I_1} - 7000I_2 = -8$.

$-6200I_2 = -12$

$\boxed{I_2} = 0.0019\ A.$

$= 1.9mA.$

~~800I~~ $800(1.9mA) - 1600(I_1) = -4$.

$800(0.0019) - 1600I_1 = -4$

$-1600I_1 = -4 - 1.52$

$-1600I_1 = -5.52$

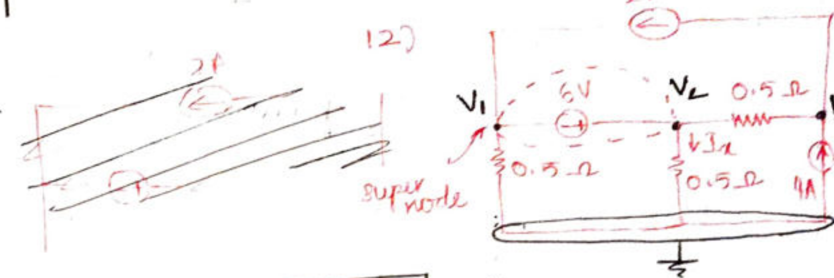
$I_1 = \frac{5.52}{1600} = 0.0034A.$

$\boxed{I_1 = 3.4\ mA}$

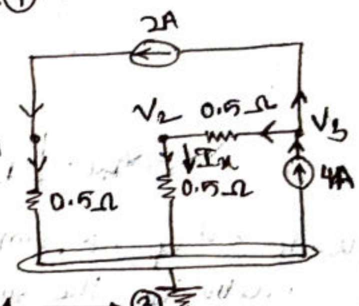
current through 800Ω = $I_1 - I_2 = 3.4mA - 1.9mA$

$= 1.5mA$.

12)



Super node eqⁿ → $\boxed{V_2 - V_1 = 6} \longrightarrow$ ①.



Nodal analysis @ V_3

$4 = \frac{V_3 - V_2}{0.5} + 2$

$4 = 2V_3 - 2V_2 + 2$

$2 = 2(V_3 - V_2)$ $V_3 - V_2 = 1 \longrightarrow$ ③

Simultaneous eq @ V_1 & V_2 including super node.

$\frac{V_2}{0.5} + \frac{V_2 - V_3}{0.5} + \frac{V_1}{0.5} - 2 = 0 \longrightarrow$ ②

$2V_2 + 2V_2 - 2V_3 + 2V_1 - 2 = 0$

$4V_2 + 2V_1 - 2V_3 - 2 = 0$

$2V_2 + V_1 - V_3 - 1 = 0 \longrightarrow$ ②.

Sub ① in ②.

$2V_2 + V_2 - 6 + V_3 + 1 = 0$

$3V_2 + V_3 - 5 = 0 \longrightarrow$ ④.

Solve ③ & ④.

$3V_3 - \cancel{3V_2} = 3$

$\cancel{3V_2} + V_3 = 5$

$4V_3 = 8$

$V_3 = 2V \longrightarrow$ ⑤.

substitute ⑤ in eq ③.

then $V_2 = 4V$.

WKT, $V = IR$

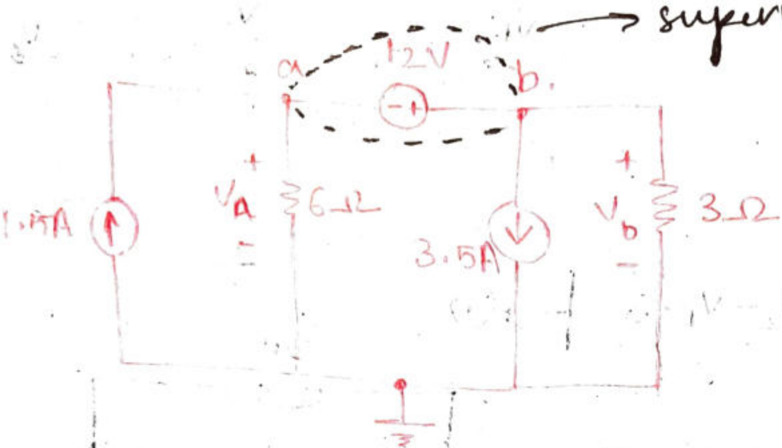
$I = \frac{V}{R}$.

$I_x = \frac{4}{0.5} = \frac{4}{1/2}$

$= 4 \times 2$

$= 8$ Amp.

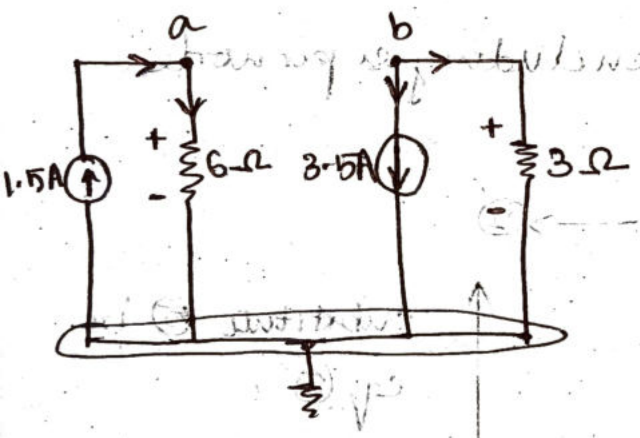
13) Determine value of node voltage V_A & V_B.



Supernode eq^n.

$\boxed{V_b - V_A = 12} \longrightarrow (1)$

Write 2nd eq i.e., simultaneously between node a & b excluding the supernode.



Incoming = Outgoing

$$1.5 = \frac{V_A}{6} + 3.5 + \frac{V_b}{3}$$

$$\frac{3}{2} = \frac{V_A}{6} + \frac{7}{2} + \frac{V_b}{3}$$

$$\cancel{6}^{3} \times \frac{3}{\cancel{7}} = V_A + 21 + 2V_b$$

$$9 = V_A + 2V_B + 21$$

$(2) \longleftarrow \boxed{-12 = V_A + 2V_B}$

~~Nodal analysis @ node 3.~~

$$V_b - \cancel{V_A} = 12$$

$$\cancel{V_A} + 2V_B = -12$$

$$3V_B = 0 \qquad V_B = 0.$$

so $\boxed{V_B = 0. \quad V_A = -12V.}$