Syllabus

Unit-I Introduction to Electrical Circuits

* Basic definitions
* Kirchhoff's Law's
* Series & Parallel connection
* source transformation
* Mesh Analysis
* Nodal Analysis
* star to Delta and Delta to star transformation

UNIT-II DC theorems and single phase AC circuits

PART-A DC Theorems

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* Reciprocity theorem
* Thevenins theorem
* Norton's theorem
* Maximum power transfer Theorem

PART-B Single phase AC circuits

* Basic definitions
* AC through series RL, RC, RLC
* Problems

UNIT-III Three phase AC circuits and PN junction diode

PART-A Three phase AC circuits

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* Three phase star connection System and Three
* Three phase Delta connection system.

PART-B P-N Junction diode

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UNIT-IV Rectifiers and Special Purpose devices

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* Half wave rectifiers
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PART-B Special purpose devices

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* Zener diode as voltage regulator

UNIT-V Bipolar Junction Transistor

* Basic definitions
* Transistor configurations
  i) CB
  ii) CE
  iii) CC
* DC and AC load line
* Need for biasing and biasing techniques

UNIT-I Introduction to Electrical Circuits

1. **Network**: A combination of various electrical elements connected in any manner in a closed path is known as network.

2. **Circuit**: A circuit is a closed path through which an electrical current flows.

3. **Brach**: Its a portion of network which lies between two nodes.

4. **Node**: It is a common point (or) junction point where two or more branches pass through it.

5. **Loop**: Its a closed path which is formed by branches and nodes.

6. **Mesh**: It is a type of loop that doesn't contain another loop within it.

Network elements

- Linear & Non-linear elements
- Unilateral & Bilateral elements
- Lumped & Distributed elements
- Time variant & Time invariant
- Active & passive elements

Linear & Non-linear elements:

Linear: An element is said to be linear when it obeys ohm's law

Ex:- RLC

Non-linear: An element is said to be non-linear when when it doesn't obeys ohm's law

Ex: Diodes, Transistors

Unilateral elements: The elements which allow the flow of current only in one direction. are called as Unilaterals

Ex: Diodes, Metal rectifiers.

Bilateral elements: The elements which allow the flow of current in both the directions are called as bilateral elements.

Ex: RLC

Lumped elements:- The elements which canbeseparated physically are called lumped elements.

Ex: Elements from mother board can be separated physically.

Distributed elements: The elements which cannot be separated physically.

Ex: The elements of transmition lines.

Time variant elements: If the coefficients of differential equations describing network are functions of time then it is called as time variant elements.

Ex: (or) The circuit which depends on time

Ex:-The circuits devides which are designed with a speed limit.

Time invariant elements:- If the coefficients of differential equations describing network are constant.

Ex:- Working of RLC.

Active elements: The elements which can produce (or) generate energy are called active elements. We have two kinds of active elements they are current source and voltage source.

Ex:- Generators, Transistors

Passive elements: The elements which consumes or stores energy

Ex:- RLC

Linear circuit: The circuit which obeys the Ohm's law.

Non-linear circuit: The circuit which doesn't obeys Ohm's law.

Source: The element (or) component producer energy.

ex: battery, generators, RPS

Load: The load is a component which consumer energy and converts electrical energy into otherforms of energy

ex: fans, lights, refridgerator

Switch: It is a mechanical device which makes and breaks the circuit.

current ~~circuit~~**:** The rate of change of charges with respect to time

$$\boxed{I = \frac{q}{t}}$$

Units: columbs/sec (or) Amperes (A)

Voltage: The potential difference between any two points.

$$\boxed{V = IR}$$ R- proportionality constant

Units: volts

Power: The workdone with respect to time.

$$\boxed{P = \frac{W}{t}}$$

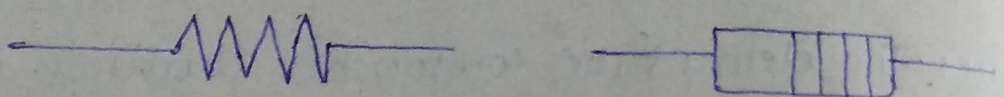
Units: Jouls / sec (or) Watts

Resistance: The property ~~whi~~ of opposing the flow of current is called resistance.

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

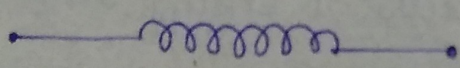
Units: Ω (ohm's)

Symbol:



Inductor: Inductor is a coil which stores energy in the form of magnetic field.

Symbol:

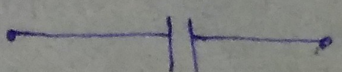


Units: Henry's

$$\boxed{V = I \times \frac{dI}{dT}}$$

Capacitor: It stores the energy in the form of electrical charge

Symbol:



C

$$\boxed{I = C \times \frac{dv}{dt}}$$

Units: Farad's.

Ohm's law: At constant temperature, the applied voltage is directly proportional to the current.

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

Limitations of Ohm's law:

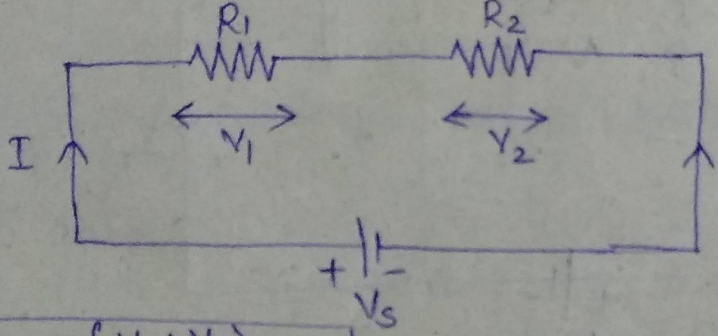
1. It can't be applied for varying temperatures.
2. It can't be applied for unilateral elements.
3. It can't be applied for non-linear circuits.
4. It can't be applied for the semiconductors.

Kirchhoff's Laws:

This laws are used to solve complex networks. It tells about the voltage and current relationships in circuit. There are two laws they are:

① Kirchhoff's Voltage Law
② Kirchhoff's Current law

① **Kirchhoff's Voltage Law:** The algebraic sum of voltage applied and voltage drops around a closed path in a network is equal to zero.



$$\boxed{V_s - (V_1 + V_2) = 0}$$

(or)

The applied voltage will be equal to the sum of voltage drops around a closed path.

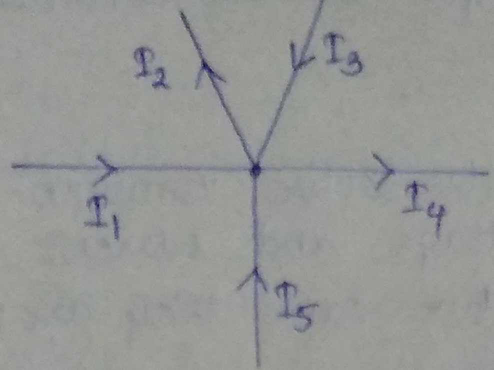
$$\boxed{V_s = V_1 + V_2}$$

* KVL is based on law of Conservation of energy.

② **Kirchhoff's ~~Voltage~~ Current law**: The algebraic sum of current at a node is equal to zero.

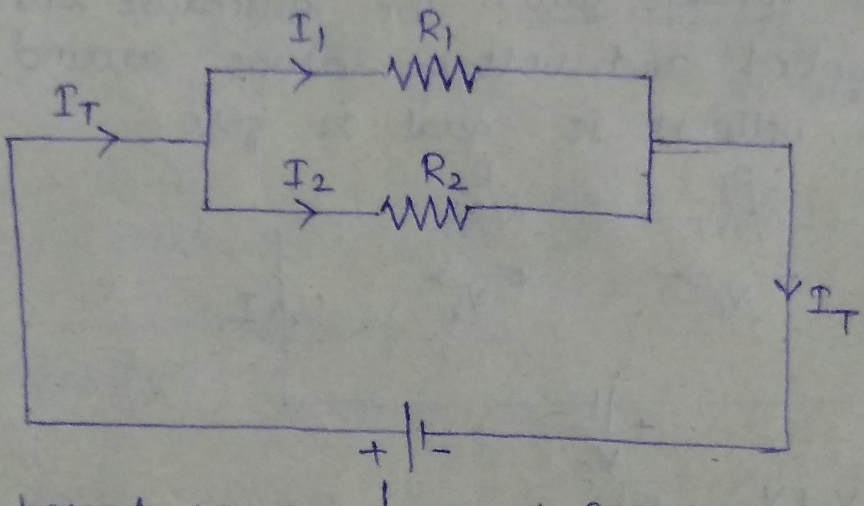
$$\boxed{\Sigma I_n = 0}$$

$$I_1 + I_3 + I_5 - I_2 - I_4 = 0$$



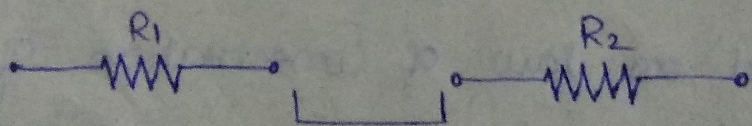
The sum of entering current is equal to sum of leaving current.

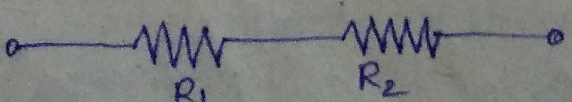
$$I_1 + I_3 + I_5 = I_2 + I_4$$



* It is based on the Law of Conservation of charges.

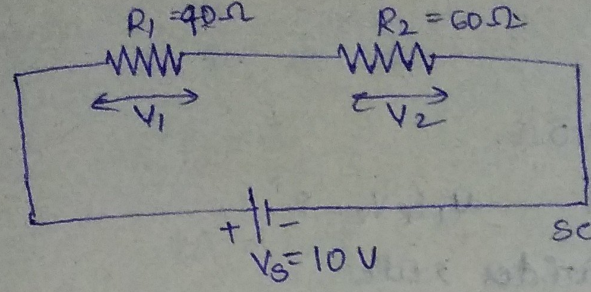
Series Connection: If the resistors are connected end-to-end then the combination (or) connection is said to be in series





→ Series Connection

Q:



series connection

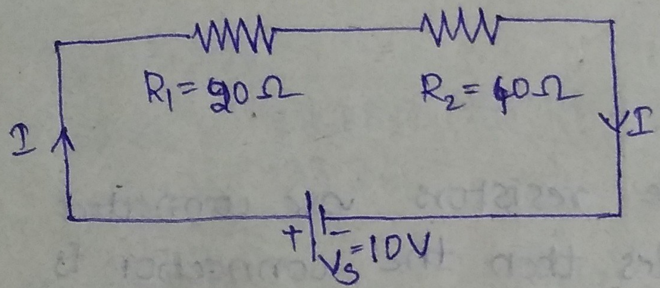
Find the flow of current (I)?

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

$I = \frac{V}{R_{eq}} = \frac{10}{100} = \underline{0.1\ A}$

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

Voltage division / divider Rule:



$\boxed{V = IR}$

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

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

Calculate the voltage drops from the circuit

(i) $V_1 = ?$ & $V_2 = ?$

I method:

Given data

$R_1 = 20\Omega$ $R_2 = 40\Omega$

$V_S = 10V$ $I = ?$ V_1 & $V_2 = ?$

$I = \frac{V}{R_{eq}}$

$= \frac{10}{20+40} = \frac{10}{60} A$

$V_1 = IR_1$

$= \left(\frac{10}{60}\right) \times 20 = 3.3V$

$V_2 = IR_2$

$= \left(\frac{10}{60}\right) \times 40 = 6.6V$

$V_S = V_1 + V_2$

$10 \cong 3.3 + 6.66$

II method

① Given data

$R_1 = 20\,\Omega$ $\quad$ $R_2 = 40\,\Omega$

$V_S = 10V$ $\quad$ $I = ?$ $\quad$ V_1 & $V_2 = ?$

According to voltage divider rule

$$\boxed{V_1 = \frac{R_1}{R_{eq}} V_S}$$

$R_{eq} = R_1 + R_2$
$= 20 + 40$
$= 60\,\Omega$

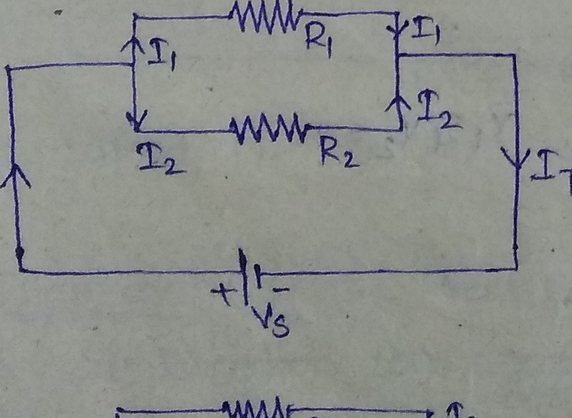
$$= \frac{20}{(60)} \times 10 = 3.33V$$

$$V_2 = \frac{R_2}{R_{eq}} V_S$$

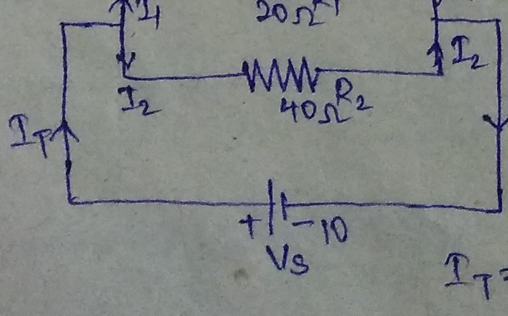
$$= \frac{40}{60} \times 10 = 6.66\,V$$

$V_S = V_1 + V_2$

Parallel Connection: If the resistors are connected through the common nodes then the connection is said to be parallel connection.



Ex:



R_{eq} in $\parallel^{al} \rightarrow \frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$

$I_T = \frac{V_S}{R_{eq}} = \_\_\, A$

$$\boxed{I_1 = I_T \times \frac{\text{opp } R}{\text{sum of } R}}$$

$I_T = \frac{V}{R_{eq}}$

$$\boxed{I_2 = I_T \times \frac{\text{opp}}{\text{sum of } R}}$$

$I_T = I_1 + I_2$

Req in $\parallel^{al}$ $\frac{1}{R} = \frac{1}{20} + \frac{1}{40}$

$\frac{1}{R} = \frac{3}{40}$

$R = 0.075$

$I_T = \frac{10}{0.075} = 133.33$

$I_1 = 133.33 \times \frac{R_2}{R_1 + R_1}$

$I_1 = 88.88$

$I_2 = 133.33 \times \frac{R_1}{R_1 + R_2}$

$I_2 = 44.44$

$I_T = I_1 + I_2$

$133.33 = 88.88 + 44.44$

$= 133.32$

Key points

* When the two resistances are connected in parallel. ~~is equal to~~ $\boxed{R_{eq} = \frac{R_1 R_2}{R_1 + R_2}}$

R_{eq} in parallel $\boxed{\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}}$

* $I_1 = I_T \times \frac{\text{opposite resistance}}{\text{sum of resistances}}$. This is the current flowing through resistance R_1, where I_T is total current

$\boxed{I_T = \frac{V_s}{R_{eq}}}$

* $I_2 = I_T \times \frac{\text{opposite resistance}}{\text{sum of resistances}}$. This is the current flowing through resistance R_2.

* When three resistances are connected in parallel

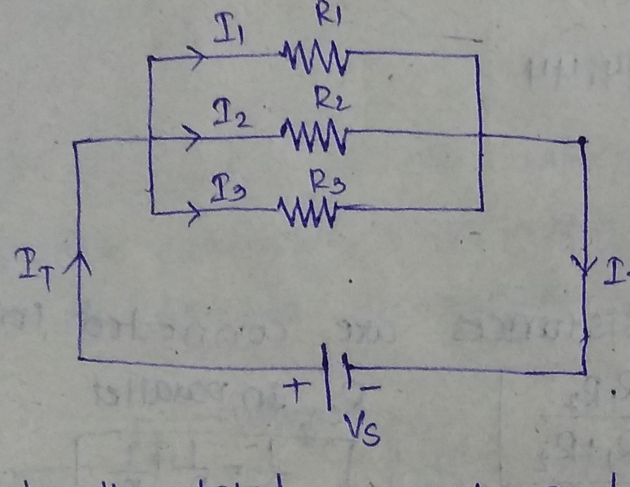
$$\boxed{R_{eq} = \frac{R_1 R_2 R_3}{R_1R_2 + R_2R_3 + R_3R_1}} \quad (or) \quad \boxed{\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

* $I_1 = I_T \times \frac{R_2 R_3}{R_1R_2 + R_2R_3 + R_3R_1}$. This is the current flowing through R_1, where I_T is total current $I_T = \frac{V_S}{R_{eq}}$

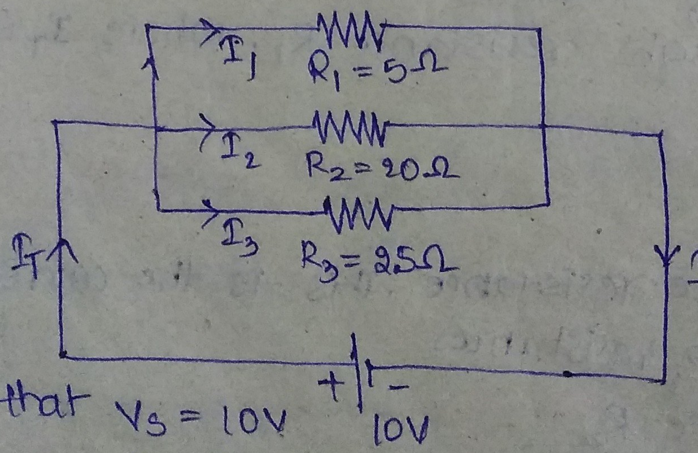
* $I_2 = I_T \times \frac{R_1 R_3}{R_1R_2 + R_2R_3 + R_3R_1}$ This is the current through R_2.

* $I_3 = I_T \times \frac{R_1 R_2}{R_1R_2 + R_2R_3 + R_3R_1}$. This is the current through R_3.

Ex:



Q. Calculate the total current and branch currents for the following circuit.



Given that $V_S = 10V$
$R_1 = 5$
$R_2 = 20$
$R_3 = 2.5$

$I_T, I_1, I_2, I_3 = ?$

$$R_{eq} = \frac{R_1 R_2 R_3}{R_1R_2 + R_2R_3 + R_3R_1}$$

$= 1.538\,\Omega$

$$I_T = \frac{V_S}{R_{eq}}$$

$$I_T = \frac{10}{1.538}\ A$$

$= 6.501\,A$

$$I_1 = \frac{6.501 \times 20 \times 2.5}{5\times 20 + 20\times 2.5 + 2.5\times 5} \quad \text{(or)} \quad \text{from Ohm's law } I_1 = \frac{V}{R_1} = \frac{10}{5} = 2A$$

$\boxed{I_1 = 2.002A}$

$$I_2 = \frac{6.501 \times 5 \times 2.5}{5\times 20 + 20\times 2.5 + 2.5\times 5} \quad \text{(or)} \quad \text{from ohm's law } I_2 = \frac{V}{R_2} = \frac{10}{20} = \frac{1}{2} = 0.5A$$

$\boxed{I_2 = 0.5A}$

$$I_3 = 6.501 \times \frac{20\times 5}{5\times 20 + 20\times 2.5 + 2.5\times 5} \quad \text{(or)} \quad \text{from Ohm's law } I_3 = \frac{V}{R_3} = \frac{10}{2.5} = 4A$$

$\boxed{I_3 = 4A}$

Sum of incoming i = Sum of outgoing i (current)

$6.501 = 2.002 + 0.5 + 4$

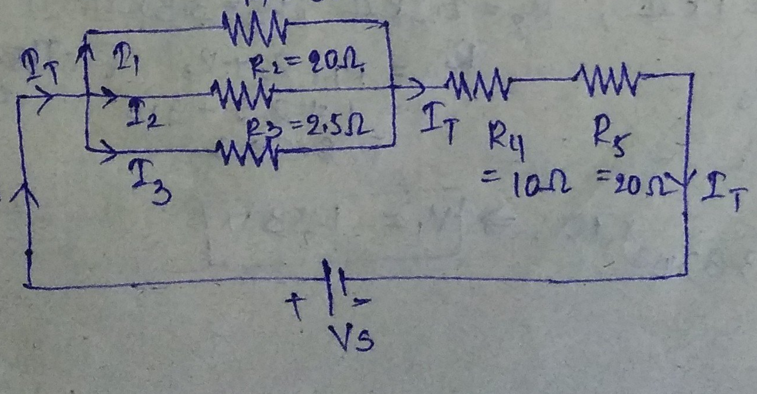
$6.501 \cong 6.502$

LHS = RHS

Series - Parallel connection:

The connection which combines the characteristics of series and parallel circuit or connection.

It is also called as combinational circuit.



Q:- Calculate the R_{eq} in the above circuit.

Given data

$R_1 = 5\Omega$ $R_2 = 20\Omega$ $R_3 = 25$

$R_4 = 10\Omega$ $R_5 = 20\Omega$

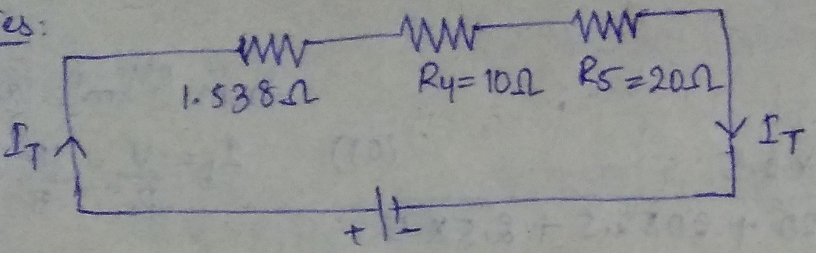
$R_{eq} = ?$

R_{eq} of $\parallel$al connection

$$R_{eq} = \frac{R_1R_2R_3}{R_1R_2 + R_2R_3 + R_3R_1}$$

$$R_{eq} = 1.538\Omega$$

series:



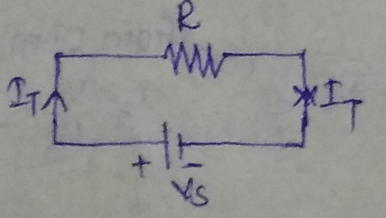
Now the circuit is connected in series connection.

in series

$$R_{eq_1} = 1.538\Omega + R_4 + R_5$$

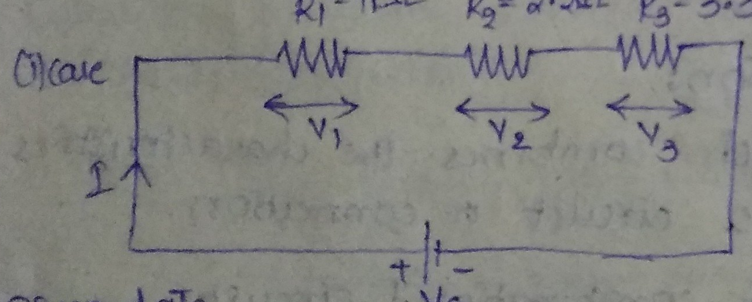
$$= 1.538\Omega + 10\Omega + 20\Omega$$

$$R_{eq} = 31.538\Omega$$



The total resistance across the circuit is 31.538Ω

① KVL



Given data

$V_S = 10V$, $R_1 = 1k\Omega$, $R_2 = 2.2k\Omega$, $R_3 = 3.3k\Omega$

$R_{eq} = R_1 + R_2 + R_3$ [∵ These series connection]

$= 1 + 2.2 + 3.3$

$= 6.5k\Omega$

$$V_1 = \frac{R_1}{R_{eq}} \times V_S$$

$$= \frac{1 \times 10^3}{(1+2.2+3.3)10^3} \times 10 \Rightarrow \boxed{V_1 = 1.53V}$$

$$V_2 = \frac{R_2}{R_{eq}} \times V_S$$

$$= \frac{2.2 \times 10^3}{(6.5) \times 10^3} \times 10$$

$$\boxed{V_2 = 3.38\,V}$$

$$V_3 = \frac{R_3}{R_{eq}} \times V_S$$

$$= \frac{3.3 \times 10^3}{(6.5) \times 10^3} \times 10$$

$$\boxed{V_3 = 5.07\,V}$$

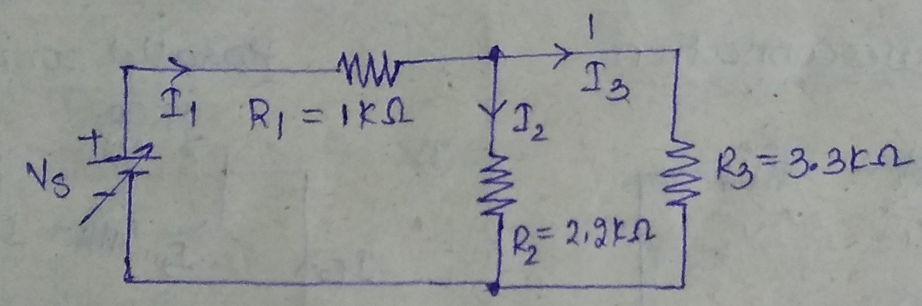
$$V_S = V_1 + V_2 + V_3$$

$$10V = 1.53 + 3.38 + 5.07$$

$$10V \cong 9.98\,V$$

② **KCL**

case(i)



Given data

$R_1 = 1k\Omega$

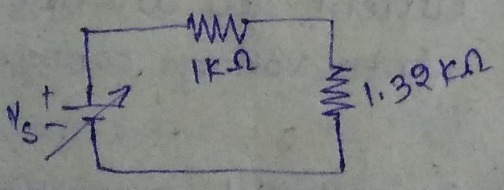
$R_2 = 2.2k\Omega$

$R_3 = 3.3k\Omega$

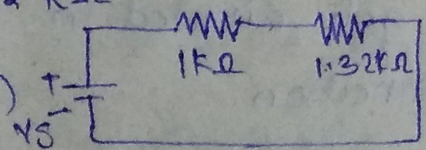
I_T, I_1, I_2, I_3 = ?

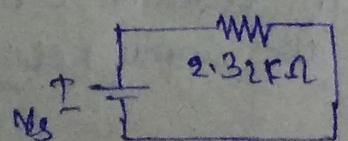
$$R_{eq} = R_2 \parallel R_3 = \frac{R_2 R_3}{R_2 + R_3} = \frac{2.2 \times 3.3\,k\Omega}{5.5\,k\Omega}$$

$$= 1.32\,k\Omega$$



(or)





$$R_{eq} = 1k\Omega + 1.32k\Omega$$

$$= 2.32\,k\Omega$$

$$\Rightarrow I_1 \text{ or } I_T = \frac{V_s}{R_{eq}} = \frac{10}{2.32k\Omega} = \boxed{4.31\,mA = I_T \text{ or } I_1}$$

$$\Rightarrow I_2 = I_T \times \frac{\text{opp } R}{\text{sum of } R} = 4.31 \times \frac{3.3 \times 10^3}{2.2 \times 10^3 + 3.3 \times 10^3}$$

$$\boxed{I_2 = 2.586\,mA}$$

$$\Rightarrow I_3 = 4.31 \times \frac{2.2 \times 10^3}{(2.2 \times 10^3 + 3.3 \times 10^3)}$$

$$\boxed{I_3 = 1.724\,mA}$$

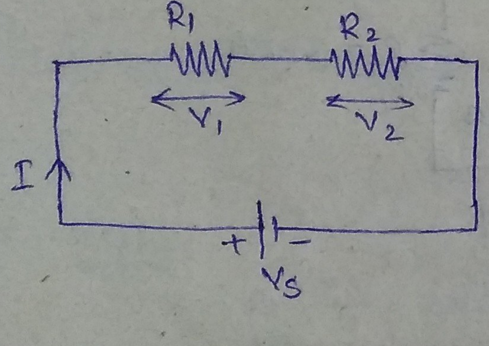
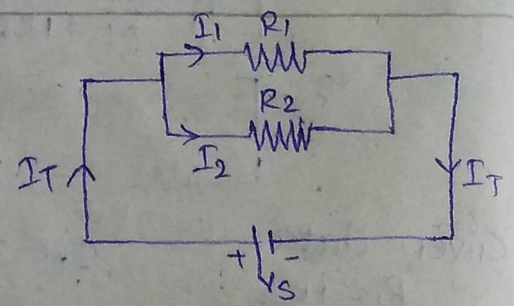
sum of Incoming currents = sum of leaving currents

$$I_1 = I_2 + I_3$$

$$4.31 = 2.586 + 1.724$$

$$4.31\,mA = 4.31\,mA$$

Differences between Series & Parallel connection

Series connection	Parallel connection
① 	① 
② Current (I) is constant in series connection.	② Voltage (V) is constant is parallel connection
③ voltage gets divided in series connection	③ current gets divided into voltage connection.
④ In series connection, we apply KVL	④ In parallel connection, we apply KCL

⑤ The applied voltage is equal to sum of voltage drops around a closed path.

⑥ $V_S = V_1 + V_2$

⑦ $V_1 = \frac{R_1}{R_1+R_2} V_S$ (or) $V_1 = IR_1$

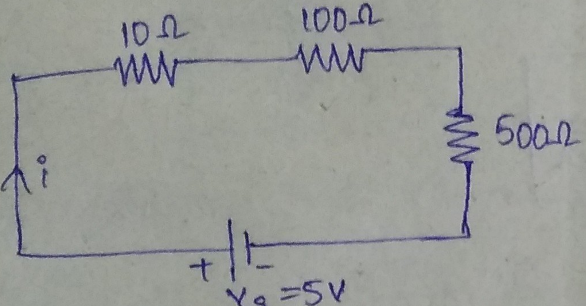
⑤ The sum of incoming currents is equals to sum of outgoing currents.

⑥ $I_T = I_1 + I_2$

⑦ $I_1 = I_T \times \frac{\text{opp } R}{\text{sum of } R}$ (or)

$I_1 = \frac{V_S}{R_1}$

1) Calculate Req



Given data

$R_1 = 10\Omega$, $R_2 = 100\Omega$, $R_3 = 500\Omega$

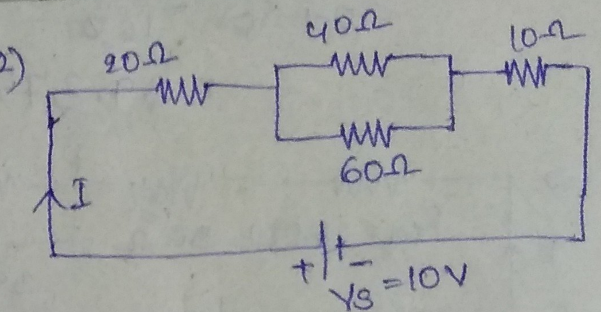
$V_S = 5V$

$Req = R_1 + R_2 + R_3$

$Req = 10 + 100 + 500$

$= 610\Omega$

2)



Given data

$R_1 = 20\Omega$, $R_2 = 40\Omega$, $R_3 = 60\Omega$

$R_4 = 10\Omega$

$V_S = 10V$

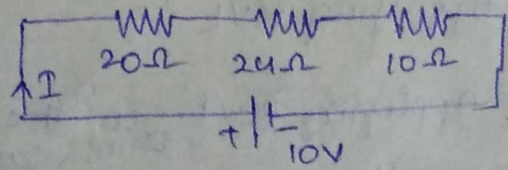
Req of ||al connection

$Req = \frac{R_2R_3}{R_1R_2 + R_2R_3 + R_3R_1,\ R_2+R_3}$

$= \frac{40 \times 60}{20\times40 + 40\times60 + 60 \cdot\ \ 40+60}$

$= \frac{2400}{100} = 24\Omega$

⇒

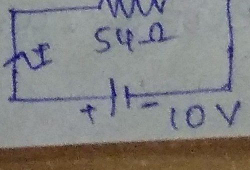


$Req = R_1 + R_2 + R_3$

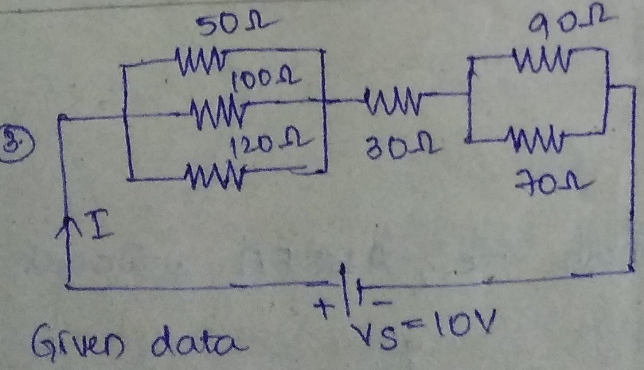
$Req = 20 + 24 + 10$

$= 54\Omega$

→



3.



Given data

$R_1 = 50\Omega$　　$R_5 = 90\Omega$

$R_2 = 100\Omega$　　$R_6 = 70\Omega$

$R_3 = 120\Omega$

$R_4 = 30\Omega$

Req of 1st || connection

$$R_{eq} = \frac{R_1R_2R_3}{R_1R_2 + R_2R_3 + R_3R_1}$$

$$= \frac{50 + 100 + 120}{50 \times 100 + 100 \times 120 + 120 \times 50}$$

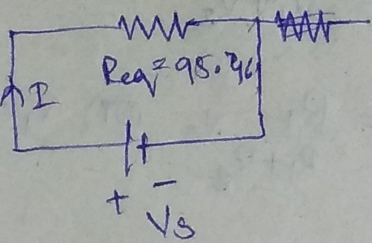
$$= 26.086$$

Req of Series connection

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

$$= 26.086 + 30 + 39.375$$

$$R_{eq} = \underline{\underline{95.461}}$$



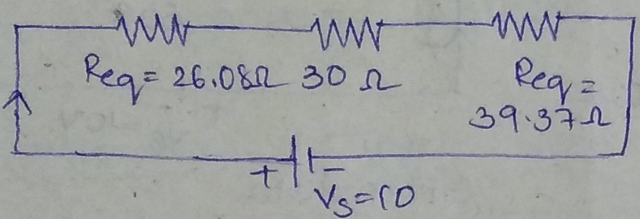
Req of 2nd || connection

$$R_{eq} = \frac{R_5R_6}{R_5+R_6}$$

$$= \frac{90 \times 70}{90+70} = \frac{6300}{160}$$

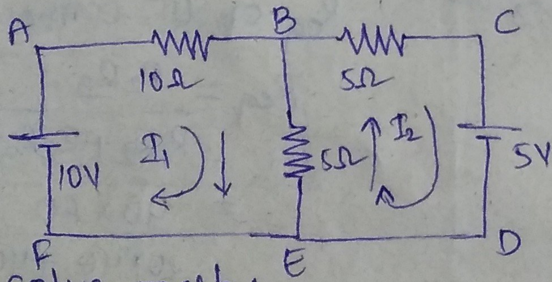
$$= 39.375$$

⇒



Mesh Analysis :-

①



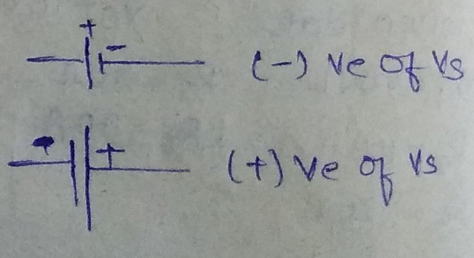
Steps to solve mesh:

1) Identify no. of meshes
2) No. of meshes = No. of i
3) Applying KVL
4) Solve equations

By Applying KVL (& Ohm's law) to the I mesh i.e., ABEFA, we get

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

$$\Rightarrow 10 = 15I_1 - 5I_2 \rightarrow ①$$



By applying KVL to the II mesh i.e, BCDEB, we get

$\Rightarrow -5 = 5I_2 + 5(I_2 - I_1)$

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

by solving (1) & (2)

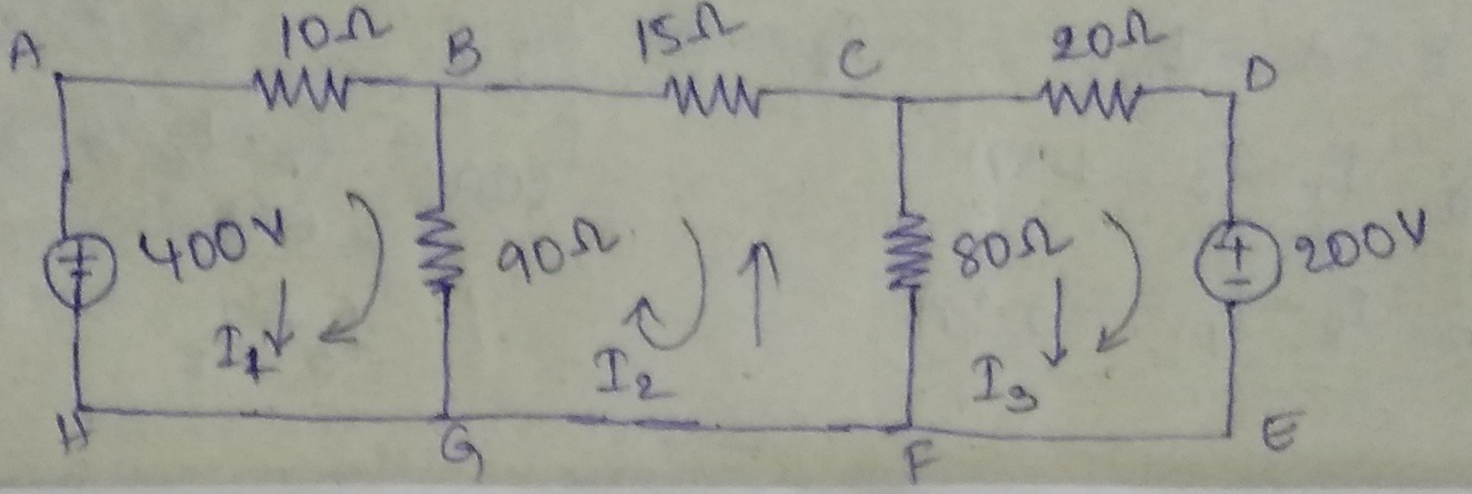
we get $I_1 = 0.6A = I_{10\Omega}$

$I_2 = -0.2A = I_{5\Omega}$

$I_{5\Omega}$ (Middle Mesh) $= I_1 - I_2$ (I Mesh) $= 0.8A$

$= I_2 - I_1$ (II mesh) $= -0.8A$ (opp)

(2) pg no: 57



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

By applying KVL to 2nd mesh i.e., BCFGB, we get

$0 = 90(I_2-I_1)+15I_2+80(I_2-I_3)$

$= 90I_2-90I_1+15I_2+80I_2-80I_3$

$0 = 185I_2-90I_1-80I_3$ —— ②

By applying KVL to 3rd mesh i.e., CDEFC, we get

$-200 = 80(I_3-I_2)+20I_3$

$= 80I_3-80I_2+20I_3$

$-200 = -80I_2+100I_3$ —— ③

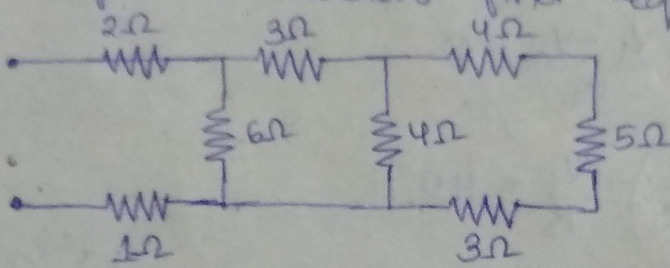
By solving ①, ② & ③ eqn's, we get

$I_1 = 8.5A = I_{10\Omega}$ $\quad I_2 = 5 = I_{15\Omega}$ $\quad I_3 = 2 = I_{20\Omega}$

$I_{90\Omega} = I_1-I_2 = 3.5A$ (or) $I_2-I_1 = -3.5A$

$I_{80\Omega} = I_2-I_3 = 3A$ (or) $I_3-I_2 = -3A$

* By combining the resistors find Req (Requivalent)

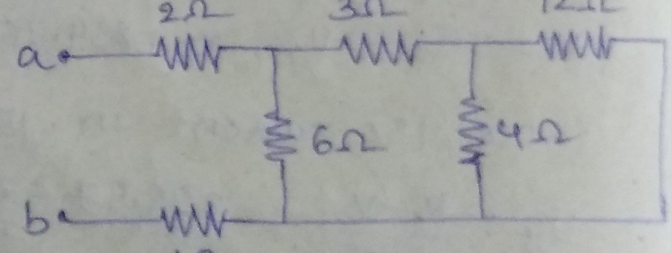


1) 4Ω, 5Ω and 3Ω are in series

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

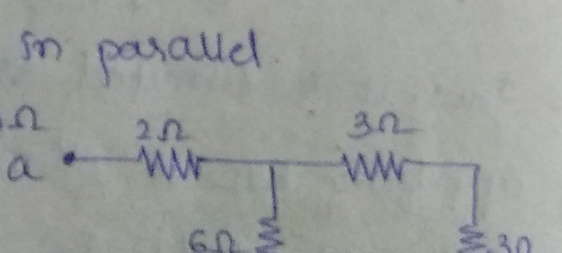
$= 4+5+3$

$= 12\Omega$



2) 12Ω and 4Ω are connected in parallel

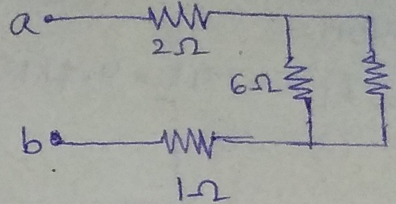
$R_{eq} = \frac{R_1R_2}{R_1+R_2} = \frac{12\times4}{12+4} = \frac{48}{16} = 3\Omega$



3) 3Ω and 3Ω are connected in series

$R_{eq} = R_1 + R_2$

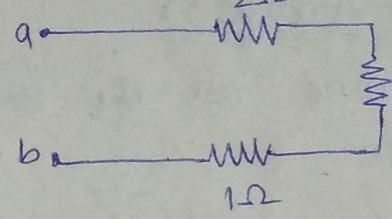
$= 3+3 = 6\Omega$



4) 6Ω & 6Ω are connected in parallel

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

$= \frac{6(6)}{6+6} = \frac{36}{12} = 3\Omega$

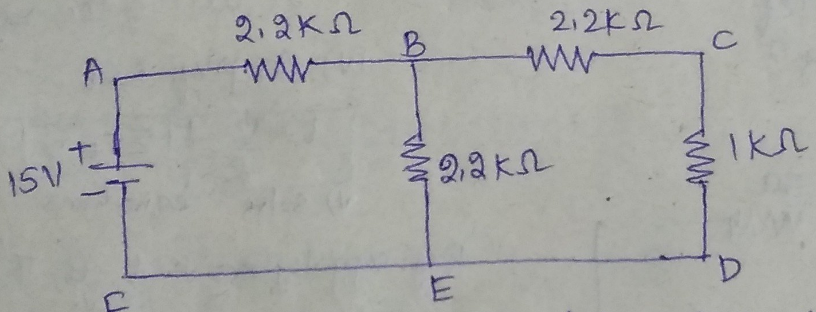


5) 2Ω, 1Ω and 3Ω are connected in series.

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

$= 2+3+1 = 6\Omega$

*



By using Mesh analysis determine current in all the Branches.

By applying KVL to Mesh I i.e ABEFA

$15V = 2.2 I_1 + 2.2(I_1 - I_2)$

$15 = 2.2 I_1 + 2.2 I_1 - 2.2 I_2$

$15 = 4.4 I_1 - 2.2 I_2 \longrightarrow (1)$

By applying KVL to Mesh II i.e BCDEB

$0 = 2.2 I_2 + 2.2(I_2 - I_1) + 1(I_2)$

$0 = 2.2 I_2 + 2.2 I_2 - 2.2 I_1 + I_2$

$0 = 4.4 I_2 - 2.2 I_1 + I_2$

$0 = 5.4 I_2 - 2.2 I_1 \longrightarrow (2)$

By solving eqn (1) & (2)

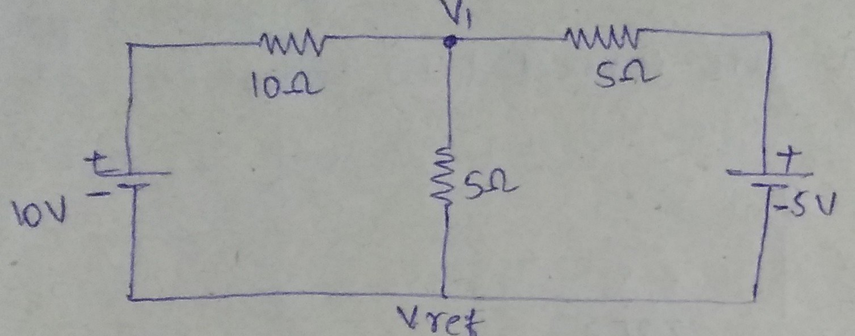
$I_1 = 4.281 mA = I_{2.2k\Omega}$

$I_2 = 1.741 mA = I_{2.2k\Omega}$

$$I_{2.2k\Omega} = I_1 - I_2 = 4.281 - 1.741 = 2.54\,mA$$
(or)
$$I_2 - I_1 = 1.741 - 4.281 = -2.54\,mA \text{ [I is in opp. direction]}$$

Nodal Analysis:

① Determine all the branch currents using nodal analysis.

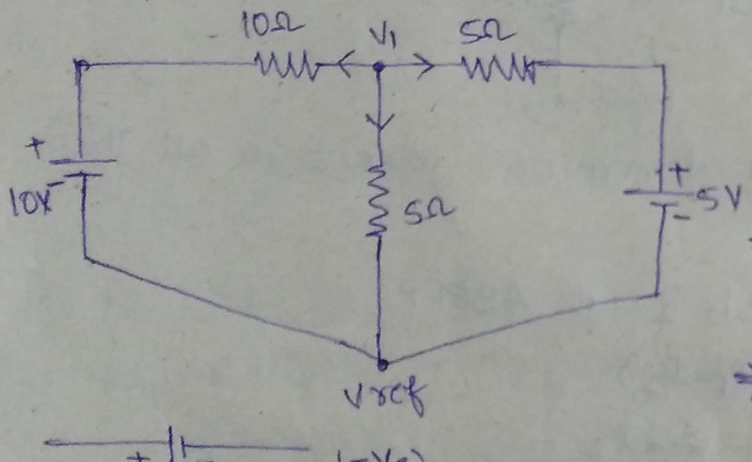


i) Identify Principal nodes
ii) redraw the current
iii) Assume all I leaving the node
iv) Apply KCL

$\boxed{i = \frac{V}{R}}$ $\boxed{\Sigma I = 0}$

v) Solve equations

$n - 1 = 2 - 1 = 1$ eqn



By applying KCL at the Principal node i.e., V_1 we get

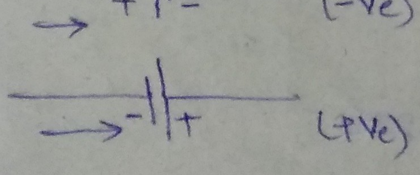
$$\Rightarrow \frac{V_1 - 10}{10} + \frac{V_1}{5} + \frac{V_1 - 5}{5} = 0$$

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

$$\Rightarrow V_1\left(\frac{1}{10} + \frac{1}{5} + \frac{1}{5}\right) = 2$$

$$\Rightarrow V_1(0.5) = 2$$

$$\Rightarrow \boxed{V_1 = 4V}$$

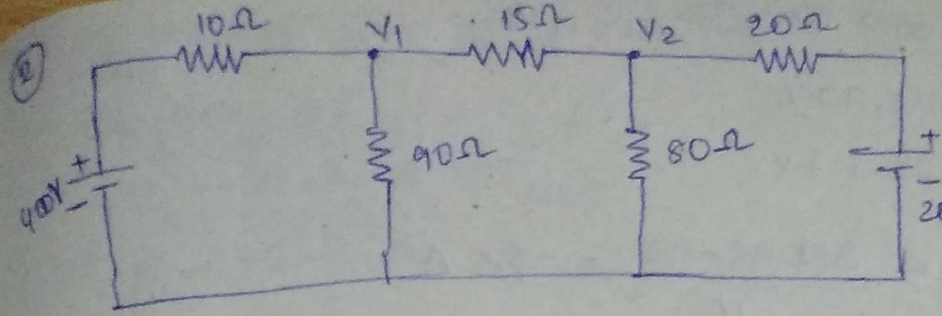


$$\Rightarrow I_{10\Omega} = \frac{V_1 - 10}{10} = \frac{4 - 10}{10} = -0.6A$$

$$\Rightarrow I_{5\Omega \text{(M.B)}} = \frac{V_1}{5} = \frac{4}{5} = 0.8A$$

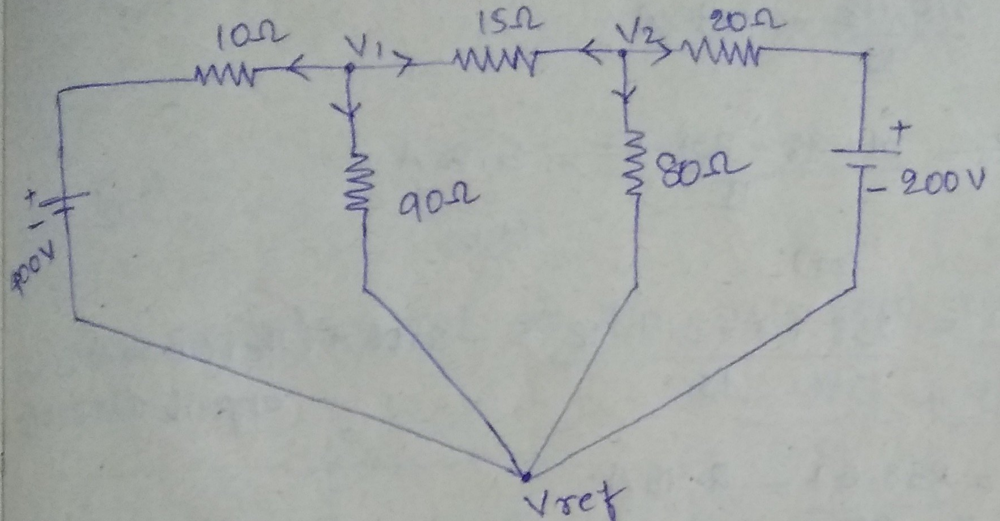
$$\Rightarrow I_{5\Omega} = \frac{V_1 - 5}{5} = \frac{4 - 5}{5} = -0.2A$$

2



Determine all the branch currents using nodal analysis.

$4-1=3-1=2$ eqns



$$\Rightarrow \frac{V_1-400}{10}+\frac{V_1}{90}+\frac{V_1-V_2}{15}=0 \longrightarrow ①$$

$$\Rightarrow \frac{V_2-V_1}{15}+\frac{V_2}{80}+\frac{V_2-200}{20}=0 \longrightarrow ②$$

from ①

$$\frac{V_1}{10}+\frac{V_1}{90}+\frac{V_1}{15}-\frac{V_2}{15}-\frac{40\cancel{0}}{1\cancel{0}}=0$$

$$V_1\left(\frac{1}{10}+\frac{1}{90}+\frac{1}{15}\right)-\frac{V_2}{15}-40=0$$

$$V_1\left(\frac{8}{45}\right)-\frac{V_2}{15}-40=0 \qquad V_1(0.177)-V_2\left(\frac{1}{15}\right)=40$$

$$V_1(0.177)-\frac{V_2}{15}-40=0 \Rightarrow V_1(0.177)-V_2(0.066)=40 \text{ — } ①$$

from eqn ②

$$\frac{V_2}{15}-\frac{V_1}{15}+\frac{V_2}{80}+\frac{V_2}{20}-\frac{20\cancel{0}}{2\cancel{0}}=0$$

$$V_2\left(\frac{1}{15}+\frac{1}{80}+\frac{1}{20}\right)-\frac{V_1}{15}-10=0$$

$$V_2(0.129)-\frac{V_1}{15}-10=0$$

$$V_2(0.129)-V_1\left(\frac{1}{15}\right)=10$$

$$V_2(0.129)-V_1(0.066)=10 \qquad -V_1(0.066)+V_2(0.129)=10 \text{ — } ②$$

By solving eqn ① & ②, we get

$V_1 = 314.98V$

$V_2 = 238.67V$

$$I_{10\Omega} = \frac{V_1-400}{10} = \frac{314.98-400}{10} = -8.5\,A$$

$$I_{90\Omega} = \frac{V_1}{90} = \frac{314.98}{90} = 3.49\,A$$

$$I_{15\Omega} = \frac{V_1-V_2}{15} = \frac{314.98-238.67}{15} = 5.08\,A$$

(or)

$$\frac{V_2-V_1}{15} = \frac{238.67-314.98}{15} = -5.08\,A$$ (The current is in opposite direction)

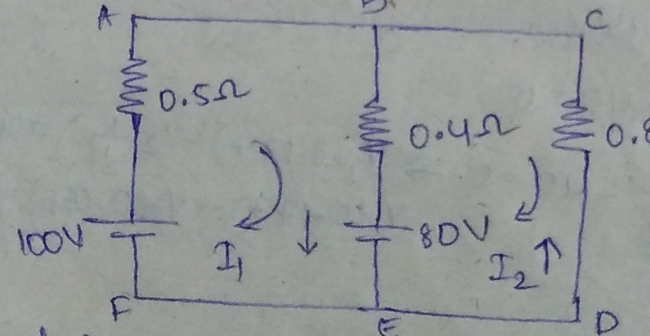
$$I_{80\Omega} = \frac{V_2}{80} = \frac{238.67}{80} = 2.98\,A$$

$$I_{20\Omega} = \frac{V_2-200}{20} = \frac{238.67-200}{20} = 1.93A$$

③ Determine all the branch currents by using mesh and nodal analysis.

i) M.A ii) N.A

i) 2 meshes



By applying KVL to the I mesh i.e., ABEFA, we get

$V_s = V_1+V_2$

$\Rightarrow 80+100\,V = 0.5I_1 + 0.4(I_1-I_2)$ —— ①

$200\,V = 0.5I_1 + 0.4I_1 - 0.4I_2 = 0.9I_1 - 0.4I_2$

By applying KVL to the II mesh i.e., BCDEB, we get

$\Rightarrow 80\,V = I_2(0.8) + 0.4(I_2-I_1)$ —— ②

$= 0.8I_2 + 0.4I_2 - 0.4I_1$

$80V = 1.2I_2 - 0.4I_1$

By solving ① & ②

we get

$I_1 = 60.86\ A = I_{0.5\Omega}$

$I_2 = 86.95A = I_{0.4\Omega}$

$I_{0.4}$ (Middlemesh) $= I_1 - I_2$ (I mesh) $= -26.09$ (opp)

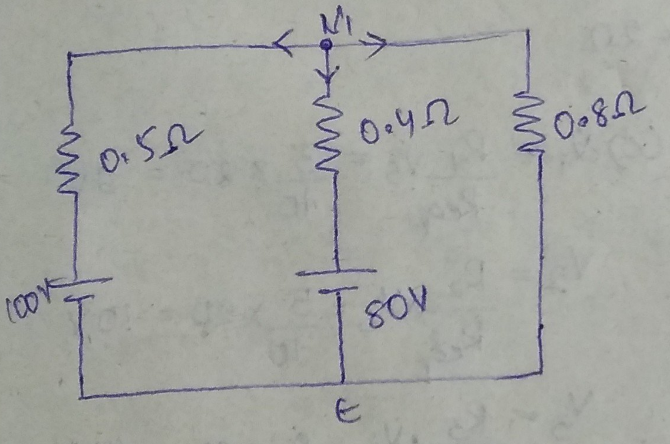
$= I_2 - I_1$ (II mesh) $= 26.09$

(ii) N.A

$n-1 = 2-1 = 1$ eqn

By applying KCL at the principal node i.e, V_1; we get

$$\Rightarrow \frac{V_1 - 100}{0.5} + \frac{V_1 - 80}{0.4} + \frac{V_1}{0.8} = 0$$



$$\Rightarrow \frac{V_1}{0.5} - \frac{100}{0.5} + \frac{V_1}{0.4} - \frac{80}{0.4} + \frac{V_1}{0.8} = 0$$

$$\Rightarrow V_1\left(\frac{1}{0.5} + \frac{1}{0.4} + \frac{1}{0.8}\right) = \left(\frac{100}{0.5} + \frac{80}{0.4}\right)$$

$$\Rightarrow V_1(5.75) = 400$$

$$\boxed{V_1 = 69.56V}$$

current across 0.5Ω

$$I_{0.5\Omega} = \frac{V_1 - 100}{0.5} = -60.86A \text{ (opp)}$$

$$I_{0.4\Omega} = \frac{V_1 - 80}{0.4} = -26.1A \text{ (opp)}$$

$$I_{0.8\Omega} = \frac{V_1}{0.8} = 86.95A$$

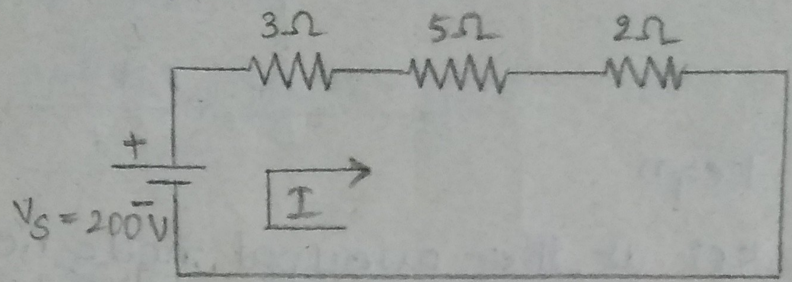
22/5/22 Hw problems

① For the circuit shown in fig. Determine the following.

(a) Equivalent resistance (R_{eq})

(b) Current (I)

(c) Voltage drop across each resistor



Sol:- Given data

$R_1 = 3\Omega$, $R_2 = 5\Omega$, $R_3 = 2\Omega$

$V_S = 200V$

(a) $R_{eq} = R_1 + R_2 + R_3$

$= 3 + 5 + 2$

$= 10\Omega$

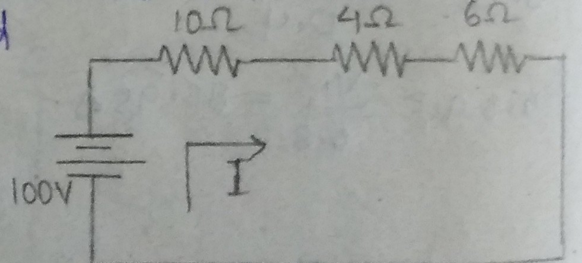
(b) $I = \frac{V_S}{R_{eq}} = \frac{20}{10} = 2A$

(c) $V_1 = \frac{R_1}{R_{eq}} V_S = \frac{3}{10} \times 20 = 6V$

$V_2 = \frac{R_2}{R_{eq}} \times V_S = \frac{5}{10} \times 20 = 10V$

$V_3 = \frac{R_3}{R_{eq}} \times V_S = \frac{2}{10} \times 20 = 4V$

② Determine the total amount of power in the series circuit and also find power across each resistance.



Sol: Given data

$R_1 = 10\Omega$, $R_2 = 4\Omega$, $R_3 = 6\Omega$

$V_S = 100V$

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

$= 10 + 4 + 6 = 20\Omega$

$I = \frac{V_S}{R_{eq}} = \frac{100}{20} = 5A$

$P_{Total} = V \times I$
$= 100 \times 5$
$= \underline{500 W}$

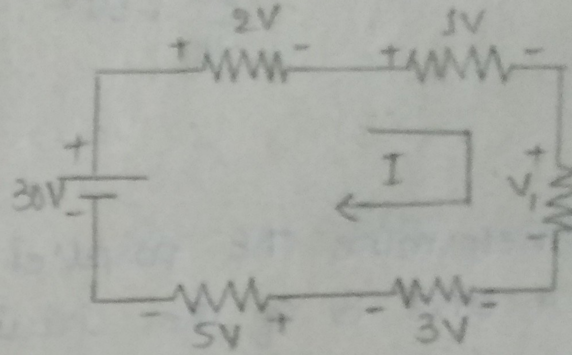
$\left\{ \begin{array}{l} [P = V \times I] \\ P = I^2R \quad [V = IR] \\ P = \frac{V^2}{R} \end{array} \right\}$

$P_{10\Omega} = I^2R$
$= (5)^2 \times 10$
$\boxed{P_{10\Omega} = 250 W}$

$P_{4\Omega} = I^2R$
$= (5)^2 \times 4$
$\boxed{P_{4\Omega} = 100 W}$

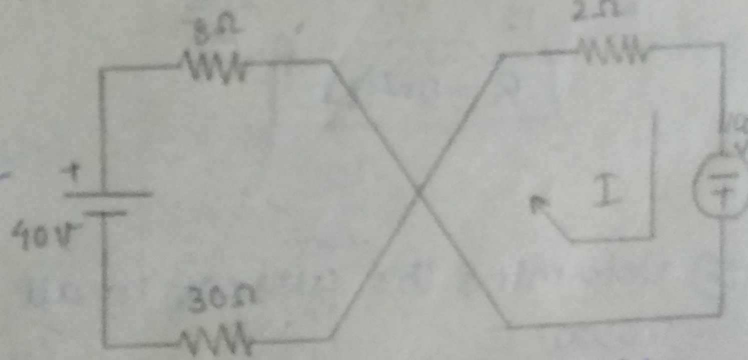
$P_{6\Omega} = I^2R$
$= (5)^2 \times 6$
$\boxed{P_{6\Omega} = 150 W}$

③ For the circuit shown in figure determine the unknown voltage drop V_r

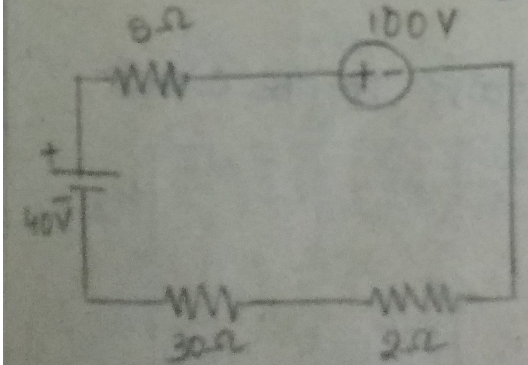


Sol: Given data
$V_S = 30V$, $V_1 = 2V$, $V_2 = 1V$,
$V_3 = 5V$, $V_4 = 3V$, $V_r = ?$
According to KVL law
$V_S = V_1 + V_2 + V_r + V_3 + V_4$
$30 = 2 + 1 + V_r + 5 + 3$
$30 = 11 + V_r$
$V_r = 30 - 11$
$\boxed{V_r = 19V}$

④ In the circuit given in figure find (a) the current I, and (b) the voltage across 30Ω



Sol: Given data
$R_1 = 8\Omega$, $R_2 = 30\Omega$,
$V_S = 30V$ $R_3 = 2\Omega$



By redrawing the circuit we get I and V

(a) $I = \frac{V_s}{R_{eq}}$

$R_{eq} = R_1 + R_2 + R_3$
$= 8 + 30 + 2$
$= 40\Omega$

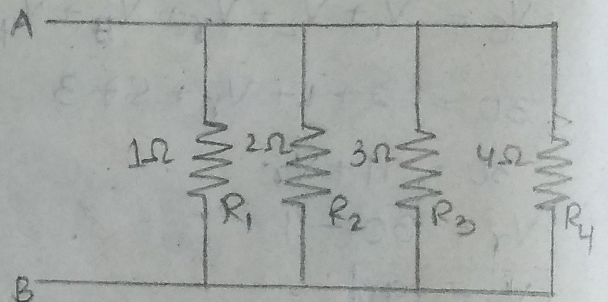
$I = \cancel{\frac{100-40}{40}} \quad \frac{100-40}{40}$

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

$V_{30\Omega} = V_s \times \frac{\text{same R}}{\text{sum of R}}$

$= \frac{40 \times 30}{40} = 30V$

⑤ Determine the parallel resistance between points A and B of the circuit shown in fig.



Sol:- Given data

$R_1 = 1\Omega \quad R_2 = 2\Omega \quad R_3 = 3\Omega$

$R_4 = 4\Omega$

R_{eq} of $\parallel^{al}$ connection

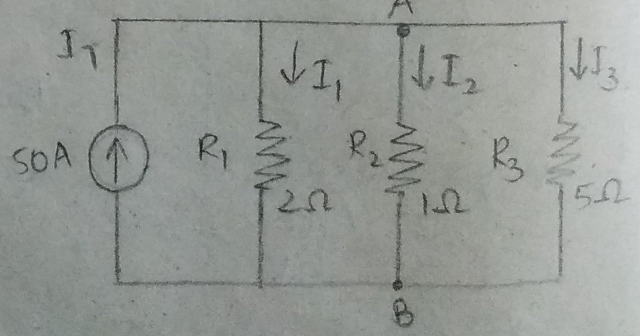
$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}$

$\frac{1}{R} = \frac{1}{1} + \frac{1}{2} + \frac{1}{3} + \frac{1}{4}$

$\frac{1}{R} = \frac{25}{12} \Rightarrow R = \frac{12}{25}$

$\boxed{R = 0.48\Omega}$

⑥ Determine the current in all resistors in the circuit shown.



Sol:- Given data

$I_T = 50A$

$R_1 = 2\Omega, \; R_2 = 1\Omega, \; R_3 = 5\Omega$

Req of $\parallel^{al}$ connection

$$R_{eq} = \frac{R_1R_2R_3}{R_1R_2 + R_2R_3 + R_3R_1}$$

$$R_{eq} = \frac{2\times1\times5}{2\times1 + 1\times5 + 5\times2} = 0.588\,\Omega$$

→ By using 'current division rule,

$$I_1 = I_T \times \frac{\text{opposite } R}{\text{sum of } R}$$

$$= I_T \times \frac{R_2R_3}{R_1R_2 + R_2R_3 + R_3R_1} = 50 \times \frac{1\times5}{2\times1 + 1\times5 + 5\times2}$$

$$\boxed{I_1 = 14.705\,A}$$

$$I_2 = I_T \times \frac{\text{opposite } R}{\text{sum of } R}$$

$$= I_T \times \frac{R_3R_1}{R_1R_2 + R_2R_3 + R_3R_1} = 50 \times \frac{5\times2}{2\times1 + 1\times5 + 5\times2}$$

$$\boxed{I_2 = 29.411\,A}$$

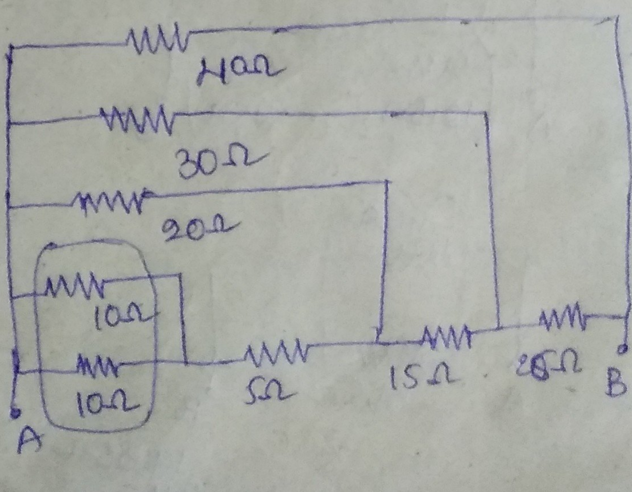
$$I_3 = I_T \times \frac{R_1R_2}{R_1R_2 + R_2R_3 + R_3R_1} = 50 \times \frac{2\times1}{2\times1 + 1\times5 + 5\times2}$$

$$\boxed{I_3 = 5.882\,A}$$

$$I_T = I_1 + I_2 + I_3$$

$$50A \cong 49.998\,A$$

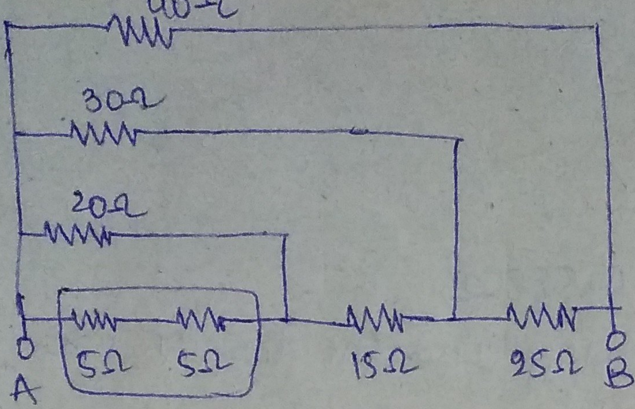
(7) calculate the Requivalent between A and B terminals.



Sol:- 10Ω & 10Ω are in parallel

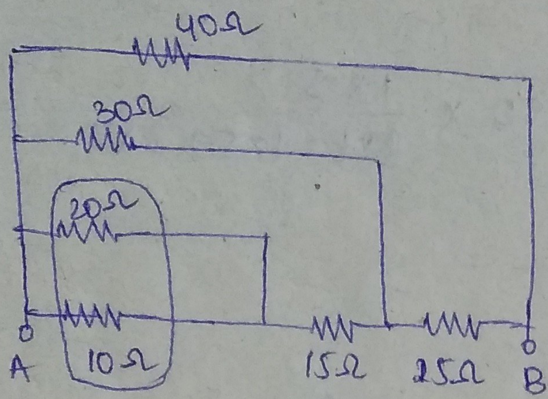
$$R_{eq} = \frac{R_1R_2}{R_1+R_2}$$

$$R_{eq} = \frac{10\times10}{10+10} = \frac{100}{20} = 5\,\Omega$$



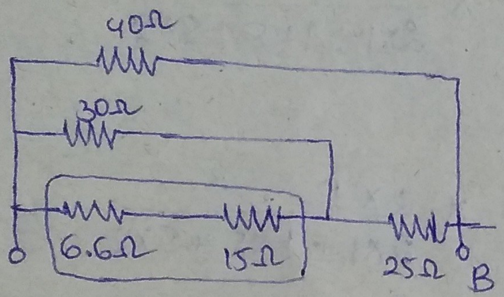
5Ω & 5Ω are in series

$R_{eq} = R_1 + R_2$
$= 5 + 5 = 10\Omega$



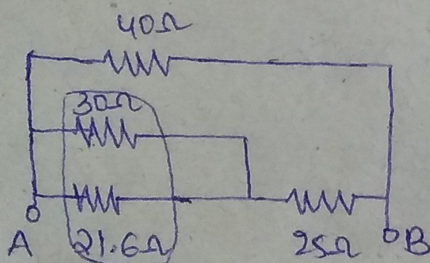
10Ω & 20Ω are in parallel

$R_{eq} = \dfrac{10 \times 20}{10 + 20}$
$= 6.6\Omega$



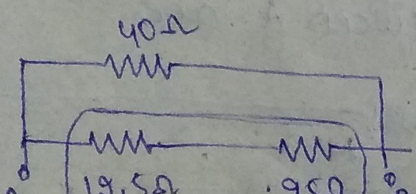
6.6Ω & 15Ω are in series

$R_{eq} = 6.6 + 15$
$= 21.6\Omega$



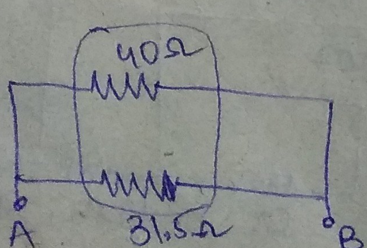
30Ω & 21.6Ω are in parallel

$R_{eq} = \dfrac{30 \times 21.6}{30 + 21.6} = 12.5\Omega$



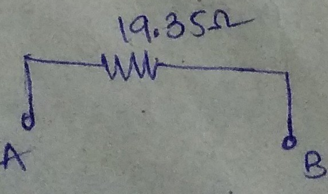
12.5Ω & 25Ω are in series

$R_{eq} = 12.5 \cancel{*} 25 = 31.5\Omega$



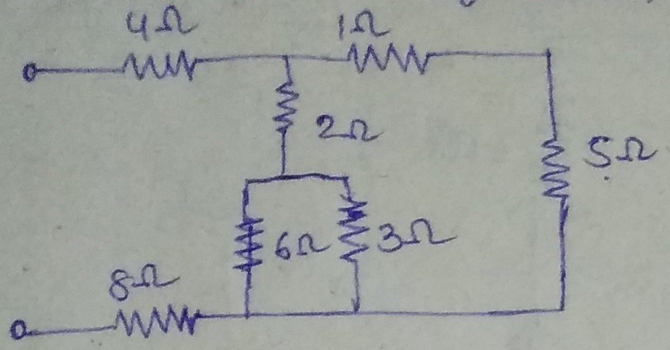
31.5Ω & 40Ω are in parallel

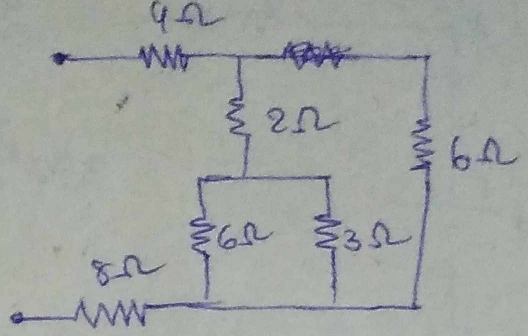
$R_{eq} = \dfrac{40 \times 31.5}{40 + 31.5}$
$= 19.35\Omega$

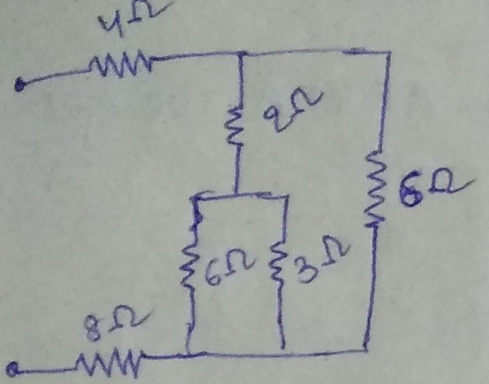


⑧ Calculate the Requivalent between A and B terminals.

sol:-





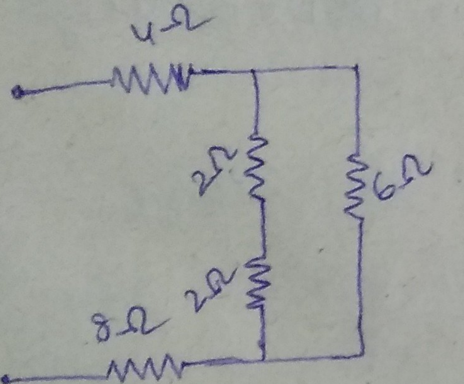


1Ω & 5Ω are in series

$R_{eq} = 1+5 = 6\Omega$

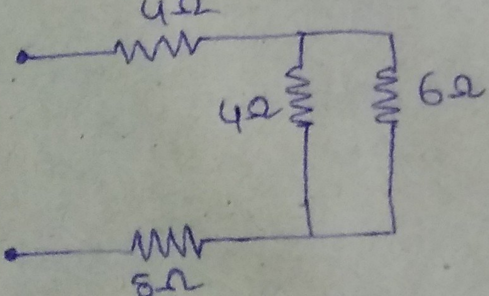
6Ω & 3Ω are in parallel

$$R_{eq} = \frac{3\times 6}{3+6} = \frac{18}{9} = 2\Omega$$



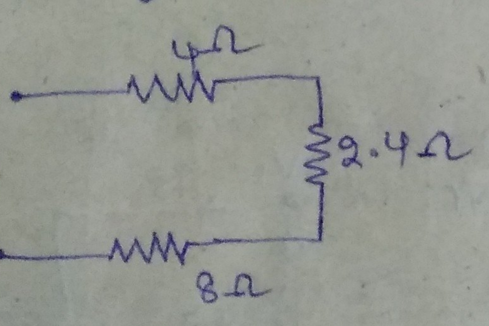
2Ω & 2Ω are in series

$R_{eq} = 2+2 = 4\Omega$



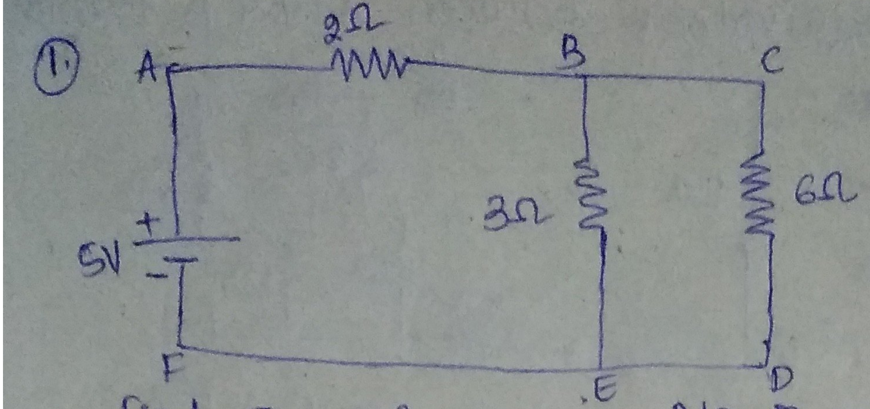
4Ω & 6Ω are in parallel

$$R_{eq} = \frac{4\times 6}{4+6} = \frac{24}{10} = 2.4$$



4Ω & 2.4 & 8Ω are in series

$R_{eq} = 4+2.4+8 = \underline{\underline{14.4\Omega}}$

1. 

Mesh Analysis

find $I_{3\Omega} = ?$ No. of meshes = 2

By applying KVL to I^{st} mesh i.e., ABEFA, we get

$\Rightarrow$ $5V = 2I_1 + 3(I_1 - I_2)$

$5V = 2I_1 + 3I_1 - 3I_2$

$5V = 5I_1 - 3I_2$ —— ①

By applying KVL to II^{nd} mesh i.e., BCDEB, we get

$\Rightarrow$ $0 = 6I_2 + 3(I_2 - I_1)$

$= 6I_2 + 3I_2 - 3I_1$

$= 9I_2 - 3I_1$ —— ②

By solving eqn ① & ②, we get

$I_1 = 1.25A$

$I_2 = 0.4166A$

$I_{3\Omega} = I_1 - I_2 = 0.834A$

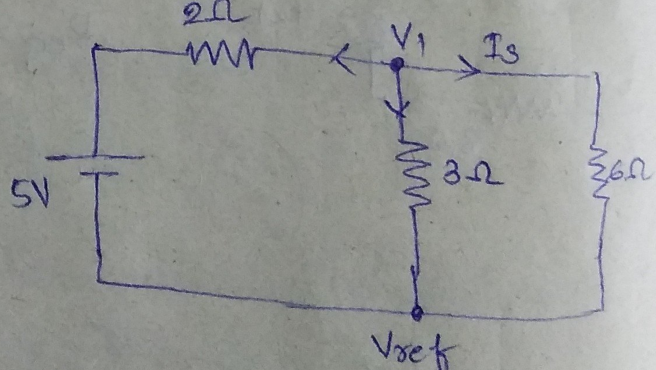
(or)

$I_2 - I_1 = -0.834A$

$V = IR$

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

Nodal Analysis



$I_1 + I_2 + I_3 = 0$

$\frac{V_1 - 5}{2} + \frac{V_1}{3} + \frac{V_1}{6} = 0$

$\frac{3(V_1 - 5) + 2V_1 + V_1}{6} = 0$

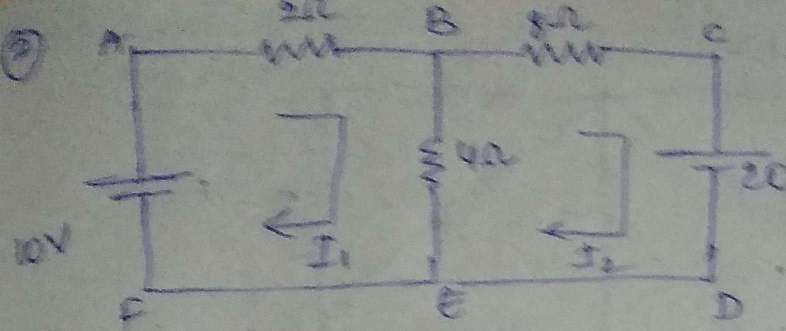
$6V_1 - 15 = 0$

$V_1 = 15/6$

$\boxed{V_1 = 2.5}$

$I_{3\Omega} = \frac{V_1 - 0}{3} = \frac{2.5}{3} = 0.83 A$

(3)



find $I_{2\Omega} = ?$

By applying KVL to 1st mesh

$\Rightarrow \quad 10V = 2I_1 + 4(I_1 - I_2)$

$10V = 6I_1 - 4I_2$ —(1)

By applying KVL to 2nd mesh

$\Rightarrow \quad 20V = 4(I_2 - I_1) + 8I_2$

$= 12I_2 - 4I_1$

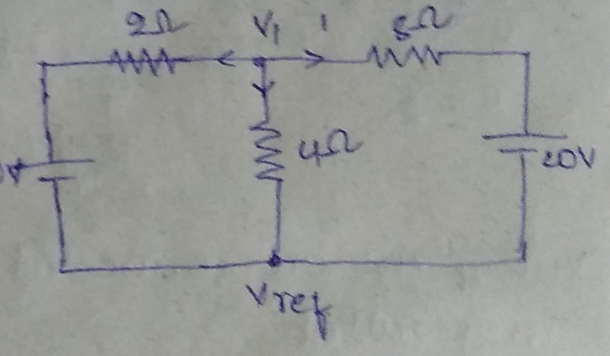
$-20V = -4I_1 + 12I_2$ —(2)

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

$I_1 = 0.714A$

$I_2 = -1.428A$

$\boxed{I_{2\Omega} = 0.714A = I_1}$



Nodal

$I_1 + I_2 + I_3 = 0$

$$\frac{V_1 - 10}{2} + \frac{V_1}{4} + \frac{V_1 - 20}{8} = 0$$

$$\frac{4(V_1 - 10) + 2V_1 + V_1 - 20}{8} = 0$$

$4V_1 - 40 + 2V_1 + V_1 - 20 = 0$

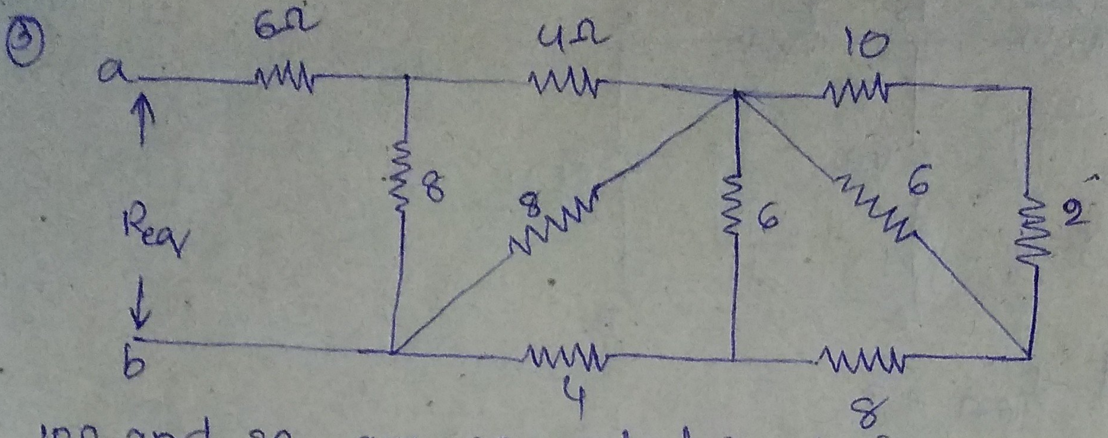
$7V_1 - 60 = 0$

$V_1 = \frac{60}{7}$

$V_1 = 8.57$

$I_{2\Omega} = \frac{V_1 - 10}{2} = \frac{8.57 - 10}{2} = -0.174A$ (i is in opp. direction)

(3)

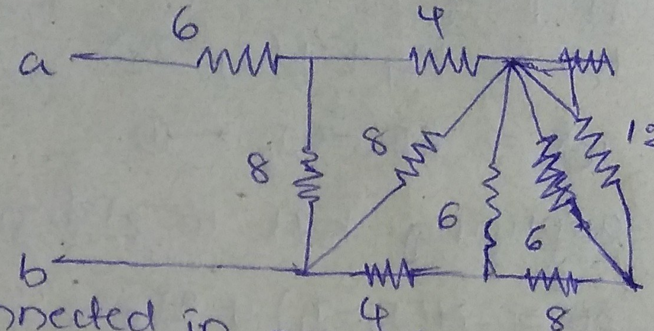


10Ω and 2Ω are connected in series

$R_{eq} = R_1 + R_2$

$= 10 + 2$

$= 12$

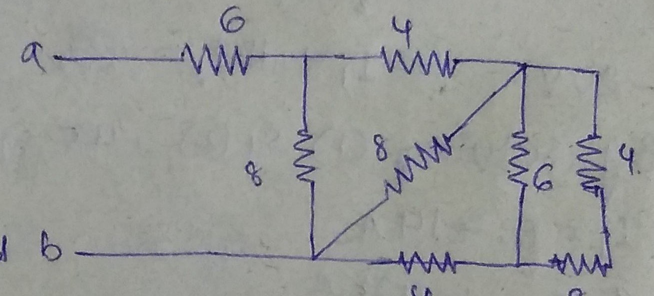


12Ω and 6Ω are connected in parallel

$\frac{1}{R} = \frac{1}{12} + \frac{1}{6}$

$= \frac{1}{4}$

$\boxed{R_{eq} = 4\Omega}$



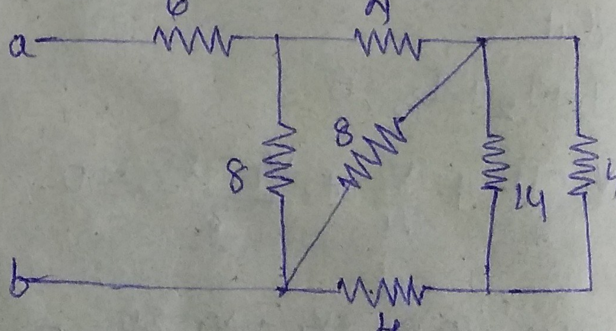
6Ω and 8Ω are connected in series

$\cancel{\frac{1}{R} = \frac{1}{6} + \frac{1}{4} = \frac{5}{12}}$

$\cancel{R = 2.}$

$R_{eq} = 6 + 8$

$R_{eq} = 14\Omega$

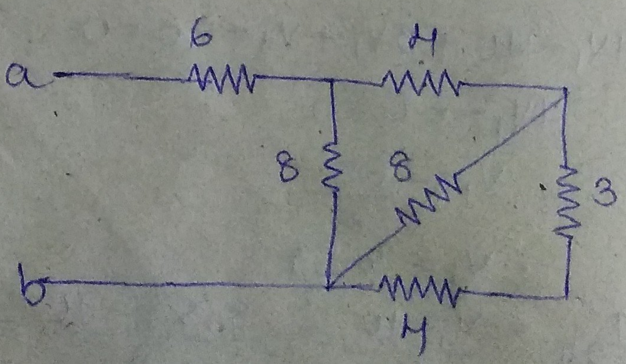


14Ω & 4Ω are connected in parallel

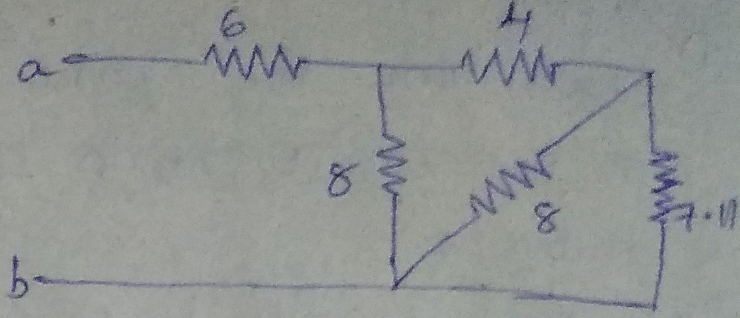
$R_{eq} = \frac{14 \times 4}{14 + 4} = 3.111\Omega$

4Ω & 3.11 are in series

$4 + 3.11 = 7.11\Omega$



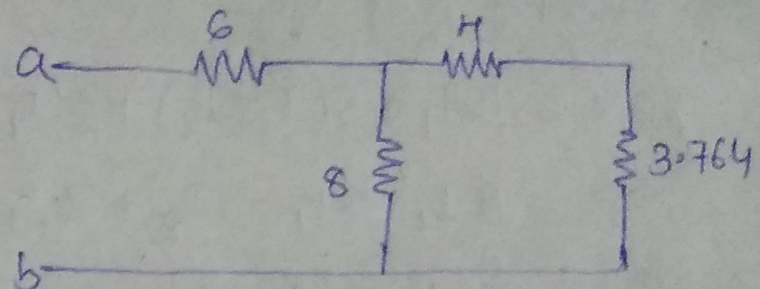
8Ω and 7.11Ω are connected in parallel



$$R_{eq} = \frac{8 \times 7.11}{8 + 7.11}$$

$$= 3.764\,\Omega$$

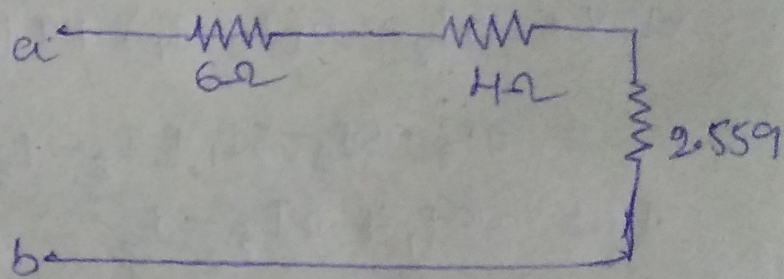
8Ω and 3.764Ω are in parallel



$$R_{eq} = \frac{8 \times 3.764}{8 + 3.764}$$

$$= 2.559\,\Omega$$

4Ω, 6Ω & 2.559Ω are connected in series



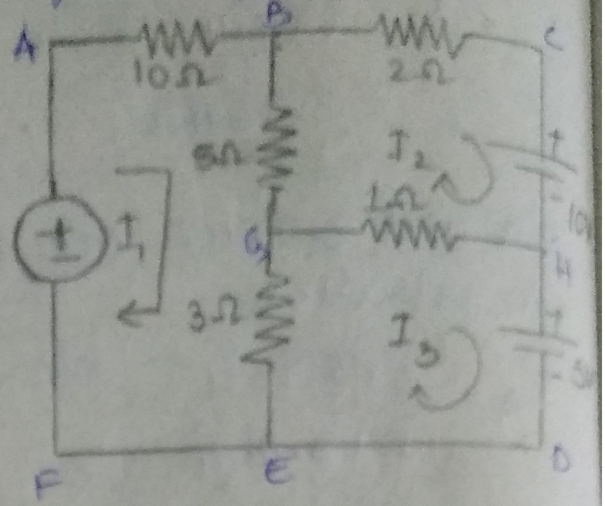
$$R_{eq} = R_1 + R_2 + R_3$$

$$= 6 + 4 + 2.559$$

$$R_{eq} = 12.559\,\Omega$$

27/5/22 H.W

① Determine the power absorbed by 5Ω resistor in the circuit shown below by using mesh analysis:



Sol: By applying KVL to 1st mesh i.e., ABEFA, we get

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

$$50 = 10I_1 + 5I_1 - 5I_2 + 3I_1 - 3I_3$$

$$50 = 18I_1 + 5I_2 - 3I_3 \quad \text{—①}$$

By applying KVL to 2nd mesh i.e., BCHGB, we get

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

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

$$-10 = -5I_1 + 8I_2 - I_3 \quad \text{—②}$$

By applying KVL to 3rd mesh i.e., GHDEG, we get

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

$$-5 = 3I_3 - 3I_1 + I_3 - I_2$$

$$-5 = -3I_1 - I_2 + 4I_3 \quad \text{—③}$$

By solving eqn's ①, ② & ③, we get

$I_1 = \frac{1175}{356}$ $= 3.3006A$

$I_2 = \frac{355}{356}$ $= 0.99719A$

$I_3 = \frac{525}{356}$ $= 1.4747A$

$P_{5\Omega} = ?$ $[P = V \times I$ $(\because V = IR)$
$P = I \times R \times I]$

$I_{5\Omega} = I_1 - I_2$ or $I_2 - I_1$

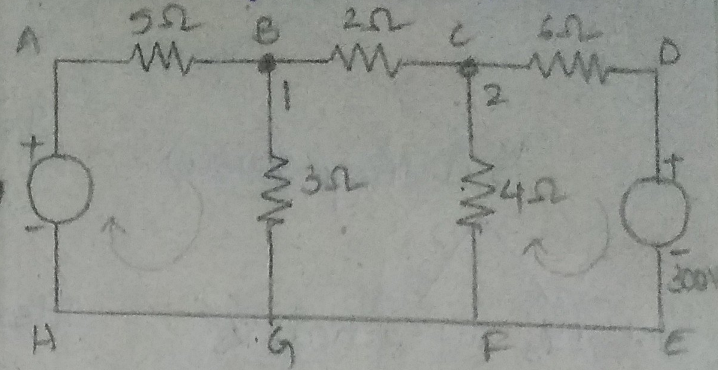
$= 2.30341$ $= -2.30341A$ (opp direction)

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

$= 26.52W$

22/5/22

(10) Solve the circuit by mesh analysis and find current in all branches.



Sol:- By applying KVL to 1^{st} mesh ABGHA, we get

$$125V = 5I_1 + 3(I_1 - I_2)$$

$$125 = 5I_1 + 3I_1 - 3I_2$$

$$125 = 8I_1 - 3I_2 \longrightarrow ①$$

By applying KVL to II^{nd} mesh BCFGB, we get

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

$$= 3I_2 - 3I_1 + 2I_2 + 4I_2 - 4I_3$$

$$0 = -3I_1 + 9I_2 - 4I_3 \text{ —— } ②$$

By applying KVL to III^{rd} mesh CDEFC, we get

$$-300 = 4(I_3 - I_2) + 6I_3$$

$$-300 = 4I_3 - 4I_2 + 6I_3$$

$$-300 = 10I_3 - 4I_2 \text{ —— } ③$$

Solving eqn's ①, ② & ③, we get

$$I_1 = 11.254\ A = I_{5\Omega}$$

$$I_2 = -11.653\ A = I_{2\Omega}$$

$$I_3 = -34.661 A = I_{6\Omega}$$

$$I_{3\Omega} = I_1 - I_2 = 22.907A$$

(or)

$$I_2 - I_1 = -22.907\ A$$

$$I_{4\Omega} = I_2 - I_3 = 23.008\ A$$

(or)

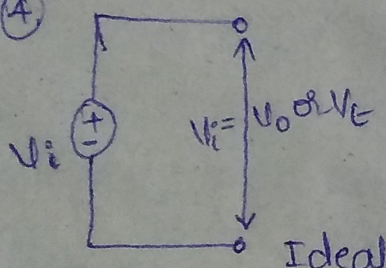
$$I_3 - I_2 = -23.008\ A$$

Types of Sources

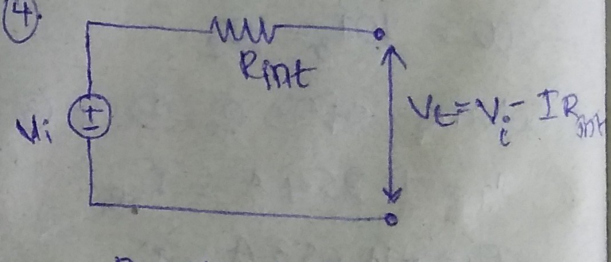
- Vs (voltage source)
  - Ideal Vs
  - Practical Vs
- Is (current source)
  - Ideal Is
  - Practical Is

Ideal sources	Practical sources
1. Ideal sources are imaginary sources.	1. ~~Ideal~~ Practical sources are real sources.
2. There is no internal resistance.	2. There is a internal resistance.
3. The voltage drop is zero. ($iR = 0$)	3. Voltage drop occurs

4.

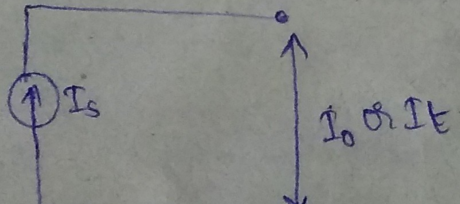


Ideal voltage source

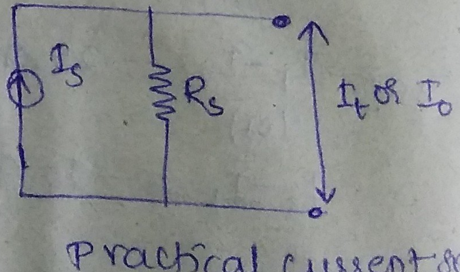


Practical voltage source

5.

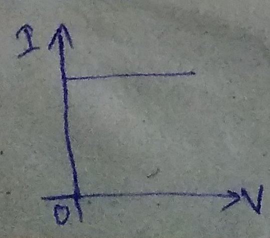


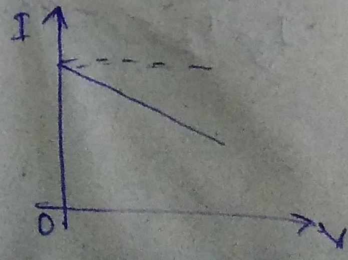
Ideal current source



Practical current source

6. V-I characteristics of ideal sources





7. It provides constant values of current and voltages	7. It provides variable values of current and voltages.
8. It is not applicable for the circuit	8. It is applicable
9. It gives only theoritical values	9. It gives both practical & theoritical values

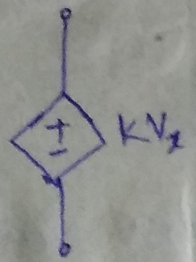
Classification of sources

Dependent sources
i) VCVS
ii) VCCS
iii) CCVS
iv) CCCS

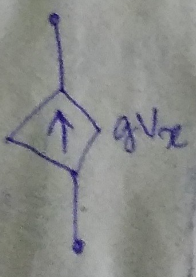
Independent sources
i) V_s
ii) I_s

Dependent Sources:

(i) Voltage control Voltage source (VCVS):
This source produces voltage as a function of voltage.

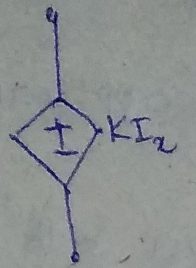


(ii) Voltage control Current source (VCCS):
This source produces voltage as a function of current



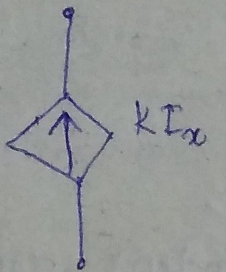
(iii) Current Control Voltage Source: (CCVS)

This source produces current as the function of voltage (2)



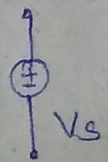
(iv) Current control current source: (CCCS)

This source produces current as the function of current



Independent Sources:

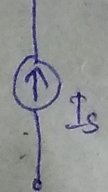
(i) Independent Voltage source:



The source which producers voltages without depending upon the other circuit parameters (or) components.

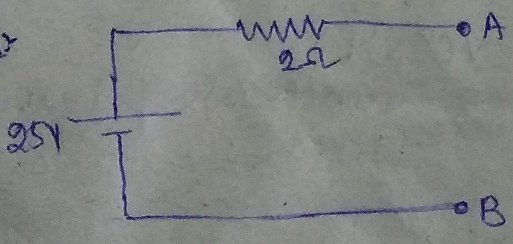
(ii) Independent current source:

The source which produces current without depending upon the other circuit parameters (or) components.



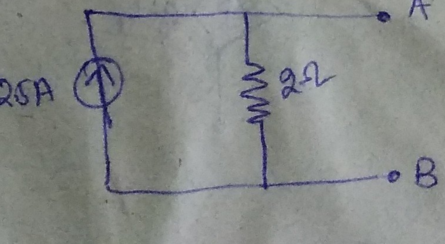
(1) Find the equivalent current source

Sol:

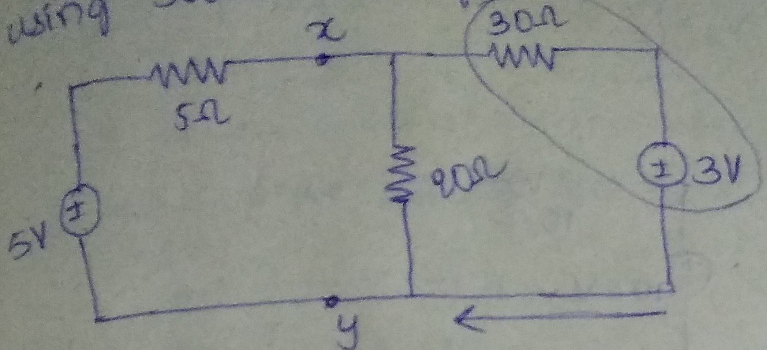


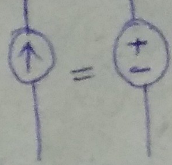
$I_s = ?$

$I_s = \frac{V_s}{R_s} = \frac{25}{2} = 12.5A$

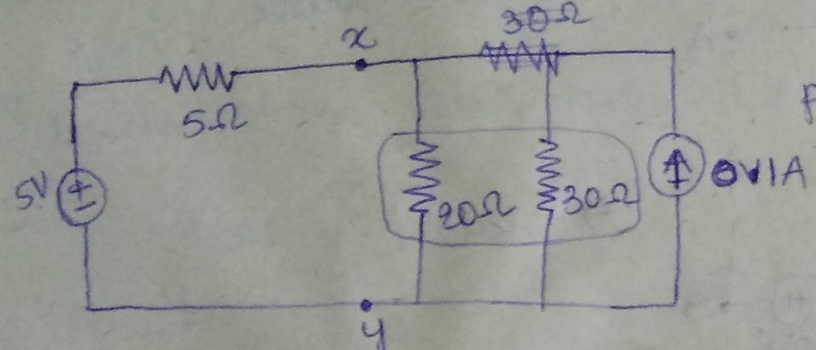


Q) Determine current by reducing the circuit to the right side of xy terminals to its simplest form by using source transformation technique.





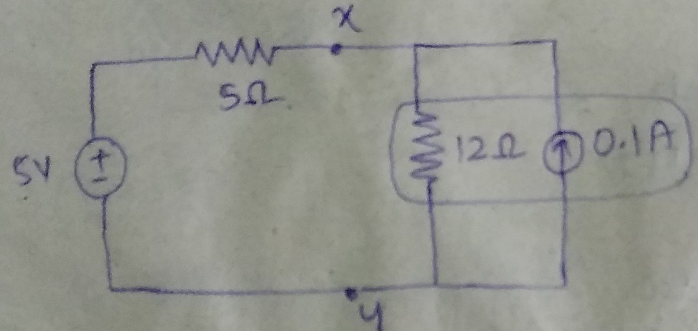
$I_s = \frac{V_g}{R} = \frac{3}{30} = 0.1A$



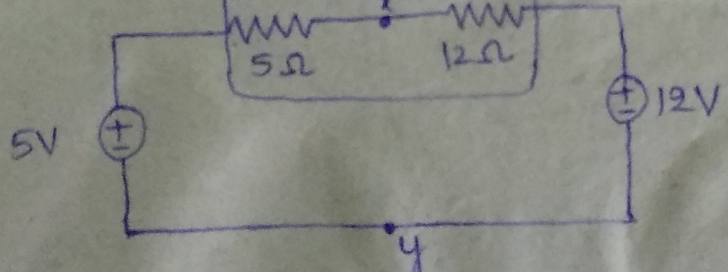
20Ω & 30Ω are in parallel,

$R_{eq} = \frac{20 \times 30}{20+30} = \frac{20 \times 30}{50}$

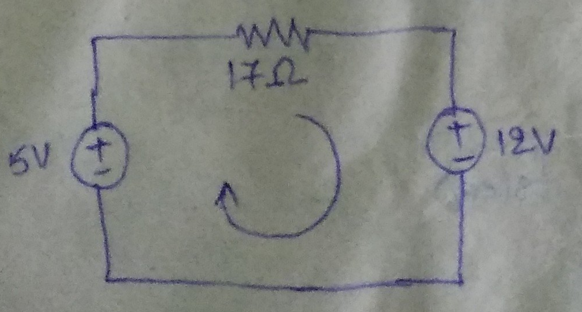
$R_{eq} = 12\Omega$



$V_s = I \times R = 0.1 \times 12 = 1.2V$



5Ω & 12Ω are in series, $R_{eq} = 5 + 12 = 17\Omega$



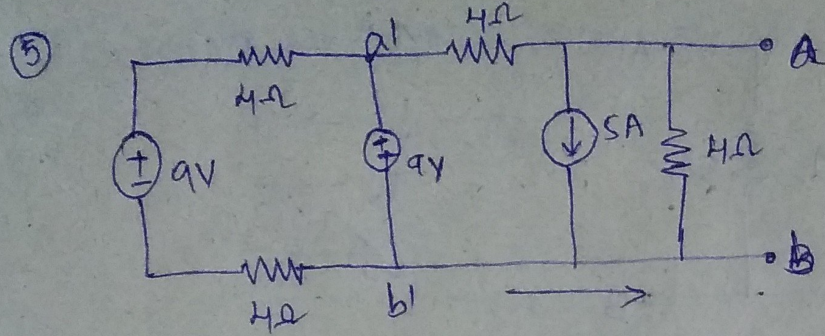
By applying KVL, we get

$V_s = V_1$

$\Rightarrow 5 - 12 = 17 I_1$

$\Rightarrow I_1 = \underline{\underline{0.2235A}}$

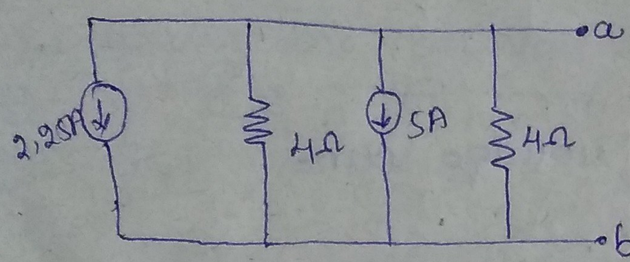
(5)



Use source transformation to convert the current circuit (i.e a'b' to ab) terminals to a single current source.

$\Rightarrow I_s = \frac{V_s}{R} = \frac{9}{4} = 2.25A$

Converting V_s into I_s

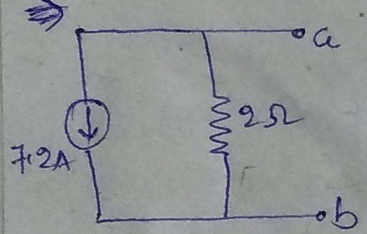


Since both the currents are in same direction we can add them.

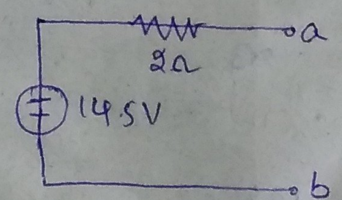
$\Rightarrow I_T = 2.25 + 5 = 7.25A$; 4Ω & 4Ω are in parallel,

$R_{eq} = \frac{R_1 R_2}{R_1 \times R_2} = \frac{4 \times 4}{4+4} = 2\Omega$

$\Rightarrow$



$\cong$

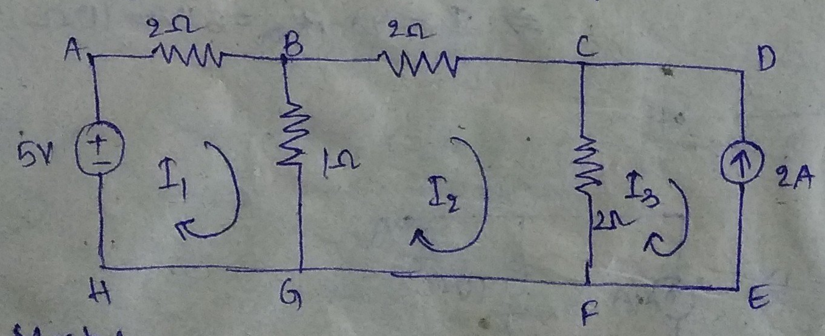


$\Rightarrow V_s = I_s \times R$

$= 7.25 \times 2 = 14.5V$

Converting the current source into voltage source.

(6) Determine the current in all branches by mesh analysis and nodal analysis.



Mesh:-

By applying KVL to I mesh ABGHA, we get

$5 = 2I_1 + 1(I_1 - I_2)$

$5 = 3I_1 - I_2 \longrightarrow (1)$

$\Rightarrow$ By applying KVL to III mesh BCFGB, we get

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

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

$\Rightarrow$

By from III mesh, $I_3 = -2A$

sub $I_3 = -2A$ in (2) $\Rightarrow -4 = -I_1 + 5I_2 \rightarrow (3)$

sol (1) & (3)

$I_{2\Omega}$ or $I_1 = 1.5A$

$I_{2\Omega}$ or $I_2 = -0.5A$

(II mesh)

$I_{1\Omega} = I_1 - I_2$ or $I_2 - I_1$

$= 2A$

$I_{2\Omega} = I_2 - I_3$ or $I_3 - I_2$

$= 1.5A$

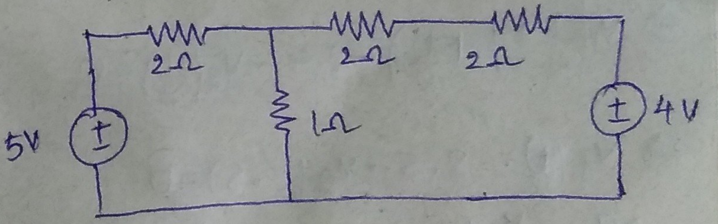
II method:

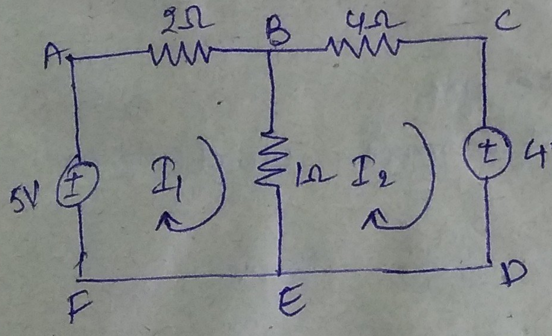
By transforming the current source we get the following circuit

$V_S = I_S \times R$

$= 2 \times 2$

$= 4V$





By applying KVL to I mesh ABEFA, we get

$$5 = 2I_1 + 1(I_1 - I_2)$$

$$5 = 3I_1 - I_2 \rightarrow (1)$$

By applying KVL to II mesh BCDEB, we get

$$-4 = 1(I_2 - I_1) + 4I_2$$

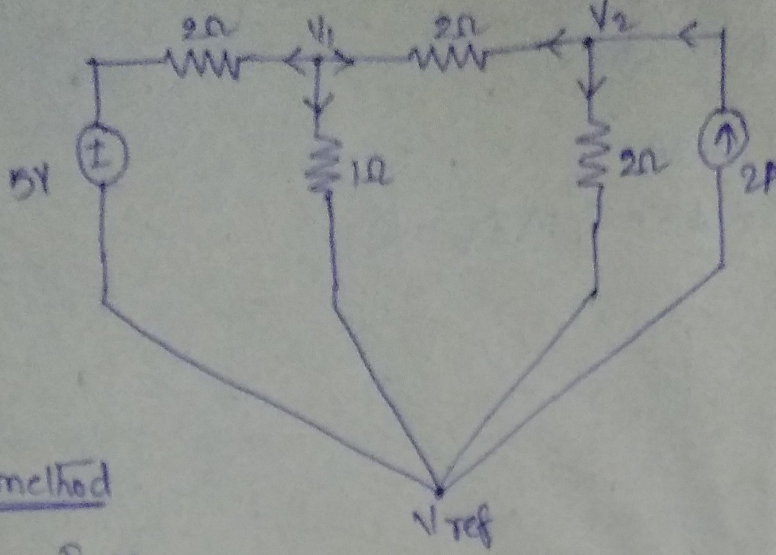
$$-4 = -I_1 + 5I_2 \rightarrow (2)$$

By solving (1) & (2) $\cdot$ $I_1 = 1.5A$ or $I_{2\Omega}$, $I_2 = -0.5A$ or $I_{4\Omega}$

$I_{1\Omega} = I_1 - I_2$ or $I_2 - I_1$

$= 2A$

Nodal analysis:



I method

$I = \frac{V}{R}$ By applying KCL to node 1, we get

$$\frac{V_1-5}{2} + \frac{V_1}{1} + \frac{V_1-V_2}{2} = 0$$

$$\Rightarrow \frac{V_1}{2} + \frac{V_1}{1} + \frac{V_1}{2} - \frac{5}{2} - \frac{V_2}{2} = 0$$

$$\Rightarrow V_1\left(\frac{1}{2}+\frac{1}{1}+\frac{1}{2}\right) - 2.5 - V_2\left(\frac{1}{2}\right) = 0$$

$$\Rightarrow V_1(2) - 2.5 - V_2(0.5) = 0$$

$$2V_1 - V_2(0.5) = 2.5 \longrightarrow ①$$

By applying KCL to node 2, we get

sum of Incoming i = sum of all going i

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

$$\frac{V_2}{2} - \frac{V_1}{2} + \frac{V_2}{2} = 2$$

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

$$-0.5V_1 + V_2 = 2 \longrightarrow ②$$

By solving ① & ②, we get $V_1 = 2V$, $V_2 = 3V$

$I_{2\Omega}$ (at node 1) $= \frac{V_1-5}{2} = \frac{2-5}{2} = -1.5A$

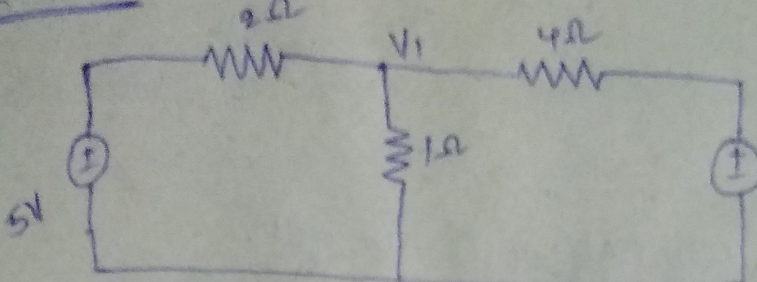
$I_{1\Omega} = \frac{V_1}{1} = 2A$

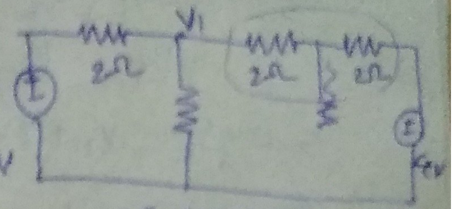
$I_{2\Omega}$ (combination branch) $= \frac{V_1-V_2}{2}$ or $\frac{V_2-V_1}{2} = \frac{2-3}{2} = \frac{-1}{2} = -0.5A$

$I_{2\Omega}$ (at node 2) $= \frac{V_2}{2} = \frac{3}{2} = 1.5A$

__II method:__

By S.T of the I.s into V.s
$\Rightarrow V_s = I_s \times R = 2\times 2 = 4V$





2Ω & 2Ω are in series
2+2 = 4V

By applying KCL at node, we get

$$\frac{V_1-5}{2} + \frac{V_1}{1} + \frac{V_1-4}{4} = 0$$

$$\Rightarrow \frac{V_1}{2} - \frac{5}{2} + \frac{V_1}{1} + \frac{V_1}{4} - \frac{4}{4} = 0 \quad \Rightarrow V_1\left(\frac{1}{2}+1+\frac{1}{4}\right) - \frac{5}{2} - \frac{4}{4} = 0$$

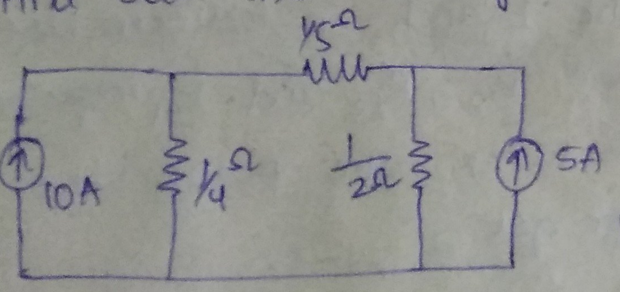
$$\Rightarrow V_1(1.75) = 3.5 \Rightarrow \boxed{V_1 = 2V}$$

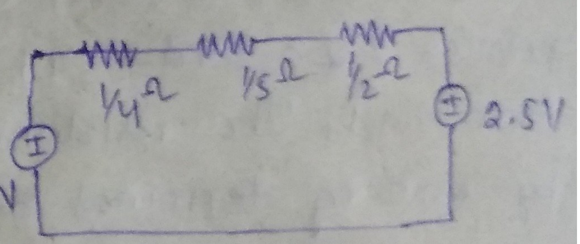
$$I_{2\Omega} = \frac{V_1-5}{2} = \frac{2-5}{2} = \frac{-3}{2} = -1.5A$$

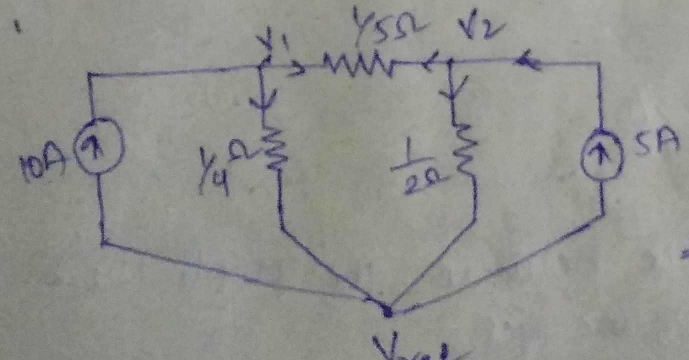
$$I_{1\Omega} = \frac{V_1}{1} = 2A$$

$$I_{4\Omega} = \frac{V_1-4}{4} = \frac{2-4}{4} = \frac{-2}{4} = -0.5A$$

② Find out the voltages at the nodes







By applying KCL to node 1 we get

V_1 – sum of e.i = sum of l.i

$$\Rightarrow 10 = \frac{V_1}{1/4} + \frac{V_1-V_2}{1/5}$$

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

$$10 = 9V_1 - 5V_2 \quad \text{—①}$$

By applying KCl to node 2, we get

sum of e.r = sum of l.r

$$5 = \frac{V_2 - V_1}{1/5} + \frac{V_2}{1/2}$$

$$5 = 5V_2 - 5V_1 + 2V_2$$

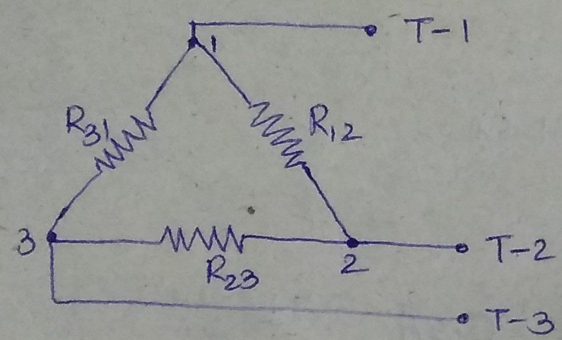
$$5 = 7V_2 - 5V_1 \longrightarrow ②$$

By solving ① & ②, we get

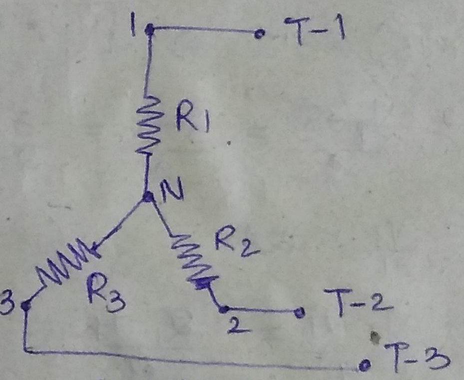
$V_1 = 2.5\ V$

$V_2 = 2.5\ V$

Derivation of Delta to star:



fig(1)



fig(2)

Consider a delta system with three corner points 1, 2 & 3 across three terminals as shown in figure.

Electrical resistance of the branch in between 1 & 2 points, 2 & 3 and 3 & 1 are R_{12}, R_{23} and R_{31} respectively.

from fig 1, The resistance between the points 1 & 2 by ignoring terminal-3, we get

$$(R_{23} + R_{31}) \parallel R_{12}$$

$$\frac{R_{12}(R_{23} + R_{31})}{R_{12} + R_{23} + R_{31}} \longrightarrow ①$$

from fig(2), The resistance between the points 1 & 2 by ignoring terminal - 3, we get

$$R_1 + R_2 \longrightarrow ②$$

Equating eq^n 1 & 2 [∵ Two systems are identical, R measured b/w 1 & 2 will be same]

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

similarly, by ignoring terminal 2, we get

$$\Rightarrow R_1 + R_3 = \frac{R_{31}(R_{12}+R_{23})}{R_{12}+R_{23}+R_{31}} \rightarrow (4)$$

By ignoring terminal -1, we get

$$R_2 + R_3 = \frac{R_{23}(R_{12}+R_{31})}{R_{12}+R_{23}+R_{31}} \rightarrow (5)$$

Now, we substract eq^n 5 from eq^n 3

$\cancel{R_1 - R_3 = R_{12}R_{23} + R_{12}}$

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

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

$$R_1 - R_3 = \frac{R_{12}R_{31} - R_{23}R_{31}}{R_{12}+R_{23}+R_{31}} \rightarrow (6)$$

Adding eq^n 4 & eq^n 6

$$(R_1+\cancel{R_3})+(R_1-\cancel{R_3}) = \frac{R_{31}(R_{12}+R_{23})}{R_{12}+R_{23}+R_{31}} + \frac{R_{12}R_{31}-R_{23}R_{31}}{R_{12}+R_{23}+R_{31}}$$

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

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

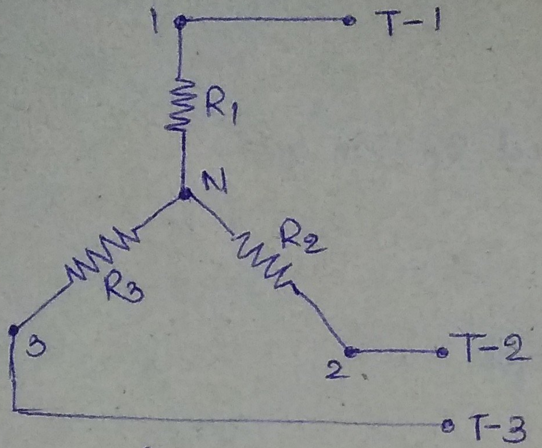
$$R_1 = \frac{R_{12}R_{31}}{R_{12}+R_{23}+R_{31}} \rightarrow (7)$$

Similarly, we get R_2 & R_3 by using another combination of subtraction & addition with eq^n 3, 4, 5

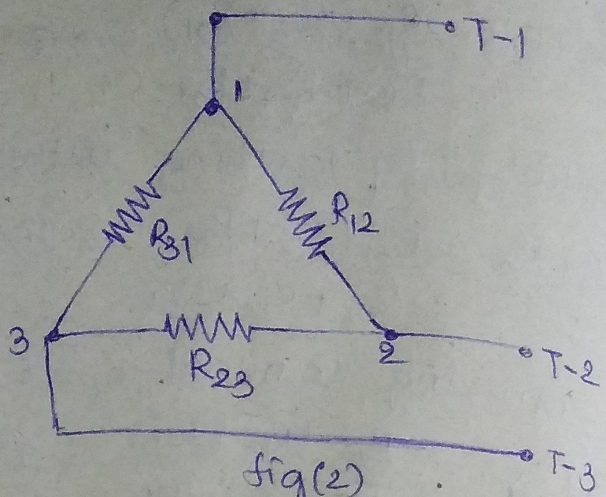
$$R_2 = \frac{R_{23}R_{12}}{R_{12}+R_{23}+R_{31}} \rightarrow (8)$$

$$R_3 = \frac{R_{23}R_{31}}{R_{12}+R_{23}+R_{31}} \rightarrow (9)$$

Derivation of star to Delta:



fig(1)



fig(2)

Consider three resistances R_1, R_2, & R_3 connected in star as shown in fig(1)

In order to get the equivalent Delta of the given star, we take the help of Delta-star transformation eqns ⑦, ⑧ & ⑨

$$R_1 = \frac{R_{12} R_{31}}{R_{12} + R_{23} + R_{31}} \rightarrow ⑦ \qquad R_2 = \frac{R_{12} \cdot R_{23}}{R_{12} + R_{23} + R_{31}} \rightarrow ⑧$$

$$R_3 = \frac{R_{23} R_{31}}{R_{12} + R_{23} + R_{31}} \rightarrow ⑨$$

Now by multiplying ⑦ × ⑧, ⑧ × ⑨ & ⑨ × ⑦ we get

$$⑦ \times ⑧ \Rightarrow R_1 R_2 = \frac{R_{12}^2 R_{23} R_{31}}{(R_{12} + R_{23} + R_{31})^2} \rightarrow ⑩$$

$$⑧ \times ⑨ \Rightarrow R_2 R_3 = \frac{R_{12} R_{23}^2 R_{31}}{(R_{12} + R_{23} + R_{31})^2} \rightarrow ⑪$$

$$⑨ \times ⑦ \Rightarrow R_3 R_1 = \frac{R_{12} R_{23} R_{31}^2}{(R_{12} + R_{23} + R_{31})^2} \rightarrow ⑫$$

Now, Add ⑩, ⑪ & ⑫ eqns

$$\Rightarrow R_1 R_2 + R_2 R_3 + R_3 R_1 =$$

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

$$= \frac{R_{12} R_{23} R_{31} \left(R_{12}+R_{23}+R_{31}\right)}{\left(R_{12}+R_{23}+R_{31}\right)^2}$$

$$\Rightarrow R_1R_2 + R_2R_3 + R_3R_1 = \frac{R_{12} R_{23} R_{31}}{\left(R_{12}+R_{23}+R_{31}\right)}$$

sub $\boxed{\frac{R_{12} R_{31}}{R_{12}+R_{23}+R_{31}} = R_1}$ by eqn (7)

$$\Rightarrow R_1R_2 + R_2R_3 + R_3R_1 = R_1 R_{23}$$

$$\Rightarrow R_{23} = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_1}$$

$$\Rightarrow R_{23} = R_2 + R_3 + \frac{R_2R_3}{R_1} \rightarrow (13)$$

similarly, by substituting remaining values, we can write relations for R_{12} & R_{31}

$$R_{12} = R_1 + R_2 + \frac{R_1R_2}{R_3} \rightarrow (14)$$

and $$R_{31} = R_3 + R_1 + \frac{R_3R_1}{R_2} \rightarrow (15)$$

D → S

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

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

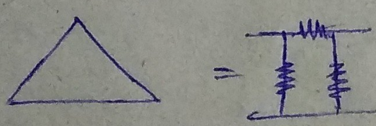
$$R_3 = \frac{R_{23} R_{31}}{R_{12}+R_{23}+R_{31}}$$

S → D

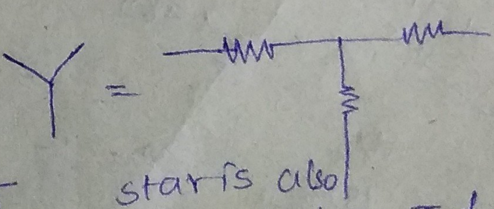
$$R_{12} = R_1 + R_2 + \frac{R_1R_2}{R_3}$$

$$R_{23} = R_2 + R_3 + \frac{R_2R_3}{R_1}$$

$$R_{31} = R_3 + R_1 + \frac{R_3R_1}{R_2}$$

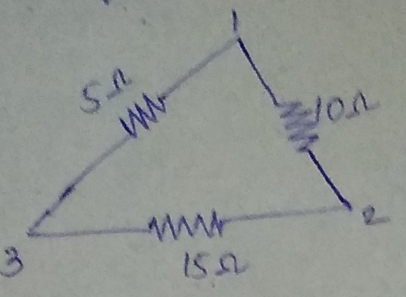


Delta is also represented as π



star is also represented as T-shape

① Transform the given circuit into star.



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

$$R_1 = \frac{10 \times 5}{10 + 15 + 5}$$

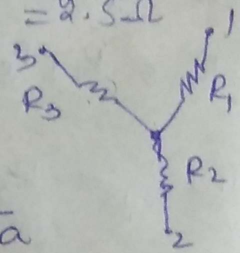
$$R_1 = 1.66\Omega$$

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

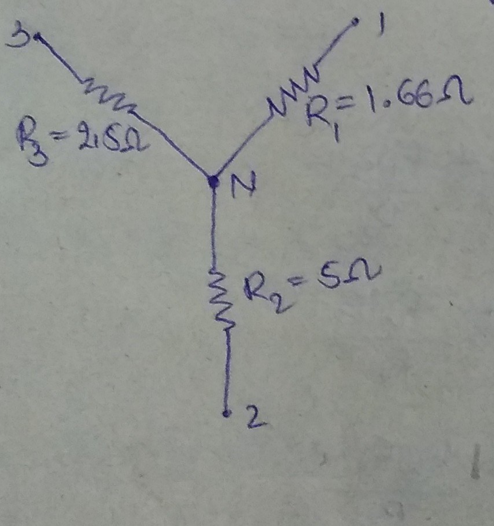
$$R_2 = \frac{10 \times 15}{10 + 15 + 5} \Rightarrow R_2 = 5\Omega$$

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

$$R_3 = \frac{15 \times 5}{10 + 15 + 5} = 2.5\Omega$$



② Transform the given diagram into Delta



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

$$R_{12} = 1.66 + 5 + \frac{1.66 \times 5}{2.5}$$

$$R_{12} = 9.98\Omega$$

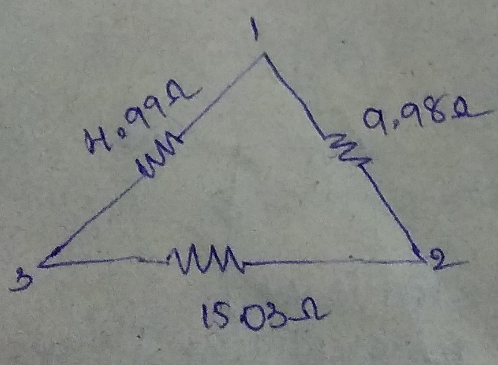
$$R_{23} = R_2 + R_3 + \frac{R_2 R_3}{R_1}$$

$$R_{23} = 15.03\Omega$$

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

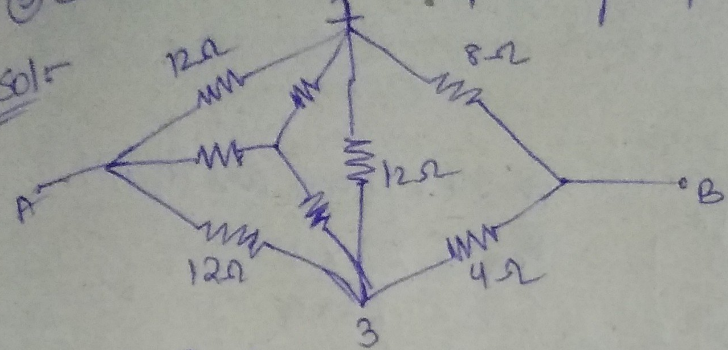
$$R_{31} = 2.5 + 1.66 + \frac{2.5 \times 1.66}{5}$$

$$R_{31} = 4.99\Omega$$



③ calculate the Req ~~using~~ by Delta to star transformation

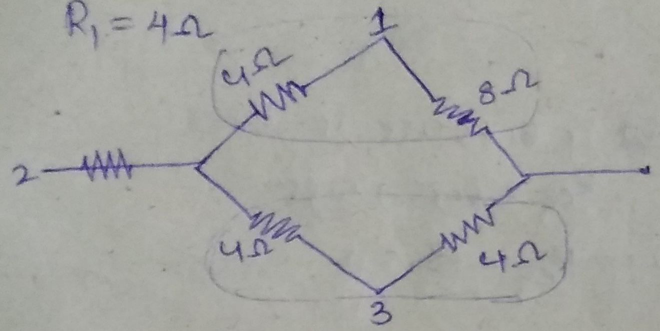
Sol:-



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

$$R_1 = \frac{12 \times 12}{12 + 12 + 12} \qquad R_2 = 4\Omega \qquad R_3 = 4\Omega$$

$R_1 = 4\Omega$

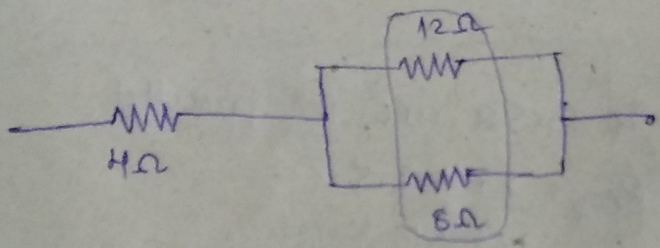


4Ω & 8Ω are in series,

Req = 4+8 = 12Ω

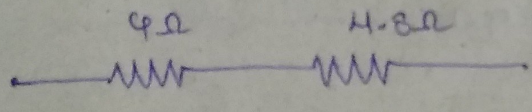
4Ω & 4Ω are in series,

Req = 4+4 = 8Ω



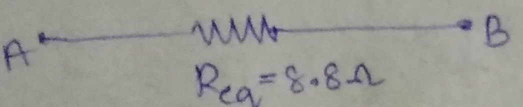
12Ω & 8Ω are in parallel,

$$Req = \frac{12 \times 8}{12+8} = 4.8\Omega$$



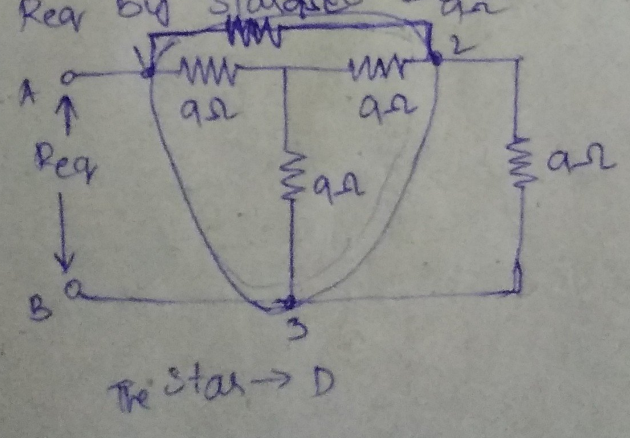
4Ω & 4.8Ω are in series,

Req = 4+4.8 = 8.8Ω



Calculate

④ Req by Star to Delta.



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

$$R_{12} = 9 + 9 + \frac{9 \times 9}{9}$$

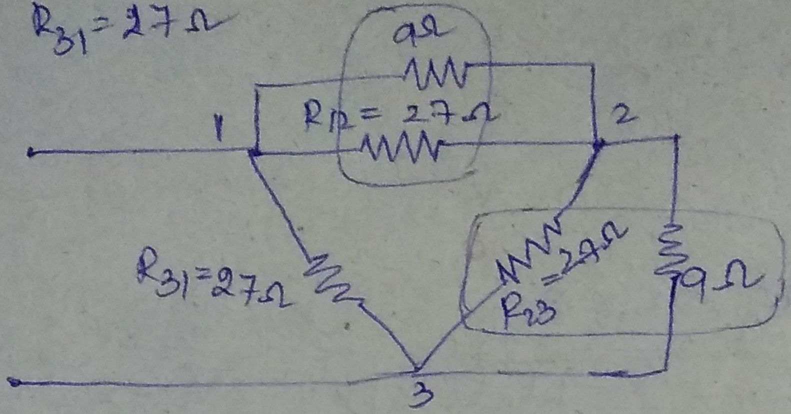
$R_{12} = 27\Omega$

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

$R_{23} = 27\Omega$

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

$R_{31} = 27\Omega$



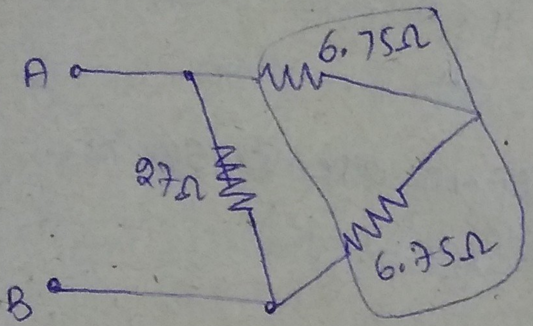
⇒ 27Ω & 9Ω are in ||el,

$$R_{eq} = \frac{27 \times 9}{27 + 9}$$

$$R_{eq} = 6.75\,\Omega$$

⇒ 27Ω & 9Ω are in ||el across II & III nodes,

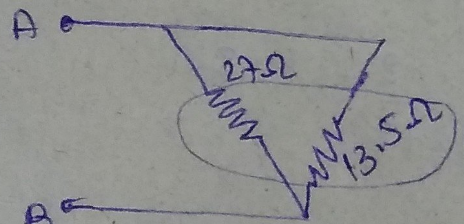
$$R_{eq} = \frac{27 \times 9}{27 + 9} = 6.75\,\Omega$$



6.75Ω & 6.75 are in series

$$R_{eq} = 6.75 + 6.75$$

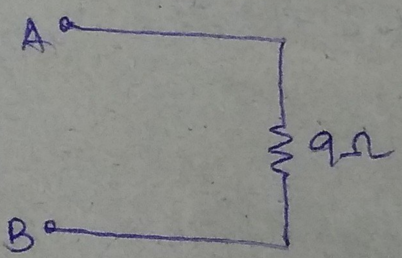
$$R_{eq} = 13.5\,\Omega$$



27Ω & 13.5Ω are in parallel

$$R_{eq} = \frac{27 \times 13.5}{27 + 13.5}$$

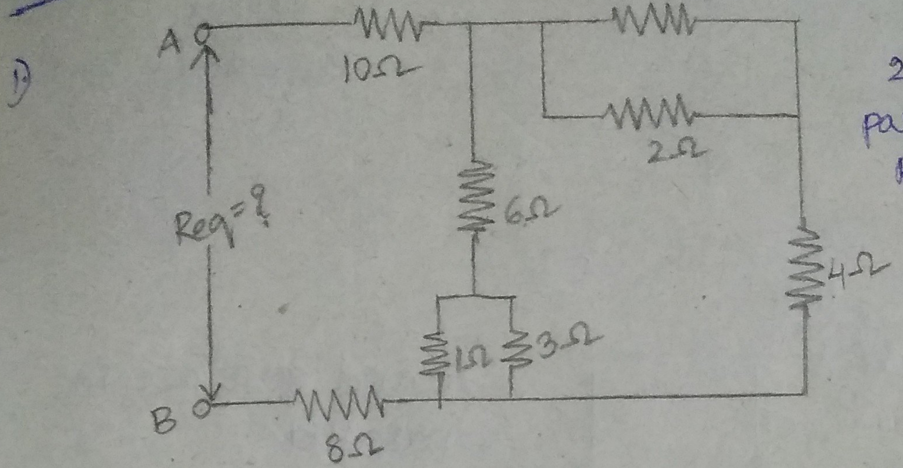
$$R_{eq} = 9\,\Omega$$



$R_{eq} = 9\Omega$

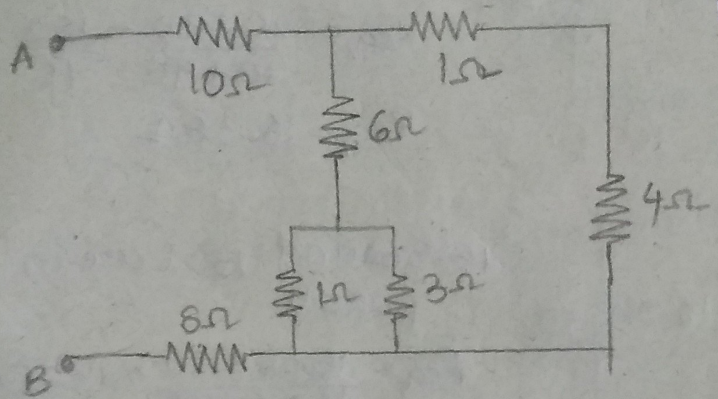
1/6/22 Hw problems

1)



2Ω & 2Ω are in parallel

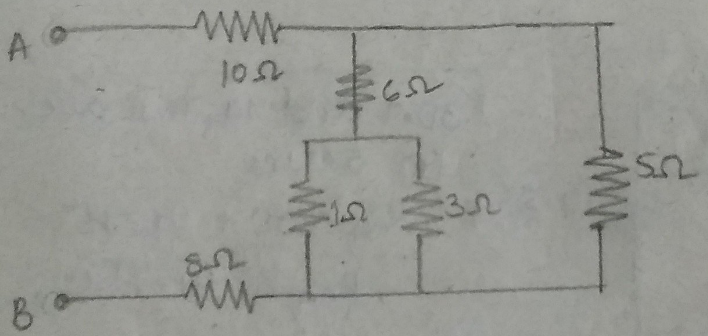
$$R_{eq} = \frac{2 \times 2}{2+2} = \frac{4}{4} = 1\Omega$$



1Ω and 4Ω are in series

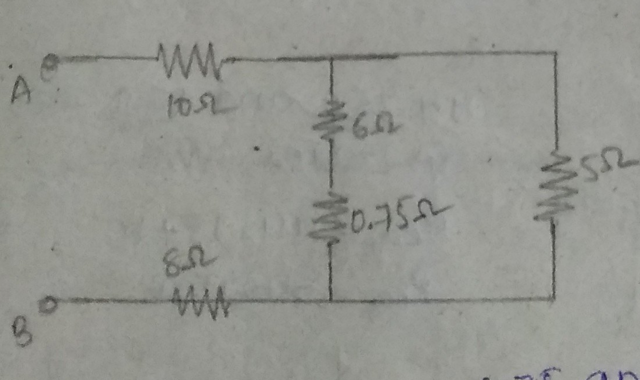
$R_{eq} = 1+4$

$R_{eq} = 5\Omega$



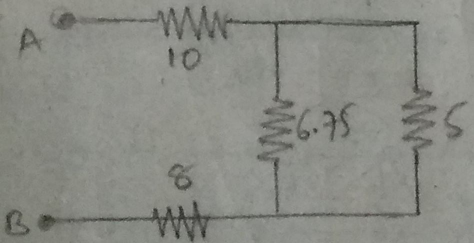
1Ω and 3Ω are in parallel

$$R_{eq} = \frac{1 \times 3}{1+3} = \frac{3}{4} = 0.75\Omega$$



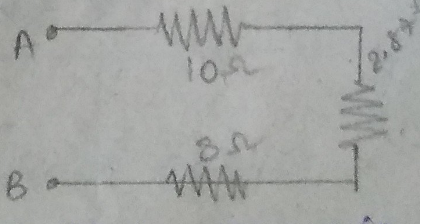
6Ω and 0.75 are in series

$6 + 0.75 = 6.75\Omega$



6.75 and 5Ω are in parallel

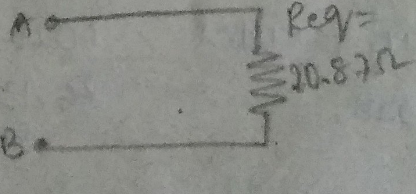
$$\frac{6.75 \times 5}{6.75+5} = 2.87$$



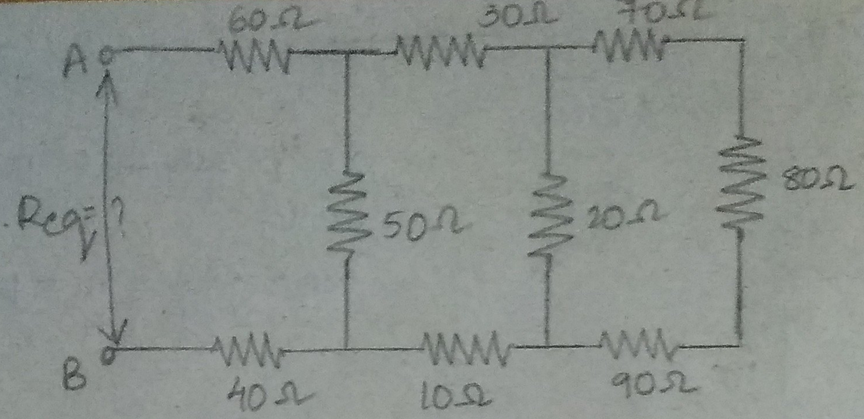
10Ω, 8Ω & 2.87 are in series

$R_{eq} = 10 + 8 + 2.87$

$R_{eq} = \underline{20.87\Omega}$

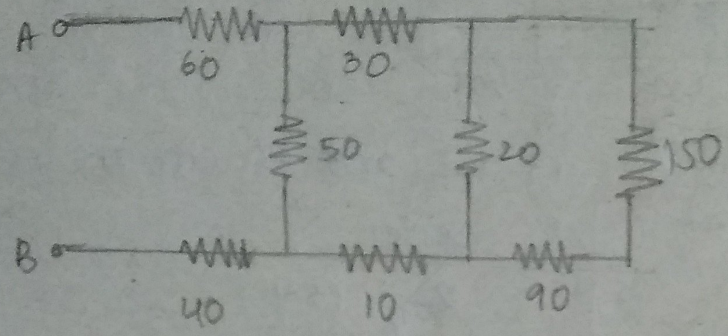


2)



70 & 80Ω are in series

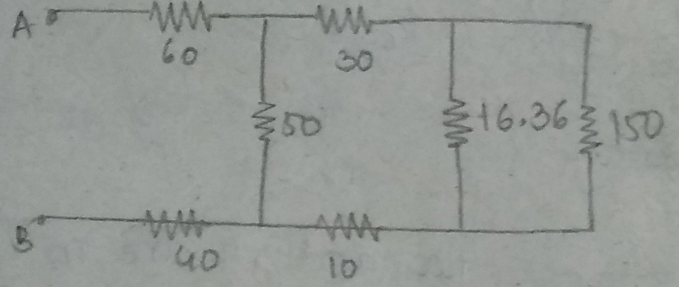
$R_{eq} = 150\Omega$



20 and 90Ω are in parallel

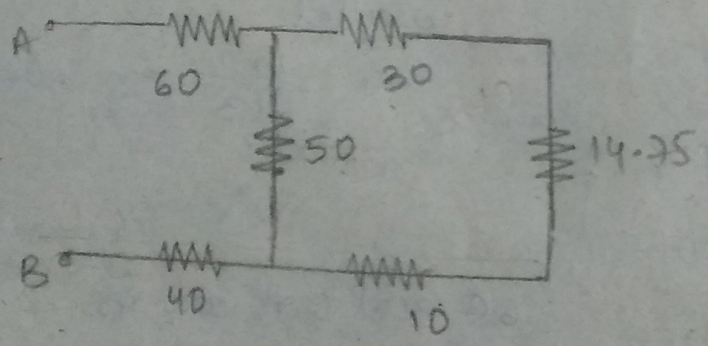
$R_{eq} = \frac{20 \times 90}{20 + 90} = \frac{180}{11}$

$R_{eq} = 16.36\Omega$



16.36Ω and 150Ω are in parall

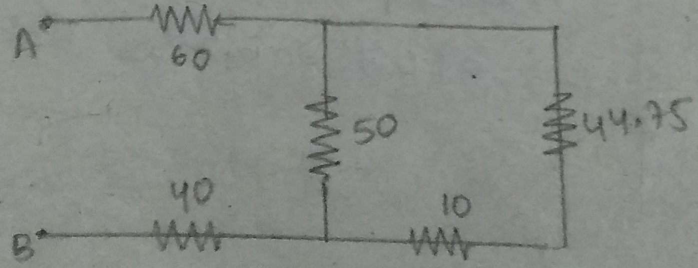
$R_{eq} = \frac{16.36 \times 150}{16.36 + 150} = 14.75$



30Ω and 14.75Ω are in series

$R_{eq} = 30 + 14.75$

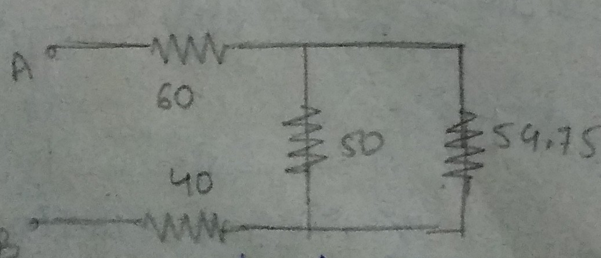
$R_{eq} = 44.75\Omega$

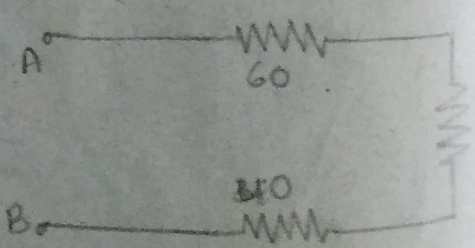


44.75Ω and 10Ω are in series

$R_{eq} = 44.15 + 10$

$R_{eq} = 54.75\Omega$





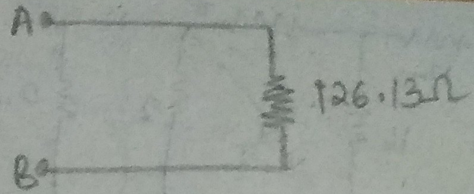
50Ω and 54.75Ω are in parallel

$R_{eq} = \frac{50 \times 54.75}{50 + 54.75} = 26.13\Omega$

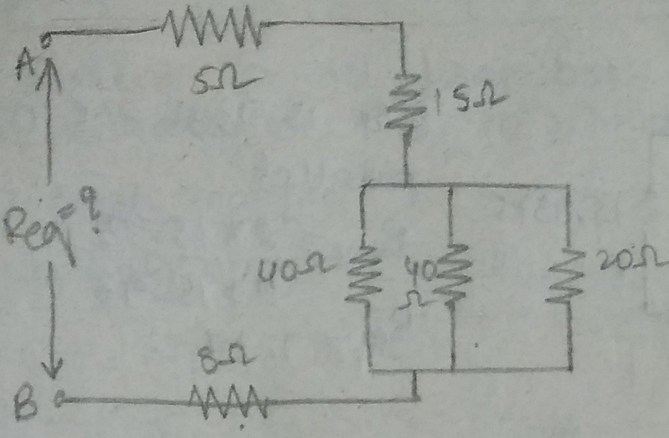
60Ω, 40Ω, & 26.13Ω are is series

$R_{eq} = 60 + 40 + 26.13$

$R_{eq} = \underline{126.13\Omega}$



(3)

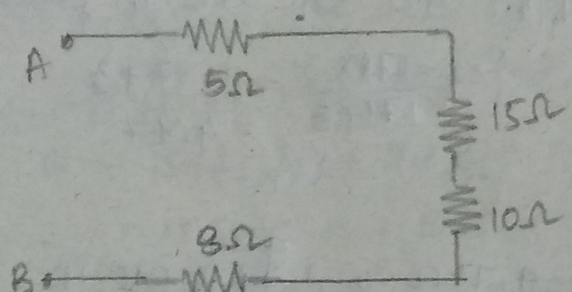


40, 40, 20Ω are in parallel

$\frac{1}{R_{eq}} = \frac{1}{20} + \frac{1}{40} + \frac{1}{40}$

$\frac{1}{R} = \frac{1}{10}$

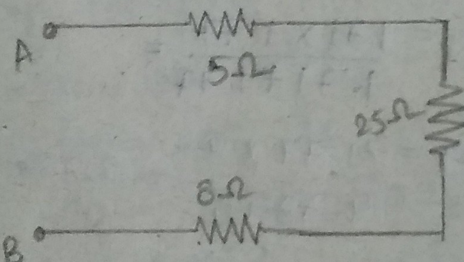
$\boxed{R = 10\Omega}$



15Ω & 10Ω are in series

$R_{eq} = 15 + 10$

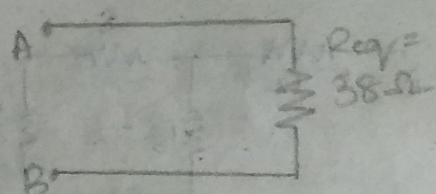
$R_{eq} = 25\Omega$



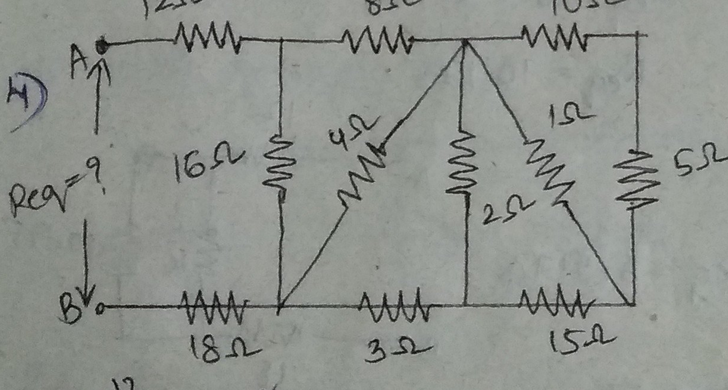
5Ω, 25Ω, 8Ω are in series

$R_{eq} = 5 + 25 + 8$

$R_{eq} = \underline{38\Omega}$



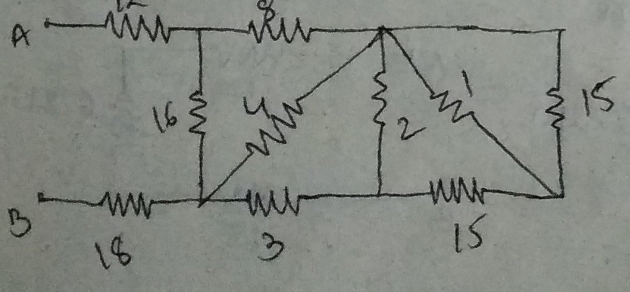
4)



10Ω & 5Ω are in series

$R_{eq} = 10 + 5$

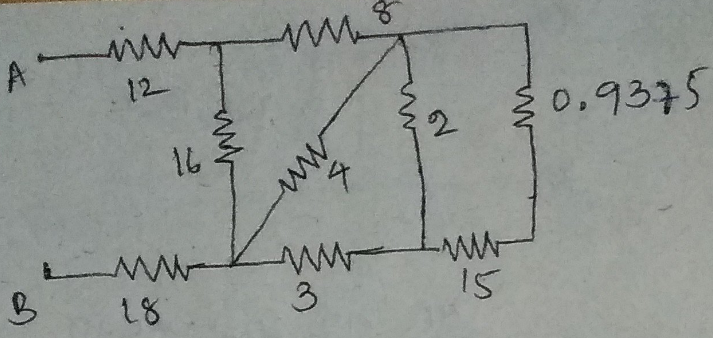
$R_{eq} = 15\Omega$



1Ω & 15Ω are in parallel

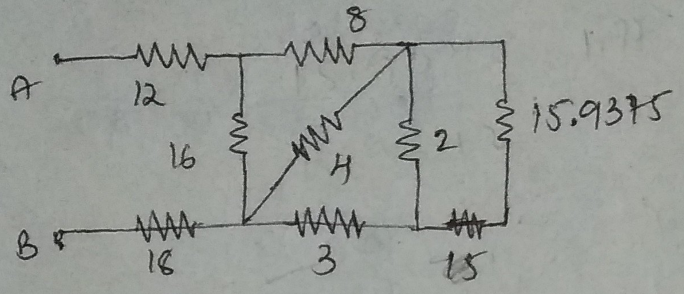
$R_{eq} = \frac{1 \times 15}{1 + 15}$

$R_{eq} = \frac{15}{16} = 0.9375$



15Ω & 0.9375Ω are in series

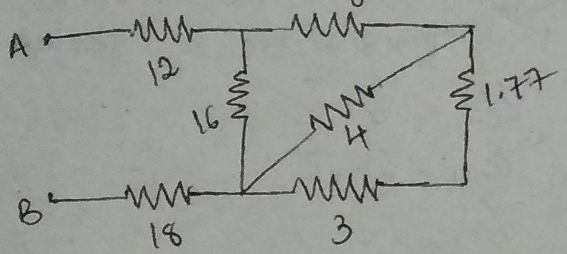
$R_{eq} = 15.9375\,\Omega$



2 & 15.93Ω are in parallel

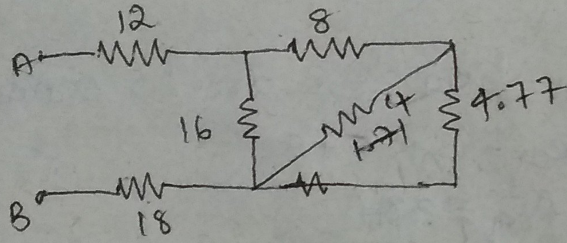
$$R_{eq} = \frac{2 \times 15.93}{2 + 15.93}$$

$R_{eq} = 1.77$



1.77Ω and 3Ω are in ~~parallel~~ series

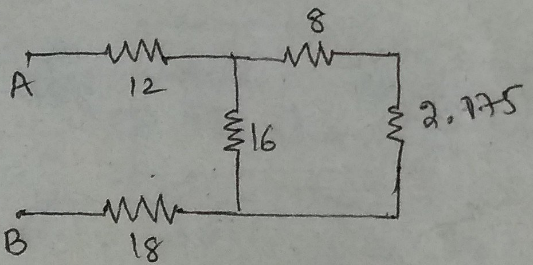
$$R_{eq} = \cancel{\frac{1.77 \times 3}{1.77 + 3}} = 1.77 + 3 = 4.77$$



4.77Ω & ~~1.77~~ 4Ω are in parallel

$$R_{eq} = \cancel{\frac{1.71 \times 1.77}{1.71 + 1.77}} =$$

$$R_{eq} = \frac{4.77 \times 4}{4.77 + 4} = 2.175$$



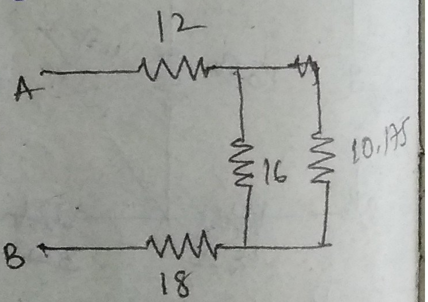
8Ω and 2.175 are in series

$R_{eq} = 8 + 2.175$

$R_{eq} = 10.175$

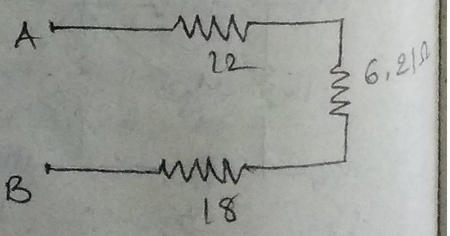
16Ω & 10.175Ω are in parallel

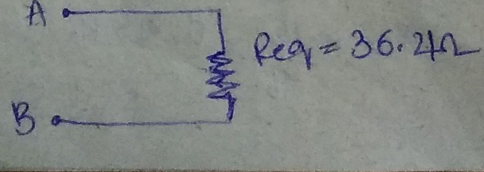
$$R_{eq} = \frac{16 \times 10.175}{16 + 10.175} \Rightarrow R_{eq} = 6.219\,\Omega$$



12Ω, 6.21Ω and 18Ω are in series

$R_{eq} = 12 + 6.21 + 18 \Rightarrow R_{eq} = 36.21\,\Omega$





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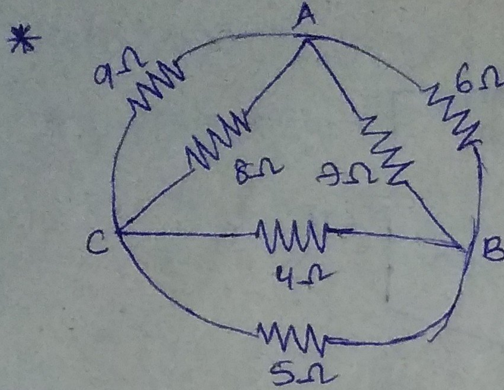


Determine the equivalent star.

9Ω and 8Ω are in parallel connection

$$R_{eq} = \frac{R_1 R_2}{R_1 + R_2} = \frac{9(8)}{9+8} = 4.23\Omega$$

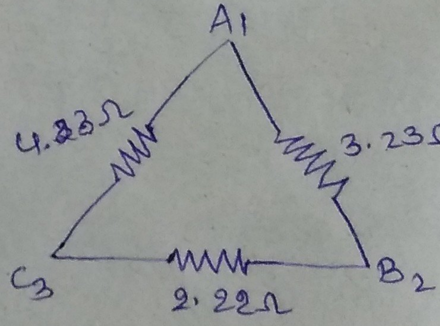
6Ω and 7Ω are in parallel connection

$$R_{eq} = \frac{6(7)}{6+7} = 3.23\Omega$$

5Ω and 4Ω are in parallel connection

$$R_{eq} = \frac{4(5)}{4+5} = 2.22\Omega$$

converting Delta to Star



$R_{12} = 3.23\Omega$, $R_{23} = 2.22\Omega$

$R_{31} = 4.23\Omega$

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

$$= \frac{3.23(4.23)}{3.23 + 2.22 + 4.23}$$

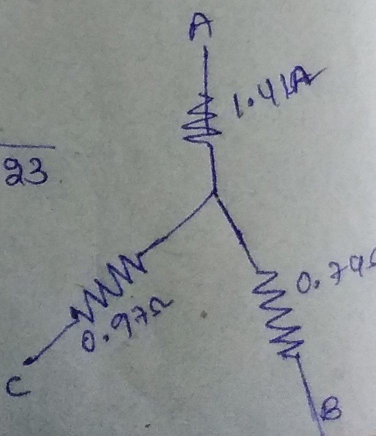
$R_1 = 1.411\Omega$

$$R_2 = \frac{R_{12} R_{23}}{R_{12} + R_{23} + R_{31}} = \frac{3.23(2.22)}{3.23 + 2.22 + 4.23}$$

$R_2 = 0.740\Omega$

$$R_3 = \frac{R_{23} R_{31}}{R_{12} + R_{23} + R_{31}} = \frac{2.22 \times 4.23}{3.23 + 2.22 + 4.23}$$

$R_3 = 0.97\Omega$



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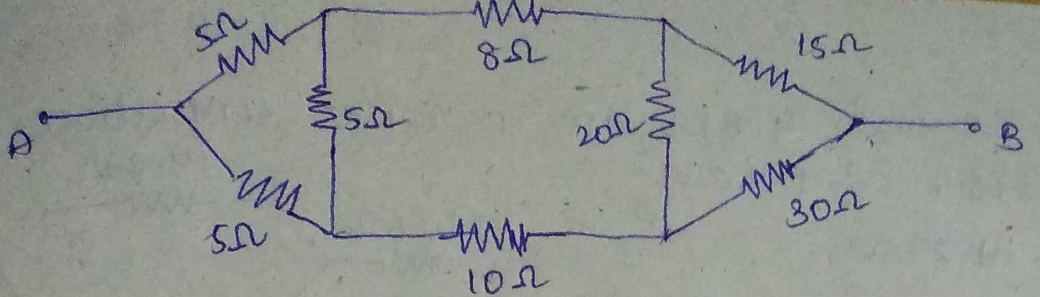
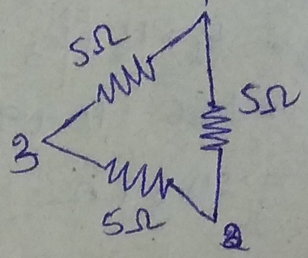


Calculate current when V=30 by using star to Delta transformation.

Converting from Delta to Star



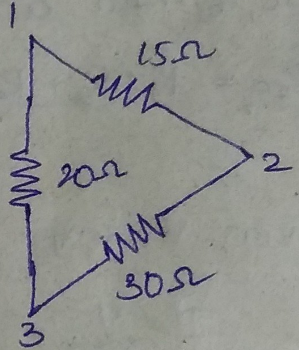
$$R_1 = \frac{R_{12} R_{31}}{R_{12} + R_{23} + R_{31}}$$

$$R_1 = \frac{5(5)}{5+5+5} = \frac{25}{15} = 1.66\Omega$$

$$R_2 = \frac{R_{12} R_{23}}{R_{12} + R_{23} + R_{31}} = \frac{5(5)}{5+5+5} = 1.66\Omega$$

$$R_3 = \frac{R_{23} R_{31}}{R_{12} + R_{23} + R_{31}} = \frac{5(5)}{5+5+5} = 1.66\Omega$$

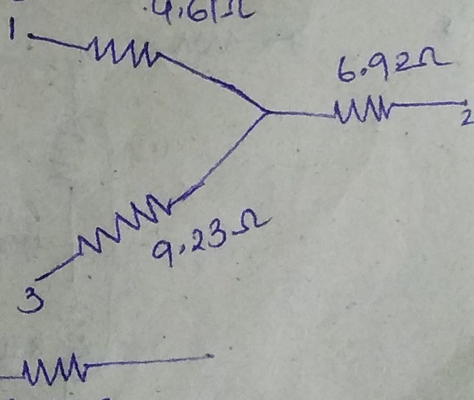
For IInd Delta



$$R_1 = \frac{R_{12} R_{31}}{R_{12} + R_{23} + R_{31}} = \frac{15(20)}{15+30+20} = 4.61\Omega$$

$$R_2 = \frac{R_{23} R_{12}}{R_{12} + R_{23} + R_{31}} = \frac{30(15)}{15+30+20} = 6.92\Omega$$

$$R_3 = \frac{R_{23} R_{31}}{R_{12} + R_{23} + R_{31}} = \frac{30(20)}{15+30+20} = 9.23\Omega$$



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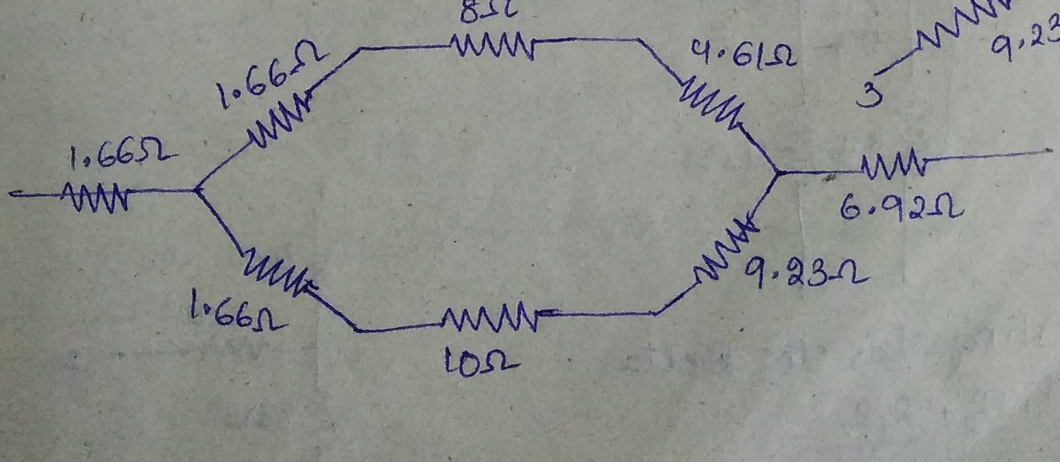
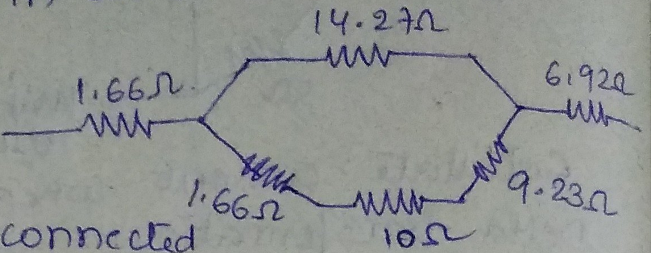


1.66Ω, 8Ω and 4.61Ω are in series connection

$R_{eq} = 1.66 + 8\Omega + 4.61\Omega$

$= 14.27\Omega$

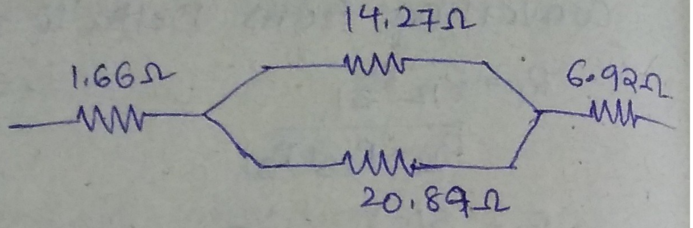


1.66Ω, 10Ω and 9.23Ω are connected in series

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

$= 1.66 + 10 + 9.23$

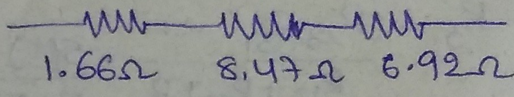
$= 20.89\Omega$



14.27Ω and 20.89Ω are connected in parallel

$$R_{eq} = \frac{R_1R_2}{R_1+R_3} = \frac{14.27(20.89)}{14.27+20.89}$$

$= 8.47$



1.66Ω, 8.47Ω and 6.92Ω are connected in series

$R_{eq} = R_1 + R_2 + R_3 = 1.66 + 8.47 + 6.92$

$= 17.05\Omega$

Given $V = 30V$, $R_{eq} = 17.05$

$$I = \frac{V}{R_{eq}} = \frac{30}{17.05} = 1.75\,A$$

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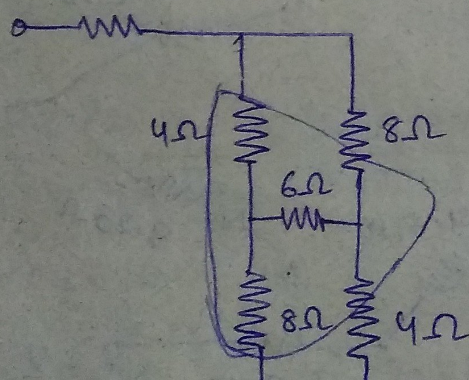
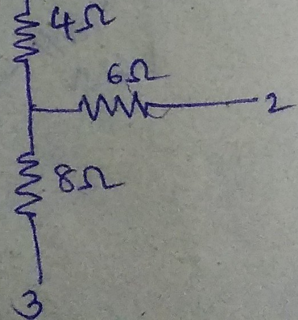




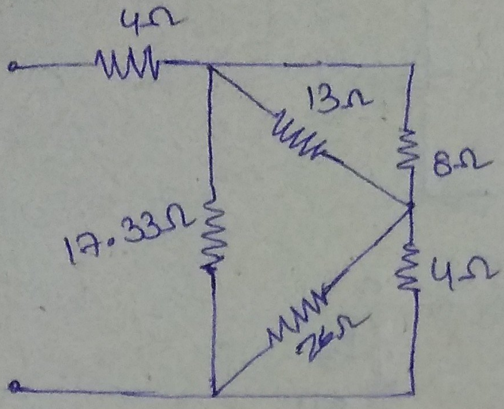
Converting star to Delta

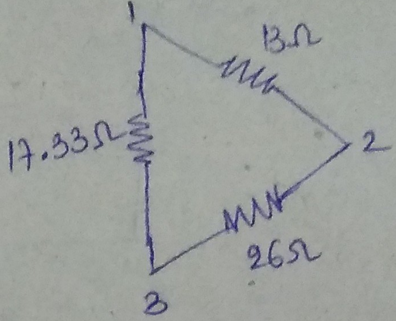
$$R_{12} = R_1 + R_2 + \frac{R_1R_2}{R_3}$$

$R_{12} = 4+6+\frac{4(6)}{8} = 13\Omega$

$R_{23} = R_2+R_3+\frac{R_2R_3}{R_1} = 6+8+\frac{6(8)}{4} = 26\Omega$

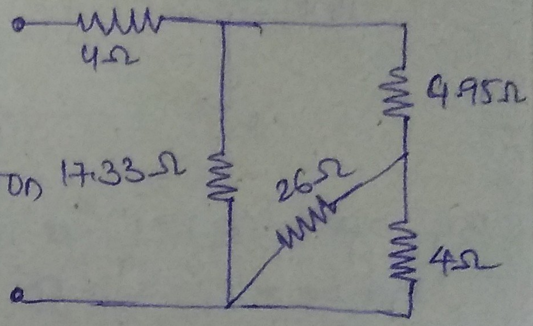
$R_{31} = R_3+R_1+\frac{R_3R_1}{R_2} = 8+4+\frac{8(4)}{6} = 17.33\Omega$





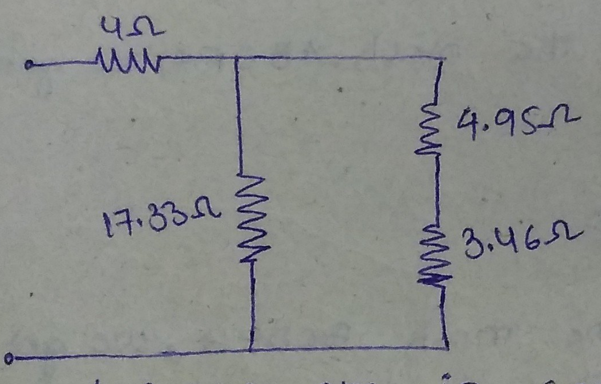
13Ω and 8Ω are in parallel connection.

$R_{eq} = \frac{R_1R_2}{R_1+R_2} = \frac{13(8)}{13+8}$
$= 4.95\Omega$



26Ω and 4Ω are in parallel connection

$R_{eq} = \frac{4(26)}{4+26} = 3.46\Omega$

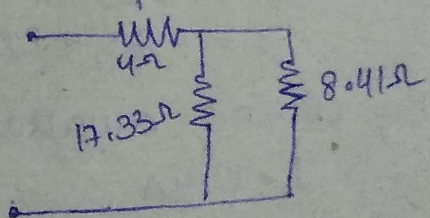


4.95Ω and 3.46Ω are in series

$R_{eq} = R_1+R_2 = 4.95+3.46 = 8.41\Omega$

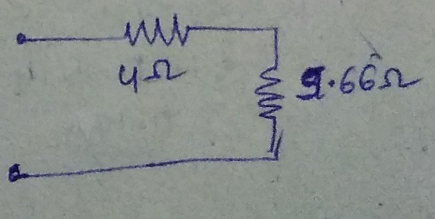
8.41Ω and 17.33Ω are connected in parallel

$R_{eq} = \frac{8.41(17.33)}{8.41+17.33} = 5.66\Omega$

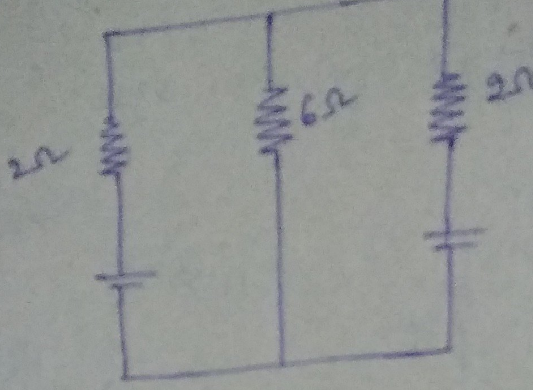


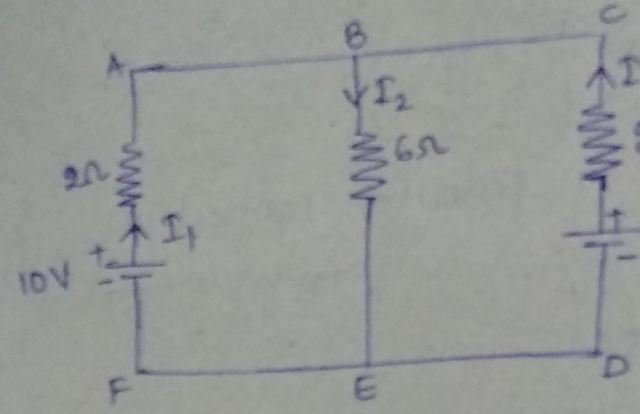
5.66Ω and 4Ω are connected in series

$R_{eq} = 5.66+4$
$= 9.66\Omega$



* Find out all the branch currents by using Kirchoff's laws





By applying KCL at node, we get

$I_1 + I_3 = I_2$ —— ①

By applying KVL to the mesh ABEFA, we get

$V_3 = V_1 + V_2$

$10 = 2 \times I_1 + 6 \times I_2$

$10 = 2I_1 + 6I_2$ —— ②

By applying KVL to the mesh BCDEB, we get

$8 = 2I_3 + 6I_2$ —— ③

Sub $I_2 - I_1 = I_3$ in ③

$8 = 2(I_2 - I_1) + 6I_2$

$8 = -2I_1 + 8I_2$ —— ④

By solving equation ① & ②, we get

$I_1 = 1.14A$ $\quad$ $I_2 = 1.28\,A$

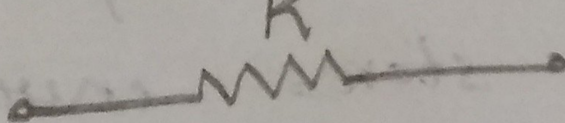
$I_3 = I_2 - I_1$

$= 1.28 - 1.14$

$= \underline{0.14A}$

Q) Write the V-I relation of R, L, C.

Ans) i. **Resistance** : It is the property of the material to oppose the flow of current. It is denoted by 'R'. It is measured by ohm. symbol is



It depends on the physical properties of the material

$$R = \frac{\rho L}{A}$$

ρ - Resistivity

L - Length in metres

A - Area crossection in square metres.

According to ohms law,

$$V = IR$$

$$I = V/R$$

$$I = GV$$

'G' is the conductance. The units are mho.

ohms law can be written as charge,

$$V = \frac{dq}{dt} R$$

The Power absorbed by the resistor is

$$P = VI = (IR)I = I^2R = \frac{V^2}{R}$$

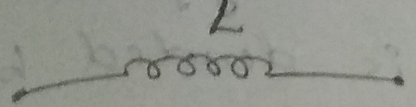
The energy lost is

$$W = \int_0^t p\,dt = pt = I^2Rt = \frac{V^2}{R}t.$$

where w is in Joules, power in watts, I in Amperes, V in volts and t in seconds.

Inductance: It is the property of the material which stores energy as electro ~~sta~~ magnetic field. It is denoted by

'L'. Its units are 'Henry'. symbol is



The voltage is directly proportional to the change in current i.e

$$v \propto \frac{di}{dt}$$

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

$$di = \frac{1}{L} v\,dt$$

Integrate on both sides

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

$$i(t) - i(0) = \frac{1}{L}\int_0^t v\,dt$$

The current depends on the integral of voltage across the terminals and the initial current over the resistor.

The power absorbed by the inductor is

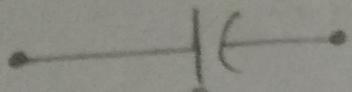
$$P = VI = LI\frac{di}{dt}$$

Energy lost is

$$W = \int_0^t p\,dt = \cancel{pt} = \int_0^t LI\frac{di}{dt}\,dt$$

$$= \frac{LI^2}{2}$$

Capacitance: It is the property of the material which stores energy as electrostatic field. It is denoted by 'c'. Its units are 'farad.' It's symbol is



C

$$C = \frac{Q}{V} = \frac{q}{v}$$

In capacitor, current is directly proportion-al to the change in voltage.

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

$$\int_0^t dv = \frac{1}{C}\int_0^t I\,dt$$

$$v(t) - v(0) = \frac{1}{C}\int_0^t I\,dt.$$

Power is

$$P = VI = VC\frac{dv}{dt}$$

Energy lost is

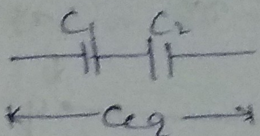
$$W = \int_0^t p\,dt = \int_0^t vc\frac{dv}{\cancel{dt}}\,\cancel{dt}$$

$$= \int_0^t v\,c\,dv$$

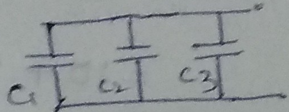
$$= \frac{cv^2}{2}$$

Capacitors are Connected in Series

$$C_{eq} = \frac{C_1 * C_2}{C_1 + C_2} \text{ f}$$

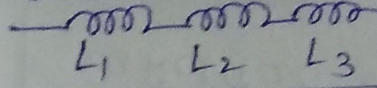


Capacitors are Connected in parallel

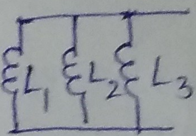


$$C_{eq} = C_1 + C_2 + C_3 \text{ F}$$

Inductors in series & parallel

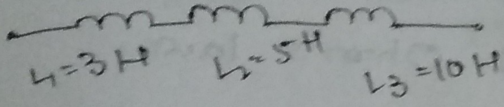


$$\boxed{L_{eq} = (L_1 + L_2 + L_3) H}$$



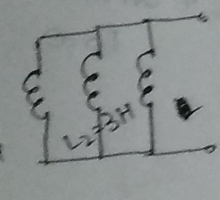
$$L_{eq} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3}$$

1)



$$L_{eq} = 18 H$$

2)

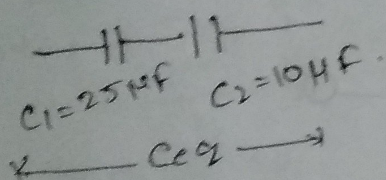


$$L_{eq} = \frac{6 * 3}{6 + 3}$$

$$L_{eq} = \frac{18}{9}$$

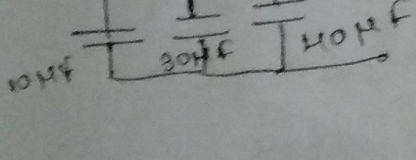
$$= 2 H$$

3)



$$C_{eq} = 4.12? \ \mu f.$$

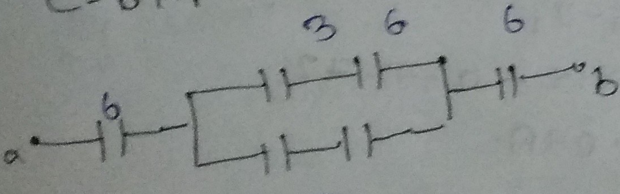
4)



$$C_{eq} = 10 \mu f + 30 \mu f + 40 \mu f$$

$$= 80 \mu f.$$

5) $C = 6 \mu F$



$$C_{eq} = \frac{6 * 6}{6 + 6}$$

$$= 3$$

$$\frac{1}{C_{eq}} = \frac{1}{6} + \frac{1}{6} + \frac{1}{6}$$

$$\frac{1}{C} = \frac{3}{6}$$

$$\frac{1}{C} = \frac{1}{2} = 0.5$$

$C = 2 f$