18EES101J – Basic Electrical and Electronics Engineering

Unit-1

Electric circuits (DC circuits)

Current (I): Flow of electrons in a closed circuit.

Unit is ampere.

Voltage (V): The difference in potential between any two points is called voltage or potential difference

Unit is Volts.

Power (P): It's the product of voltage and current.

Unit is Watts / KW

$$P = VI \quad (\text{Watt})$$

Energy (E): It's the product of power and time

Unit is Watt Sec or (kWhr)

$$\text{Electrical Energy } (E) = P \times t \quad (\text{Watt Sec})$$

Resistance (R) : It's the property of the Conductor that opposes the flow of current through it.

Unit is ohm (Ω).

Ohm's Law:

At Constant temperature the potential difference between two points is directly propotional to the current flowing through it.

$$V = IR$$

$R \propto$ Temp (Constant)

R - Const

Where,

V - voltage

I - current

R - resistance

1. The Current flowing through a resistor is 0.8A when a potential difference of 20V is applied. What is the value of resistance

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

$$= \frac{20}{0.8}$$

$$\boxed{R = 25\,\Omega}$$

2. A Source of emf of 15V supplies a current of 2A. How much energy is provided in this time (t = 6 mins).

$$P = VI$$

$$= 15 \times 2$$

$$P = 30 \text{ watts}$$

$$E = P \times t$$

$$= 30 \times (6 \times 60)$$

$$\boxed{E = 10800 \text{ Watt Sec}}$$

3. Determine the power dissipated by an element of an electrical device of resistance 20Ω. when a current of 10A flows through it. If the device is on for 6 hrs, Determine the energy used and the cost, if 1 unit of electricity costs 7 paise.

$$E = P \times t$$

$$P = V \times I$$

$$P = I^2 R$$

$$= 10^2 (20)$$

$$P = 2000 \text{ watts} \quad \text{or} \quad 2 \text{ kW}$$

$$E = 2 \text{ kW} \times 6 \text{ hr}$$

$$E = 12 \text{ kWhr}$$

1 unit of electricity = 1kWhr

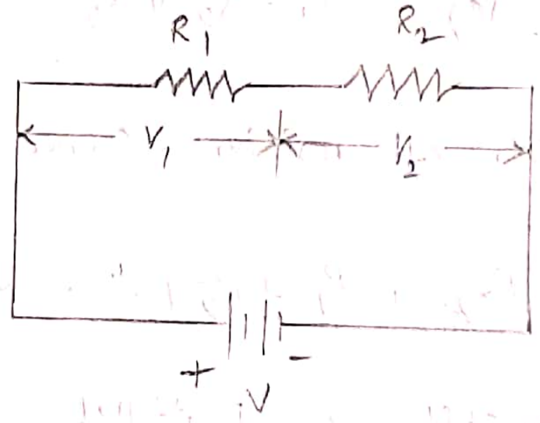
Hence number of units used = 12

$$\boxed{\text{Cost of Energy} = 12 \times 7 = 84 \text{ Paise.}}$$

Kirchhoff's Voltage Law (KVL)

In a closed loop the algebraic sum of potential differences is zero.

In a closed loop the sum of potiential rises is equal to sum of potential drops.

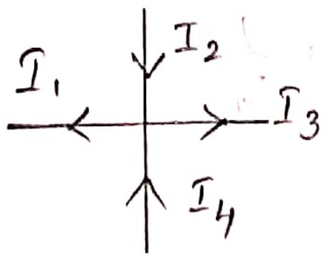


$$\boxed{V = V_1 + V_2}$$

Kirchhoff's current law: (KCL)

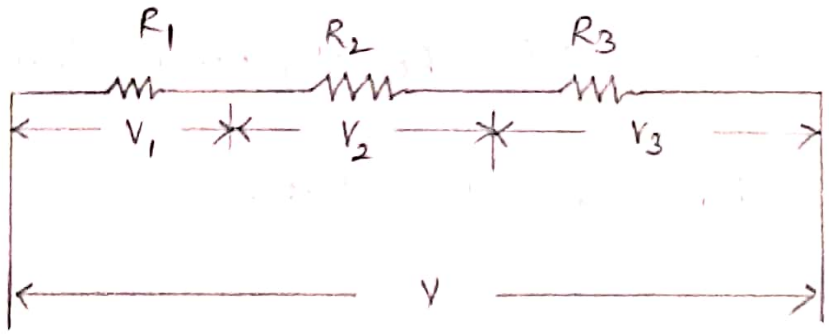
The algebraic sum of currents meeting at a junction is zero.

The sum of incoming currents is equal to outgoing currents.



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

Resistors Connected in Series



equivalent Resistance

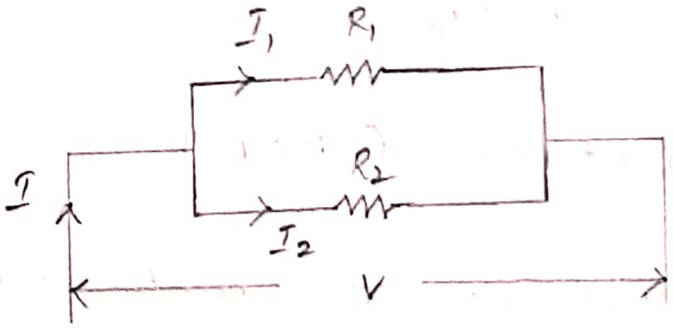
$$V = V_1 + V_2 + V_3$$

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

For n-number of resistors connected in series, then

$$R_{eq} = R_1 + R_2 + \cdots + R_n$$

Resistors Connected in parallel



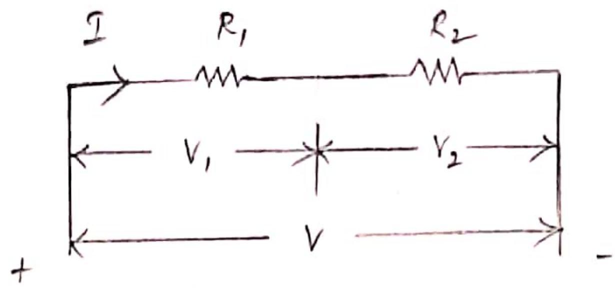
$$I = I_1 + I_2$$

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

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

Voltage division rule:

Consider two resistors connected in series



$$V_1 = I R_1$$

$$V_2 = I R_2$$

Apply KVL

$$V = V_1 + V_2$$

$$= I R_1 + I R_2$$

$$V = I (R_1 + R_2)$$

$$I = \frac{V}{R_1 + R_2}$$

Total voltage V is dropped in two resistors

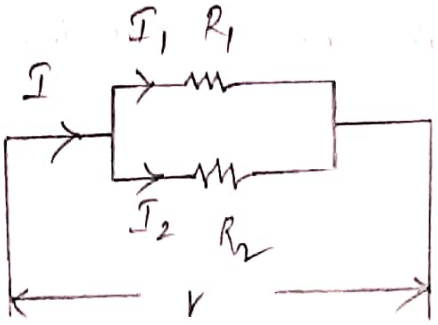
Voltage across element = Total voltage $\times \frac{\text{Voltage across same resistance}}{\text{Total resistance}}$

$\therefore$

$$\boxed{V_1 = V \frac{R_1}{R_1 + R_2}}$$

$$\boxed{V_2 = V \frac{R_2}{R_1 + R_2}}$$

Current division rule :

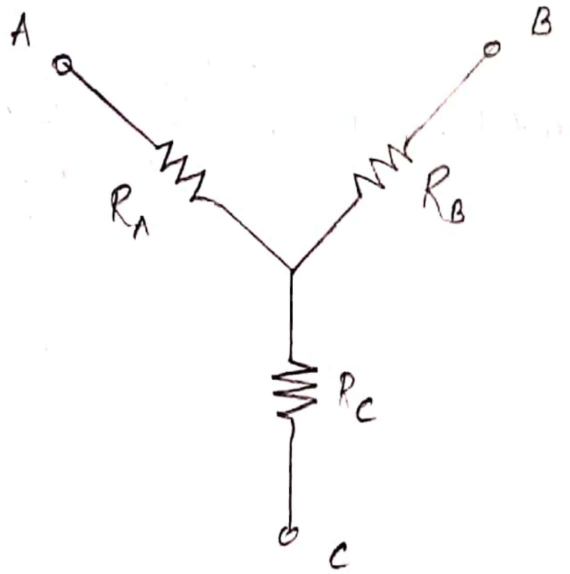


Consider two resistors are Connected in parallel

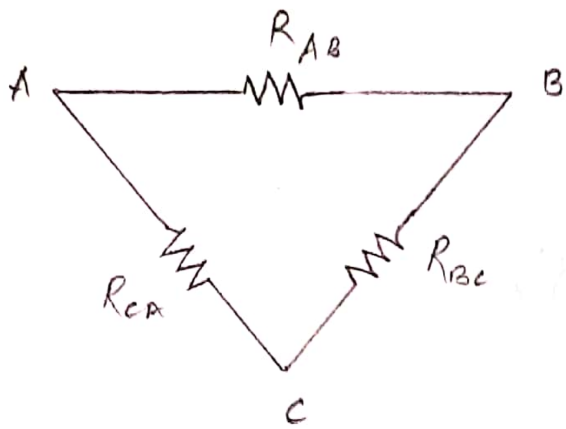
$$\text{Current through the element} = \text{Total current} \times \frac{\text{current through opposite resistance}}{\text{Total resistance}}$$

$I_1 = I \dfrac{R_2}{R_1 + R_2}$
$I_2 = I \dfrac{R_1}{R_1 + R_2}$

Star - Delta - Star Transformation



Star Connection



Delta Connection

Star (Y) to Delta (Δ)

$$R_{AB} = \frac{R_A R_B + R_B R_C + R_C R_A}{R_C}$$

$$R_{BC} = \frac{R_A R_B + R_B R_C + R_C R_A}{R_A}$$

$$R_{CA} = \frac{R_A R_B + R_B R_C + R_C R_A}{R_B}$$

If three resistance are equal

then, $R_A = R_B = R_C = R$

$$R_{AB} = R_{BC} = R_{CA} = 3R$$

(Δ) (Y)
Delta to Star :

$$R_A = \frac{R_{AB} R_{AC}}{R_{AB} + R_{BC} + R_{CA}}$$

$$R_B = \frac{R_{AB} R_{BC}}{R_{AB} + R_{BC} + R_{CA}}$$

$$R_C = \frac{R_{BC} R_{CA}}{R_{AB} + R_{BC} + R_{CA}}$$

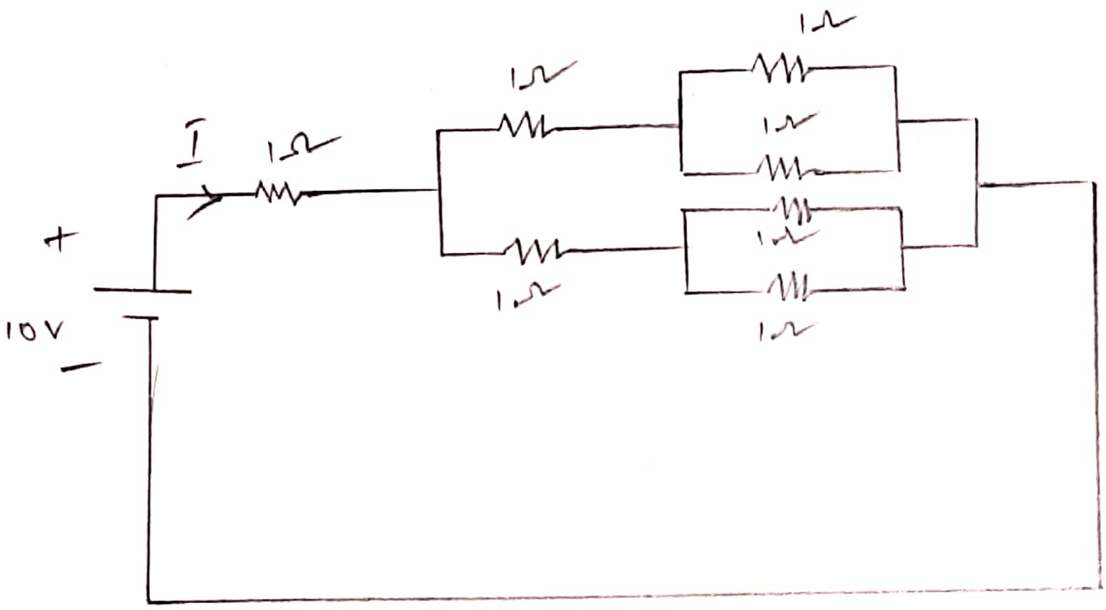
If three resistances are equal

then,

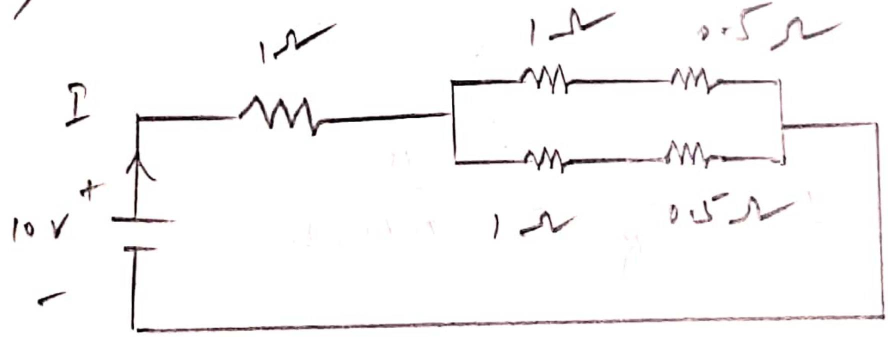
$$R_{AB} = R_{BC} = R_{AC} = R$$

$$R_A = R_B = R_C = R/3$$

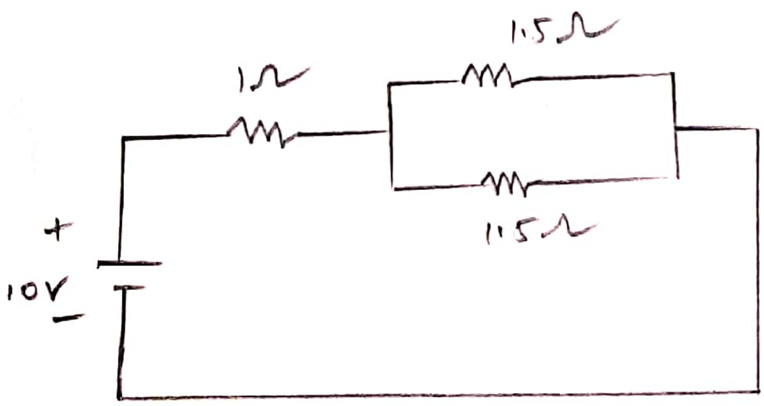
① All the resistances in Fig are 1Ω each. Find the value of current I.



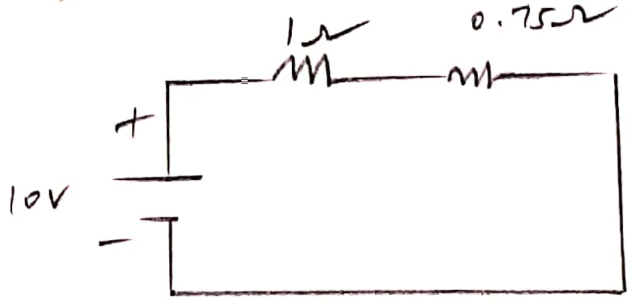
⇒



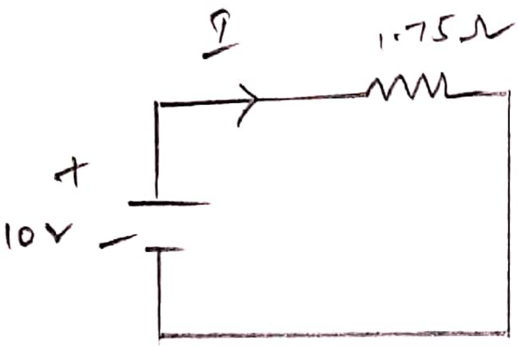
⇒



$\Rightarrow$



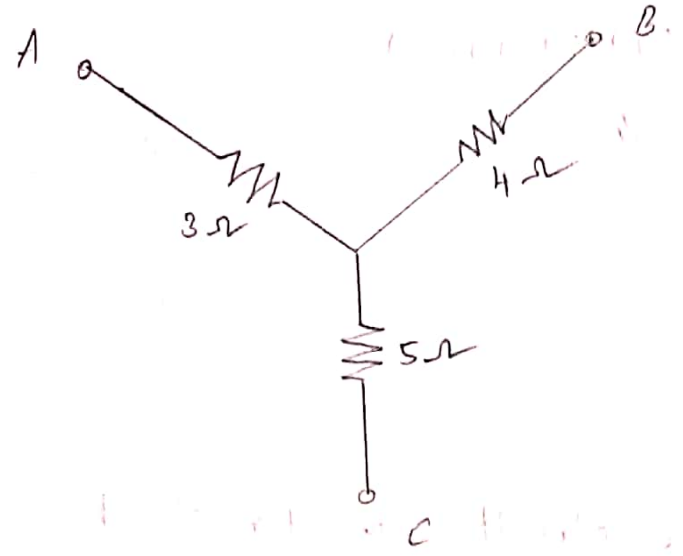
$\Rightarrow$



$$\text{Current } I = \frac{V}{R} = \frac{10}{1.75\,\Omega}$$

$$\boxed{I = 5.714\text{ A}}$$

1. Convert the star circuit into delta circuit.



$$R_{AB} = \frac{R_A R_B + R_B R_C + R_C R_A}{R_C}$$

$$= \frac{(3)(4) + (4)(5) + (5)(3)}{5}$$

$$= \frac{12 + 20 + 15}{5}$$

$$= \frac{47}{5}$$

$$\boxed{R_{AB} = 9.4\ \Omega}$$

$$R_{BC} = \frac{R_A R_B + R_B R_C + R_C R_A}{R_A}$$

$$= \frac{(3)(4) + (4)(5)(5)(3)}{3}$$

$$= \frac{47}{3}$$

$$\boxed{R_{BC} = 15.67\ \Omega}$$

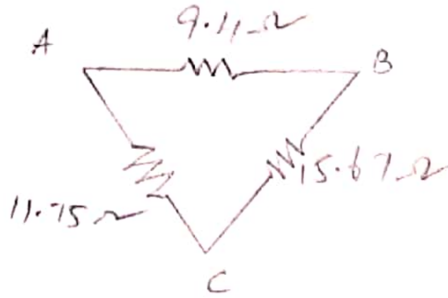
Scanned with CamScanner

$$R_{CA} = \frac{R_A R_B + R_B R_C + R_A R_C}{R_B}$$

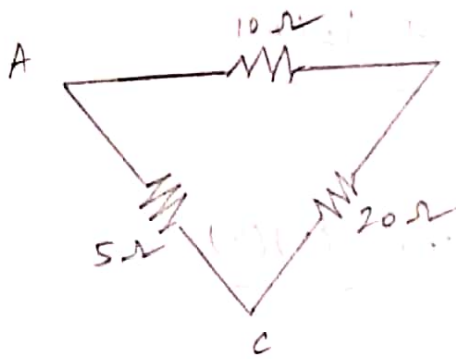
$$= \frac{(3)(4)\ (4)(5)\ (5)(3)}{4}$$

$$= \frac{47}{4}$$

$$\boxed{R_{CA} = 11.75\,\Omega}$$



2. Convert the delta circuit into star circuit.



$$R_A = \frac{R_{AB} R_{AC}}{R_{AB} + R_{BC} + R_{CA}}$$

$$= \frac{10 \times 5}{5 + 10 + 20}$$

$$= \frac{50}{35}$$

$$\boxed{R_A = 1.43\,\Omega}$$

$$R_B = \frac{R_{AB} R_{BC}}{R_{AB} + R_{BC} + R_{CA}}$$

$$= \frac{(10)(20)}{5 + 10 + 20}$$

$$= \frac{100}{35}$$

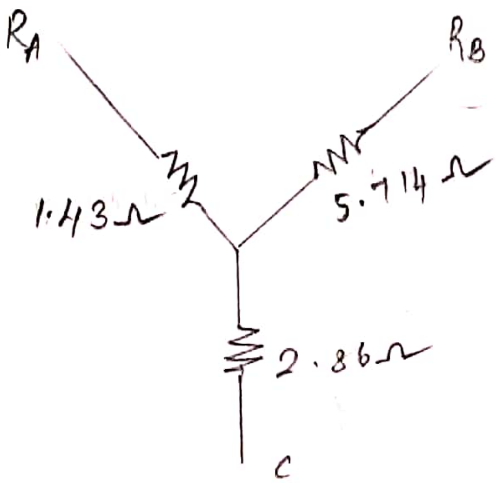
$$\boxed{R_B = 5.714\ \Omega}$$

$$R_C = \frac{R_{BC} R_{CA}}{R_{AB} + R_{BC} + R_{CA}}$$

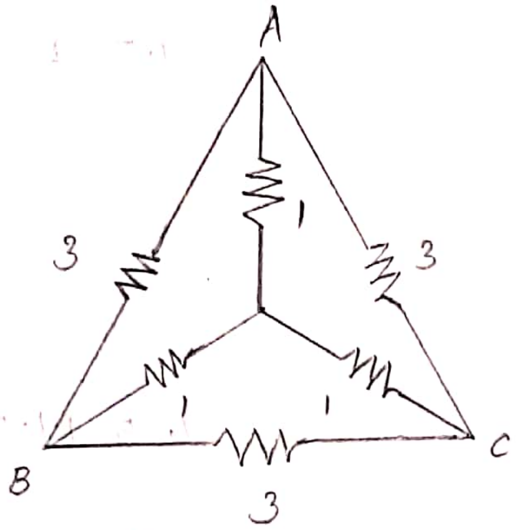
$$= \frac{(20)(5)}{5 + 10 + 20}$$

$$R_C = \frac{100}{35}$$

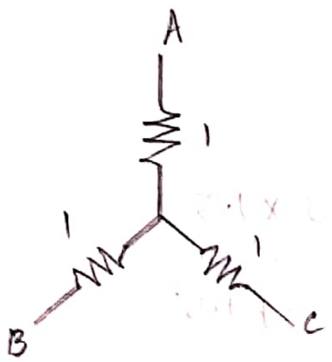
$$\boxed{R_C = 2.86\ \Omega}$$



3. For the network shown in figure, find the equivalent resistance b/w the terminals B & C. All resistance values are in ohm.



$\Rightarrow$



$$R_{AB} = \frac{R_A R_B + R_B R_C + R_C R_A}{R_C}$$

$$= \frac{1+1+1}{1}$$

$$\boxed{R_{AB} = 3\,\Omega}$$

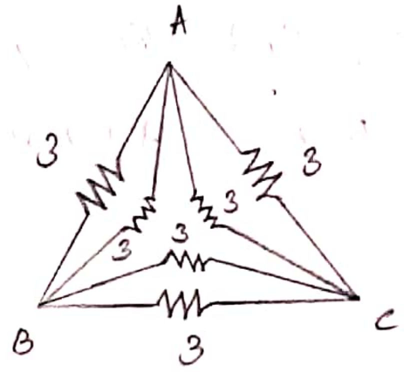
$$R_{BC} = \frac{R_A R_B + R_B R_C + R_C R_A}{R_A} = \frac{1+1+1}{1}$$

$$\boxed{R_{BC} = 3\,\Omega}$$

$$R_{CA} = \frac{R_A R_B + R_B R_C + R_C R_A}{R_B} = \frac{1+1+1}{1}$$

$$\boxed{R_{CA} = 3\,\Omega}$$

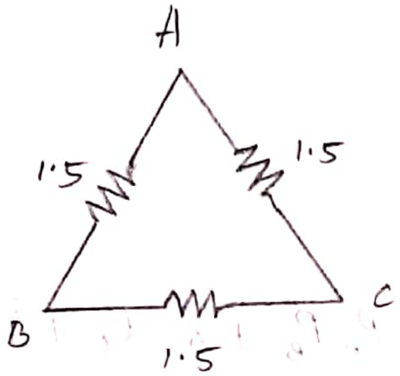
⇒



$$= \frac{3 \times 3}{3+3} = \frac{9}{6}$$

$$= 1.5\,\Omega$$

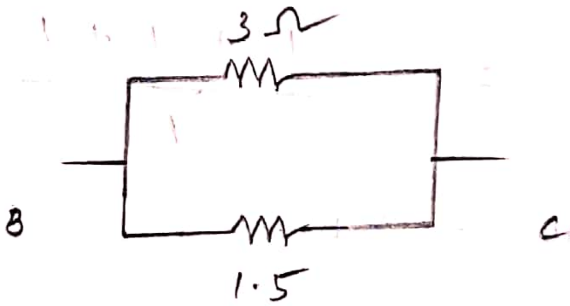
⇒



$$= 1.5 + 1.5$$

$$= 3\,\Omega$$

⇒

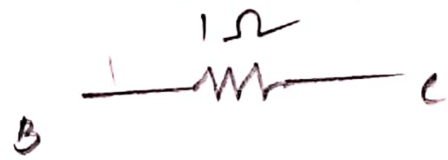


$$= \frac{3 \times 1.5}{3 + 1.5}$$

$$= \frac{4.5}{4.5}$$

$$= 1\,\Omega$$

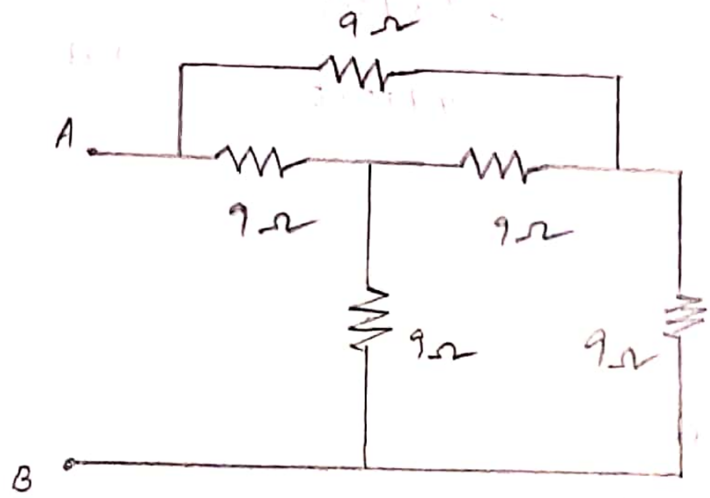
⇒

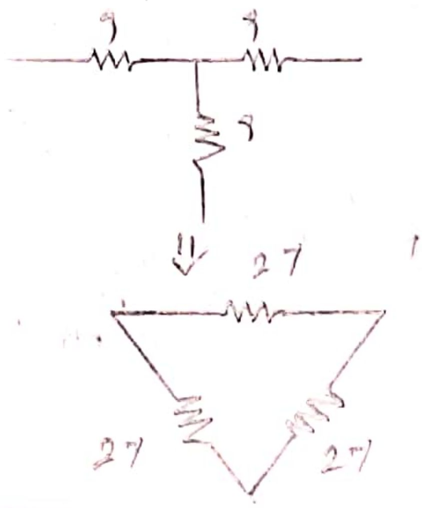


equivalent resistance b/w B & C

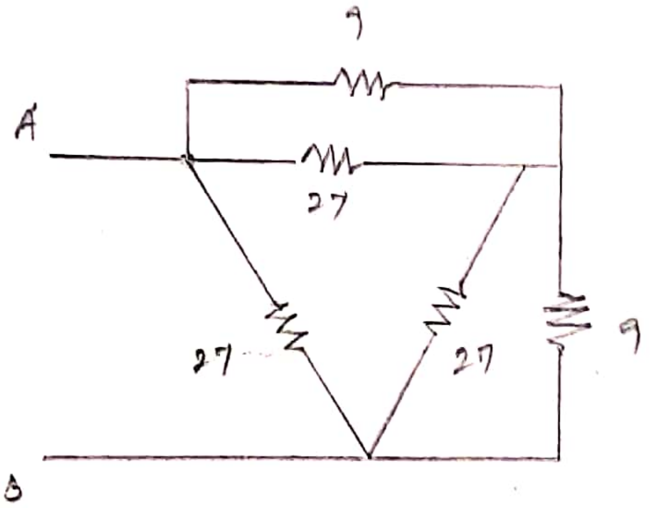
$$\boxed{R_{BC} = 1\,\Omega.}$$

4. Determine the equivalent resistance. All resistance values are in ohm.





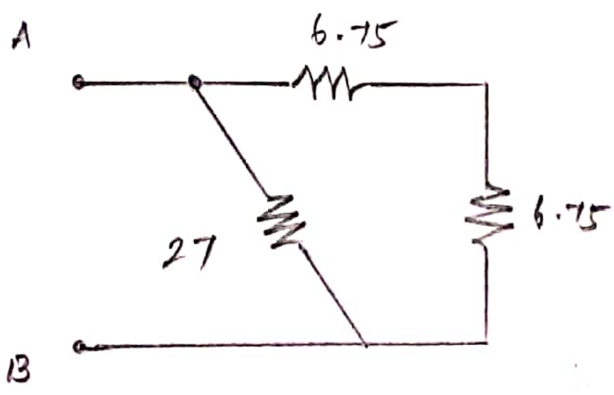
=>



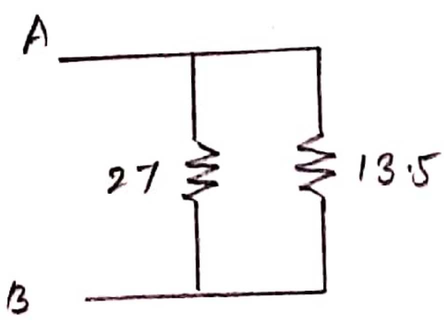
$$\frac{27 \times 9}{27+9} = 6.75\,\Omega$$

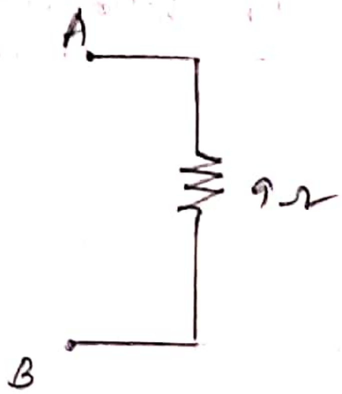
$$\frac{27 \times 9}{27+9} = 6.75\,\Omega$$

=>



=>





$$\frac{27 \times 13.5}{27 + 13.5} = 9\Omega$$

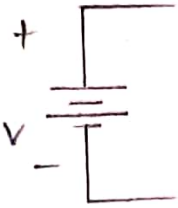
$$\boxed{R_{AB} = 9\Omega}$$

V - I Relationship of circuit elements

Circuit Elements	Voltage	Current	Power
$R(\Omega)$	$V = IR$	$I = \frac{V}{R}$	$P = VI$
$L(H)$	$V = L\frac{di}{dt}$	$i = \frac{1}{L}\int v\,dt$	$p = Li\frac{di}{dt}$
$C(F)$	$V = \frac{1}{C}\int i\,dt$	$i = C\frac{dv}{dt}$	$p = Cv\frac{dv}{dt}$

Active elements:

The Source of energy is called active element.

Voltage source 

Current source 

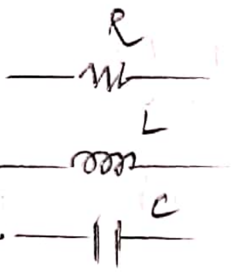
Passive elements:

elements which dissipate energy

Resistance

Inductance

Capacitance



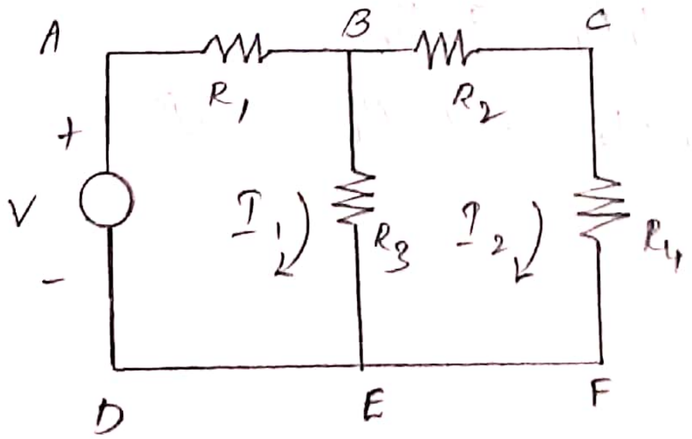
Mesh:

A mesh is a loop that doesnot Contain other loops. ABED, BCFE are meshes

Loop:

A loop is any closed path of branches.

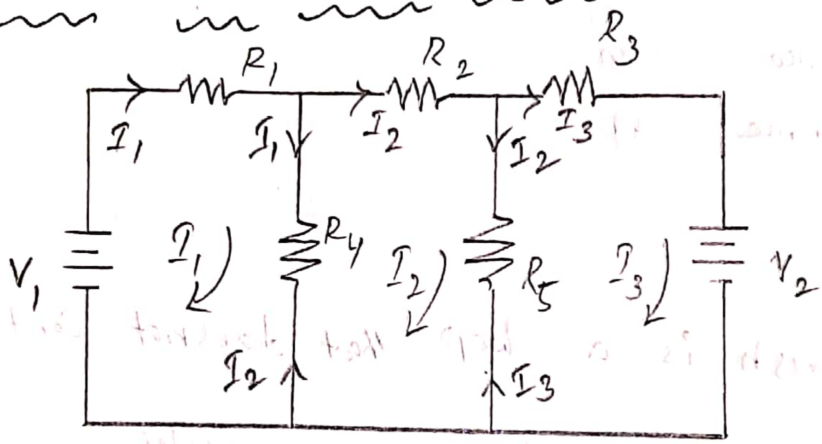
ABED, BCFE, ABCFED.



Node: The point at which two or more elements joined together is called node

Branch : part of the network which connects various points of the network.

Mesh analysis (loop current Method)



Loop : 1 Apply KVL

$$V_1 = I_1 R_1 + (I_1 - I_2) R_4$$

$$= I_1 R_1 + I_1 R_4 - I_2 R_4$$

$$V_1 = I_1 (R_1 + R_4) - I_2 R_4 \quad -①$$

Loop : 2

$$0 = (I_2 - I_1) R_4 + I_2 R_2 + (I_2 - I_3) R_5$$

$$0 = I_2 R_4 - I_1 R_4 + I_2 R_2 + I_2 R_5 - I_3 R_5$$

$$0 = -I_1 R_4 + I_2 (R_2 + R_4 + R_5) - I_3 R_5 \quad — ②$$

loop : 3

$$-V_2 = (I_3 - I_2) R_5 + R_3 I_3$$

$$-V_2 = -I_2 R_5 + I_3 (R_3 + R_5) \quad — ③$$

$$\begin{bmatrix} V_1 \\ 0 \\ -V_2 \end{bmatrix} = \begin{bmatrix} R_1 + R_4 & -R_4 & 0 \\ -R_4 & R_2 + R_4 + R_5 & -R_5 \\ 0 & -R_5 & R_3 + R_5 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix}$$

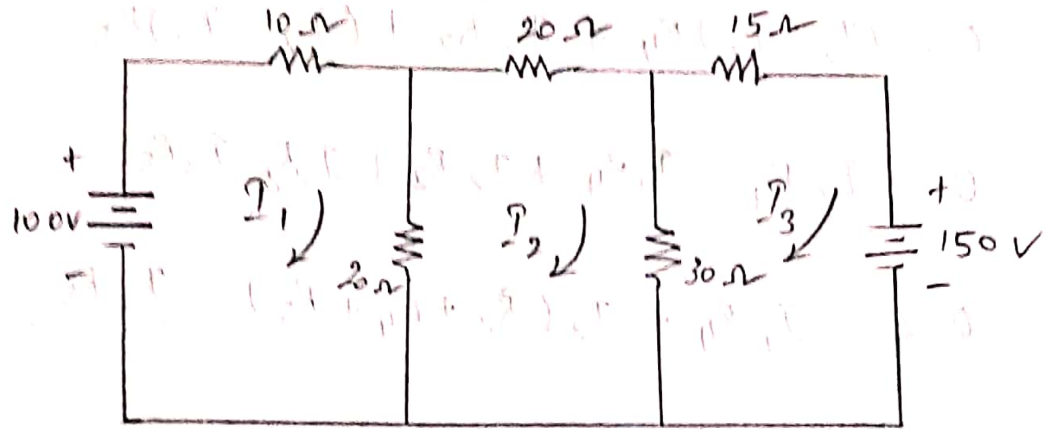
$$\Delta = \begin{vmatrix} R_{11} & R_{12} & R_{13} \\ R_{21} & R_{22} & R_{23} \\ R_{31} & R_{32} & R_{33} \end{vmatrix}$$

$$I_1 = \frac{\Delta_1}{\Delta}$$

$$I_2 = \frac{\Delta_2}{\Delta}$$

$$I_3 = \frac{\Delta_3}{\Delta}$$

1. Using mesh analysis, find mesh current in each loop for the given network.



loop: 1

Apply KVL

$$100 = 10 I_1 + 20 (I_1 - I_2)$$

$$100 = 10 I_1 + 20 I_1 - 20 I_2$$

$$100 = 30 I_1 - 20 I_2 \quad - ①$$

loop: 2

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

$$0 = 20 I_2 - 20 I_1 + 20 I_2 + 30 I_2 - 30 I_3$$

$$0 = -20 I_1 + 70 I_2 - 30 I_3 \quad - ②$$

loop: 3

$$-150 = 30 (I_3 - I_2) + 15 I_3$$

$$-150 = 30 I_3 - 30 I_2 + 15 I_3$$

$$-150 = -30 I_2 + 45 I_3 \quad - ③$$

$$\begin{bmatrix} 100 \\ 0 \\ -150 \end{bmatrix} = \begin{bmatrix} 30 & -20 & 0 \\ -20 & 70 & -30 \\ 0 & -30 & 45 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix}$$

$$\Delta = \begin{vmatrix} 30 & -20 & 0 \\ -20 & 70 & -30 \\ 0 & -30 & 45 \end{vmatrix}$$

$$= 30\left((70 \times 45) - (-30 \times -30)\right) - (-20)\left((-20 \times 45) - (0 \times -30)\right) + 0$$

$$= (94500 - 27000) + 20(-900)$$

$$= 67500 - 18000$$

$$\boxed{\Delta = 49,500}$$

$$\Delta_1 = \begin{vmatrix} 100 & -20 & 0 \\ 0 & 70 & -30 \\ -150 & -30 & 45 \end{vmatrix} = 100((70 \times 45) - 900) + 20(0 - (-30 \times -150)) + 0$$

$$= 225000 - 20(4500)$$

$$= 225000 - 90000$$

$$\boxed{\Delta_1 = 135000}$$

$$\Delta_2 = \begin{vmatrix} 30 & 100 & 0 \\ -20 & 0 & -30 \\ 0 & -150 & 45 \end{vmatrix} = 30(0-4500) - 100(-20 \times 45 - 0) + 0$$

$$= 30(-4500) - 100(-900)$$

$$= -135000 + 90000$$

$$\boxed{\Delta_2 = -45{,}000}$$

$$\Delta_3 = \begin{vmatrix} 30 & -20 & 100 \\ -20 & 70 & 0 \\ 0 & -30 & -150 \end{vmatrix} = 30(70 \times -150) + 20(-20 \times -150) - 0 + 100(-20 \times -30) + 0$$

$$= 30(-10500) + 20(+3000) - 0 + 100(600)$$

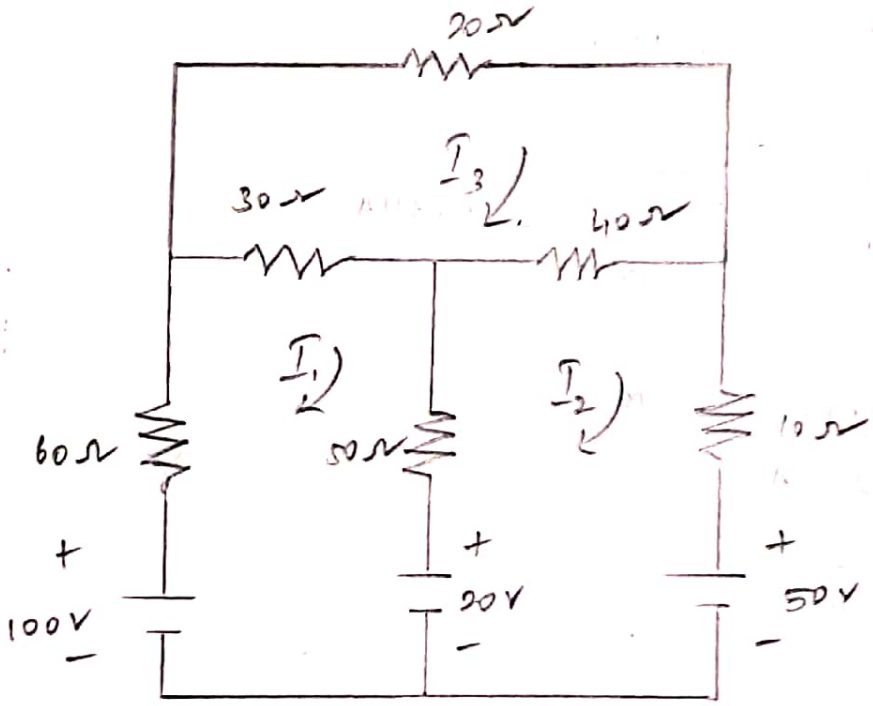
$$= -315000 + 60000 + 60000$$

$$\boxed{\Delta_3 = -195000}$$

$I_1 = \frac{\Delta_1}{\Delta} = \frac{135000}{49500}$	=	$I_1 = 2.73\ A$
$I_2 = \frac{\Delta_2}{\Delta} = \frac{-45000}{49500}$	=	$I_2 = -0.909\ A$
$I_3 = \frac{\Delta_3}{\Delta} = \frac{-195000}{49500}$	=	$I_3 = -3.94\ A$

In loop 2 & 3 the assumed current direction is opposite.
(anticlockwise → I_2 & I_3)

2. Find the loop currents for the given network using mesh analysis.



$$\begin{bmatrix} 100-20 \\ 20-50 \\ 0 \end{bmatrix} \begin{bmatrix} 60+30+50 & -50 & -30 \\ -50 & 50+40+10 & -40 \\ -30 & -40 & 20+30+40 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix}$$

$$\begin{bmatrix} 80 \\ -30 \\ 0 \end{bmatrix} \begin{bmatrix} 140 & -50 & -30 \\ -50 & 100 & -40 \\ -30 & -40 & 90 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix}$$

$$\Delta = \begin{bmatrix} 140 & -50 & -30 \\ -50 & 100 & -40 \\ -30 & -40 & 90 \end{bmatrix}$$

$$= 140(9000-1600)+50(-4500-1200)-30(2000-(-3000)$$

$$= 1036000 - 285000 - 150000$$

$$\boxed{\Delta = 601000}$$

Scanned with CamScanner

$$\Delta_1 = \begin{vmatrix} 80 & -50 & -30 \\ -30 & 100 & -40 \\ 0 & -40 & 90 \end{vmatrix}$$

$$= 80(9000 - 1600) + 50(-2700 - 0) - 30(1200 - 0)$$

$$= 592000 - 135000 - 36000$$

$$\boxed{\Delta_1 = 421000}$$

$$\Delta_2 = \begin{vmatrix} 140 & 80 & -30 \\ -50 & -30 & -40 \\ -30 & 0 & 90 \end{vmatrix}$$

$$= 140(-2700) - 80(-4500 - 1200) - 30(0 - 900)$$

$$= -378000 + 456000 + 27000$$

$$\boxed{\Delta_2 = 105000}$$

$$\Delta_3 = \begin{vmatrix} 140 & -50 & 80 \\ -50 & 100 & -30 \\ -30 & -40 & 0 \end{vmatrix}$$

$$= 140(0 - 1200) + 50(0 - 900) + 80(2000 + 3000)$$

$$= 140(-1200) + 50(-900) + 80(5000)$$

$$= -168000 - 45000 + 40000$$

$$\boxed{\Delta_3 = 1,87000}$$

,

$$I_1 = \frac{\Delta_1}{\Delta} = \frac{421000}{601000} = 0.7A$$

$$I_2 = \frac{\Delta_2}{\Delta} = \frac{105000}{601000} = 0.174\ A$$

$$I_3 = \frac{\Delta_3}{\Delta} = \frac{187000}{601000} = 0.311A$$

The loop currents are

$I_1 = 0.7A$
$I_2 = 0.174\ A$
$I_3 = 0.311A$