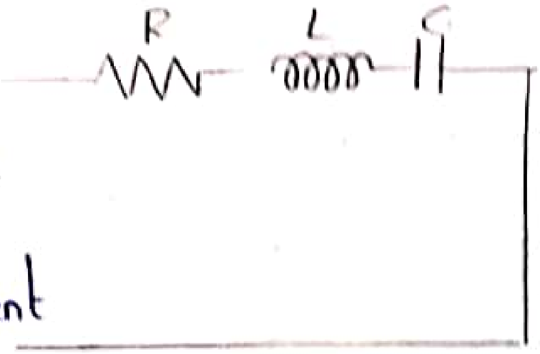
18/6/19

4. Introduction To Electrical Circuits

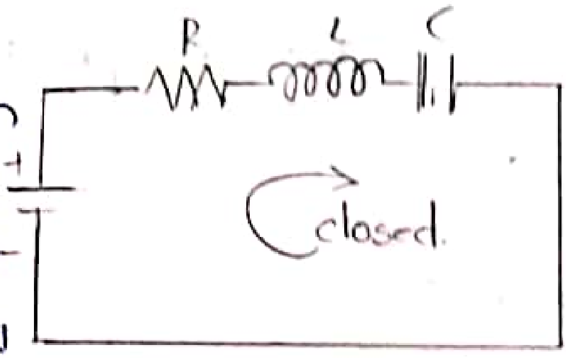
Electric Network:

An electric network is an interconnection of various network elements. It does not have any closed path for the electric current to flow.



Electrical Circuits:

It is an interconnection of network elements and also possess (or) contains a closed path for the current to flow through it.



All electrical circuits can be electrical network.

Basic Definitions:

i) Electric Charge: [that causes it to experience a force when placed in an electromagnetic field.

It is the basic property of matter. It is represented by q (or) Q.

@. If a body possess more no.of positive chg compare to electrons then it is said to be positively charged body.

(b) If a body possess more electrons compare to protons it is said to be negatively charged body.

(c) If both charges are equal then the body is said to be neutrally charged.

Units: Coulombs.

Electric Current:

The rate of flow of electric charge is called Electric current. It is represented by i (or) I.

Units: Amperes = $\frac{\text{coloumbs}}{\text{sec.}}$

Electric Potential (or) Pontential Difference (or) Voltage:

The work done by charge. $V = \frac{W}{q}$.

→ Voltage or potential is defined as work done by unit charge

→ The difference in the electric potential of two charged body's is known as Potential Difference.

Units: Volts.

Electric Power:

Power is the rate of change of energy.

Power (P) = $\frac{\text{Energy}}{\text{time}}$ $\boxed{\therefore P = VI}$

Units: J/s (or) watts.

Electric Energy:

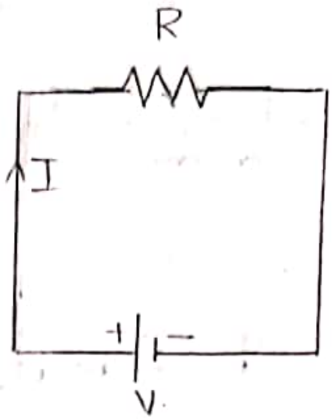
The capacity of doing work (E).

Units: watt - hrs.

$E = P \times t$.

Ohm's Law:

At a constant temperature, the current flowing through a conductor is directly proportional to applied voltage (or) potential difference.



$V \propto I$

$V = IR$

Resistance.

$I \propto V$

$I = \frac{1}{R} \cdot V$

$I = K \cdot V$

i.e, $K = 1/R$

$G = \frac{1}{R}$ = conductance
℧

EMF:

When other forms of energy is converted into electrical energy then that developed energy is named as ElectroMotive Force (EMF)

Units: Volts

Eg: Emf of transformer, generator, Lead Cell.

Classification Of Network Elements:

1. Active And Passive Elements.
2. Linear and Non-linear Elements.
3. Unilateral and Bilateral Elements.
4. Lumped and Distributed Elements.

1. Active Elements And Passive Elements:

Active Elements:

The elements that are capable of generating the electric power are known as Active Elements.

Eg: Batteries, A.C generators, D.C generators, Transformers, Solar Cells etc.,

Passive Elements:

The elements that are not capable of generating the electric power are known as Passive Elements. They absorbs electric power. They act as sinks.

Eg: Resistors, Inductors, Capacitors.

2. Linear & Non-linear Elements:

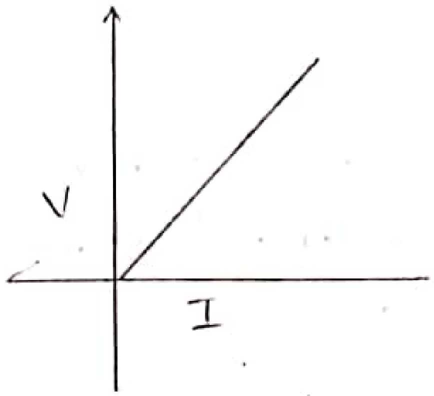
Linear Elements:

The elements which obey ohm's law (or) The elements in which the V-I characteristics is a straight line passing through origin are known as linear Elements

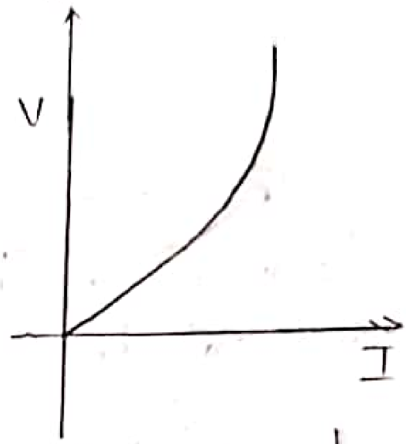
→ The elements.

Non-Linear Elements:

The elements which doesnot obey ohm's law(or) The elements in which the V-I characteristic is a curve path passing through origin are known as Non-linear Elements.



Linear elements



Non-Linear elements

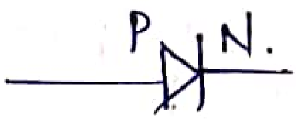
Eg: Resistor.

Eg: P-N diode, zener diode, transistor etc..,

Unilateral And Bilateral Elements: (Unidirection & bidirection elements.)

The elements which allows the current to flow through them in only one direction are known as unidirectional elements (or) unilateral elements.

Eg:- Diodes, transformer.



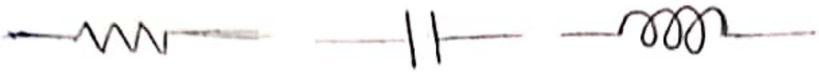
The elements which allows the current to flow through them in either directions

Eg:- resistors, inductors and capacitors.

Lumped And Distributed Parameters:

These elements are very small in size and have a physical appearence and can be electrically seperable.

Eg: Small resistances, capacitors, inductors, diodes etc.,



The elements (or) parameters spreads over long distances and they don't have any physical appearence and can't be electrically seperable.

Eg: RLC parameters of a transmission line.

Resistance:

It is a property of matter by which it opposess the flow of current through it.

→ It is represented by R.

Units: ohm (Ω)

→ Whenever a current passes through a resistor some power loss takes place in the resistor and is disspated in the form of heat to the outside atmosphere.

$V = IR.$

$P = VI$

$P = V^2/R.$

$P = I^2 R$

→ It is physically represented as

$$R = \frac{\rho l}{a}.$$

ρ = resistivity (or) specific resistance (Ω-m)

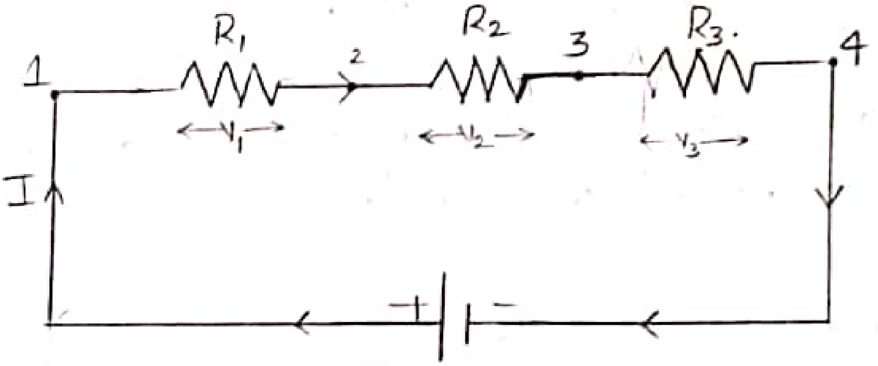
l = length of resistor (m)

a = area of cross section (m^2)

→ Specific resistance is defined as the resistance offered by a cube (1 unit length 1 unit cross sectional area).

It varies from material to material.

Resistors Connected In Series:



Characteristics Of Series Circuit:

→ Current through each element connected in series circuits is same.

→ Voltage division across each element takes place.

→ The total voltage across the circuit is equal to sum of voltage drops across each resistor.

$$V = V_1 + V_2 + V_3.$$

According to ohm's law

$$V = IR$$

$$V_{eq} = I R_{eq}$$

According to characteristics of series equivalent,

$$V = V_1 + V_2 + V_3$$

$$I R_{eq} = IR_1 + IR_2 + IR_3$$

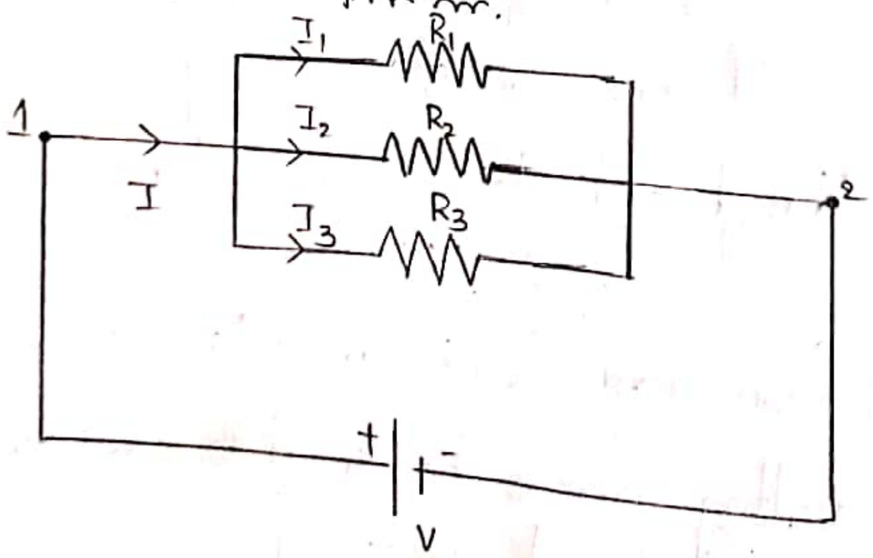
$$R_{eq} = R_1 + R_2 + R_3.$$

If n resistors are connected in series then,

$$R_{eq} = R_1 + R_2 + R_3 + \ldots\ldots + R_n.$$

Note: If two resistors are said to be connected in series if they are connected to one node.

Resistors Connected In parallel:



Characteristics Of Parallel Circuits:

→ Current division in each element connected in parallel will takes place.

→ Voltage is same through each element connected in parallel

According to ohm's law,

$$V = IR$$

$$V = I R_{eq}.$$

According to characteristic of parallel equivalent.

$$I = I_1 + I_2 + I_3$$

$$\frac{V}{R_{eq}} = \frac{V}{R_1} + \frac{V}{R_n} + \frac{V}{R_3}$$

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

If n resistors are connected in parallel then,

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

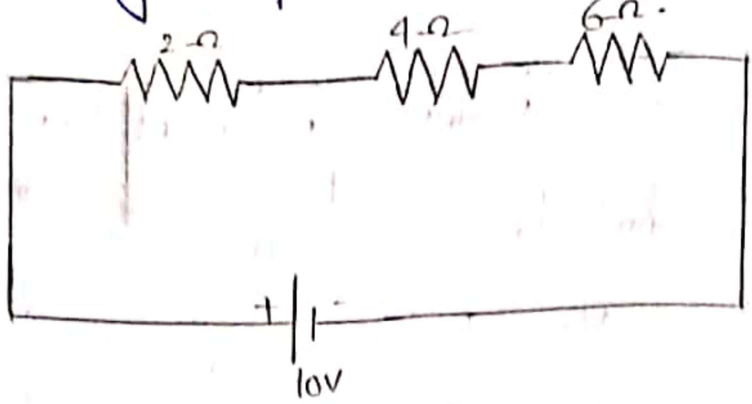
Note: If two resistors are said to be connected in parallel if the two ends of terminals connected to two different nodes.

For n equivalent resistors i-e, $R_1 = R_2 = R_3 = \cdots = R_n$

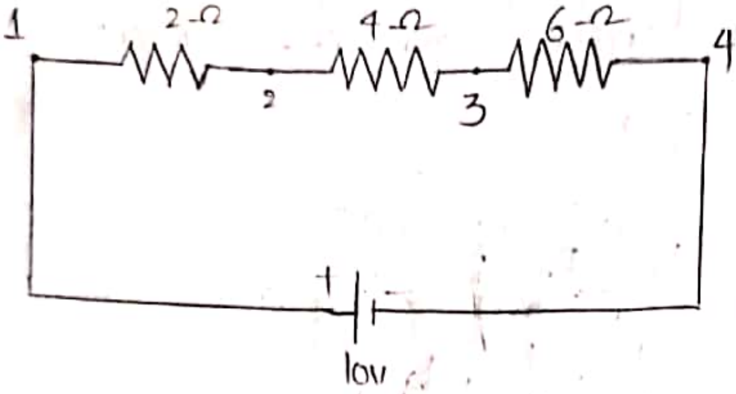
In series $R_{eq} = nR_n$

parallel $R_{eq} = \frac{R_n}{n}.$

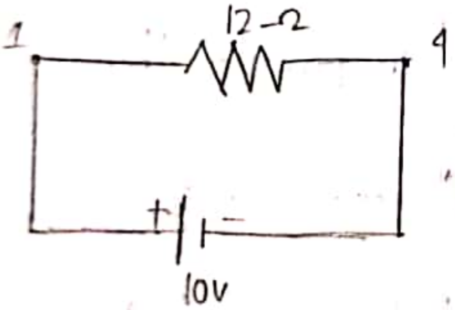
Q Find the equivalent resistance of the circuit shown below and find the voltage drop across each resistor.



Ans:



The resistances b/w 1^{st} node and 4^{th} nodes are in series i.e,



$$R_{eq} = R_1 + R_2 + R_3$$
$$= 2 + 4 + 6$$
$$= 12\Omega.$$

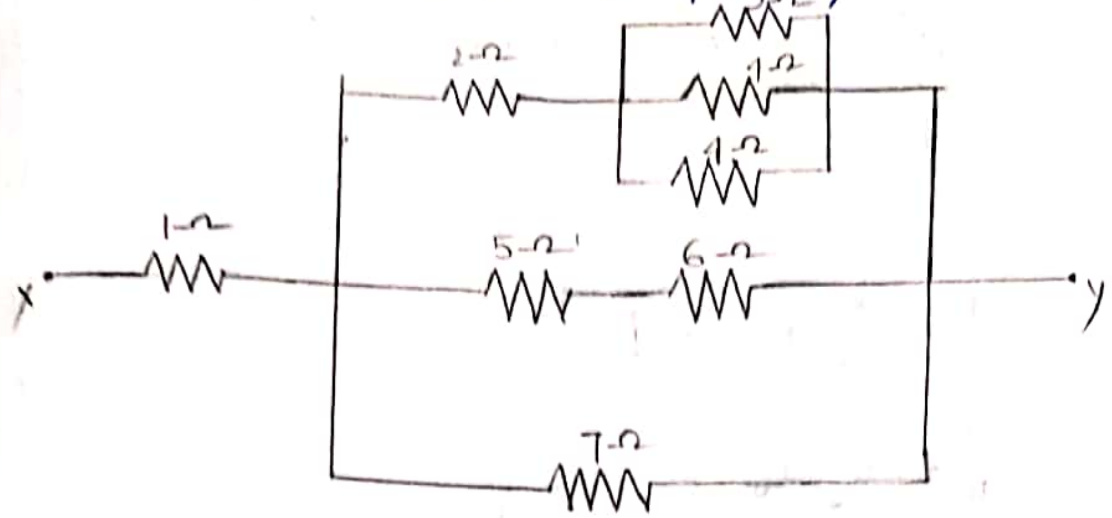
as we know $V = I R_{eq}$

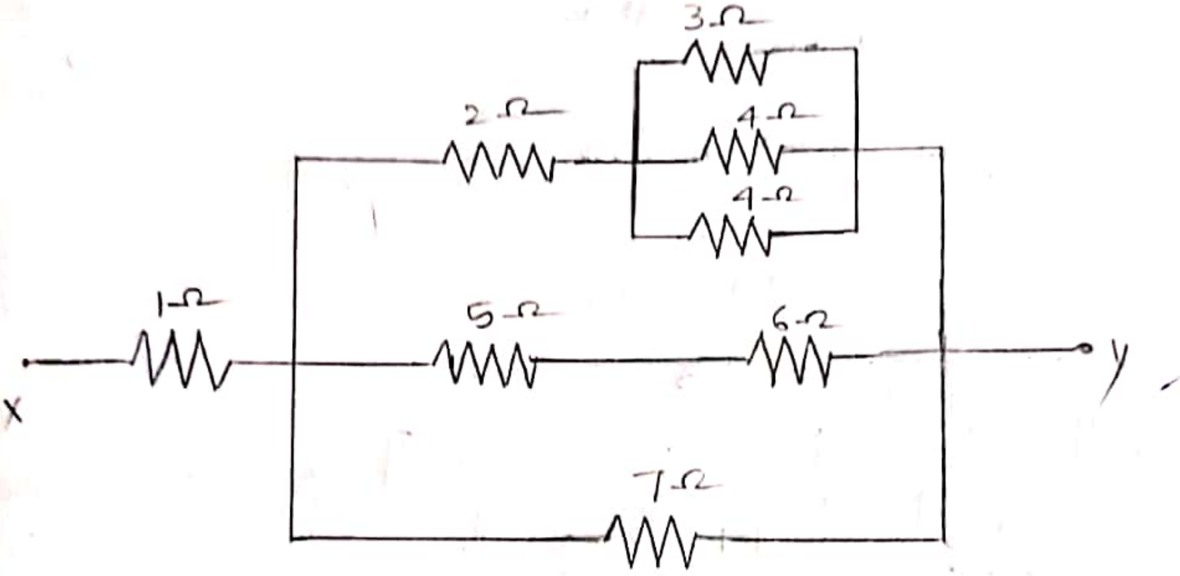
$$I = \frac{V}{R_{eq}} = \frac{10}{12} = \frac{5}{6} = 0.833A$$

V across 2Ω	V across 4Ω	V across 6Ω
$V_1 = IR_1$	$V_2 = IR_2$	$V_3 = IR_3$
$= (0.833)(2)$	$= 0.833 \times 4$	$= 0.833 \times 6$
$= 1.66\ V$	$= 3.32\ V$	$= 4.998V$

∴ Voltage across each resistors are 1.66V, 3.32V, 4.998V

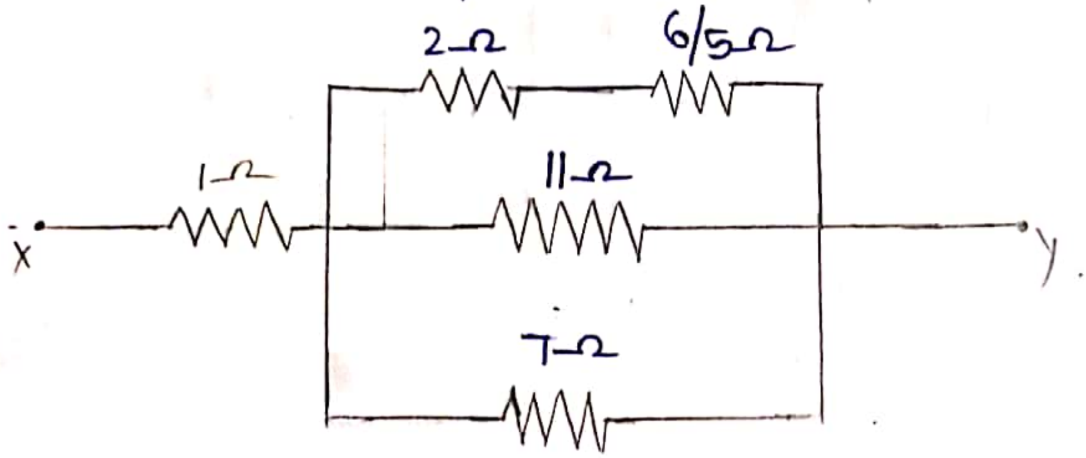
Q Find the equivalent resistance b/w x & y.





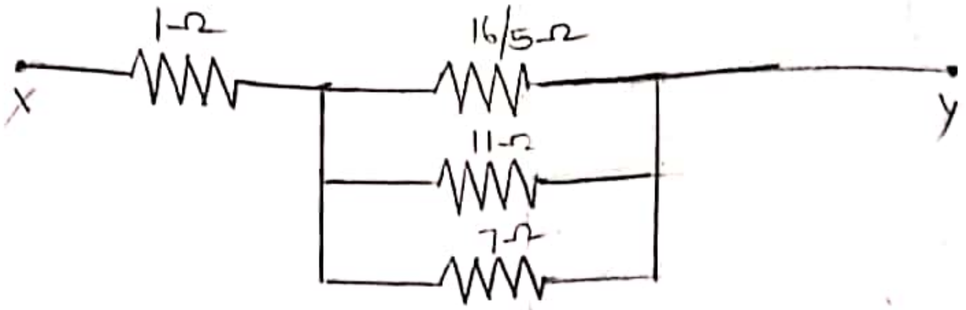
$$1/R = \frac{1}{3} + \frac{1}{4} + \frac{1}{4} = 5/6$$

$$R = 6/5\ \Omega.$$



$R = 2 + 6/5 = 16/5\,\Omega$

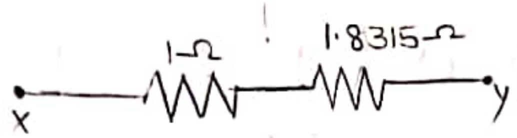
Ans:



$$\frac{1}{R} = \frac{5}{16} + \frac{1}{11} + \frac{1}{7}$$

$$\frac{1}{R} = 0.546$$

$$R = \frac{1}{0.5462} = 1.8315\,\Omega.$$

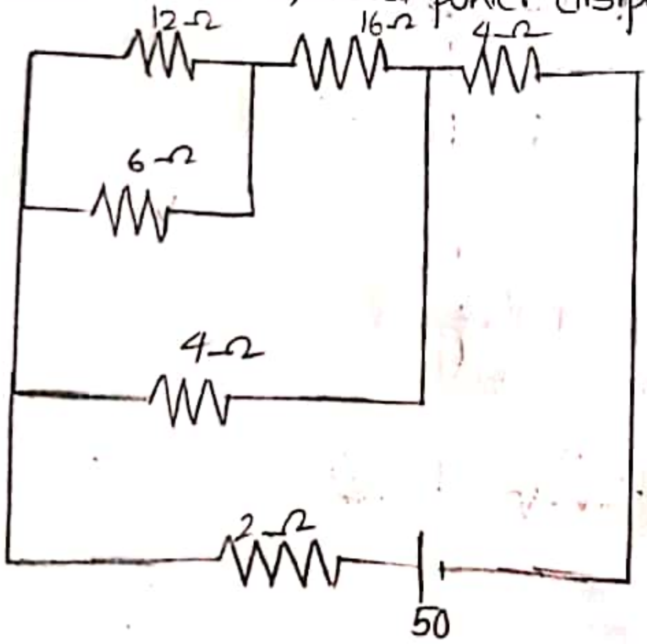


$R = 1 + 1.8315$

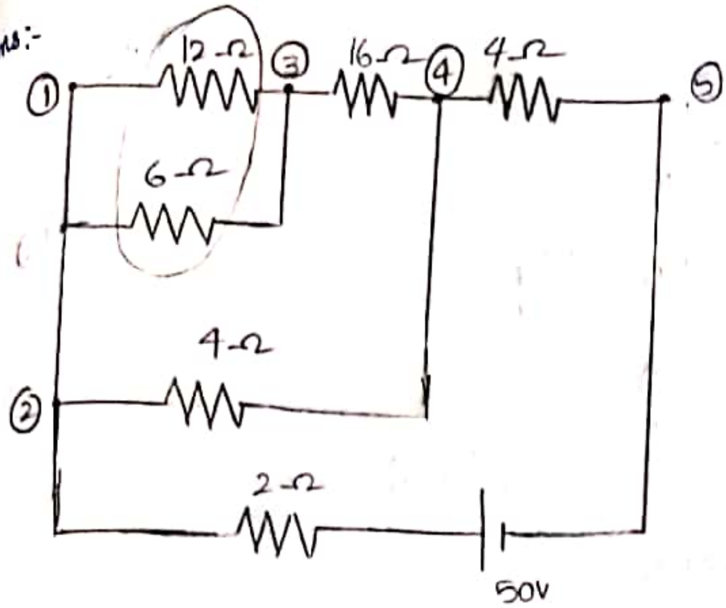
$= 2.8315.$

Q For the network shown below calculate the equivalent resistance, source current, total power dissipated.

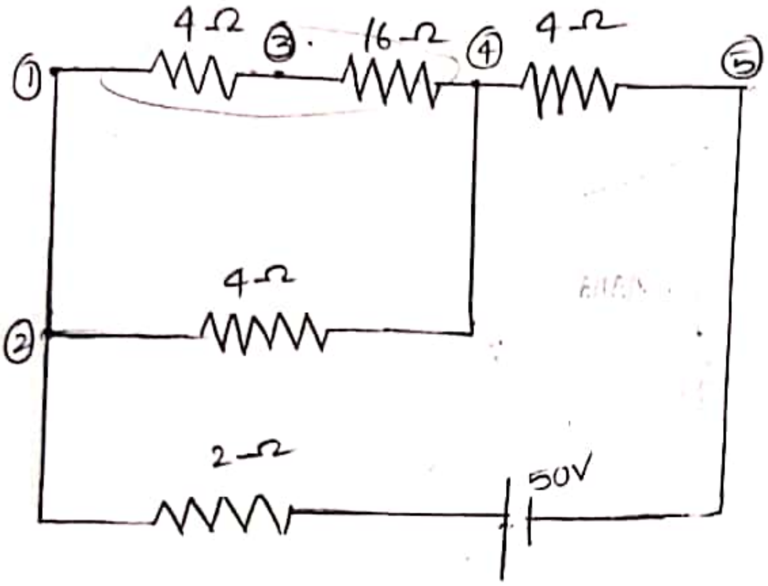
Ans:



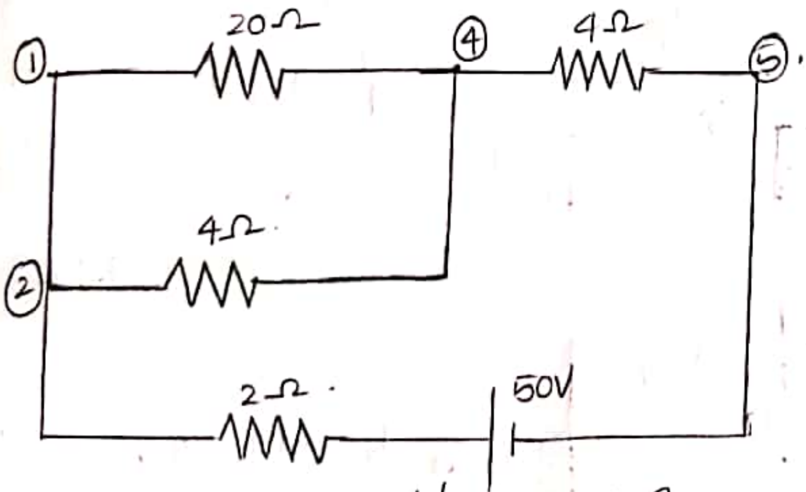
Ans:-



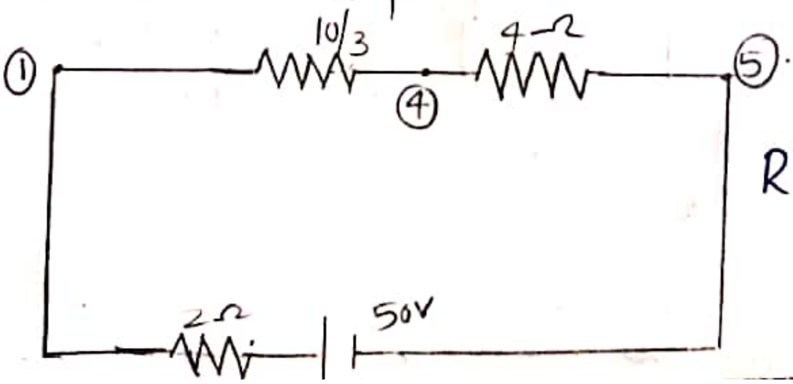
$$\frac{1}{R} = \frac{1}{6} + \frac{1}{12}$$
$$= \frac{2+1}{12} = \frac{\cancel{3}\,1}{\cancel{12}\,4}$$
$$R = 4\Omega.$$



$$R = 4\Omega + 16\Omega$$
$$= 20\Omega.$$



$$\frac{1}{R} = \frac{1}{20} + \frac{1}{4}$$
$$= \frac{1+5}{20} = 3/10$$
$$R = 10/3.$$



$$R = \frac{10}{3} + 4 + 2 = 22/3 + 2\,\Omega.$$
$$= 28/3\,\Omega$$
$$= 9.33\Omega.$$

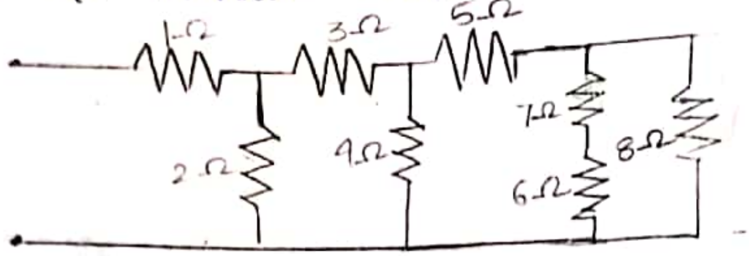
$V = IR$.

$$P_{dis} = VI = V^2/R = \frac{50 \times 50}{9.33}$$

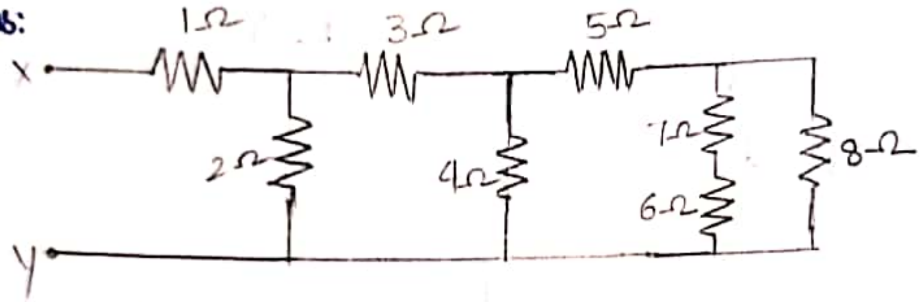
$$= 267.95W$$

$$I = \frac{50}{9.33} = 5.33A.$$

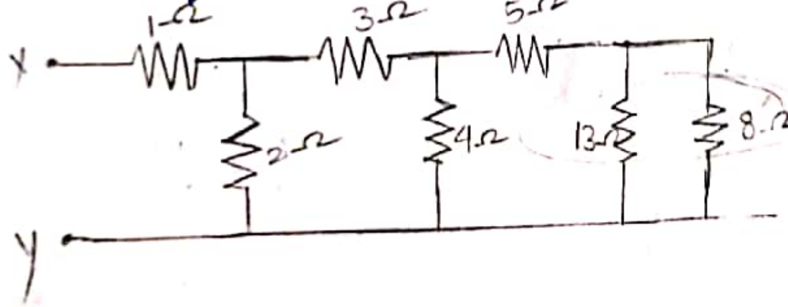
Q Find the equivalent resistance b/w the terminals x and y of the network shown.



Ans:



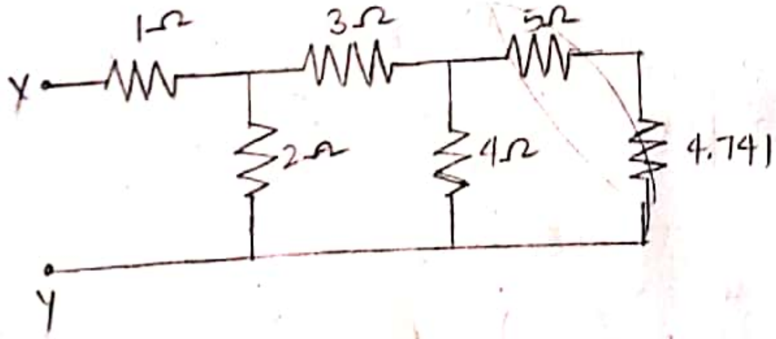
$R_{eq} = 7+6 = 13\Omega$.



$$\frac{1}{R} = \frac{1}{13} + \frac{1}{8}$$

$1/R = 0.2\cancel{10}\Omega$

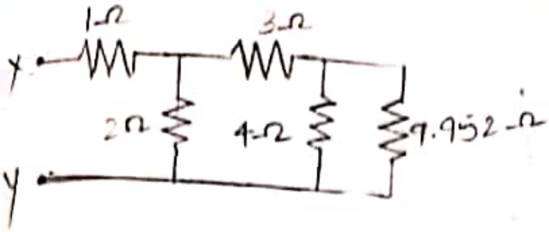
$\cancel{R = 4.9741}$ $R = 4.9529$



$R = 5 + 4.9529\Omega$

$\cancel{= 9.741\Omega}$.

$= 9.9529\Omega$.

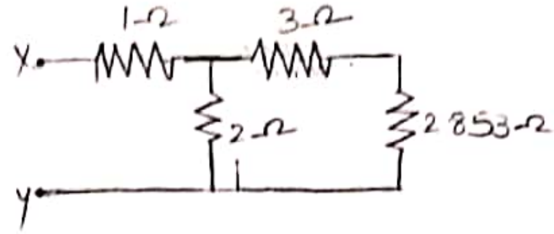


$$\frac{1}{R} = \frac{1}{4} + \frac{1}{9.9529}$$

$$\frac{1}{R} = 0.3504$$

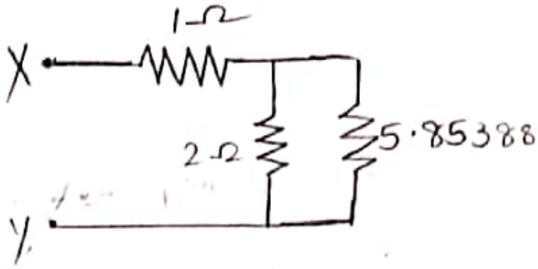
$$R = \frac{1}{0.3504}$$

$$= 2.853$$



$$R = 3 + 2.85388$$

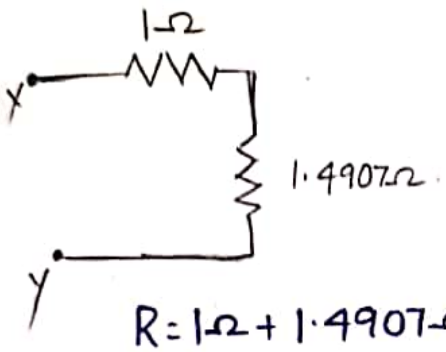
$$= 5.85388\,\Omega.$$



$$1/R = \frac{1}{2} + \frac{1}{5.853}$$

$$1/R = 0.6708$$

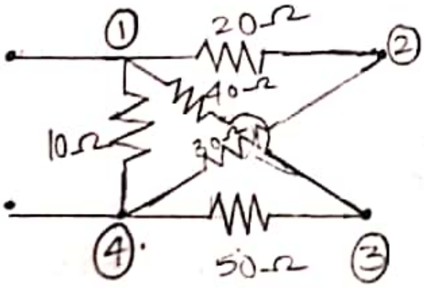
$$R = 1/0.6708 = 1.4907$$



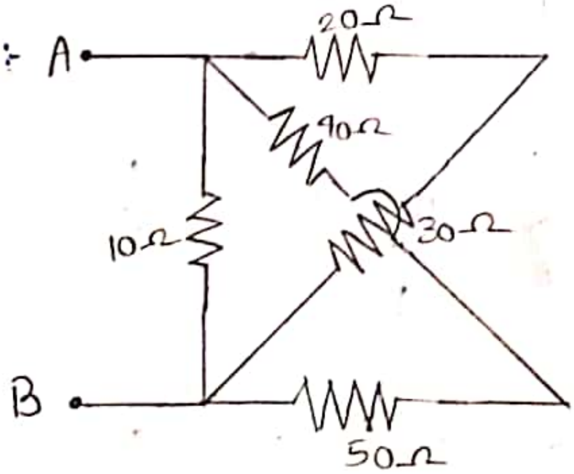
$$R = 1\Omega + 1.4907\,\Omega$$

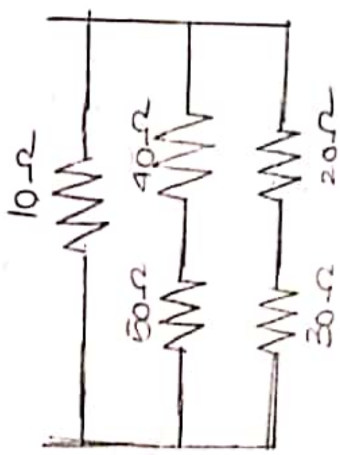
$$= 2.4907\,\Omega.$$

Q



Ans:-



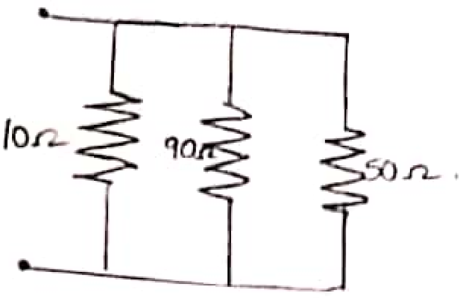


$$R_{eq} = 30 + 20$$

$$= 50\,\Omega$$

$$R_{eq} = 50 + 40$$

$$= 90\,\Omega.$$



$$\frac{1}{R} = \frac{1}{10} + \frac{1}{90} + \frac{1}{50}$$

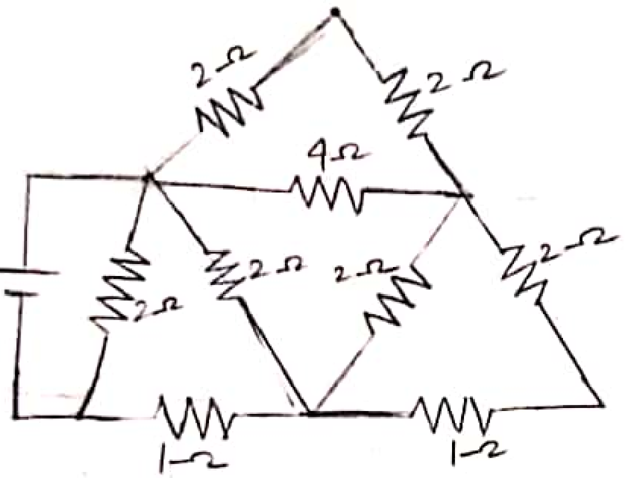
$$= \frac{1}{10}\left(1 + \frac{1}{9} + \frac{1}{5}\right)$$

$$= \frac{1}{10}\left(\frac{45+5+9}{45}\right)$$

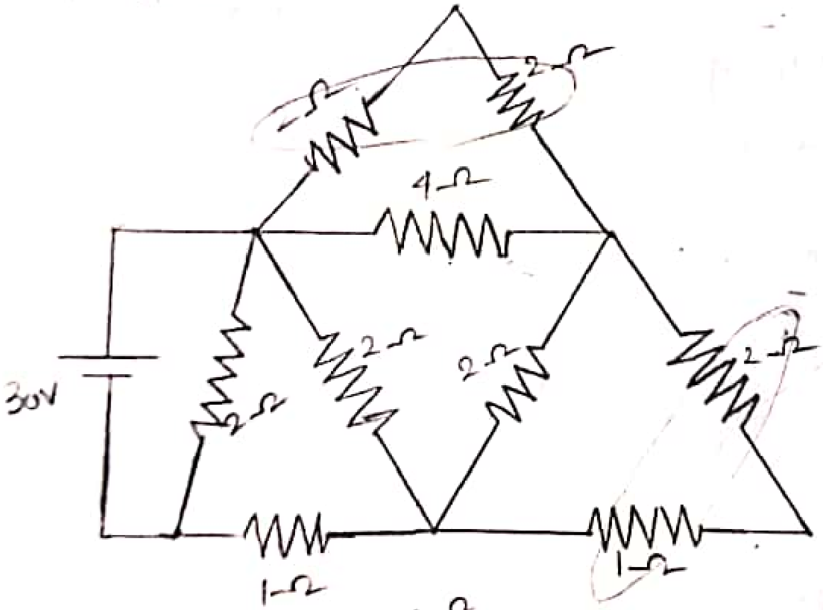
$$\frac{1}{R} = \frac{59}{450} \qquad R = \frac{450}{59}\,\Omega$$

$$= 7.6271\,\Omega.$$

Q2)

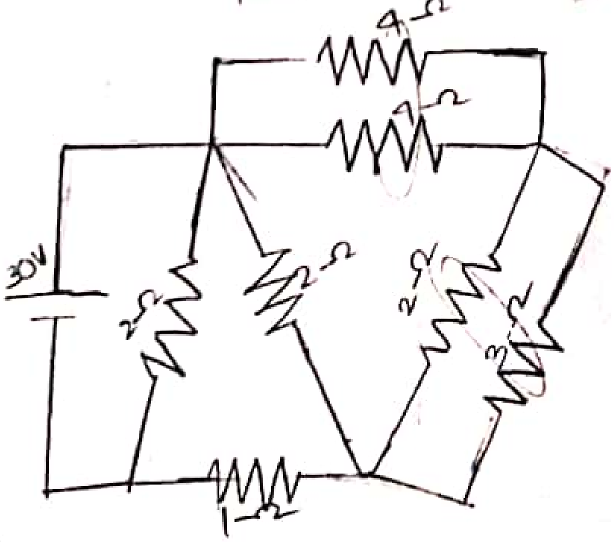


Ans:



Req = 2+1
= 3Ω

Req = 2+2
= 4Ω

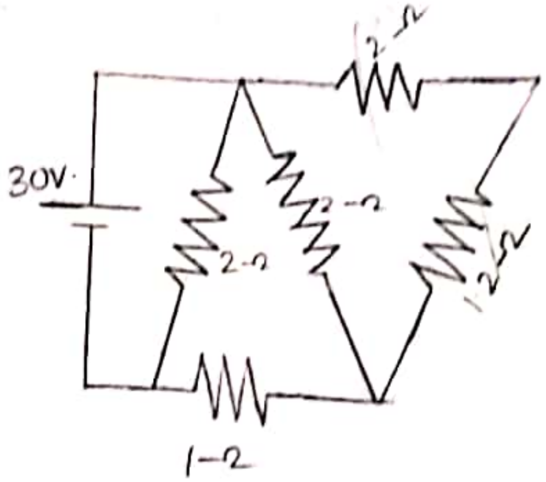


$$\frac{1}{R} = \frac{1}{4} + \frac{1}{4} = \frac{1}{2}$$

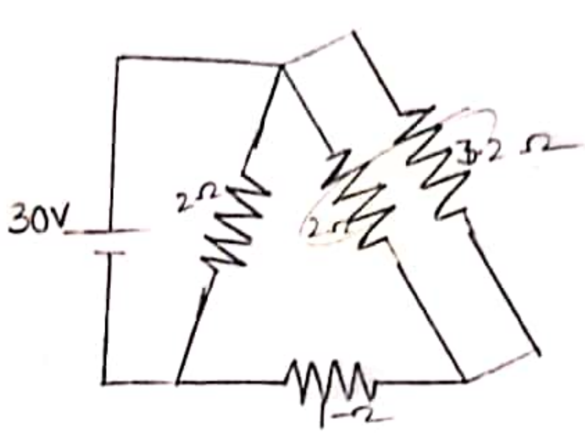
$$R = 2\,\Omega$$

$$\frac{1}{R} = \frac{1}{2} + \frac{1}{3} = \frac{5}{6}$$

$$R = \frac{6}{5} = 1.2\,\Omega$$

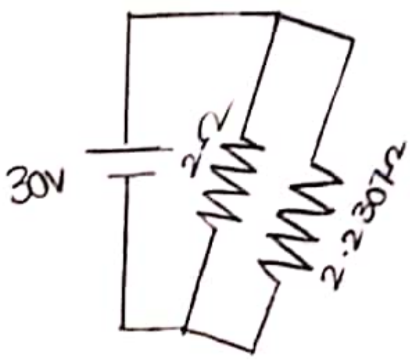


$$R_{eq} = 2\,\Omega + 1.2\,\Omega$$
$$= 3.2\,\Omega.$$



$$\frac{1}{R_{eq}} = \frac{1}{2} + \frac{1}{3.2}$$
$$\frac{1}{R_{eq}} = \frac{13}{16}$$
$$R_{eq} = \frac{16}{13}$$
$$= 1.2307$$

$$R_{eq} = 1.2307 + 1\,\Omega$$
$$= 2.2307\,\Omega.$$

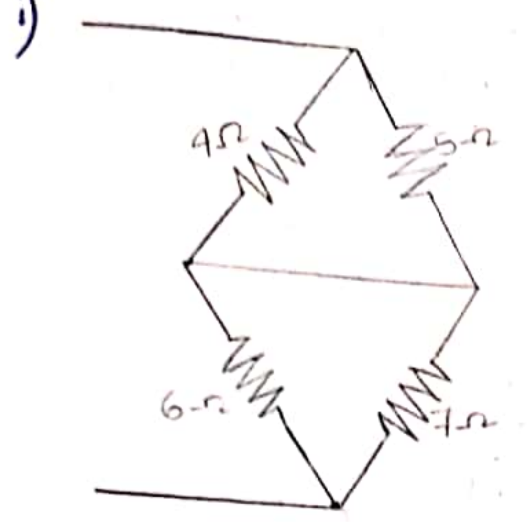


$$\frac{1}{R_{eq}} = \frac{1}{2} + \frac{1}{2.307}$$
$$\frac{1}{R_{eq}} = 0.98334$$
$$R_{eq} = \frac{1}{0.9334} = 1.07135$$

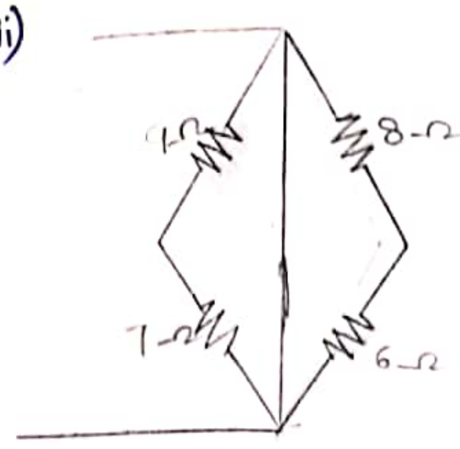
$$I = V/R = \frac{30}{1.0713} = 28.0033\,A$$

Q. Find the equivalent resistance b/w the terminals x and y of the networks shown

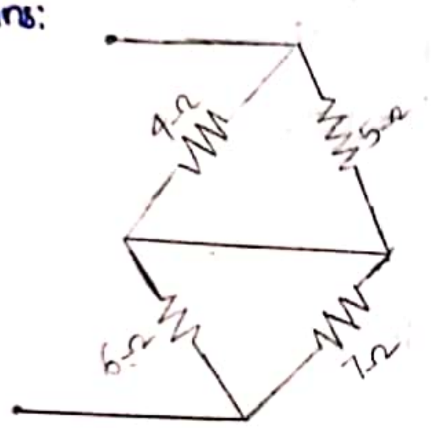
i)



ii)



Ans:



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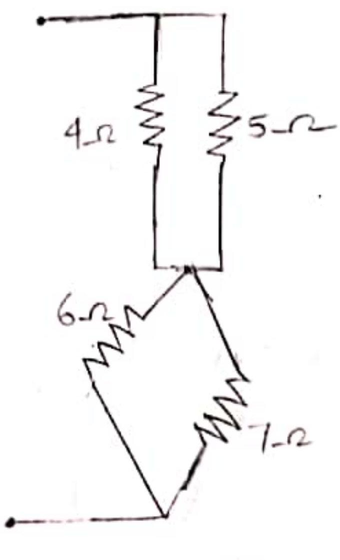


$$\frac{1}{R_{eq}} = \frac{1}{4} + \frac{1}{5}$$

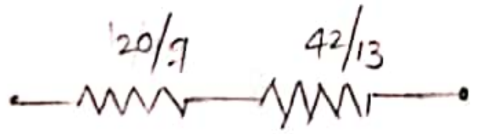
$$= \frac{9}{20}$$

$$R_{eq} = 20/9.$$

$$1/R_{eq} = \frac{1}{6} + \frac{1}{7}$$

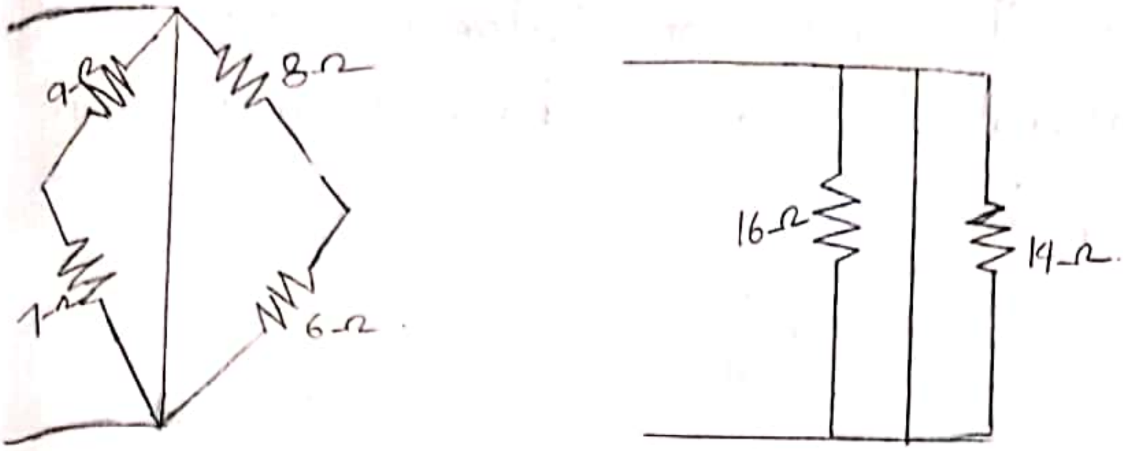
$$= \frac{13}{42}$$

$$R_{eq} = \frac{42}{13}.$$



$$R_{eq} = \frac{20}{9} + \frac{42}{13}$$

$$= 5.4529\,\Omega.$$



A short circuit wire is parallel with two resistors.
∴ the resistance among all the resistors is equal to zero.

Inductor:

It is the property of matter by virtue of it opposes the change of current flowing through it. It is represented by L.

Units: Henry's

Mathematically inductance is given by,

$$l = \frac{N\phi}{i}$$

where, N = No. of turns in the coil
ϕ = flux linking the coil.
i = current passing through coil.

Inductor stores energy in the form of electro magnetic field.

The coil possess a self inductance of 1 Henry when a current of 1A flowing through it produces a flux linkage of 1 Wb-turn in it.

The voltage across an inductor induced is directly proportional to the rate of change of current flowing through it i.e.,

$$V \alpha \frac{di}{dt}$$

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

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

where L = inductance of the coil.

The current through an inductor cannot change instantly. i.e.,

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

$$Vdt = L\,di$$

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

Integrating on both sides with dt. limits 0 to t

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

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

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

Power:

power through an inductor is given by

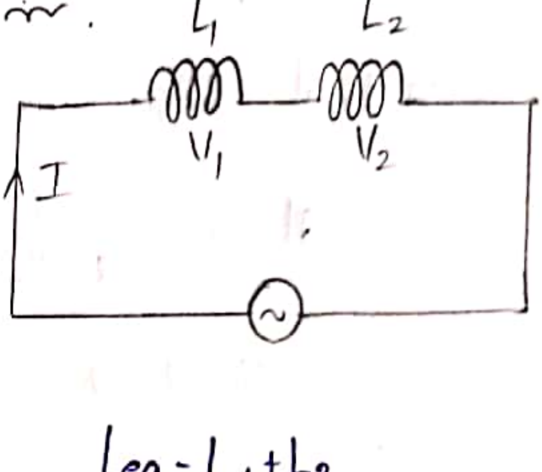
$$P = Vi$$
$$= L\frac{di}{dt} \cdot i$$
$$= Li\frac{di}{dt}.$$

Energy:

$$\text{Energy} = p \times t$$
$$= \int_0^t p\,dt$$
$$= \int_0^t Li\frac{di}{dt}\,dt = \frac{1}{2}LI^2.$$

$$\boxed{E = \tfrac{1}{2}LI^2}$$

Inductors Connected In Series:



$$V = V_1 + V_2.$$

$$V = L_{eq}\frac{di}{dt} \quad V_1 = L_1\frac{di}{dt}$$

$$V_2 = L_2\frac{di}{dt}.$$

$$L_{eq} = L_1 + L_2.$$

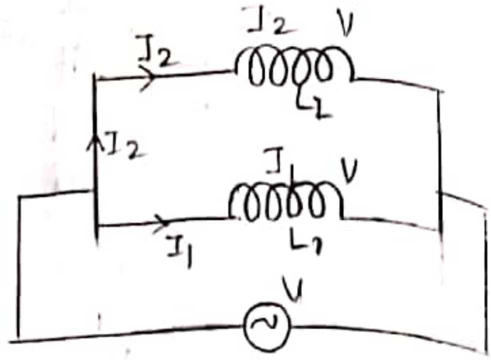
$$V = V_1 + V_2$$

$$L_{eq}\cancel{\frac{di}{dt}} = L_1\cancel{\frac{di}{dt}} + L_2\cancel{\frac{di}{dt}}$$

If n inductors are connected in series then,

$$L_{eq} = L_1 + L_2 + \dots\dots + L_n$$

Inductors Connected in parallel:



$$V = L_{eq}\frac{di}{dt}$$

$$V_1 = L_1\frac{di_2}{dt} \qquad V_2 = L_2\frac{di_2}{dt}$$

$$I = I_1 + I_2$$

$$\frac{di}{dt} = \frac{di_1}{dt} + \frac{di_2}{dt}.$$

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

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

(or)

$$I = I_1 + I_2$$

$$i = \frac{1}{L_{eq}}\int v\,dt$$

$$i_1 = \frac{1}{L_1}\int v_1 dt \qquad i_2 = \frac{1}{L_2}\int V_2\,dt.$$

$$V_1 = V_2 = V$$

$$\frac{1}{L_{eq}}\cancel{\int v\,dt} = \frac{1}{L_1}\cancel{\int v\,dt} + \frac{1}{L_2}\cancel{\int v\,dt} \Rightarrow \frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2}$$

If 'n' inductors are connected in parallel, then,

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

Capacitance (C):

It is a property of a material which opposess the applied voltage across unit.

Unit: Farad's (F).

Two Conducting plates seperated by air (or) any other dielectric medium acts as a capacitor.

Mathematically capacitance is given by,

$$C = \frac{\varepsilon A}{d}.$$

$$\varepsilon = \varepsilon_0 \varepsilon_r.$$

ε_0 = permability of free space

$= 8.84 \times 10^{-2}$ F/m.

ε_r = Relative permability of dielectric medium.

A = Area of plates

d = distance b/w plates.

When voltage is applied across a capacitor a charge will be deposited (or) acquired across the plates. The charge deposited is directly proportional to the applied voltage.

i.e.,

$$q \propto v$$

$$q = kv$$

$$q = CV$$

The current flowing through a capacitor can be obtained as:

$$q = CV$$

differeventiating on bothsides.

$$\frac{dq}{dt} = \frac{d}{dt}(CV)$$

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

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

→ Voltage across capacitor is

$$i\,dt = C\,dv$$

$$dv = \frac{1}{C}\,i\,dt$$

Integrating on both sides

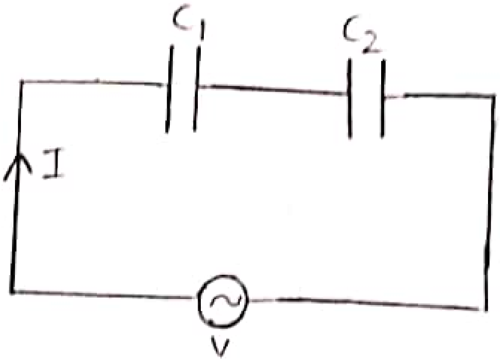
$$\int_0^t dv = \int_0^t \frac{1}{C}\,i\,dt.$$

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

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

Capacitors In Series:

$$V = V_1 + V_2$$



$$V = \frac{I}{C_{eq}} \quad V_1 = \frac{I}{C_1} \quad V_2 = \frac{I}{C_2}.$$

$$\frac{I}{C_{eq}} = \frac{I}{C_1} + \frac{I}{C_2}$$

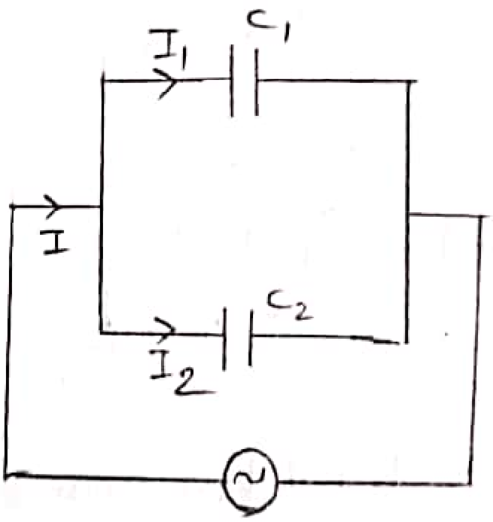
$$\Rightarrow \frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$

If n capacitors are connected in series then the capictance is given as

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

Capacitors In parallel:

$$I = I_1 + I_2.$$



$$V = V_1 = V_2$$

$$I = C_{eq}V \quad I_1 = C_1V_1 \quad I_2 = C_2V_2.$$

$$I = I_1 + I_2$$

$$C_{eq}V = C_1V_1 + C_2V_2$$

$$C_{eq} = C_1 + C_2.$$

If 'n' capacitors are connected in paralle then the capacitance is given by

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

Energy Sources:

Active & Passive Elements.

- Active Elements.
  - Dependent Source
    - VDVS
    - VDCS
    - CDVS
    - CDCS
  - Independent Source.
    - Ideal.
      - Voltage
      - Current
    - Practical.
      - Voltage
      - Current.
- Passive Elements.
  - Resistors
    - linear
    - Non linear
  - Inductors
    - linear
    - Non-linear
  - Capacitors
    - linear
    - Non linear

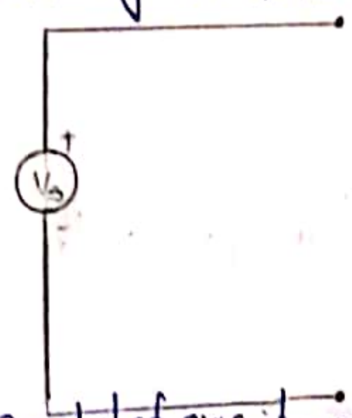
Independent Sources:

1) Voltage Sources:

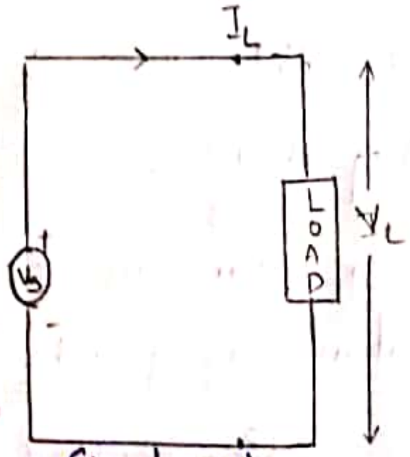
i) Ideal Voltage sources:

ii) Practical Voltage Sources

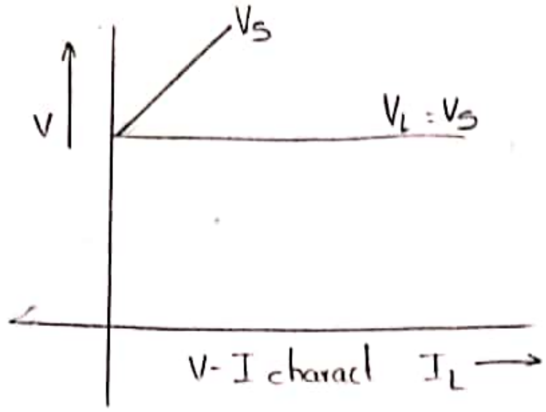
i) Ideal Voltage Sources:



Symbol of circuit model

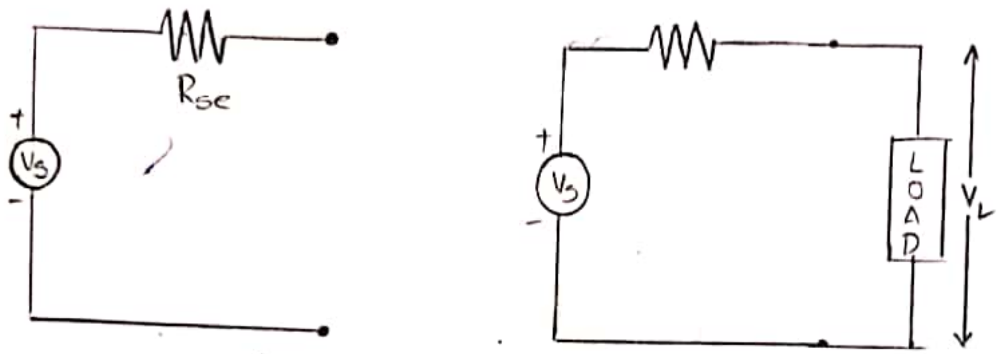


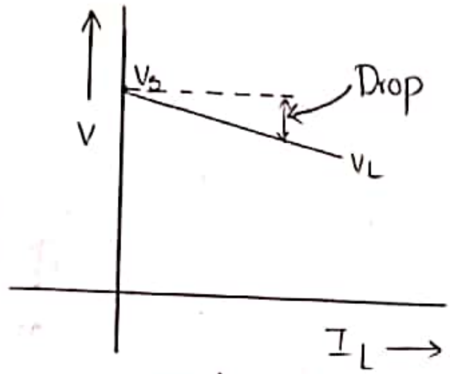
Circuit mode.



V-I charact

ii) Practical Voltage Sources:





V-I characteristics

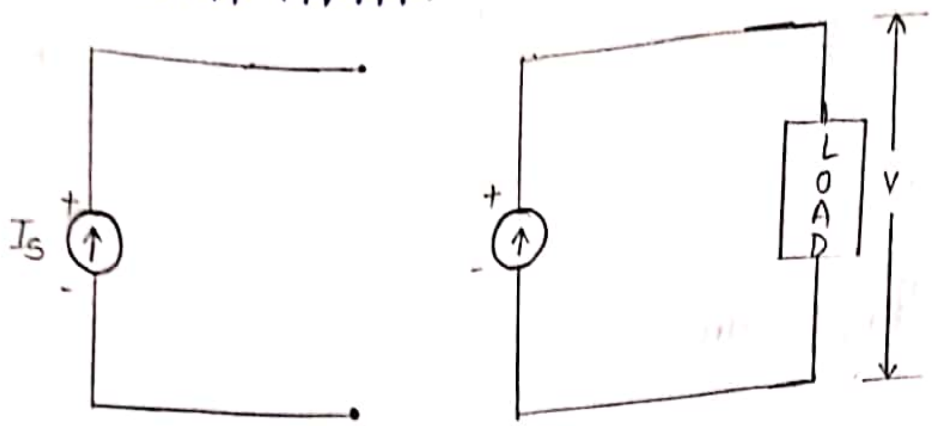
Ideal voltage source is defined as energy source which gives constant voltage across its terminals irrespective of the current drawn by the load.

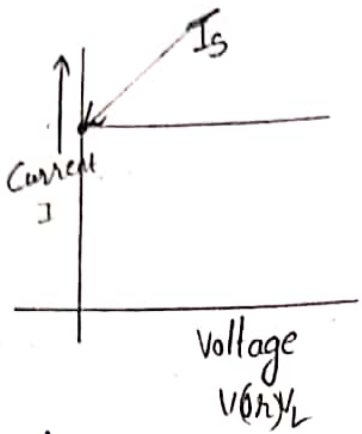
Practical voltage source has some internal resistance in which some voltage drop takes place and there by the voltage across its terminals decreases

$$V_L = V_S - I_S R_{se}.$$

Current Source:

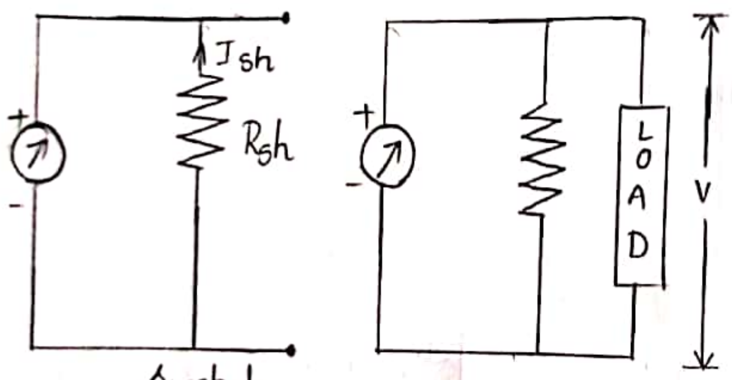
1) Ideal Current Source:





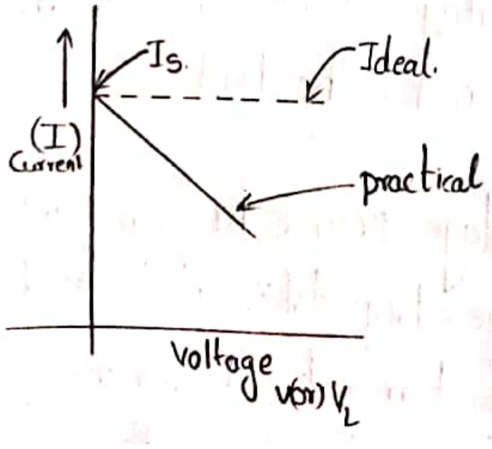
V-I characteristics

2) Practical Current Source:



Symbol.

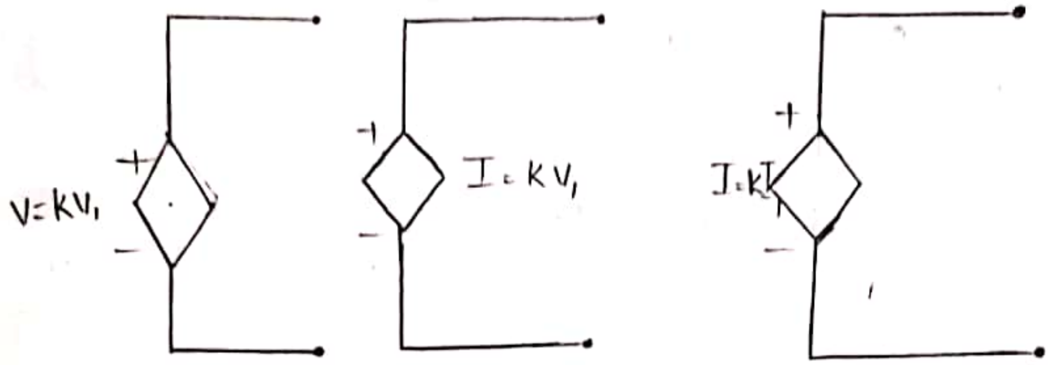
Eg:- lightening stroke, impulse generator (laboratory)

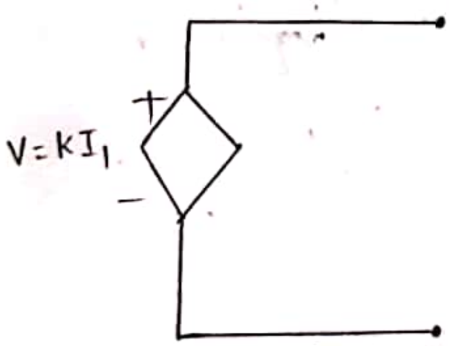


→ Ideal current source is the source which gives constant current across its terminals irrespective of the voltage appearing across terminals.

→ Practical current source has some internal resistance which is in parallel with the current source because of internal resistance some voltage drop takes place there by current falls.

Dependent Sources:

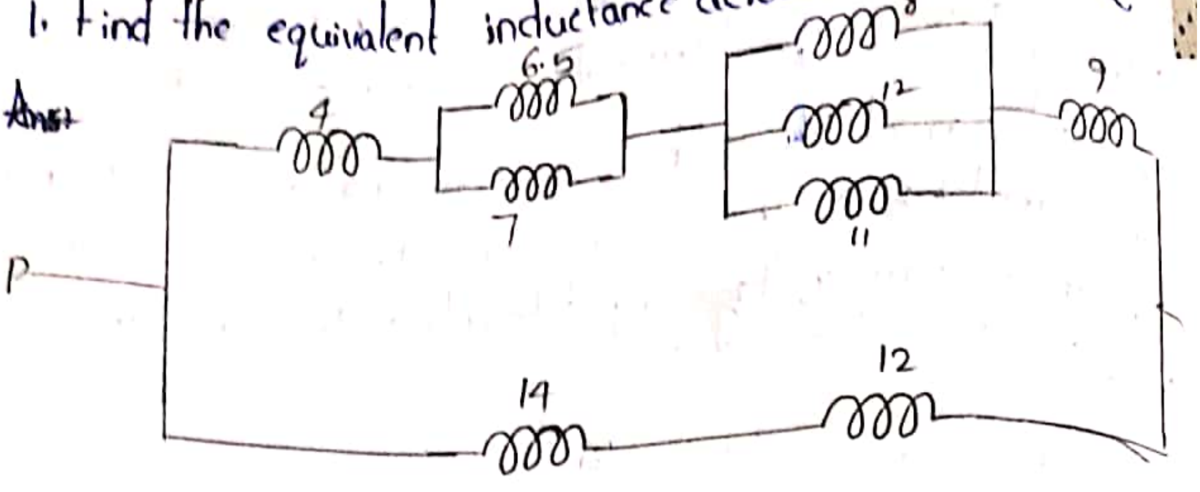




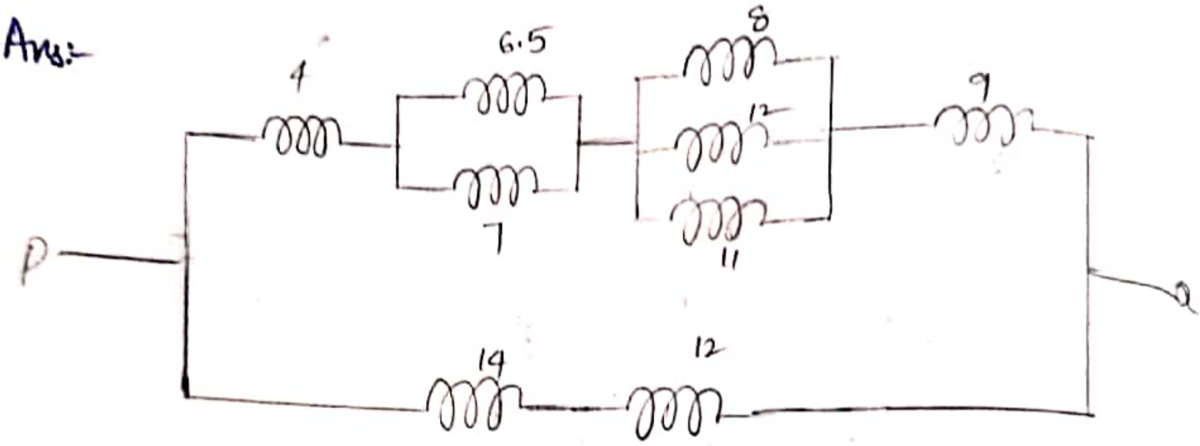
Scanned by CamScanner

1. Find the equivalent inductance across terminals PQ.

Ans:



Ans:-



Leq for 6.5 & 7.

$$L_{eq} = \frac{6.5 \times 7}{6.5 + 7}$$

$= 3.3703.$

Leq for 8, 12, 11.

$$\frac{1}{L_{eq}} = \frac{1}{8} + \frac{1}{12} + \frac{1}{11}$$

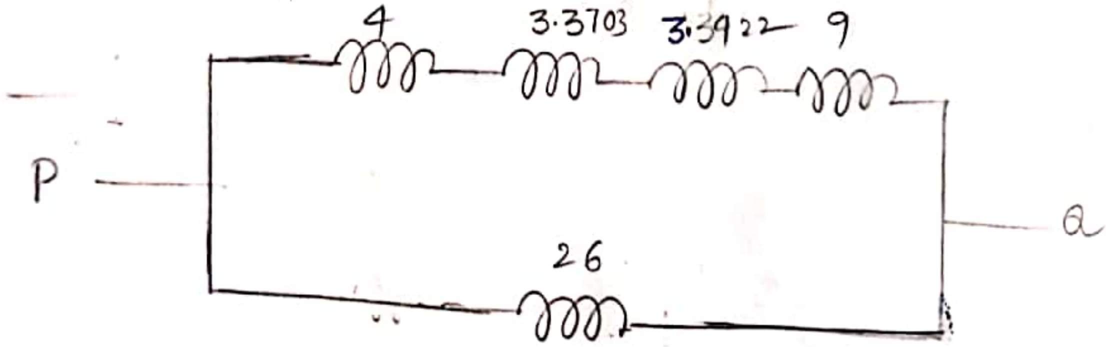
$1/L_{eq} = 0.2992$

$L_{eq} = 3.3422$

Leq for 14 & 12

$L_{eq} = 14 + 12$

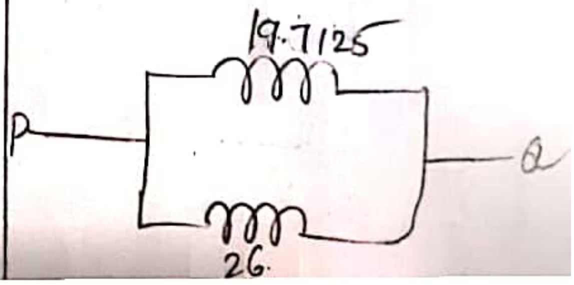
$= 26$



$L_{eq} = 4 + 3.3703 + \cancel{0.2992}\ 3.3422 + 9$

$= \cancel{16.6695}$

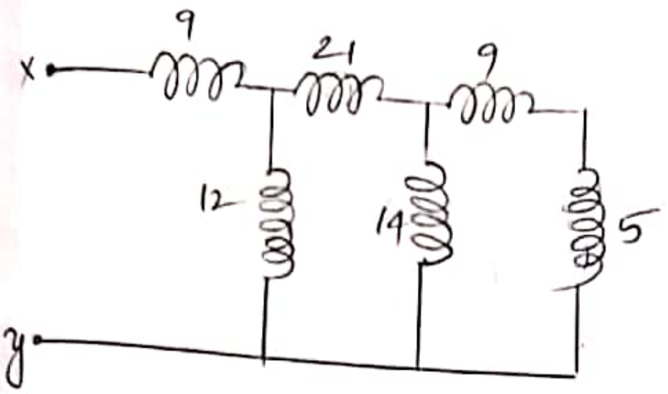
$= 19.7125$



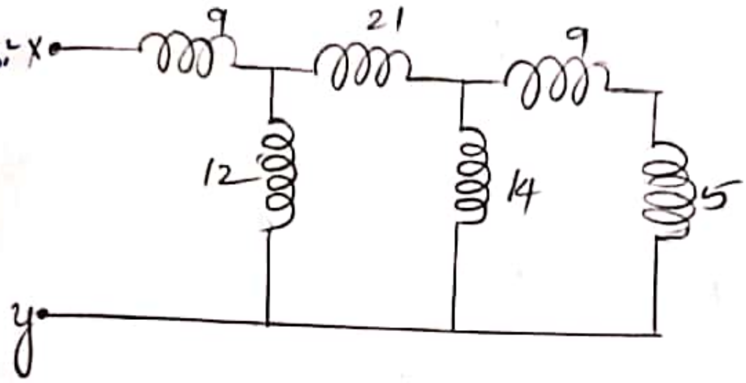
$$L_{eq} = \frac{\cancel{16.6695 \times 26}}{16.6695 + 26}$$

$$L_{eq} = \frac{19.7125 \times 26}{19.7125 + 26} = 11.211.$$

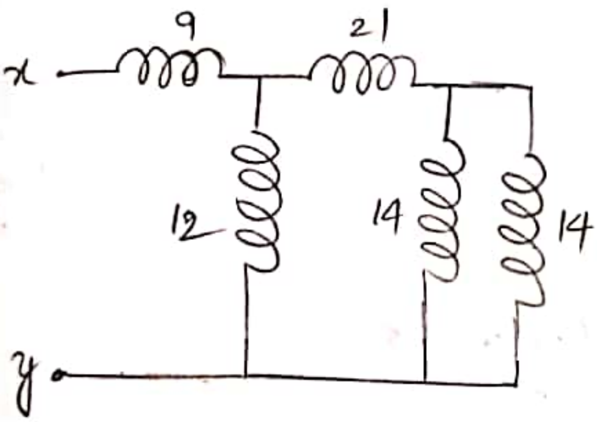
2)



Ans:-

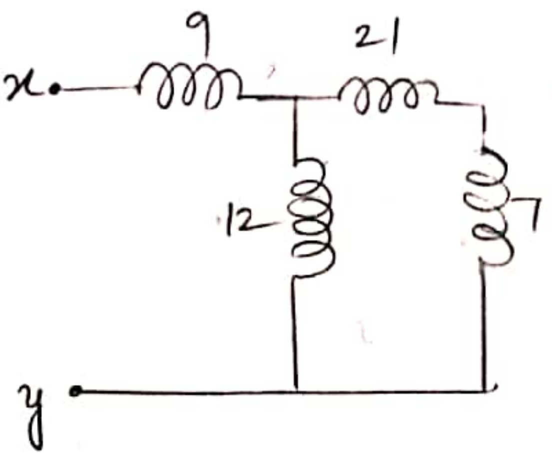


$L_{eq} = 9 + 5 = 14.$



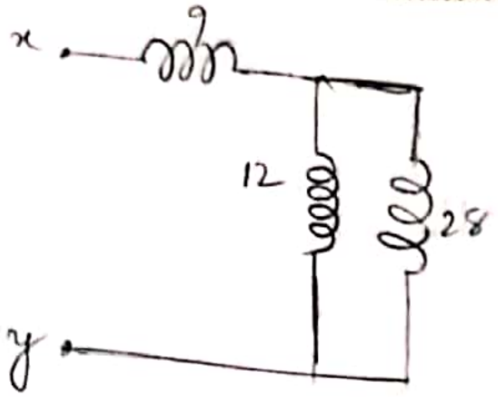
$$\frac{1}{L_{eq}} = \frac{1}{14} + \frac{1}{14}$$

$L_{eq} = 7.$



L_{eq} for 21 & 7.

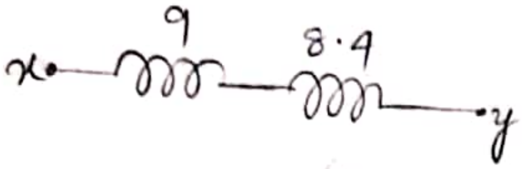
$L_{eq} = 21 + 7 = 28$



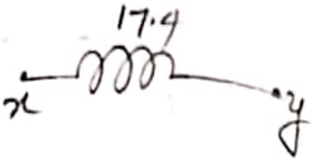
$$\frac{1}{L_{eq}} = \frac{1}{12} + \frac{1}{28}$$

$$L_{eq} = \frac{28 \times 12}{28+12}$$

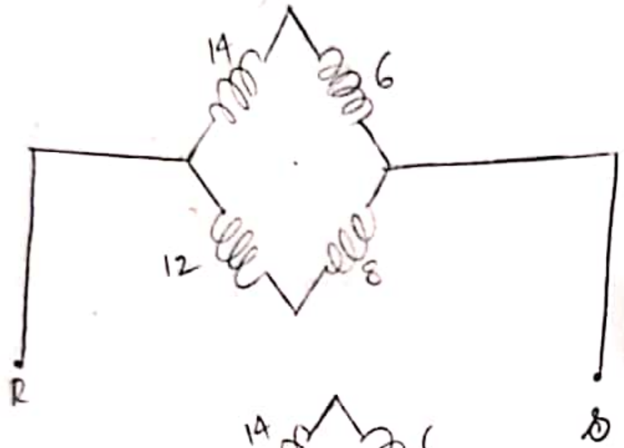
$$= 8.4.$$



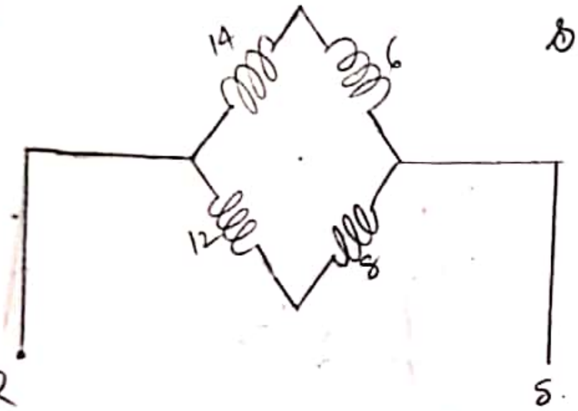
$$L_{eq} = 8.4 + 9$$
$$= 17.4$$



2)



Ans:-

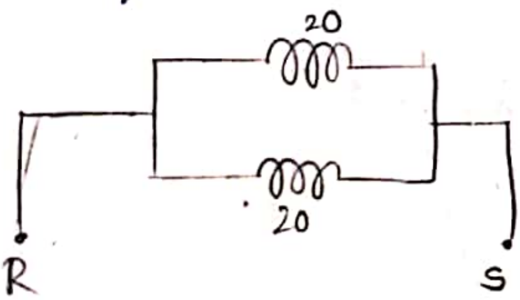


L_{eq} of 14 & 6.

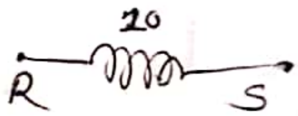
$L_{eq} = 14+6 = 20$

L_{eq} of 12&8

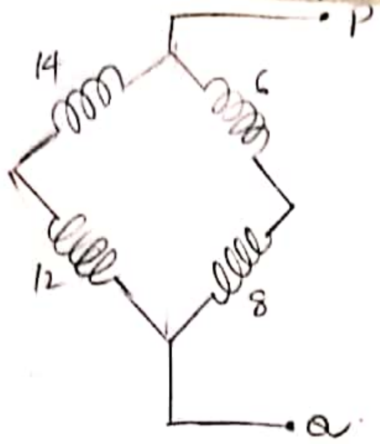
$L_{eq} = 12+8$
$= 20.$



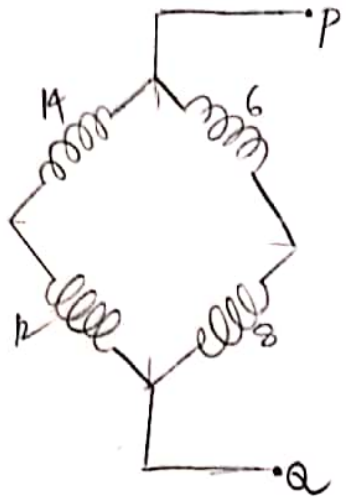
$$L_{eq} = \frac{20}{2} = 10\,\mu F$$



Q



Ans:-



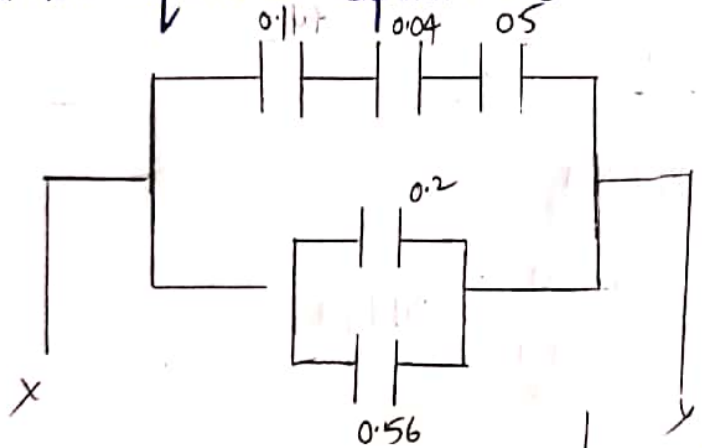
$$L_{eq} = 14+12 = 26$$

$$L_{eq} = 6+8 = 14$$

$$L_{eq} = \frac{26\times14}{26+14} = \frac{\cancel{26}^{13}\times\cancel{14}^{7}}{\cancel{40}_{\cancel{20}\,10}} = \frac{91}{10} = 9.1$$

Q) Find the equivalent Capacitance.

Ans:-



C_{eq} for 0.1, 0.04, 0.5

$$\frac{1}{C} = \frac{1}{0.1} + \frac{1}{0.04} + \frac{1}{0.5}$$

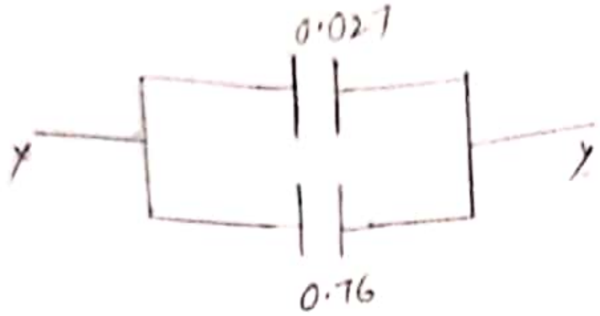
$$= 10 + 25 + 2$$

$$\frac{1}{C} = 37$$

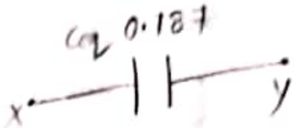
$$C = 1/37 = 0.027$$

C_{eq} for 0.2, 0.56.

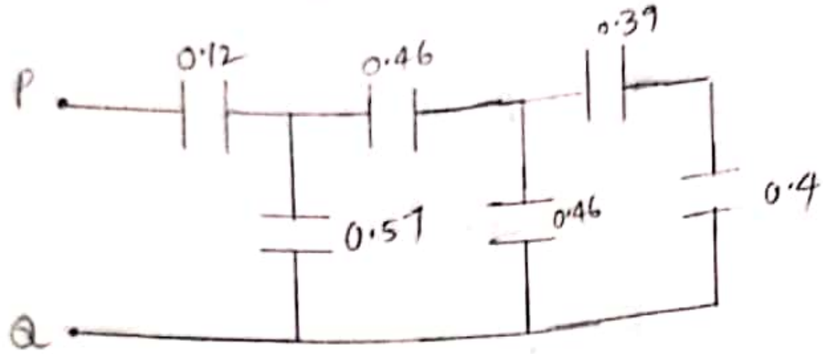
$$C_{eq} = 0.2+0.56 = 0.76.$$



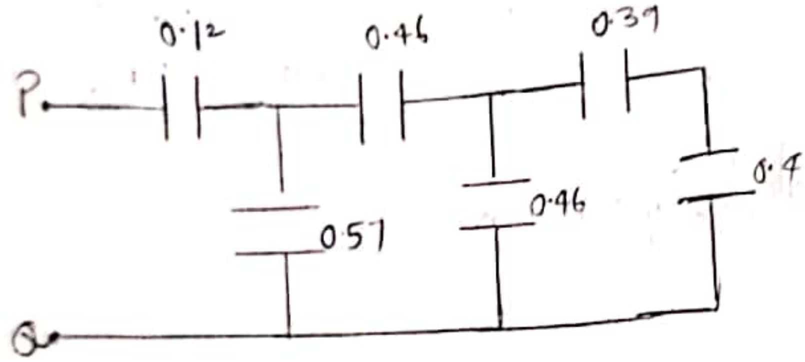
$$C_{eq} = 0.76 + 0.027 = 0.787$$



Q

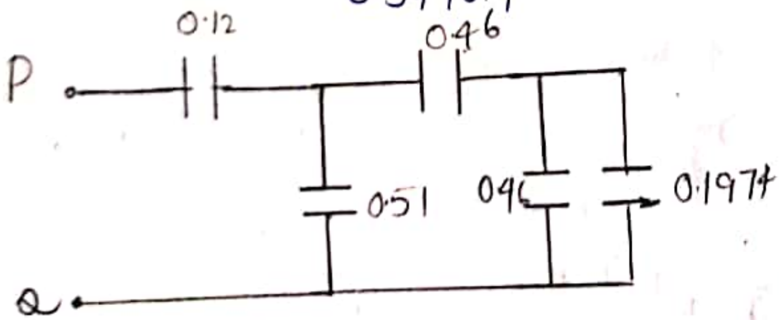


Ans:

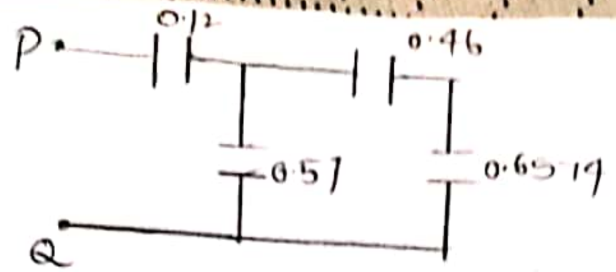


C_{eq} for $0.39 + 0.4$

$$C_{eq} = \frac{0.39 \times 0.4}{0.39 + 0.4} = 0.1974.$$



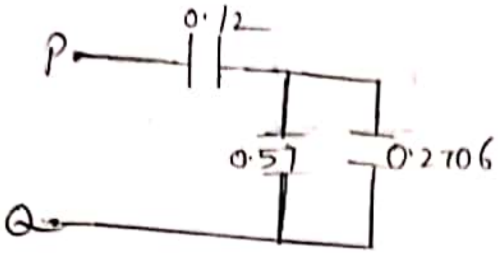
$$C_{eq} = 0.46 + 0.1974$$
$$= 0.6574$$



Ceq for 0.46 & 0.6574.

$$Ceq = \frac{0.46 \times 0.6574}{0.46 + 0.6574}$$

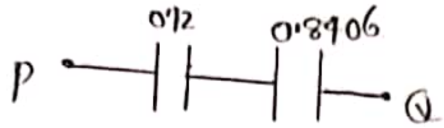
$$= 0.2706$$



Ceq for 0.57 & 0.2706.

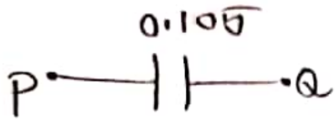
$$Ceq = 0.57 + 0.2706$$

$$= 0.8406.$$



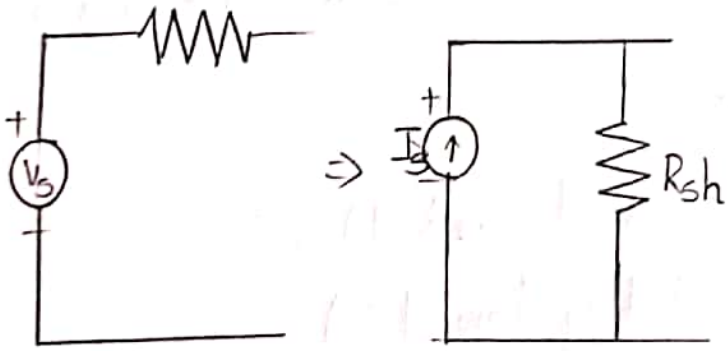
Ceq for 0.12 & 0.8406

$$Ceq = \frac{0.12 \times 0.8406}{0.12 + 0.8406}$$



$$= 0.105$$

Source Transformation:



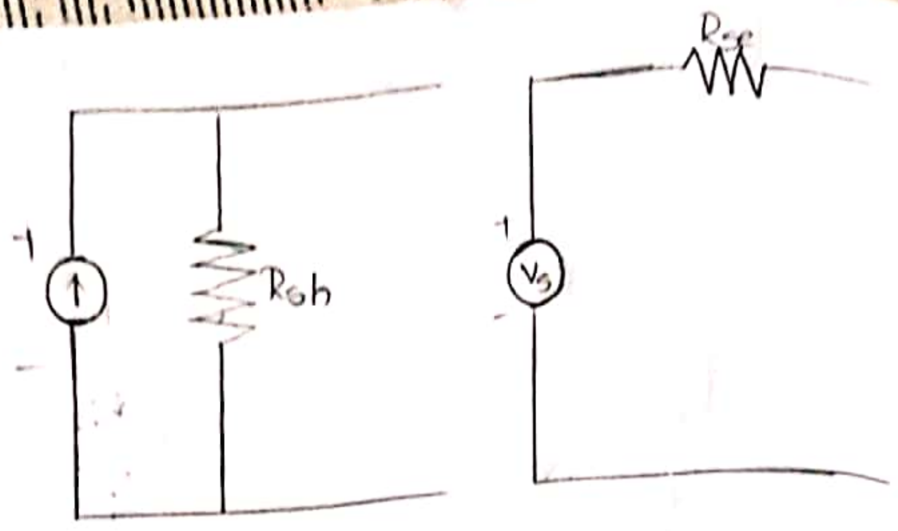
Let $V_s = 10V$

(voltage → Current)

$R_{se} = 2\Omega.$

$$I = \frac{V}{R} = \frac{10V}{2\Omega} = 5A$$

$I_s = 5A.$



$I = 10A$.

$R = 5\Omega$.

$V_s = 10 \times 5$

$= 50V$.

The voltage and current sources are mutually interchangable, any practical voltage source can be replaced by an equivalent practical current source as shown and viceversa

Kirchoff's law:

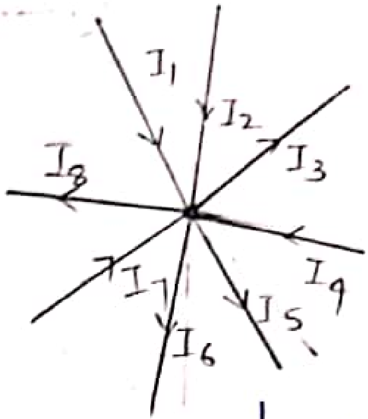
1) Kirchoff's Current Law (KCL)
2) Kirchoff's Voltage Law (KVL)

A german scientist Robert Gustav Kirchoff developed two laws enabling (or) making easier analysis of an interconnected network

1. Kirchoff's Current Law:

The algebriac sum of currents meeting at any node of a circuit is equal to zero.

↓ +ve ↑ -ve.

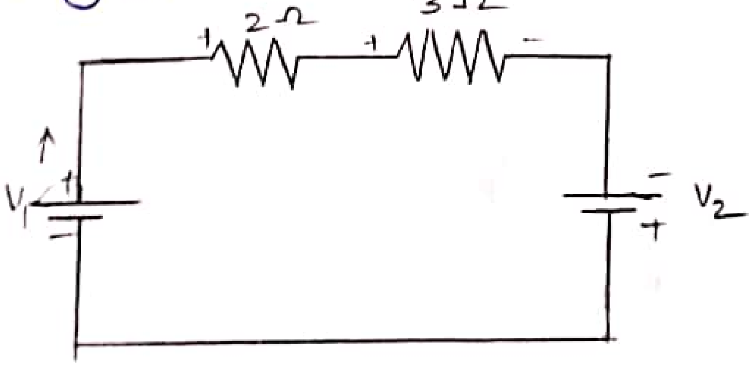


$I_1 + I_2 - I_3 + I_4 - I_5 - I_6 + I_7 - I_8 = 0.$

KCl states that the sum of incoming currents is equal to the sum of outgoing currents.

2. Kirchoff's Voltage Law.

It states that the algebriac sum of all the branch voltages around any closed path in a circuit is equal to zero. At all instants of time



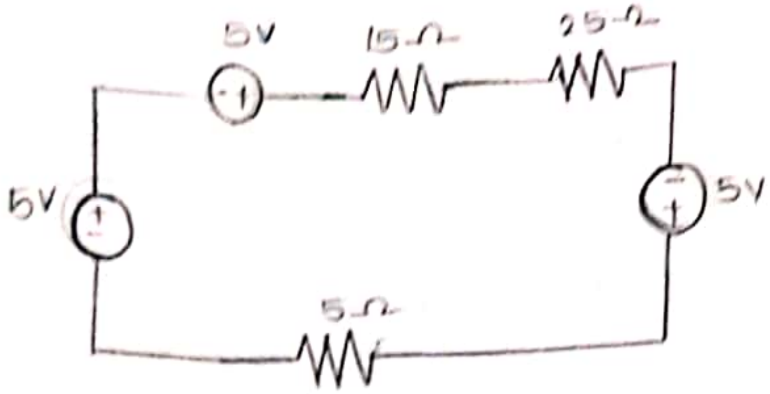
$V_1 - V_3 - V_4 + V_2 = 0.$

− + V is +ve (v gain)

+ − V is −ve (v drop)

Q) Determine the current flowing through the circuit shown below.

Ans:



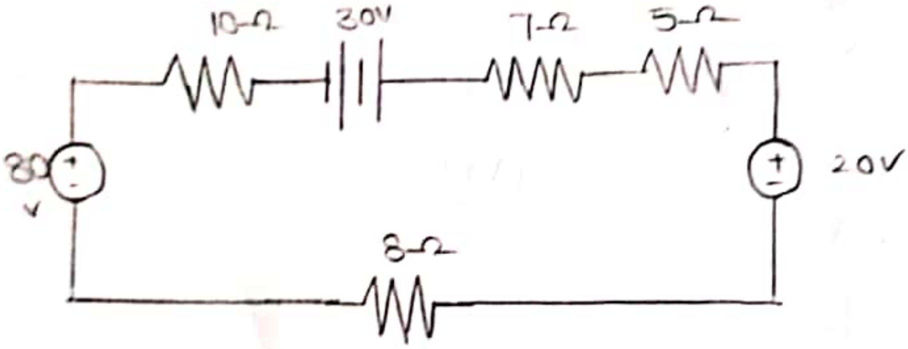
Ans: $5V + 5V - 15I - 25I + 5V - 5I = 0$

$15V - 45I = 0$

$i = \frac{\cancel{15}}{\cancel{45}_3}$

$i = 1/3 = 0.33A$

Q)



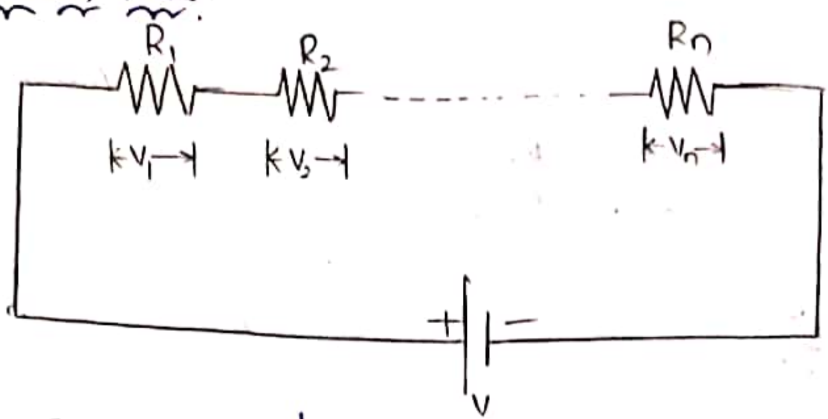
Ans: $80 - 10I + 30 - 7I - 5I - 20 - 8I = 0$

$90 = 30I$

$I = \frac{\cancel{90}}{\cancel{30}} = 3A$

$I = 3A$.

Voltage Division Rule:



→ In a series circuit the remains, same and voltage division takes place across each element.

→ Using the voltage division rule different voltages across different elements can be found out.

$$I = \frac{V}{R_{eq}} = \frac{V}{(R_1 + R_2 + \dots + R_n)}$$

$$V = IR$$

$$V_{eq} = I R_{eq} \qquad V_{eq} = \frac{V}{(R_1 + R_2 + \dots + R_n)} \cdot R_n$$

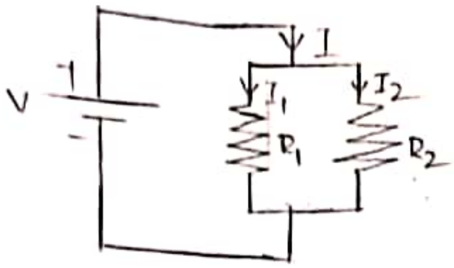
$$\Rightarrow V_{n} = \frac{V}{R_{eq}} \cdot R_n$$

$$\boxed{\therefore V_n = \frac{V}{R_{eq}} \cdot R_n}$$

Current Division Rule:

In the case of parallel circuits the voltage across each element remains the same and current division takes place across each element.

Case-1: If 2 resistors connected in parallel.



$$I = I_1 + I_2.$$

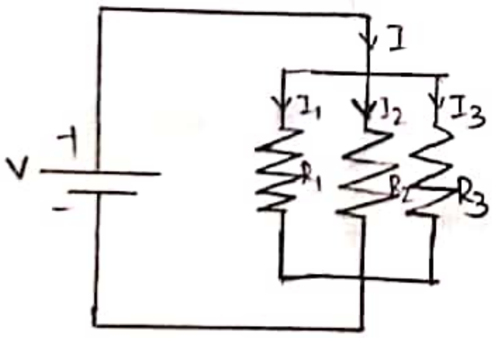
$$I = \frac{V}{R_{eq}} = \frac{V}{\frac{R_1 \cdot R_2}{R_1 + R_2}}$$

$$I = \frac{V}{R_1}\left(\frac{R_1 + R_2}{R_2}\right)$$

$$\boxed{I = I_1\left(\frac{R_1 + R_2}{R_2}\right)}$$

$$\boxed{I_1 = \frac{I R_2}{(R_1 + R_2)}} \qquad \boxed{I_2 = \frac{I R_1}{(R_1 + R_2)}}$$

3 resistors In parallel:

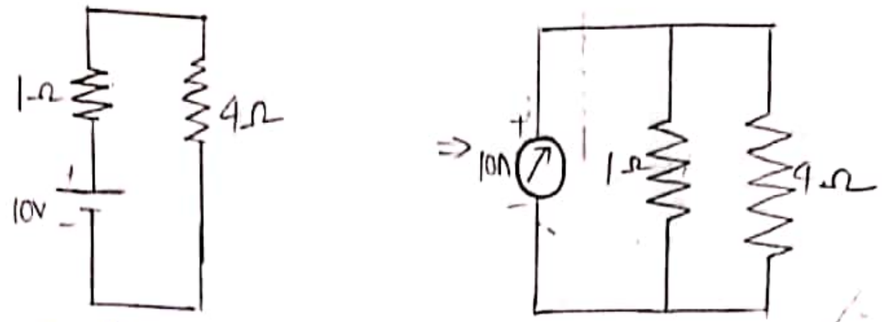


$$I_1 = I \cdot \frac{R_2 \| R_3}{R_1 + (R_2 \| R_3)}$$

$$I_2 = I \cdot \frac{R_1 \| R_3}{R_2 + (R_1 \| R_3)}$$

$$I_3 = I \cdot \frac{R_1 \| R_2}{R_3 + (R_1 \| R_2)}$$

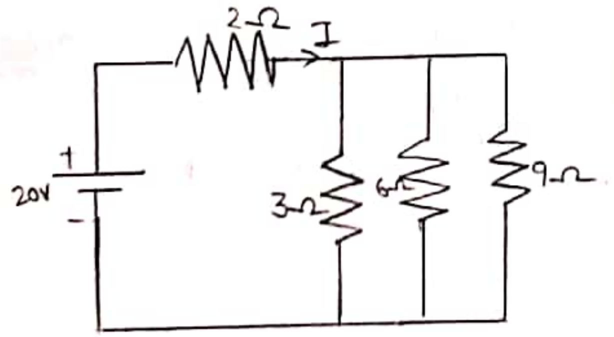
1. Find the load current in the network shown below using source transformation.



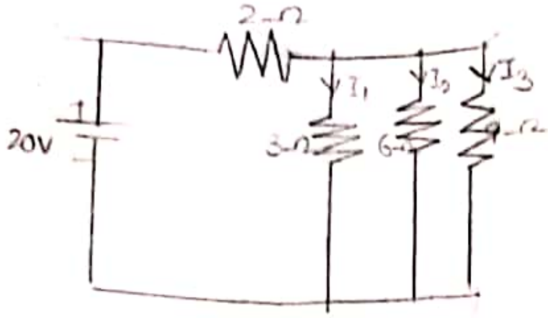
$I = \frac{10}{5} = 2A$ $\quad I = \frac{10}{1} = 10A$ $\quad I_{4\Omega} = I \cdot \frac{R_{1\Omega}}{R_{1\Omega} + R_{4\Omega}} = 10 \times \frac{1}{5}$

$= 2A.$

3. find I in each branch

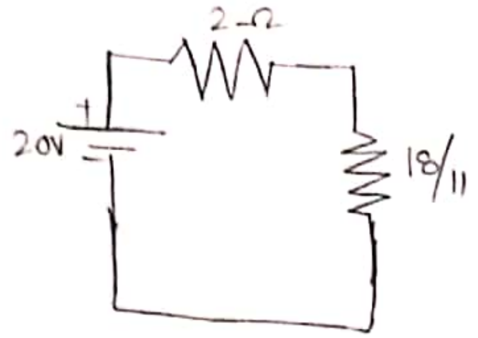


Ans:-



Req of 3, 6, 9

$$\frac{1}{R_{eq}} = \frac{1}{3}+\frac{1}{6}+\frac{1}{9}$$
$$= \frac{6+3+2}{18}$$
$$R_{eq} = \frac{11}{18} = \frac{18}{11}$$



Req of 2 & $\frac{18}{11}$

$$R_{eq} = 2+\frac{18}{11} = \frac{40}{11} = 3.6363$$

$$I = \frac{V}{R_{eq}} = \frac{20}{3.6363} = 5.50009$$

$$I_1 = I\,\frac{R_2 \parallel R_3}{R_1 + R_2 \parallel R_3} = 5.50009\,\frac{\left(\frac{6\times 9}{6+9}\right)}{3+\left(\frac{6\times 9}{6+9}\right)} = \frac{5.50009\times 3.6}{6.6}$$
$$= 3.00004A$$

$$I_2 = I\,\frac{R_1 \parallel R_3}{R_2 + R_1 \parallel R_3} = 5.50009\,\frac{\frac{3\times 9}{3+9}}{6+\frac{3\times 9}{3+9}} = \frac{5.50009\times 2.25}{8.25}$$
$$= 1.500024A$$

$$I_3 = \cancel{5.50009}\, I\,\frac{R_1 \parallel R_2}{R_3 + R_1 \parallel R_2} = 5.50009\times\frac{\frac{3\times 6}{3+6}}{9+\frac{3\times 6}{3+6}} = \frac{5.50009\times 2}{11}$$
$$= 1.000016A$$

Alternation:

The positive or negative half cycle of a alternat-ing quantity.

Time Period:

The time required to complete one cycle of an Alternating quantity.

Frequency:

The no. of cycles completed by an alternating quantity in 1 second

$$f = \frac{1}{T}.$$

Angular Velocity:

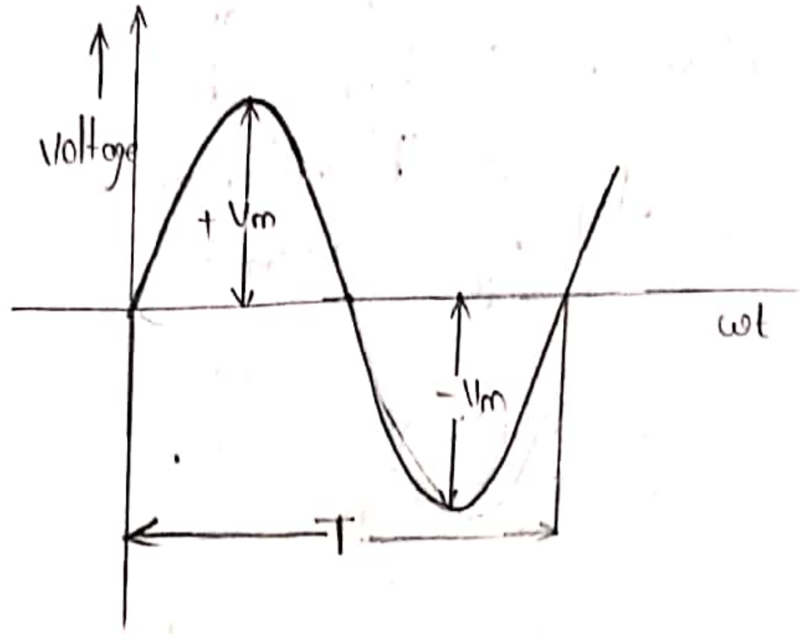
$$\text{Angular velocity} = \frac{\text{Angular displacement}}{\text{time}}$$

$$\text{Angular displacement} = \text{Angular velocity} \times \text{time}.$$

Mathematical Representation Of Sinusoidal Quantities:

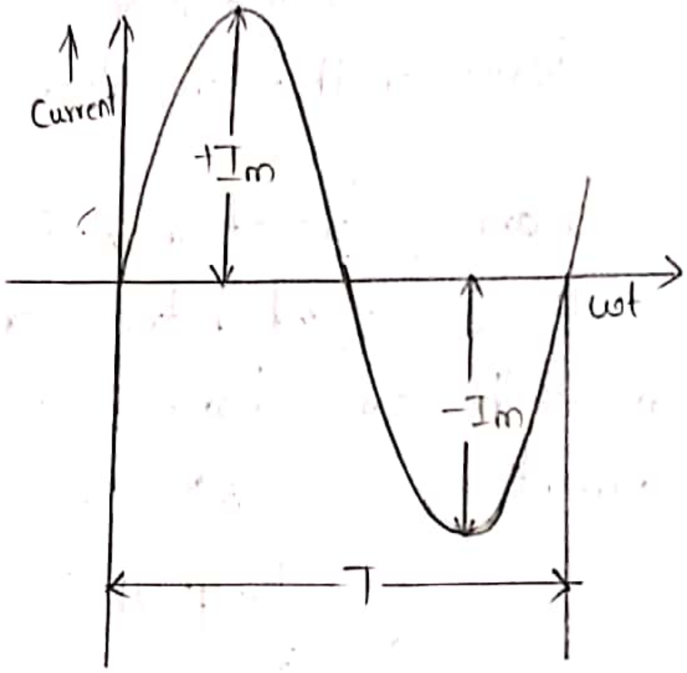
Voltage:

$v = V_m \sin\omega t$.



Current:

$i = I_m \sin\omega t$.



Peak Value (or) Maximum Value (V_m):

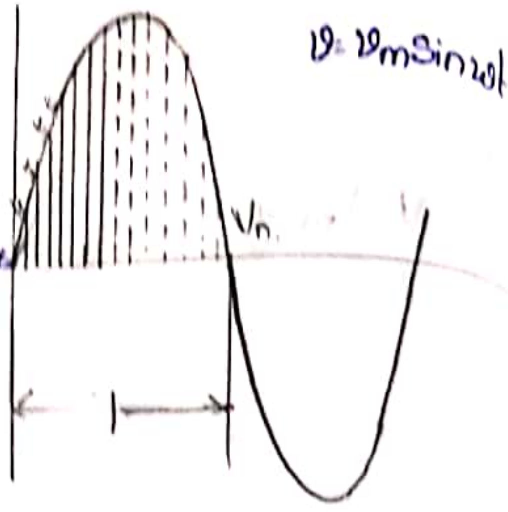
The maximum value attained by an alternating quantity is known as Peak value.

Peak- Peak Value:

The maximum value from positive peak to negative peak

Average Value:

The average value of an alternating quantity is the average of all the instantaneous values during one alteration



$$V_{avg} = \frac{V_1 + V_2 + V_3 + \dots + V_n}{n}$$

$$= \frac{\text{Area of one alteration}}{\text{Wave length of one alteration}}$$

The avarage value of an A.Q is expressed by that DC current which transfers accross any point of circuit the same charge. as is transfered by the A.C current.

$$V_{ag} = \frac{\int_0^t v(t)\,dt}{T}$$

$$V_{avg} = \frac{\int_0^{\pi} V_m \sin wt\,dt}{\pi}$$

$$V_{avg} = \frac{v_m}{\pi} \; -\frac{\cos wt}{w}\Big|_0^{\pi} = \frac{2v_m}{\pi}$$

$$= 0.637 v_m$$

$$\therefore V_{avg} = \frac{2V_m}{\pi}$$

$$= 0.637\, V_m.$$

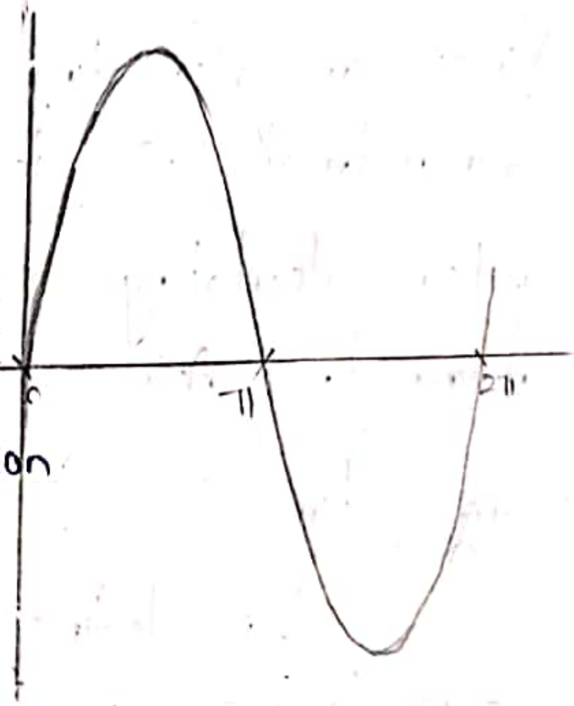
RMS Value:

RMS - Root Mean Square Value.

The RMS value of an alternating is defined as the study on DC current which when flowing through a circuit for a given period of time produces the same heat as produced by the ac current flowing through the same circuit for the same period.

$$V_{rms} = \sqrt{\frac{V_1^2 + V_2^2 + \dots + V_n^2}{n}}$$

$$= \sqrt{\frac{(\text{Area of one alternation})^2}{\text{wave length of one alternation}}}$$



$$V_{rms} = \left[\frac{\int_0^t [v(t)]^2 dt}{T}\right]^{1/2}$$

$$= \sqrt{\frac{1}{\pi}\int_0^{\pi} V_m^2 \sin^2 \omega t\, dt}$$

$$V_{avg} = \sqrt{\frac{1}{\pi} V_m^2 \left[\int_0^{\pi} \frac{1}{2} - \int_0^{\pi} \frac{\cos 2m\omega t}{2} d\omega t \right]}$$

$$= \frac{V_m}{\cancel{\sqrt{\pi}}} \left[\frac{\cancel{\sqrt{\pi}}}{\sqrt{2}} \right]$$

$$= \frac{V_m}{\sqrt{2}} = 0.707 V_m.$$

$$\boxed{V_{rms} = 0.707 V_m}$$

Note: For calculating average value or RMS value of any symmetrical A.Q we consider half cycle only.

2. For calculating average or RMS values of any unsymmetrical A.Q we consider full cycle.

Form factor:

It is defined as the ratio of rms value to average value

$$\text{form factor} = \frac{\text{RMS value}}{\text{Average value}}$$

$$= \frac{0.707 V_m}{0.637 V_m}$$

$$= 1.11$$

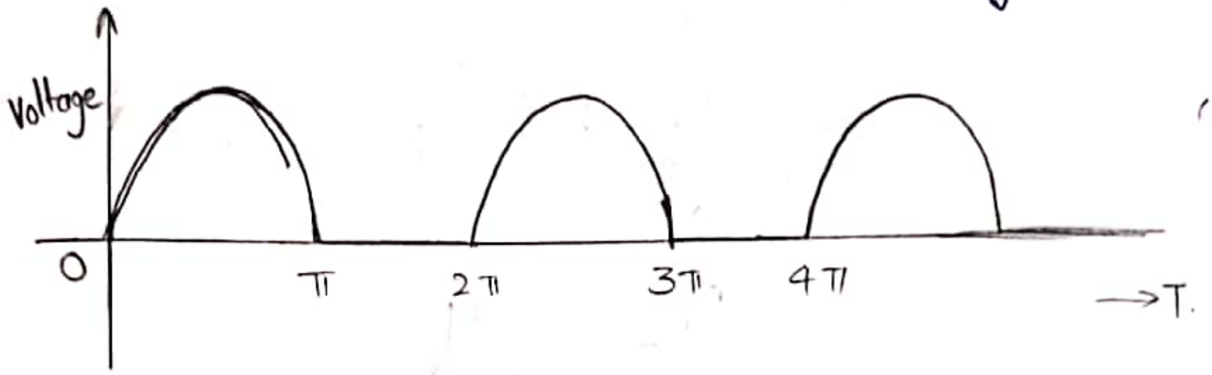
~~peak factor~~

Peak factor:

It is defined as the ratio of peak value to RMS value.

$$\text{peak factor} = \frac{\text{Peak value}}{\text{RMS value}} = 1.414$$

Q Calculate the form factor for the given signals



Ans:- $$V_{avg} = \frac{\int_0^{2\pi} v_m \sin\omega t \, dt}{2\pi}$$

$$= \frac{v_m}{2\pi} \int_0^{2\pi} \sin\omega t \, dt$$

$$= \frac{v_m}{2\pi} \left[\int_0^{\pi} \sin\omega t \, dt + \int_{\pi}^{2\pi} \sin\omega t \, dt \right]$$

$$= \frac{v_m}{2\pi} \left[\int_0^{\pi} \sin\omega t \, dt \right]$$

$$V_{avg} = \frac{v_m}{\cancel{2}\pi} \left[\cancel{2} \right]$$

$$V_{avg} = \frac{V_m}{\pi}$$

$$V_{avg.} = 0.3183 V_m$$

$$V_{rms} = \sqrt{\frac{1}{2\pi}\int_0^{\pi} V_m^2 \sin^2 2\omega t \, dt}$$

$$= \sqrt{\frac{1}{2\pi} V_m^2 \int_0^{\pi} \sin^2 2\omega t \, dt}$$

$$= \frac{V_m}{\sqrt{2\pi}} \sqrt{\int_0^{\pi} \frac{1}{2} t - \int_0^{\pi} \frac{\cos 2\omega t}{2} \, dt}$$

$$= \frac{V_m}{\sqrt{2\pi}} \sqrt{\frac{\pi}{2} - \frac{\sin 2\omega t}{4}\Big|_0^{\pi}}$$

$$= \frac{V_m}{\sqrt{2\pi}} \sqrt{\frac{\pi}{2}}$$

$$= \frac{V_m}{2}.$$

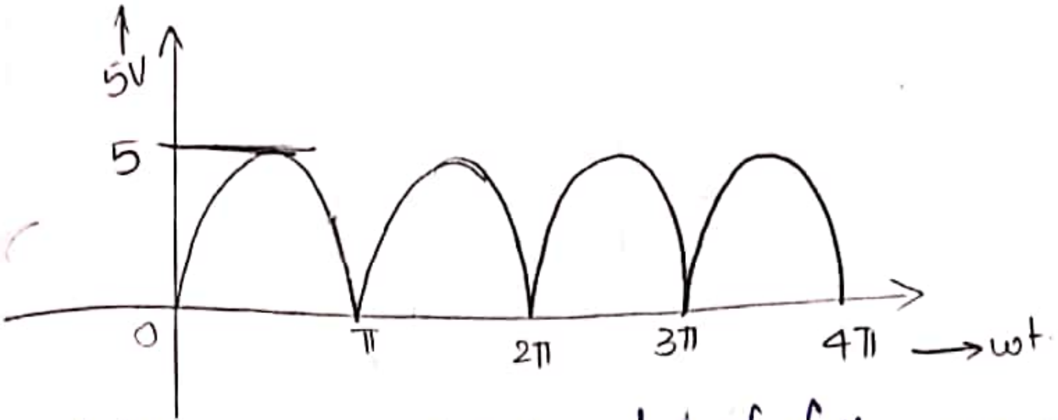
$$V_{rms.} = 0.5 V_m$$

peak ~~factor~~

form factor = $\frac{\text{RMS value}}{\text{avg value}}$

$$= \frac{0.5}{0.3183} = 1.5708$$

$\therefore$ form factor = 1.5708 V.



Q. Find the average & RMS value of full wave rectifier?

Ans:- $V_{avg} = \frac{1}{\pi}\int_0^{\pi} v_m \sin\omega t \, dt$

$= \frac{v_m}{\pi}\int_0^{\pi} \sin\omega t \, dt$

$= \frac{v_m}{\pi} \times 2 = \frac{2v_m}{\pi}$

$= 0.636(5)$

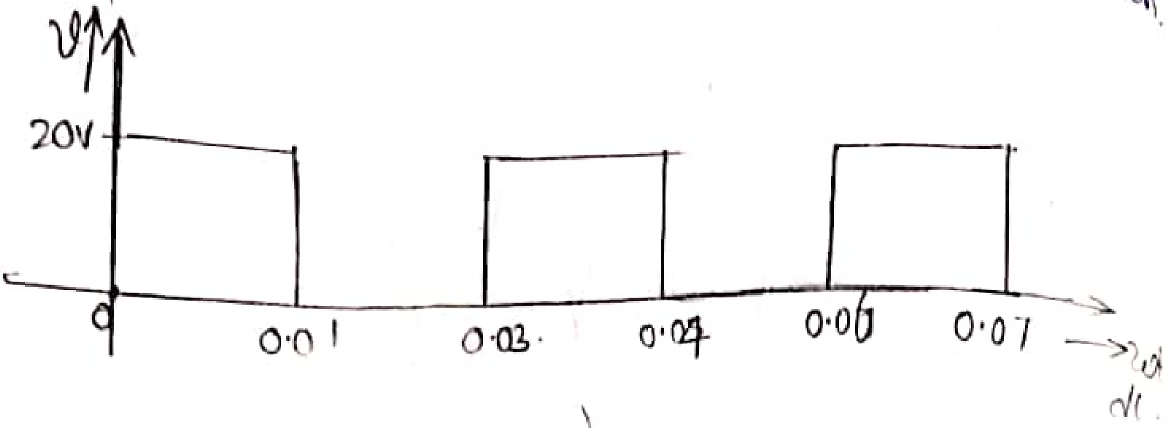
$= 3.185$

$v_{rms} = \sqrt{\frac{1}{\pi}\int_0^{\pi} v_m^2 \sin^2\omega t \, dt}$

$= \frac{v_m}{\sqrt{\pi}}\sqrt{\int_0^{\pi} \sin^2\omega t \, dt}$

$= \frac{v_m}{\cancel{\sqrt{\pi}}} \times \frac{\cancel{\sqrt{\pi}}}{\sqrt{2}} = \frac{5}{\sqrt{2}} = 3.5355$

Q) Determine the form factor for the square wave shown.



Ans:-

$$V_{avg} = \frac{1}{0.03}\int_{0}^{0.03} v_m \sin\omega t \, dt.$$

$$= \frac{v_m}{T} \cos\omega t \, dt.$$

$$= \frac{20}{0.03}\left[\cos(0.03) - \cos(0)\right]$$

$$= \cancel{666(1.5}$$

$$= 666.667\,(1.52\times10^{-8})$$

$$V_{avg} = \frac{1}{0.03}\int_{0}^{0.03} v_m t \, dt.$$

$$= \frac{v_m}{0.03}\left[\int_{0}^{0.01} t\, dt + \int_{0.01}^{0.03} dt\right]$$

$$= \frac{20}{0.03}(0.01) = \frac{20}{3} = 6.666$$

$$V_{rms} = \sqrt{\frac{1}{T}\int_{0}^{0.01}(20)^2\,dt + \int_{0}^{0.03}(20)^2\,dt}$$

$$= \sqrt{\frac{(20)^2}{0.03}\,0.01}$$

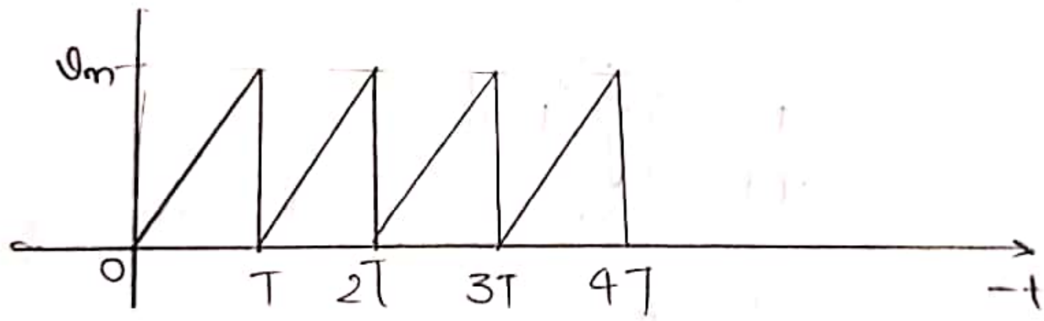
$$= \frac{20}{\sqrt{3}} = 11.547005.$$

$$\text{form factor} = \frac{V_{rms}}{V_{avg}} = \frac{11.547}{6.666}$$

$$= 1.7322.$$

$\therefore$ form factor $= 1.7322.$

Q) Calculate the average and effective values for the wave form shown.



$(0,0)$ (T, v_m)

$$y = \frac{v_m}{T}(x)$$

$$v = \frac{v_m}{T}(t)$$

$$V_{avg} = \frac{1}{T}\int_0^T v(t)\,dt.$$

$$= \frac{1}{T}\int_0^T \frac{V_m}{T} t \, dt$$

$$= \frac{V_m}{T^2}\int_0^T t\,dt$$

$$= \frac{V_m}{\cancel{T^2}} \cdot \frac{\cancel{T^2}}{2}$$

$$= \frac{V_m}{2}$$

$$V_{rms} = \sqrt{\frac{1}{T}\int_0^T (v(t))^2\,dt}.$$

$$= \frac{1}{\sqrt{T}} \frac{V_m}{T}\sqrt{\int_0^T t^2\,dt}.$$

$$= \frac{1}{\cancel{\sqrt{T}}} \frac{V_m}{\cancel{T}} \frac{\cancel{T^{3/2}}}{\sqrt{3}}$$

$$= \frac{V_m}{\sqrt{3}}$$

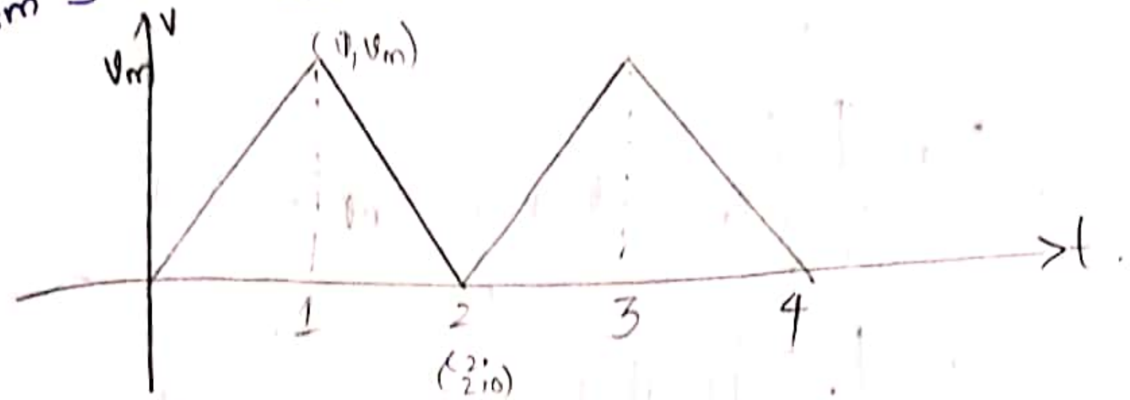
$$\text{form factor} = \frac{V_{rms}}{V_{avg}} = \frac{\cancel{V_m}}{\sqrt{3}} \times \frac{2}{\cancel{V_m}}$$

$$= \frac{2}{\sqrt{3}}$$

$$= 1.1547$$

Q Calculate the average and rms values for the wave form shown below

Ans:



Ans:- $V = V_m t \qquad 0 < t < 1$

$(V - V_m) = \frac{-V_m}{1}(t - 1) \qquad 1 < t < 2.$

$v - V_m = -V_m t + V_m.$

$V = -V_m t + 2V_m. \qquad 1 < t < 2.$

$$V_{avg} = \frac{1}{T}\int_0^2 v(t)\,dt.$$

$$= \frac{1}{2}\left[\int_0^1 V_m t\,dt + \int_1^2 -V_m t\,dt + \int_1^2 2V_m\,dt.\right]$$

$$= \frac{1}{2}\left[\frac{V_m}{2} + -V_m\left(3/2\right) + 2V_m\right]$$

$$V_{avg} = \frac{V_m}{2}$$

$$v_{rms} = \sqrt{\frac{1}{T}\int_0^T v(t)^2\, dt}$$

$$= \frac{1}{\sqrt{2}}\sqrt{\int_0^1 v_m^2 t^2\, dt + \int_1^2 (v_m)^2 (2-t)^2\, dt}$$

$$= \frac{1}{\sqrt{2}}\sqrt{v_m^2\int_0^1 t^2\, dt + v_m^2\int_1^2 4 + t^2 - 4t\, dt}$$

$$= \frac{v_m}{\sqrt{2}}\sqrt{\frac{1}{3} + 4 + \left(\frac{7}{3}\right) - 2(3)}$$

$$= \frac{v_m}{\sqrt{2}}\sqrt{\frac{8}{3} - 2}$$

$$= \frac{v_m}{\cancel{\sqrt{2}}}\,\frac{\cancel{\sqrt{2}}}{\sqrt{3}}$$

$$= \frac{v_m}{\sqrt{3}}$$

form factor $= \frac{\cancel{v_m}}{\sqrt{3}} \times \frac{2}{\cancel{v_m}}$

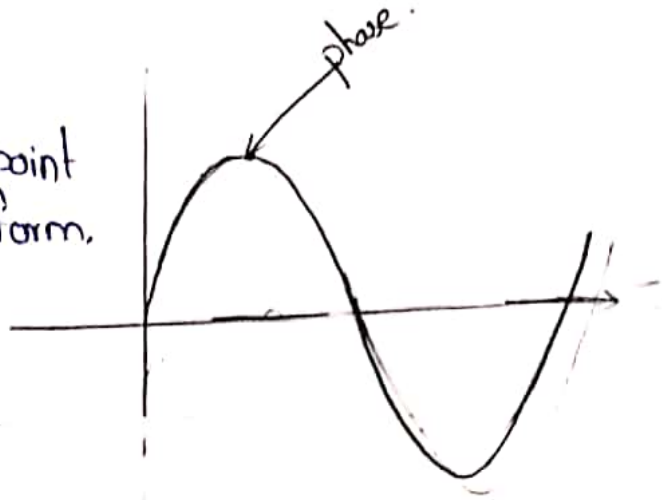
$$= \frac{2}{\sqrt{3}}$$

$$= 1.1547$$

Concept Of Phase & Phase Difference:

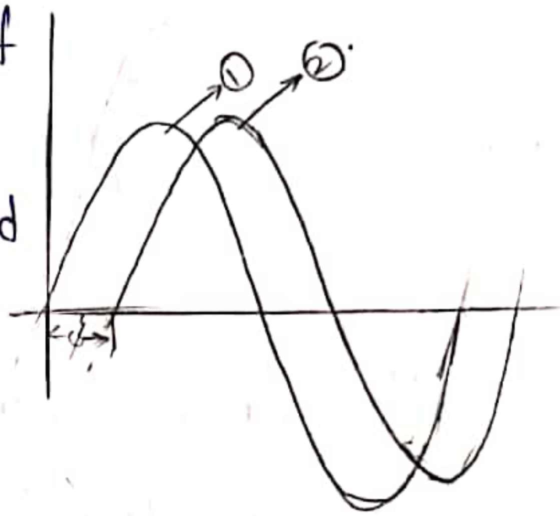
Phase:

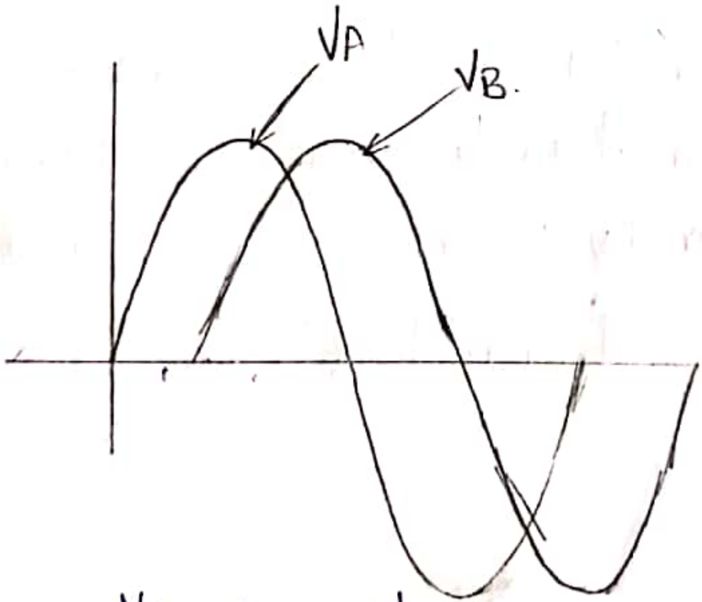
It denotes a particular point in the cycle of a wave form.



Phase Difference:

When two alternating quantities of same frequency have different origin points then they are said to have a phase difference.





$V_A = V_m \sin \omega t$

$V_B = V_m \sin \omega t.$

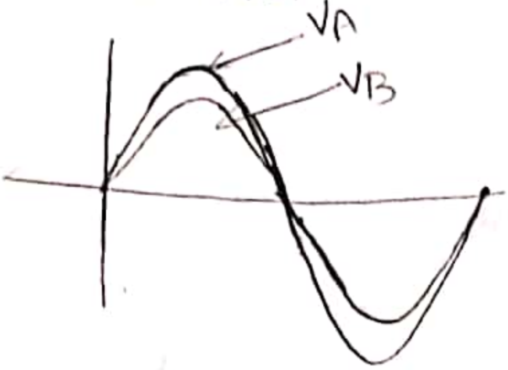
V_A as reference. (lagging)

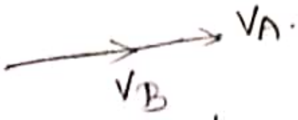
$V_B = V_m \sin(\omega t - \phi)$

V_B as reference $V_B = V_m \sin \omega t$

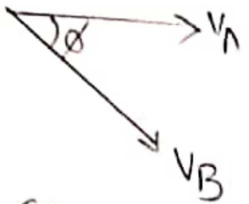
$V_A = V_m \sin(\omega t + \phi)$ (leading)

Phasor Notation:



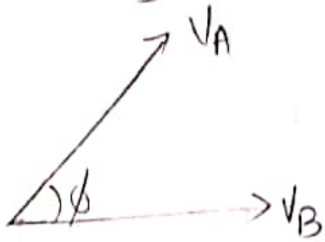


V_B is in phase with V_A.



(Here V_B is lagging w.r.t V_A)

V_A is leading w.r.t V_B



(Here V_A is leading w.r.t V_B)

J- Notation (or) J-operator:

It is defined as a vector operator when applied to a phasor it produces an anticlockwise rotation of phasor by 90°. without change in magnitude.

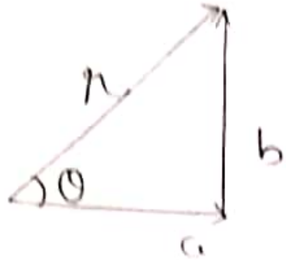
→ J operator is used when L and C are connected to R

Representation Of Phasors:

phasors can be represented int two forms.

1. Rectangular form. ($r = a + jb$)
2. Polar form ($r \angle \theta$)

Recto



$r = \sqrt{a^2 + b^2}$

$\theta = \tan^{-1}\left(\frac{b}{a}\right)$.

$$\cos\theta = \frac{a}{r} \qquad \sin\theta = \frac{b}{r}$$

$$a = r\cos\theta \quad b = r\sin\theta$$

$$r = \sqrt{a^2 + b^2}.$$

Addition, Subtration, Multiplication & Division Of Phasors:

let $x = a + jb$

$y = c + jd.$

Addition of phasors:

$$(x+y) = (a+c) + j(b+d)$$

Subtraction of phasors:

$$x - y = (a-c) + j(b-d)$$

Multiplication Of Phasors:

$$x = p\angle\theta_1$$

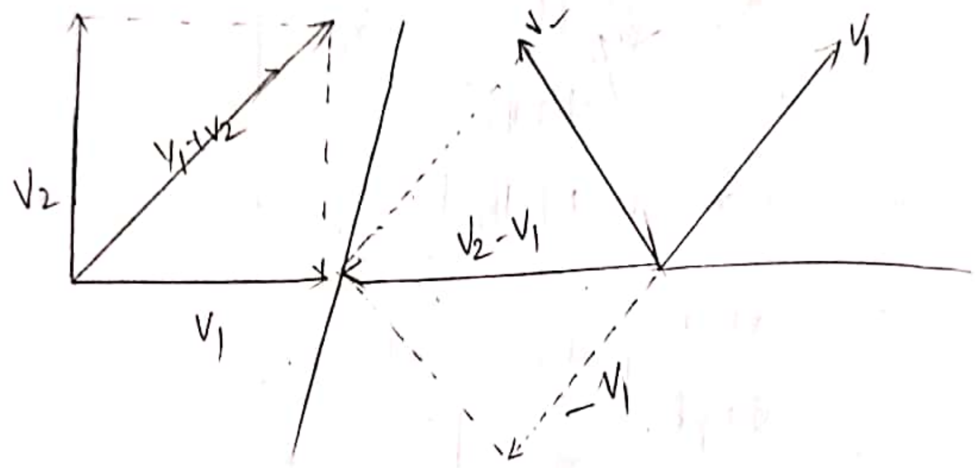
$$y = q\angle\theta_2.$$

$$x \times y = p \times q \angle\theta_1 + \theta_2.$$

Division Of Phasors:

$$\frac{x}{y} = \frac{p}{q}\angle\theta_1 - \theta_2.$$

Addition & Subtraction Of Phasors:



Mathematical Representation Of Sinosoidal Q

In the time domain representation sine wave is represented as

$$V = V_m \sin\omega t.$$

In the phasor representation it is denoted as

$$|V| \angle\theta.$$

$$|V| = V_{rms} \quad \frac{V_m}{\sqrt{2}}\angle 0$$

$V = V_m \sin(\omega t + \phi) \longrightarrow |V| \angle \phi$

$V = V_m \sin(\omega t - \phi) \longrightarrow |V| \angle -\phi$

Duality:

Two circuits are said to be Duals if the mesh equation characterizing the one have the same mathematical form as the nodal equation that characterize the other.

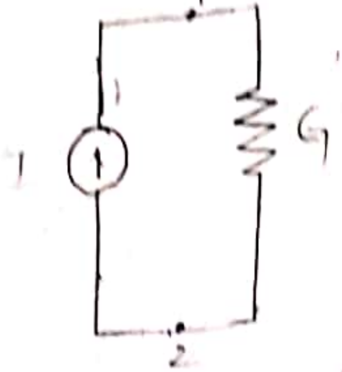
Element	Dual Element
Voltage source	Current source.
current source	Voltage source.
Resistance	conductance.
Inductance (L)	capictance. (C)
capacitance (C)	Inductance. (L)
open circuit (OC)	short circuit (SC)
Short circuit (SC)	Open circuit (OC)

Procedure:

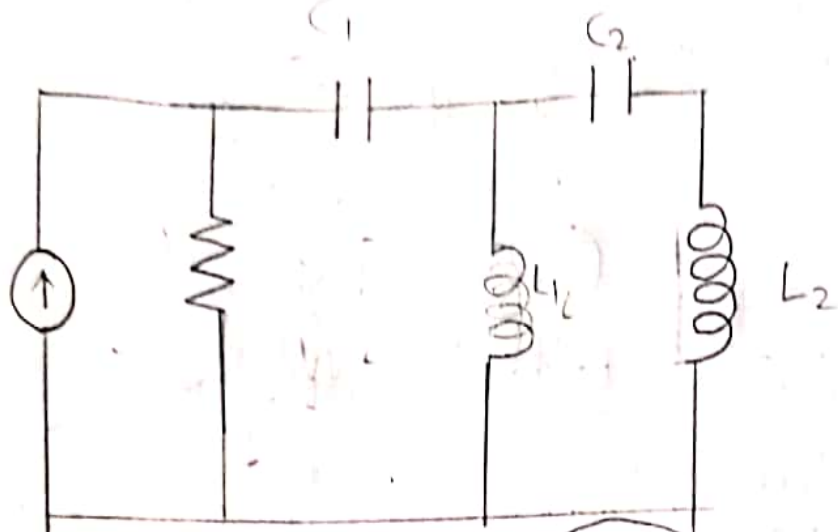
1. Place a node in each loop

no. of nodes = no of loops + 1 reference node.

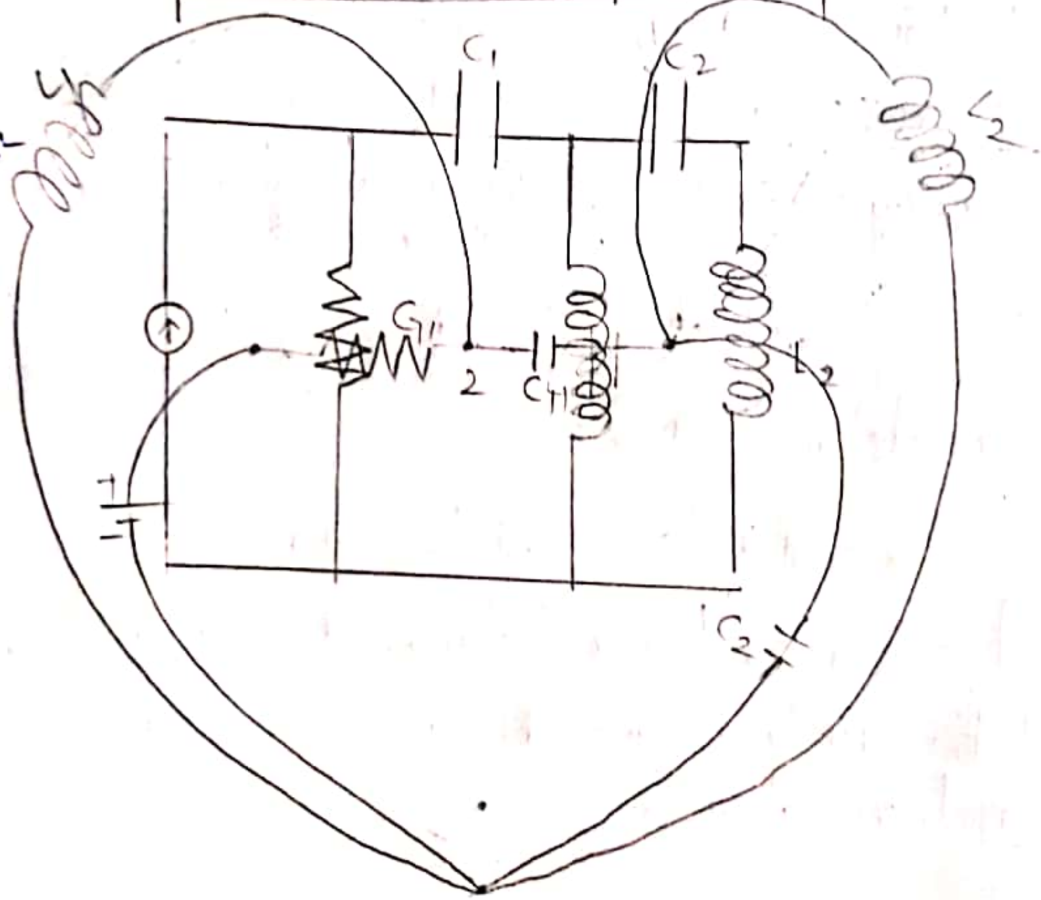
2. Connect a corresponding dual element b/w the node 4 external load by traversing through one element of the original network at a time.

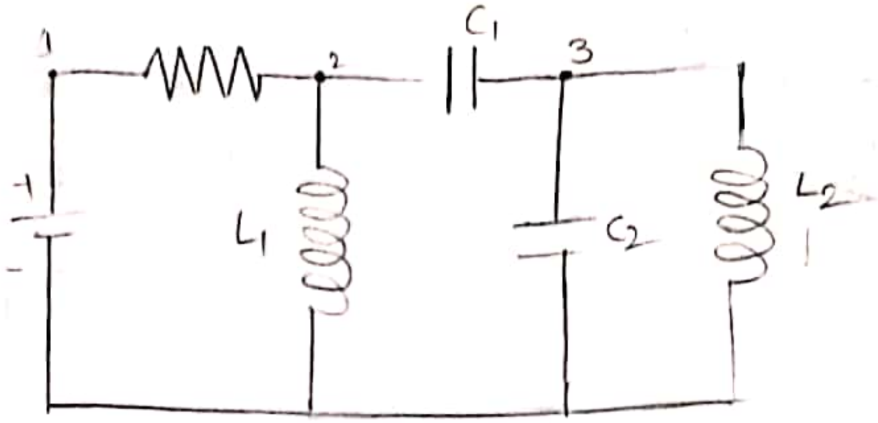


Q

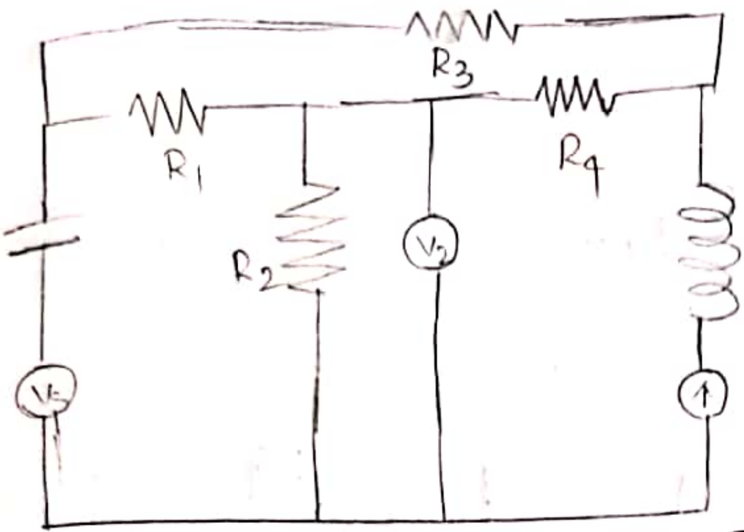


Ans:-

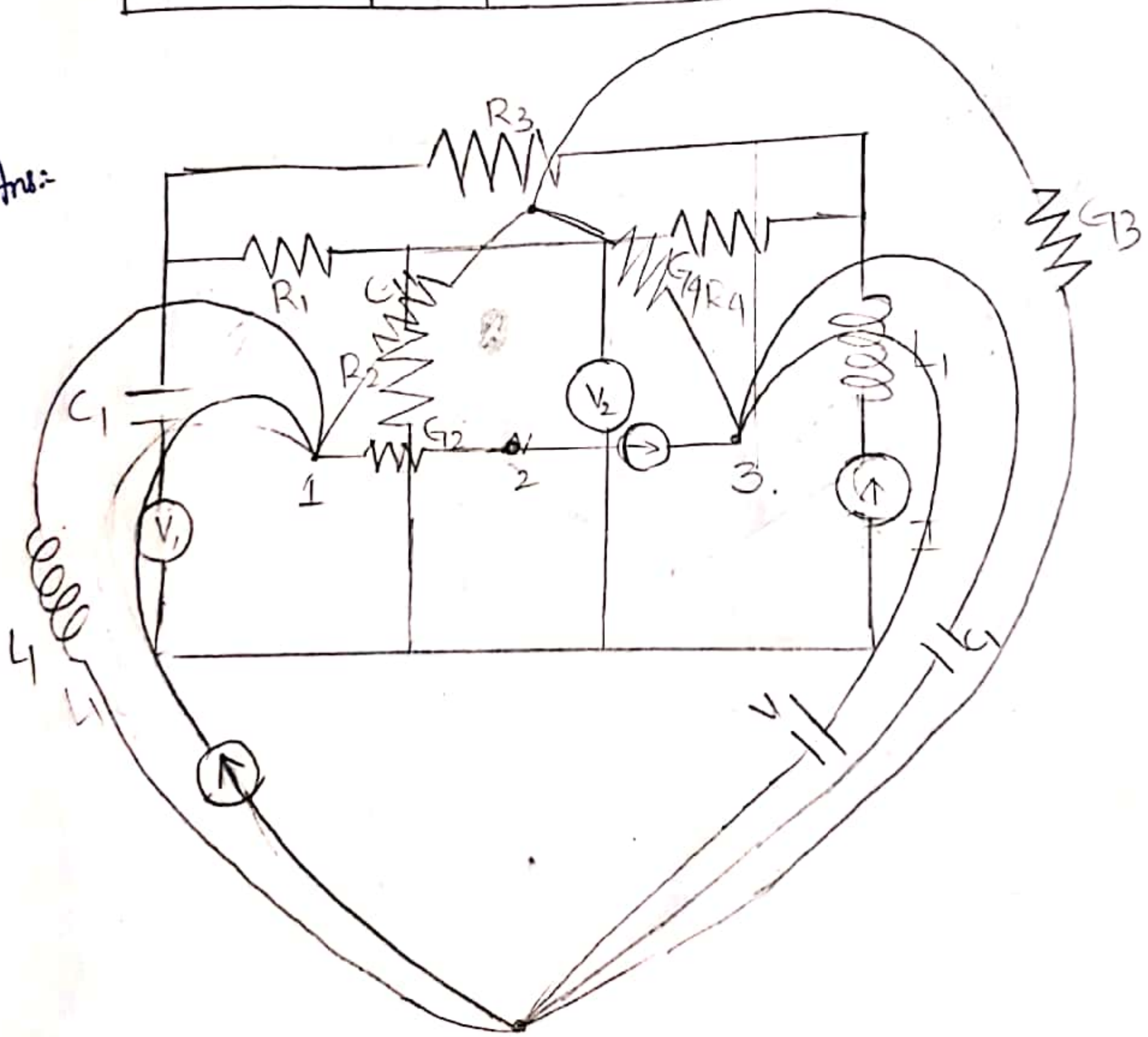


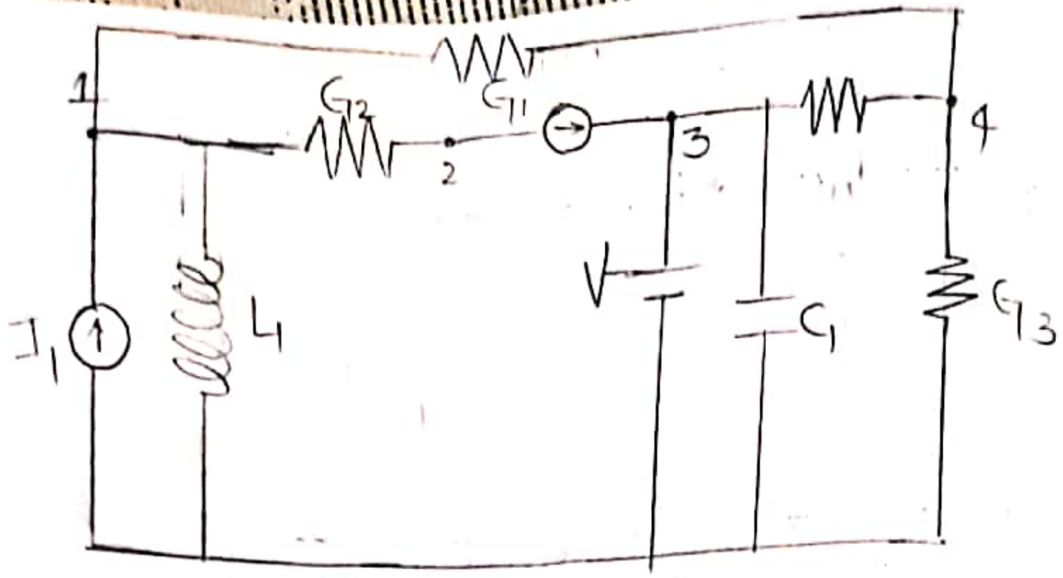


Q)

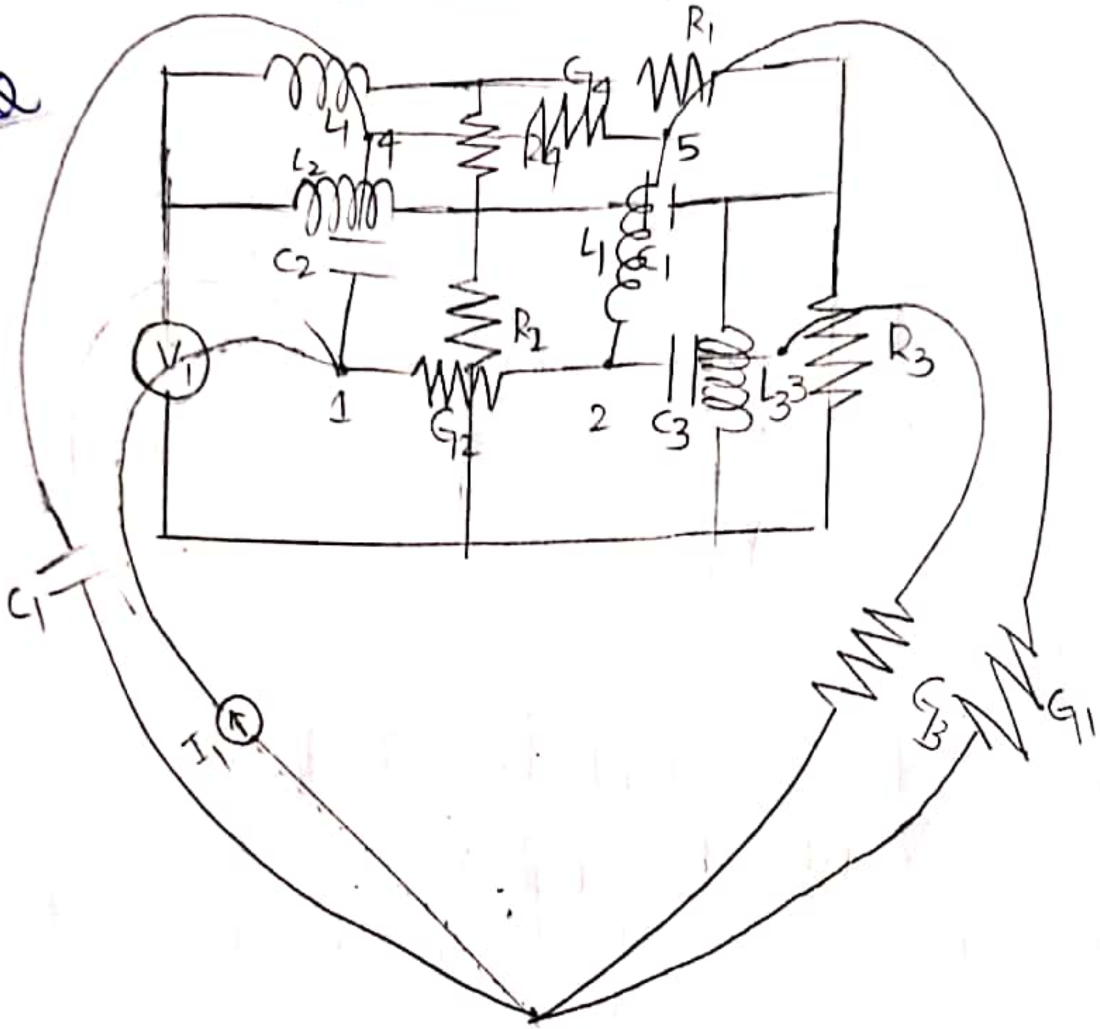


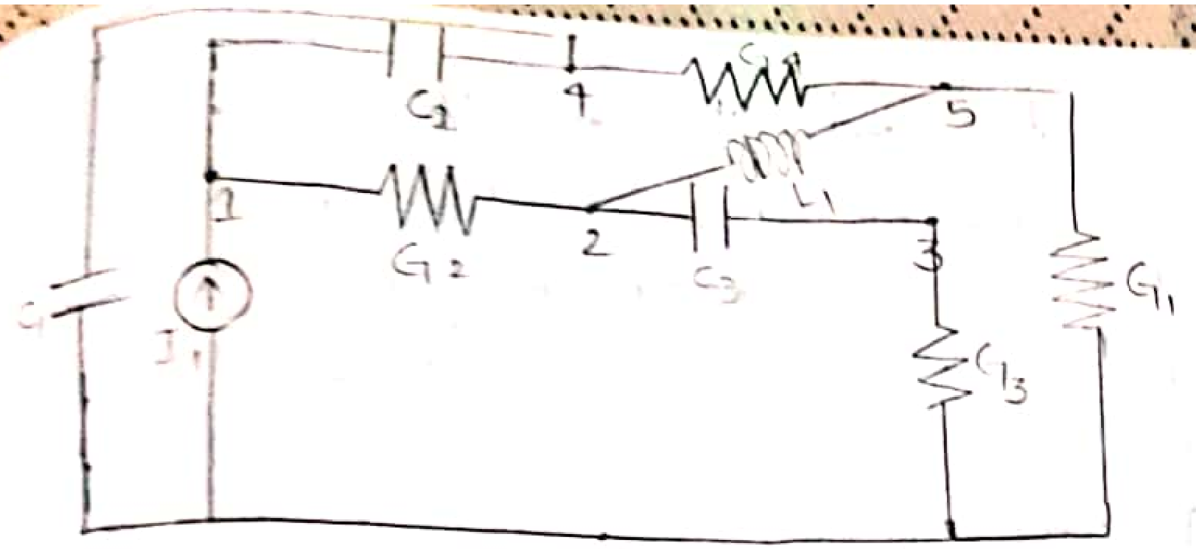
Ans:-




1
G12
G11
2
3
4
V
C1
G13
I1
L1

Q


R1
L
G4
4
R4
5
L2
C2
L1
C1
V1
1
R2
G12
2
C3
L3
R3
C1
I1
G3
G1


C2
4
G4
5
1
G2
2
L1
C3
3
G1
G3
J1

Part-c: Network Topology:

It's a branch of mathematics that deals with the geometry of figures which remains unchanged when the figure is twisted, bent, folded, streched, squeezed or tied in ~~nods~~ knots.

The systematic way of analysing the network in which network properties are studied by investigating the interconnection b/w the branches and nodes of the network

Node:

The interconnection b/w two or more elements.

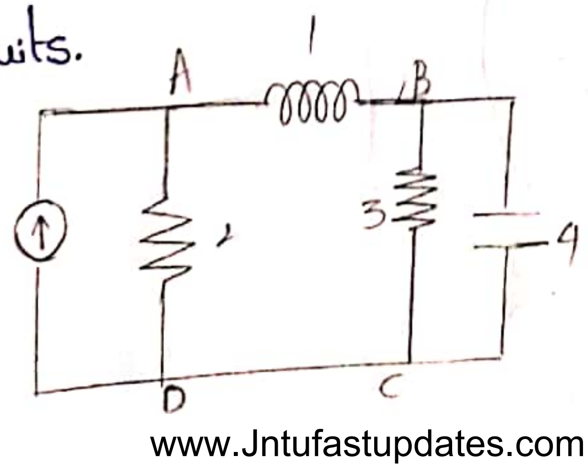
Branch:

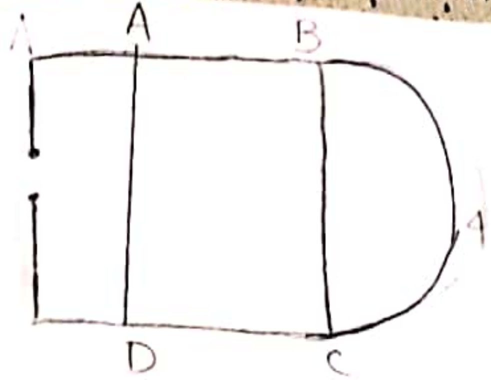
Each line segenent in a graph or figure.

Graph:

It is defined as set of nodes along with set of edges (branches) with each end terminating at one of the vertices.

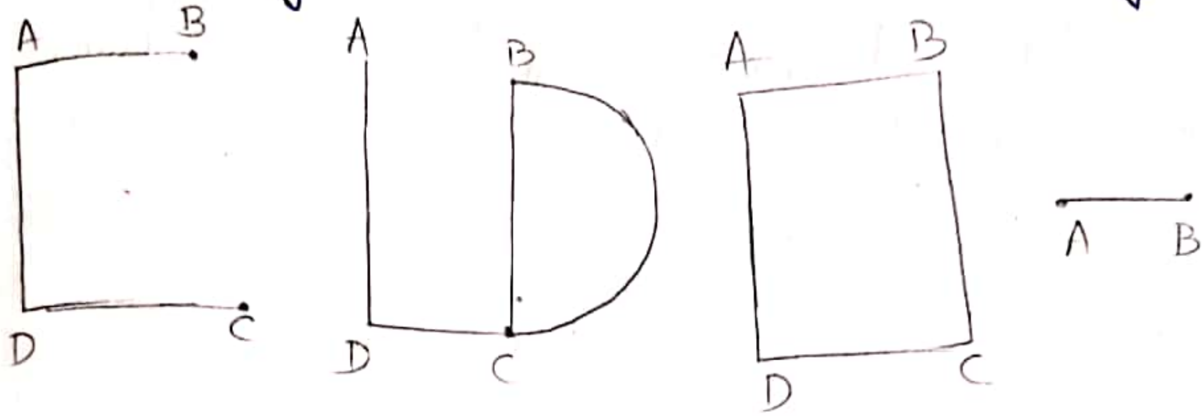
All elements for example RLC are replaced by line segments joined together at various nodes. Voltage sources are replaced by short circuits and current sources are replaced by open circuits.





Sub Graph:

A sub graph is obtained by removing some elements i.e., by removing some branches from the main graph.

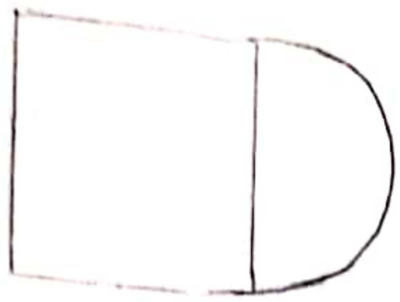


Path:

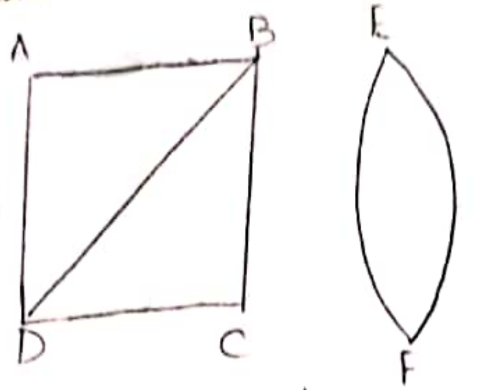
Connected Graph And Un Connected Graph:

A graph is connected graph if their exists atleast one path between any two vertices of the network. otherwise it is an unconnected graph.

Eg:



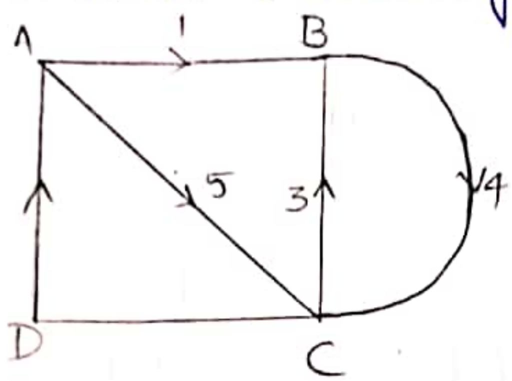
Connected Graphs.



Unconnected graphs.

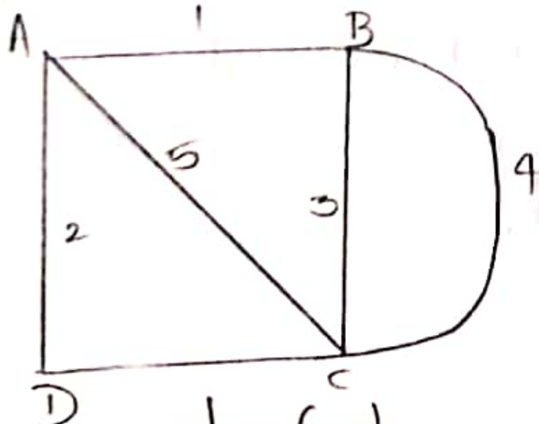
Oriented Graph:

When each branch in a graph is given an arbitary direction then it is known as oriented graph.

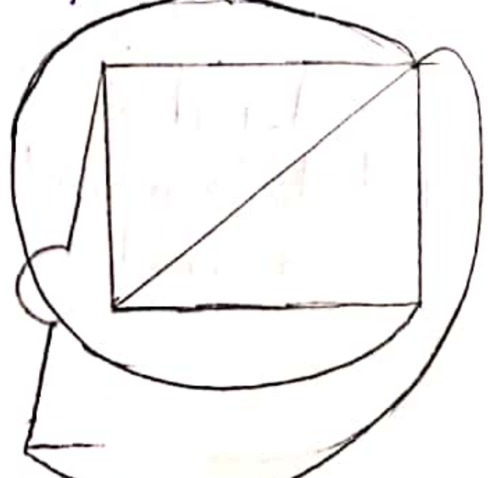


Planar & Non-Planar Graph:

If a graph can be drawn on a plane then it is called as planar graph. if not it is ~~not~~ a Non-planar Graph.



Planar Graph



Rank: The rank of a connected graph is (n-1) ~~where n is no. of nodes~~

Where,

n is no. of nodes.

Tree:

The tree of a graph contains all the nodes as in the main graph with (n-1) no. of branches without any closed loop.

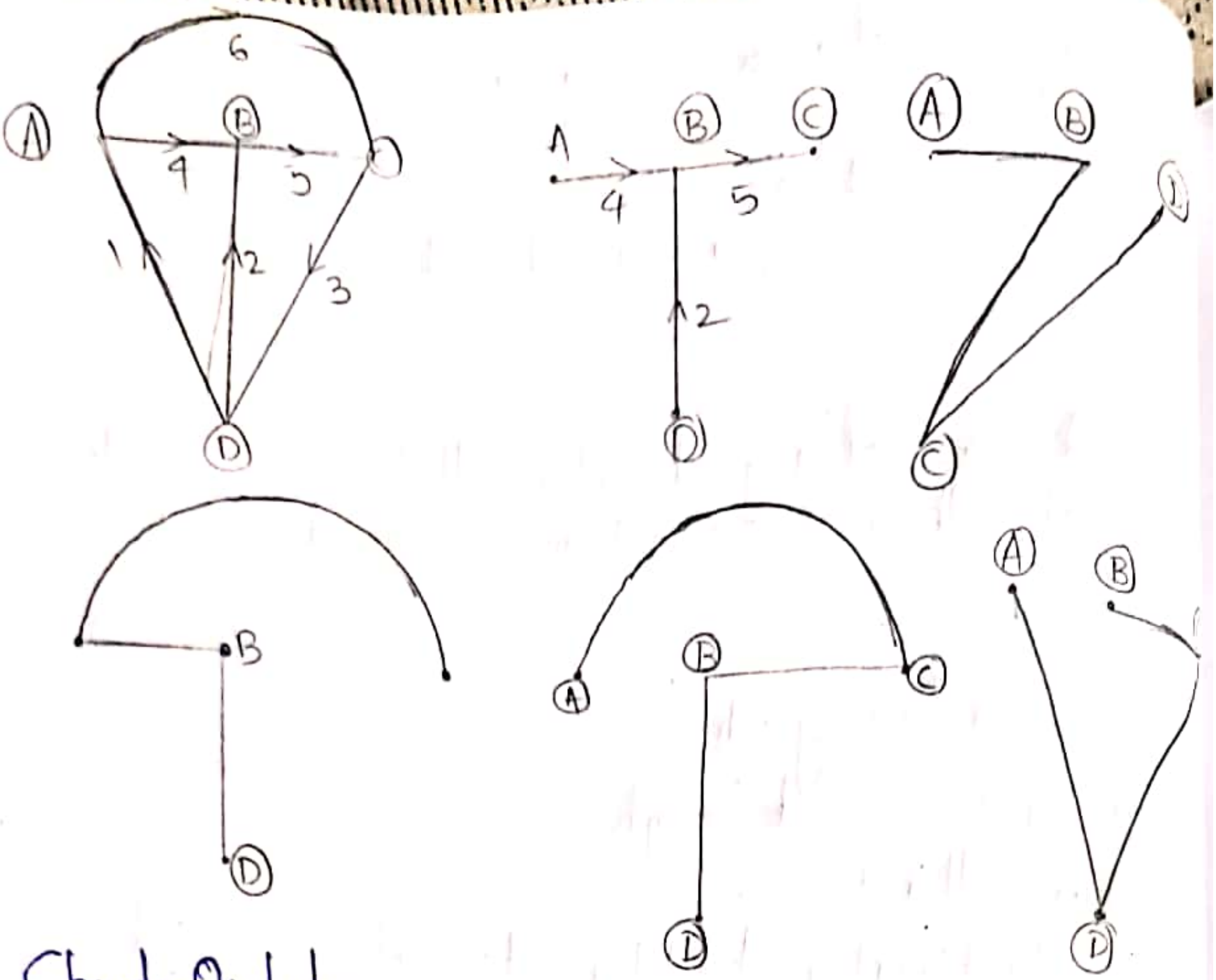
Conditions for Drawing a Tree:

1. Should be connected Graph.
2. Contains all nodes.
3. Shouldn't contain closed loops, have only one path b/w any two nodes.
4. should have n-1 branches

Where, n is no. of nodes.

5. If there are n nodes and b branches we need (n-1) branches to draw a tree
6. The branches of a tree are known as twigs & links.

$$l = b - n + 1$$



Chords Or links:

The branches which are removed from a graph to form a tree are called as Chords or links.

The set of branches which are not in tree is called as Co-tree.

Incidence Matrix [A]:

This matrix gives analytical description of oriented graphs. This is a systematic representation of KVL and KCL applied to a network.

Order is n×b

where n → is rows (nodes).

b → is coloums (branches)

Procedure for Obtaining Matrix [A]:

i) Graph with branches and nodes is drawn

ii) Make Oriented Graph by giving orbitary directions in each branch.

iii) Construct incidence matrix with branch numbers horizontally, node numbers vertically.

iv) Entries are made as follows

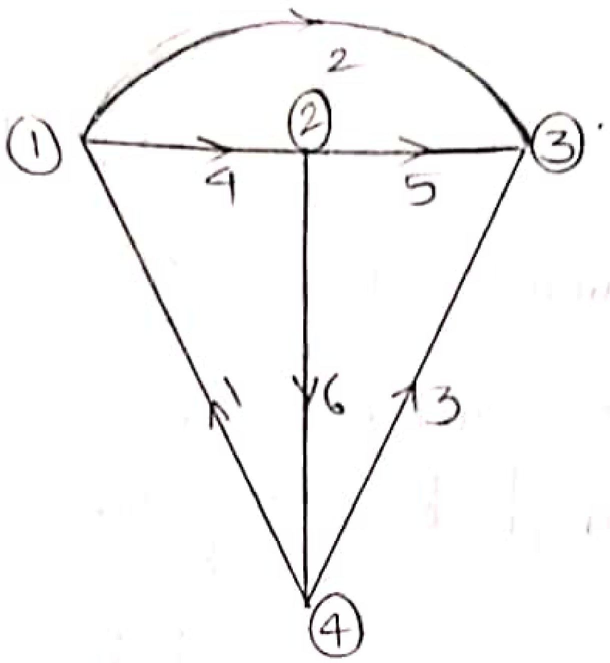
$$a_{ij} = \begin{cases} +1 & \text{if branch 'j' is incident at node 'i' and is directed away from it.} \\ -1 & \text{if branch 'j' is incident at node 'i' and it is directed towards it.} \\ 0 & \text{if branch 'j' is not connected to node 'i'} \end{cases}$$

Properties of Incident Matrix [A]:

i) Addition of each column of the matrix is zero.

ii) Determinant of complete matrix A is zero.

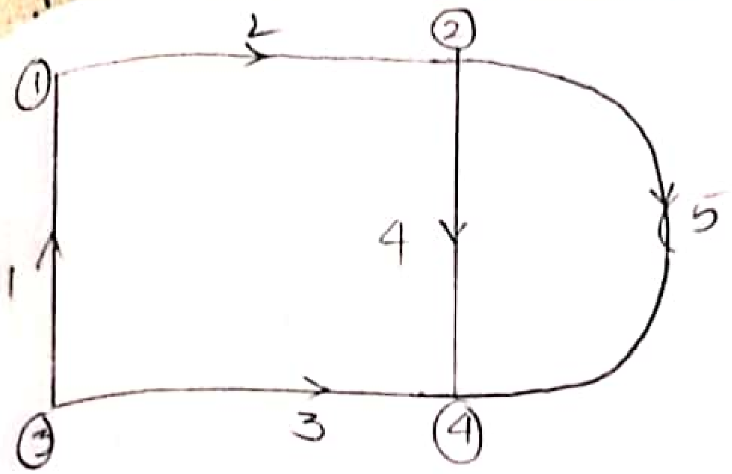
Q Find the incident matrix[A] for the given oriented Graph.



Ans:

	1	2	3	4	5	6
1	-1	1	0	1	0	0
2	0	0	0	-1	1	-1
3	0	-1	-1	0	-1	0
4	1	0	1	0	0	-1

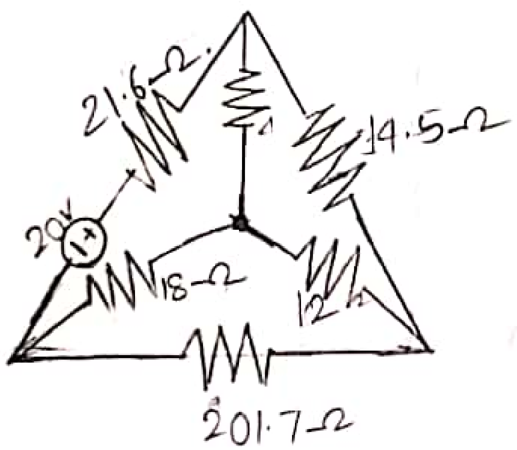
e)



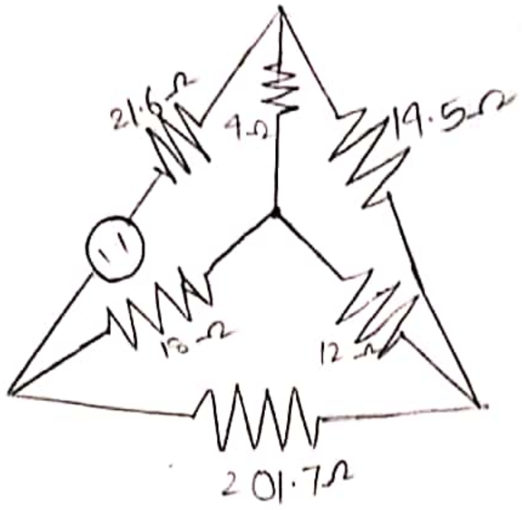
Ans:-

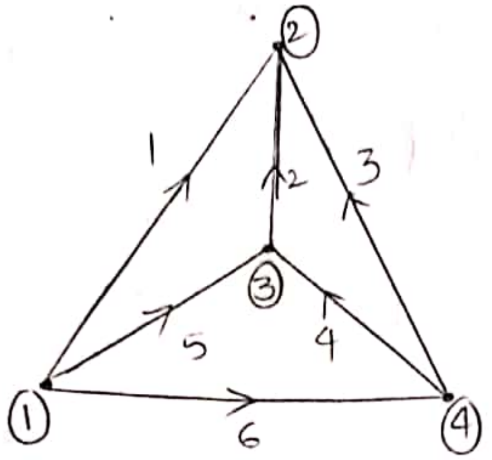
	1	2	3	4	5
①	-1	1	0	0	0
②	0	-1	0	1	1
③	1	0	1	0	0
④	0	0	-1	-1	-1

6)



Ans:





	1	2	3	4	5	6
1	1	0	0	0	1	1
2	-1	-1	-1	0	0	0
3	0	1	0	-1	-1	0
4	0	0	1	1	0	-1

Tie-Set Matrix (or) Circuit Matrix [B]:-

Tie Set Matrix is completely based on tress. It gives the relationship between branch currents and loop currents. The set

The tie set of a graph with respect to tree is a loop formed from fundamental loop. The no.of loops is equal to no.of links

where, $l = b - n + 1$.

$b \rightarrow$ branches
$n \rightarrow$ nodes
$l \rightarrow$ links.

Procedure:

1. Draw the graph and make it oriented.
2. From the graph select a tree which consists of n-1 branches.
3. By adding one link to the tree at a time a closed loop is ~~to~~ should be formed. The closed loop current direction is link current direction.
4. Entries of matrix is given by

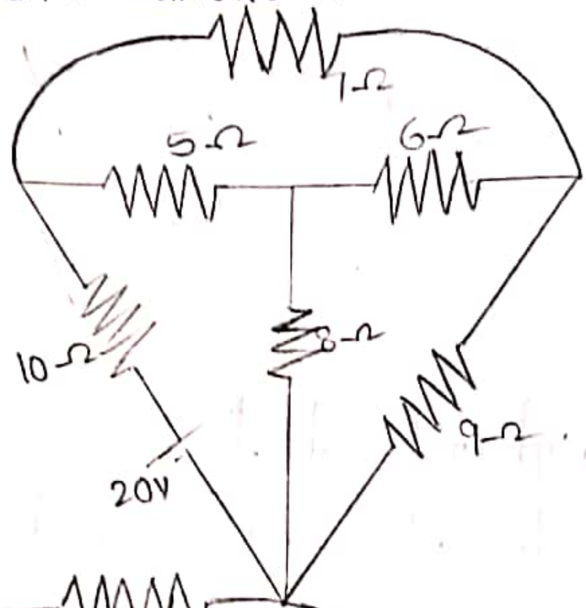
$$b_{ij} = \begin{cases} +1 & \text{when branch } j \text{ is in fundamental loop } i \text{ and its reference direction is same as link direction} \\ -1 & \text{when branch } j \text{ is in fundamental loop } i \text{ and its reference direction is opposite to link direction} \\ 0 & \text{when } j \text{ is in not associated with } i. \end{cases}$$

After writing the tie set Matrix the equation which analyses circuits are written.

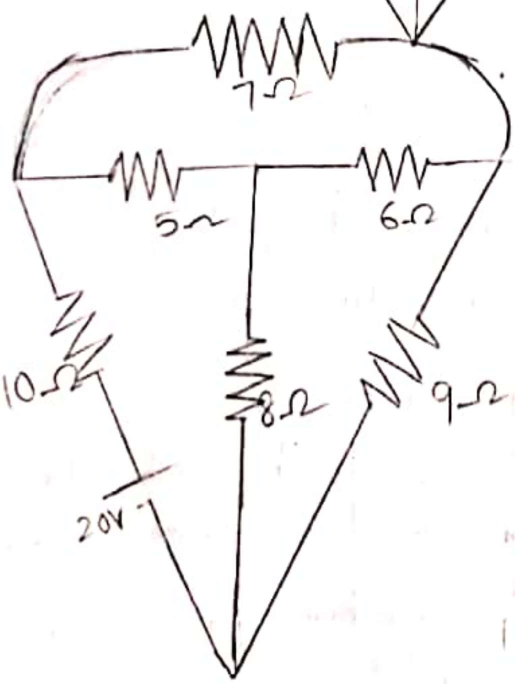
The branch currents are written in terms of loop currents in a coloumn wise manner.

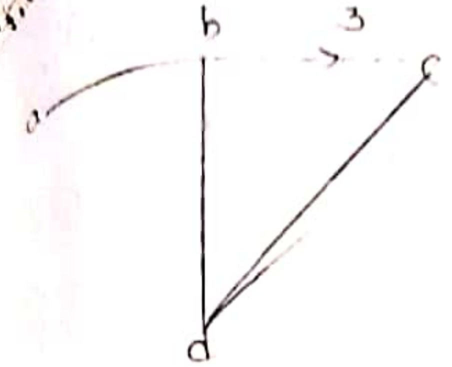
The volt branch voltages are written in terms of row-wise branch voltages in row wise manner.

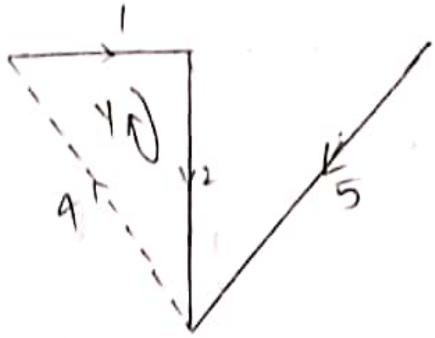
Q) Find the branch currents in the circuit

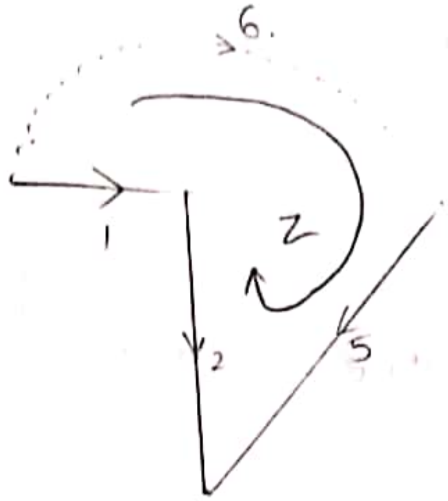


Ans:-









	1	2	3	4	5	6.
x	0	−1	1	0	1	0
y	1	1	0	1	0	0
z	−1	−1	0	0	1	1

$$\left.\begin{aligned} i_1 &= y - z \\ i_2 &= -x + y - z \\ i_3 &= x \\ i_4 &= y \\ i_5 &= x + z \\ i_6 &= z \end{aligned}\right\} \text{ ①}$$

$$\left.\begin{aligned} -V_2 + V_3 + V_5 &= 0. \\ V_1 + V_2 + V_4 &= 0. \\ -V_1 - V_2 + V_5 + V_6 &= 0 \end{aligned}\right\} - ②.$$

Considering coloum wise entries branch currents can be writt as

$$\left.\begin{aligned} i_1 &= y-z \\ i_2 &= -x+y+z \\ i_3 &= x \\ i_4 &= y \\ i_5 &= x+z \\ i_6 &= z \end{aligned}\right\} \rightarrow (1).$$

considering row wise entries branch voltages can be written as

$$\left.\begin{aligned} -V_2+V_3+V_5 &= 0 \\ V_1+V_2+V_4 &= 0 \\ -V_1-V_2+V_5+V_6 &= 0 \end{aligned}\right\} \rightarrow (2).$$

→ From the circuit we can write the branch voltages as

$$\left.\begin{aligned} V_1 &= 5i_1 \\ V_2 &= 8i_2 \\ V_3 &= 6i_3 \\ V_4 &= -20+10i_4 \\ V_5 &= 9i_5 \\ V_6 &= 7i_6. \end{aligned}\right\} \rightarrow (3)$$

(In this problem $V\uparrow$ is taken as -ve)

The relationship b/w branch currents and loop currents are shown in equation ①.

Substituting eq① in eq③.

③ becomes

$$\left.\begin{aligned} V_1 &= 5(y-z) \\ V_2 &= 8(-x+y+z) \\ V_3 &= 6x \\ V_4 &= -20+10(y) \\ V_5 &= 9(x+z) \\ V_6 &= 7z \end{aligned}\right\} \longrightarrow ①$$

substitute eq④ in ② we get.

$\Rightarrow \quad -V_2+V_3+V_5 = 0.$

$-8(-x+y+z)+6x+9(x+z)=0.$

$8x-8y+8z+6x+9x+9z=0.$

$23x-8y+17z=0$

$\Rightarrow V_1+V_2+V_4=0.$

$5(y-z)+8(-x+y+z)-20+10(y)=0.$

$5y-5z-8x+8y+8z-20+10y=0$

$$-8x + 23y + 3z = 0$$

$$-V_1 - V_2 + V_5 + V_6 = 0$$

$$-5(y-z) - 8(-x+y-z) + 9(x+z) + 7z = 0$$

$$-5y + 5z + 8x - 8y + 8z + 9x + 9z + 7z = 0.$$

$$17x - 13y + 29z = 0.$$

$$23x - 8y + 17z = 0.$$
$$-8x + 23y + 3z = 0$$
$$17x - 13y + 29z = 0$$

Solve the above equations.

$$x = 0.0339$$

$$y = 1.165$$

$$z = 0.502$$

Cut - Set Matrix [Q]: (nodal analysis)

Another method of obtaining the analysis of given method.

A cut set matrix [Q] consists of minimum sets of elements such that the graph is divided into two parts.

Procedure:-

1. Draw graph make it oriented.
2. Select a tree.
3. Select minimum number of elements and draw the cut set line. Along the selected elements such that graph is divided into two parts.
4. It is better when elements are selected such that node is seperated.
5. Cutset orientation is same as element orientation i-e direction of cutset is same as direction of branch.
6. The entries of cutset matrix are q

$$q_{ij} = \begin{cases} +1 & \text{if } j^{th} \text{ branch belongs to } i^{th} \text{ cut set and has same direction.} \\ -1 & \text{if } j^{th} \text{ branch belongs to } i^{th} \text{ cut set and has opposite direction} \\ 0 & \text{- if } j^{th} \text{ branch doesn't belongs to } i^{th} \text{ cut set.} \end{cases}$$

After constructing cut set matrix equations are formed

coloumn wise - branch voltages interms of node voltages

row wise - Summation of branch currents.

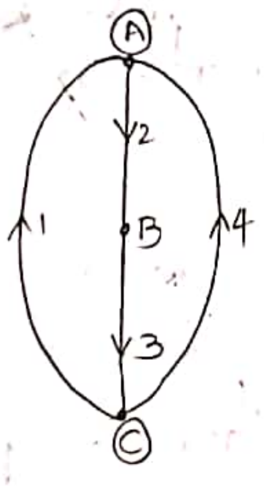
The voltages and currents of various branches in the main circuit are also considered

No. of links $l = b - n + 1$

b = branches

n = no. of nodes.

Q Form a Cut set matrix from the given Oriented Graph:



Ans:-

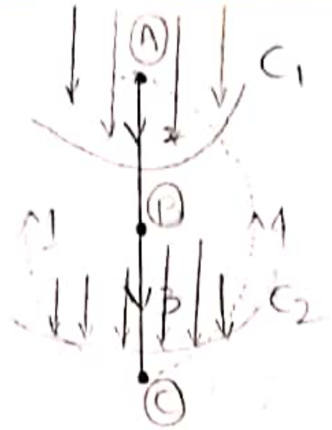
$n = 3$

$b = 4$

$l = b - n + 1$

$= 4 - 3 + 1$

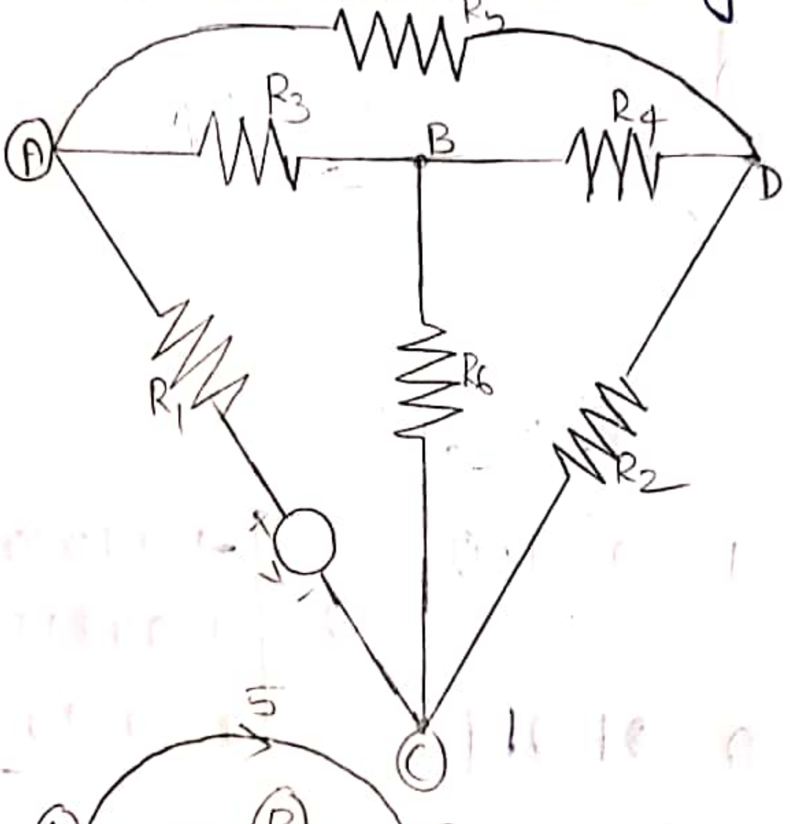
$= 2.$



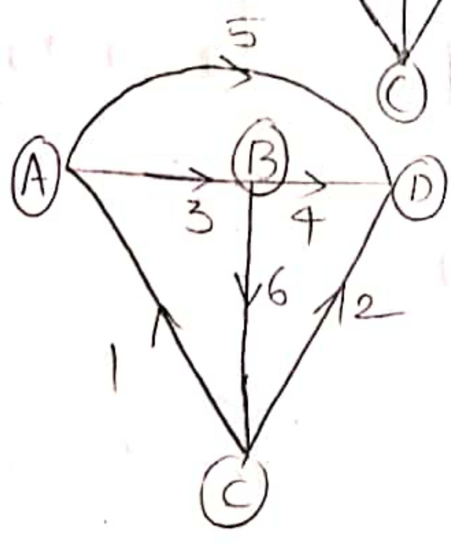
	1	2	3	4
C_1 (1,2,4)	-1	1	0	-1
C_2 (1,3,4)	-1	0	1	-1

$$Q = \begin{bmatrix} -1 & 1 & 0 & -1 \\ -1 & 0 & 1 & -1 \end{bmatrix}$$

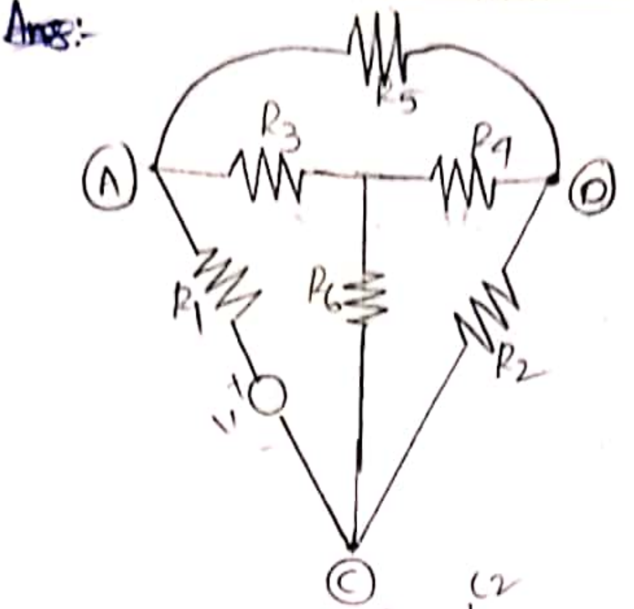
Q) Form the cut set matrix for the given circuit/network?



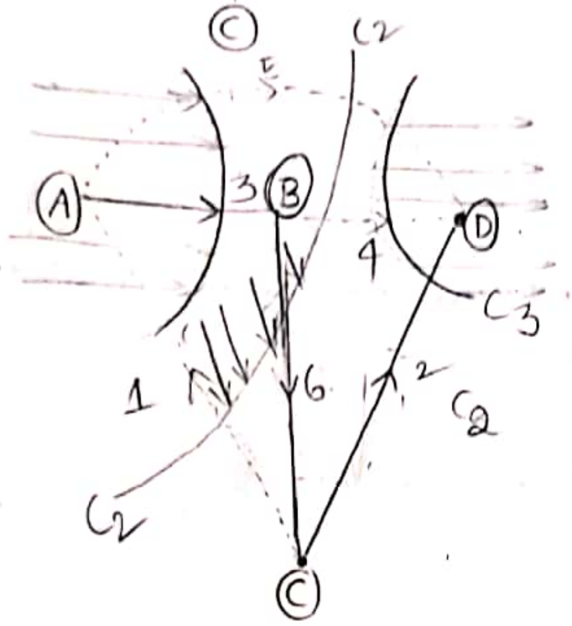
Ans:-



Ans:-



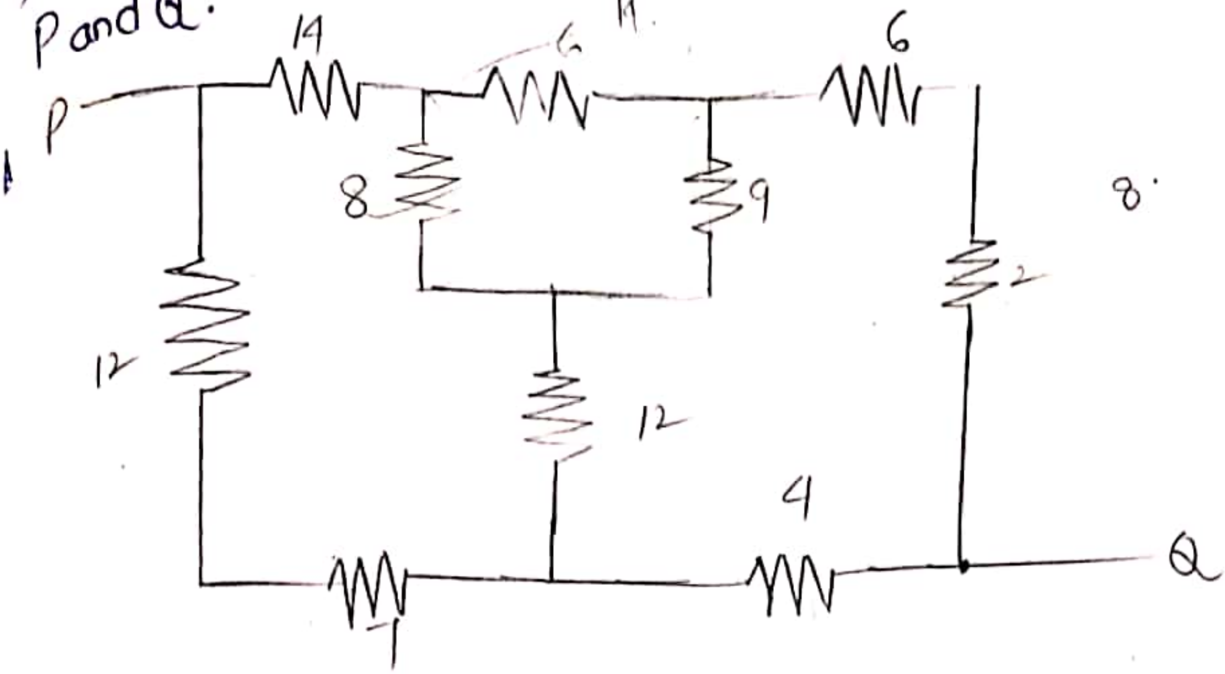
$$l = b - n + 1$$
$$= 6 - 4 + 1$$
$$= 3.$$



	1	2	3	4	5	6
C_1 (1,3,5)	−1	0	1	0	1	0
C_2 (1,2,6)	−1	0	0	1	1	1
C_3 (2,4,5)	0	1	0	1	1	0

$$Q = \begin{bmatrix} -1 & 0 & 1 & 0 & 1 & 0 \\ -1 & 0 & 0 & 1 & 1 & 1 \\ 0 & 1 & 0 & 1 & 1 & 0 \end{bmatrix}$$

Q) Find the equivalent resistance b/w the terminals P and Q.

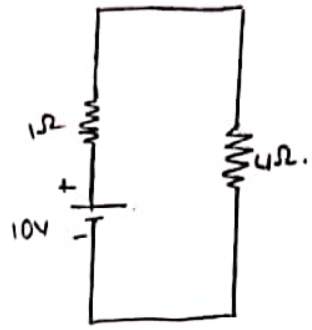


Ans:-

$$I_3 = I \frac{R_1 \| R_2}{R_3 + (R_1 \| R_2)}$$

Problem-1:-

Find the load current in the network shown below using source transformation.



10V.

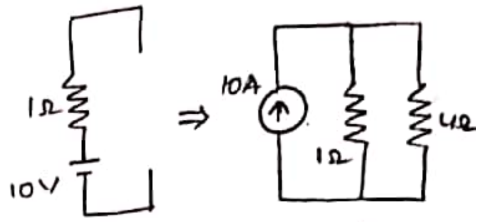
$$I = \frac{V}{R} = \frac{10}{5} = \cancel{10}\ 2A.$$

$$\cancel{I} = \cancel{\frac{10}{4}} = \frac{\cancel{5}}{\cancel{2}} \qquad I = 2A.$$

$V = 10V$

$R_i = 1\Omega$

$$I = \frac{V}{R_i} = \frac{10}{1} = 10A.$$



voltage source

current source.

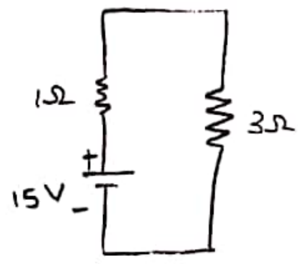
$$I_{4\Omega} = \frac{IR_1}{R_1 + R_4}$$

$$= \frac{10 \times 1}{5} = 2A.$$

$$I_{1\Omega} = \frac{I R_4}{R_1 + R_4} = \frac{\overset{2}{\cancel{10}} \times 4}{\cancel{5}} = 8A.$$

Problem-2:-

Determine the current flowing through load resistor (3Ω), Using Source transformation.

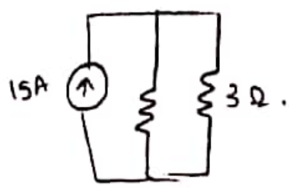


$V = 15V.$

$R_i = 1\Omega$

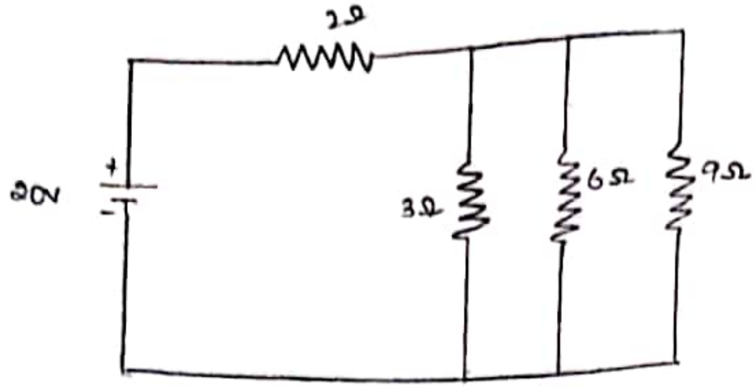
$$I = \frac{V}{R_1} = 15A$$

$$I = \frac{15 \times 1}{4} = 3.75A.$$



Problem-3:-

Find I in each branch.



$$\frac{1}{R_{eq}} = \frac{1}{3}+\frac{1}{6}+\frac{1}{9} = \frac{6+3+2}{18} = \frac{11}{18}$$

$$R_{eq} = \frac{18}{11}+2 = \frac{18+22}{11} = \frac{40}{11}$$

$$I = \frac{V}{R} = \frac{20\times 11}{40} = 5.5A.$$

$$I_1 = \frac{I\,(R_2 \| R_3)}{R_1+(R_2\|R_3)}$$

$$R_2\|R_3 = \frac{6\times 9}{6+9} = \frac{54}{15}$$

$$I_1 = \frac{\frac{11}{2}\times\frac{54}{15}}{3+\frac{54}{15}} = \frac{\cancel{11}^{1}}{2}\times\frac{\cancel{54}^{3}}{\cancel{15}}\times\frac{\cancel{15}}{\cancel{99}_{9,1}}$$

$$= 3A.$$

$$I_2 = \frac{I\,(R_1\|R_3)}{R_2+(R_1\|R_3)}$$

$$R_1\|R_3 = \frac{3\times 9}{3+9} = \frac{27}{12}.$$

$$I_2 = \frac{\frac{11}{2}\times\frac{27}{12}}{6+\frac{27}{12}} = \frac{\cancel{11}^{1}}{2}\times\frac{\cancel{27}^{3}}{\cancel{12}}\times\frac{\cancel{12}}{\cancel{99}_{9}}$$

$$= \frac{3}{2} = 1.5\,A.$$

$$I_3 = \frac{I(R_1 \| R_2)}{R_3 + (R_1 \| R_2)}$$

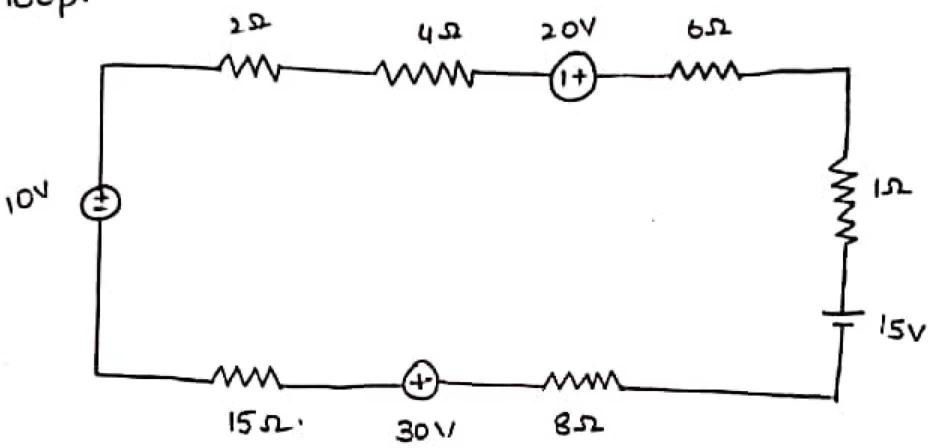
$$R_1 \| R_2 = \frac{3\times 9}{3+9} = \frac{27}{12} = \frac{18}{9} = 2.$$

$$I_3 = \frac{\frac{11}{2}\times\frac{27}{12}}{} = \frac{\frac{11}{2}\times 2}{9+2}$$

$$= \frac{11}{11} = 1A.$$

Problem-4:-

Determine the voltage across 15Ω resistor for the given loop.



From Kirchoff's 2^{nd} law

$$10-2I-4I+20-6I-I-15-8I+30-15I = 0.$$

$$45-36I=0$$

$$45 = 36I$$

$$I = \frac{45}{36} = 1.25$$

$$V=IR$$
$$= (1.25)\times 15 = 18.75$$

Mesh Analysis (or) Loop Analysis:-

Mesh is nothing but closed path of a network. Mesh Analysis is a application of KVL

From BGCD

$$-10I_3-5(I_3-I_2)-8(I_3-I_1)=0$$

$$-10I_3-5I_3+5I_2-8I_3+8I_1=0$$

$$-18I_3-5I_3+8I_1+5I_2=0$$

$$8I_1+5I_2-23I_3=0 \quad \text{— (3)}$$

From (1) (2) (3)

$$\begin{bmatrix} -11 & 3 & 8 \\ 3 & -10 & 5 \\ 8 & 5 & -23 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} -15 \\ 0 \\ 0 \end{bmatrix}.$$

$$\Delta = -11(230-25)-3(-69-40)+8(15+80)$$

$$= -1168.$$

$$\Delta_1 = \begin{bmatrix} -15 & 3 & 8 \\ 0 & -10 & 5 \\ 0 & 5 & -23 \end{bmatrix} = -15(230-25) = -3075$$

$$\Delta_2 = \begin{bmatrix} -11 & -15 & 8 \\ 3 & 0 & 5 \\ 8 & 0 & -23 \end{bmatrix} = 15(-69-40) = -1635$$

$$\Delta_3 = \begin{bmatrix} -11 & 3 & -15 \\ 3 & -10 & 0 \\ 8 & 5 & 0 \end{bmatrix} = -15(15+80) = -1425$$

$$I_1 = \frac{\Delta_1}{\Delta} = \frac{-3075}{-1168} = 2.632$$

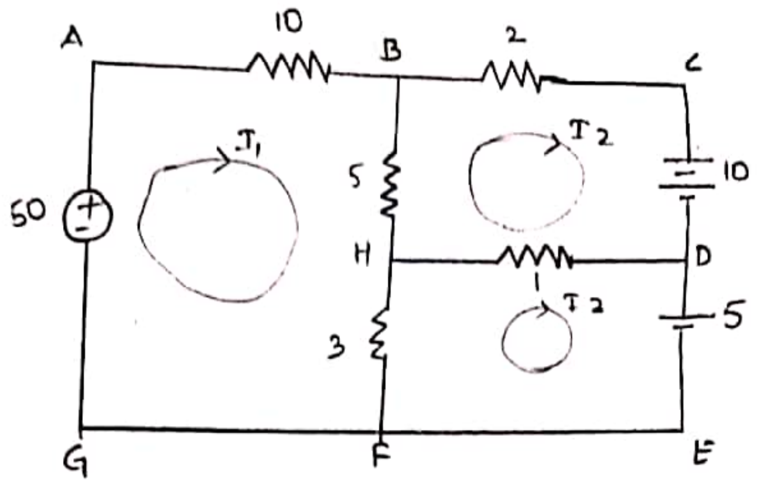
$$I_2 = \frac{\Delta_2}{\Delta} = \frac{-1635}{-1168} = 1.309$$

$$I_3 = \frac{\Delta_3}{\Delta} = \frac{-1425}{-1168} = 1.220$$

$$P = I^2R$$
$$= (1.220)^2 \times 10$$
$$= 14.88.$$

Problem-3:-

Determine the current in each resistor.



From loop ABFG

$$50 - 10I_1 - 5(I_1 - I_2) - 3(I_1 - I_3) = 0.$$
$$50 - 10I_1 - 5I_1 + 5I_2 - 3I_1 + 3I_3 = 0$$
$$50 - 18I_1 + 5I_2 + 3I_3 = 0 \quad \text{—(1)}.$$

From loop BCDH.

$$-5(I_2 - I_1) - 2I_2 - 10 - 1(I_2 - I_3) = 0.$$
$$-5I_2 + 5I_1 - 2I_2 - 10 - I_2 + I_3 = 0.$$
$$5I_1 - 8I_2 + I_3 = 10 \quad \text{—(2)}$$

From loop FEDH

$$-3(I_3 - I_1) - 1(I_3 - I_2) - 5 = 0.$$
$$-3I_3 + 3I_1 - I_3 + I_2 = 5$$
$$3I_1 - 4I_3 + I_2 = 5 \quad \text{— (3)}.$$

From ① ② ③

$$\begin{bmatrix} -18 & 5 & 3 \\ 5 & -8 & 1 \\ 3 & 1 & -4 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} -50 \\ 10 \\ 5 \end{bmatrix}.$$

$$\Delta = -18(32-1) - 5(-20-3) + 3(5+24)$$

$$= -18\times31 + 23\times5 + 29\times3.$$

$$= -558 + 115 + 87$$

$$= -356$$

$$\Delta_1 = \begin{vmatrix} -50 & 5 & 3 \\ 10 & -8 & 1 \\ 5 & 1 & -4 \end{vmatrix} = -50(32-1) - 5(-40-5) + 3(10+40)$$

$$= -1550 + 225 + 150$$

$$= -1175$$

$$\Delta_2 = \begin{vmatrix} -18 & -50 & 3 \\ 5 & 10 & 1 \\ 3 & 5 & -4 \end{vmatrix} = -18(-40-5) + 50(-20-3) + 3(25-30)$$

$$= 810 - 1150 - 15$$

$$= -355$$

$$\Delta_3 = \begin{vmatrix} -18 & 5 & -50 \\ 5 & -8 & 10 \\ 3 & 1 & 5 \end{vmatrix} = -18(-40-10) - 5(25-30) - 50(5+24)$$

$$= 900 + 25 - 1450$$

$$= -525$$

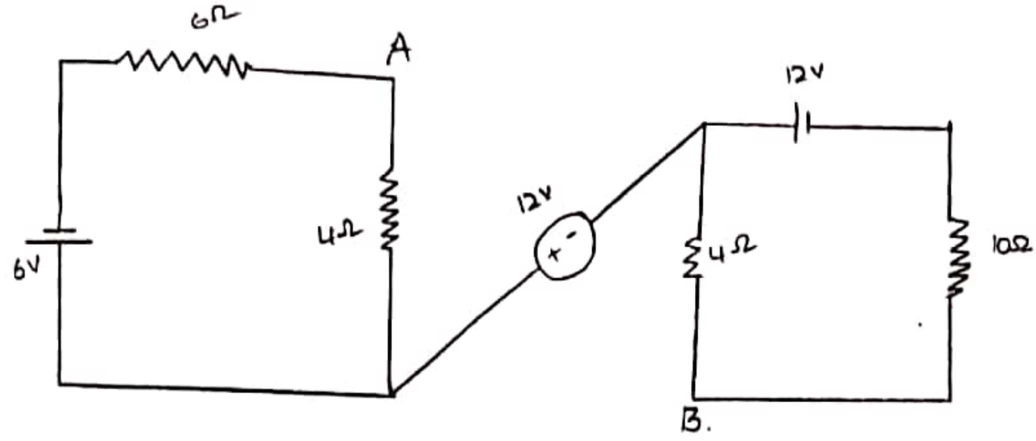
$$I_1 = \frac{\Delta_1}{\Delta} = \frac{-1175}{356} = 3.3$$

$$I_2 = \frac{\Delta_2}{\Delta} = \frac{-355}{-356} = 0.99$$

$$I_3 = \frac{\Delta_3}{\Delta} = \frac{+525}{+356} = 1.47.$$

Problem- 4:-

Determine V_{AB}.



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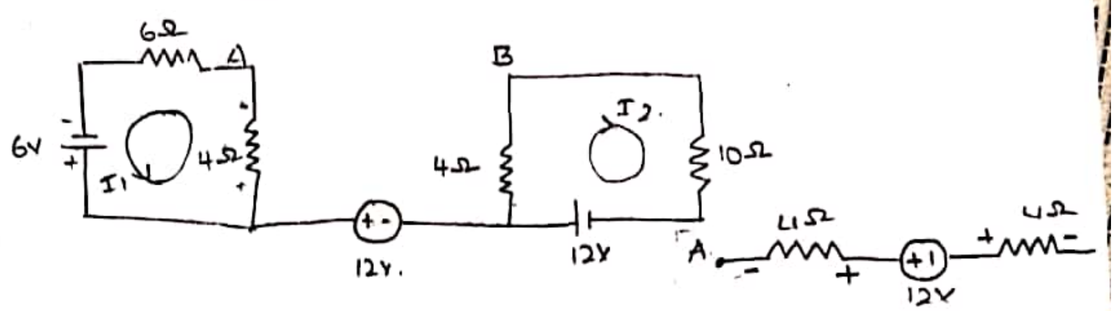


$+6-6I_1-4I_1=0$

$-10I_1=-6$.

$I_1=\frac{+6}{+10}=+0.6A$

$-10I_2+12-4I_2=0$.

$-14I_2=-12$

$I_2=\frac{12}{14}=\frac{6}{7}=0.85A$

$V=IR_1$

$=(+0.6)4$

$=+2.4V$

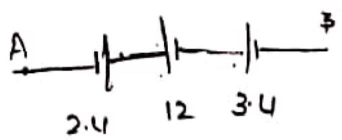
$V=I_2R_2$

$=(0.85)4$

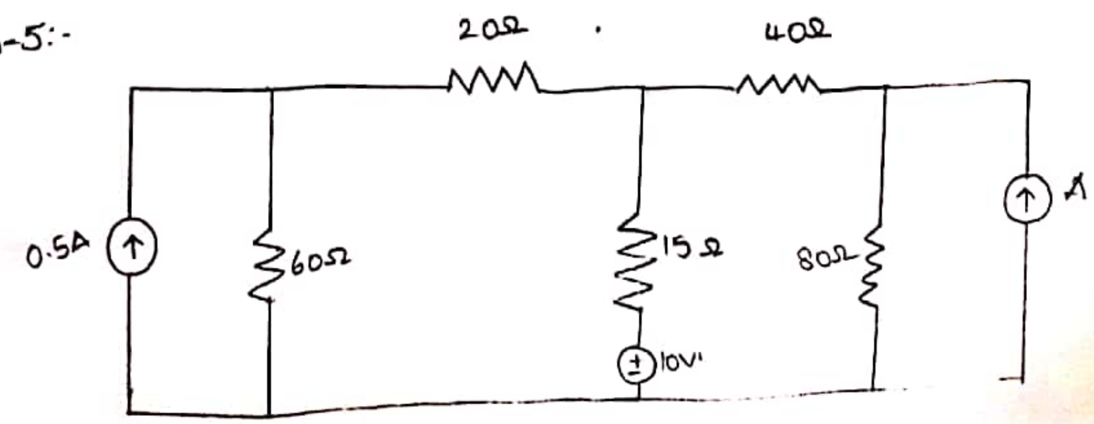
$=3.4V$.

$V_{AB}=2.4-(3.4+12)$

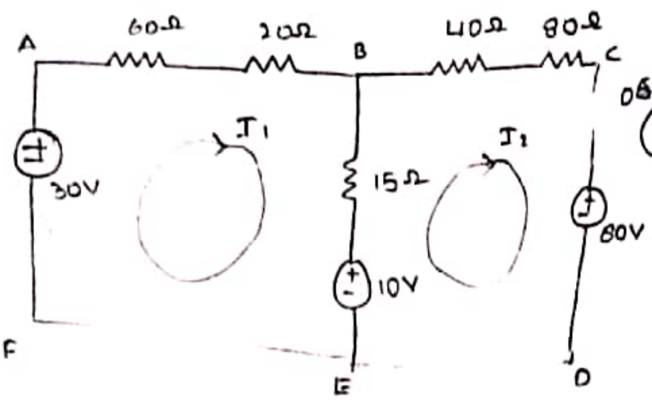
$=13$.

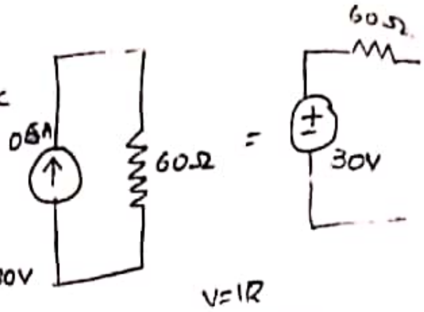


Problem-5:-



Find the current in each resistor.

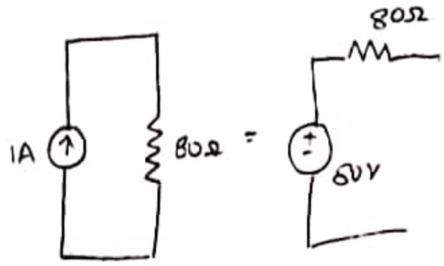




$V = IR$

$= 0.5 \times 60$

$= 30$



$V = IR$

$= 1 \times 80$

$= 80$

From loop ABEF.

$$30 - 60I_1 - 20I_1 - 15(I_1 - I_2) - 10 = 0.$$

$$30 - 60I_1 - 20I_1 - 15I_1 + 15I_2 - 10 = 0.$$

$$30 - 95I_1 + 15I_2 - 10 = 0.$$

$$-95I_1 + 15I_2 = -20 \text{ — (1)}$$

From loop BCDE

$$10 - 15(I_2 - I_1) - 40I_2 - 80I_2 - 80 = 0.$$

$$-70 - 15I_2 + 15I_1 - 120I_2 = 0.$$

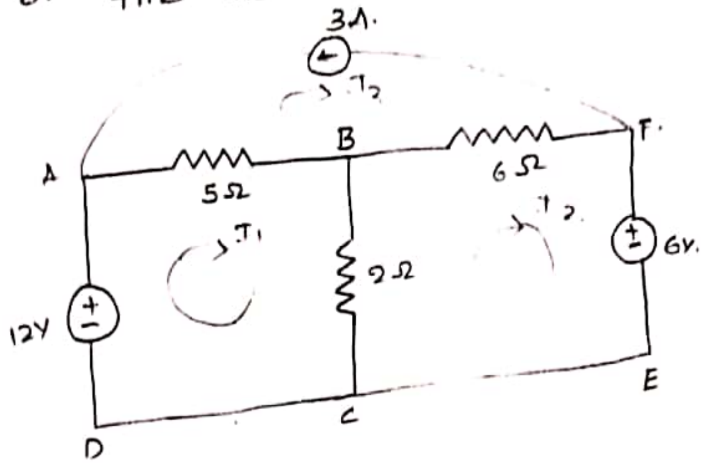
$$15I_1 - 135I_2 = 70. \text{ — (2)}.$$

On Solving (1) & (2).

$$I_1 = +0.13A$$

$$I_2 = -0.5A$$

Problem-6:- Find the current in each loop.



From loop ABCDA $\qquad I_3 = 3A$

$$12 - 5(I_1 + I_3) - 2(I_1 - I_2) = 0$$

$$12 - 5(I_1 + 3) - 2I_1 + 2I_2 = 0$$

$$12 - 5I_1 - 15 - 2I_1 + 2I_2 = 0$$

$$-3 - 7I_1 + 2I_2 = 0$$

$$-7I_1 + 2I_2 = 3 \quad \text{— (1)}$$

From loop BFCEB

$$-2(I_2 - I_1) - 6(I_2 + 3) - 6 = 0$$

$$-2I_2 + 2I_1 - 6I_2 - 18 - 6 = 0$$

$$2I_1 - 8I_2 = 24$$

$$I_1 - 4I_2 = 12 \quad \text{— (2)}$$

From (1) & (2)

$$-7I_1 + 2I_2 = 3$$

$$\cancel{7I_1} - 28I_2 = 84$$

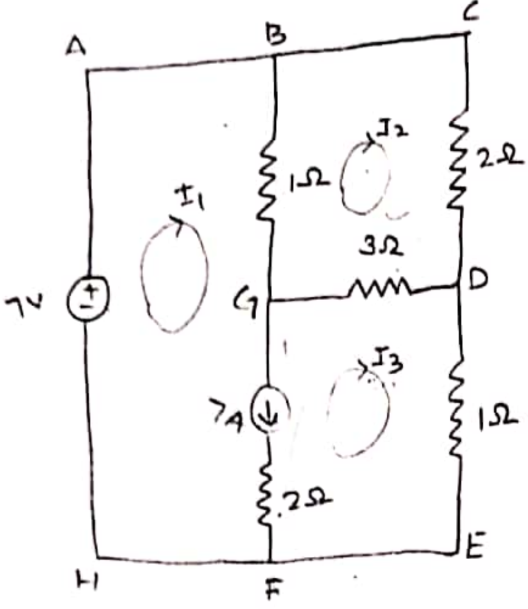
$$-26I_2 = 87$$

$$I_2 = \frac{87}{-26} = -3.34$$

$$I_1 = -1.36.$$

Problem-7:-

Super Mesh Analysis:-



If the current source is present, in the interior of the network, which is common to two loops. That branch containing the current source can be treated as super mesh. Thus, we can reduce the number of meshes by one. There by, we will get less number of meshes for analysis.

From loop ABGDEFHA.

$$7-(I_1-I_2)-3(I_3-I_2)-1I_3=0.$$

$$7-I_1+I_2-3I_3+3I_2-I_3=0.$$

$$\cancel{-5I_1+4I_2=-7}$$

$$-I_1+4I_2-4I_3=-7 \quad \text{—(1)}$$

From loop BCDGB.

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

$$I_1-I_2-2I_2-3I_2+3I_3=0.$$

$$I_1-6I_2+3I_3=0. \quad \text{—(2)}$$

Solving ① & ②.

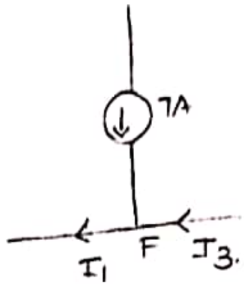
$$\cancel{-I_1} + 4I_2 - 4I_3 = -7$$
$$\cancel{I_1} - 6I_2 + 3I_3 = 0$$

$$-2I_2 - I_3 = -7$$

From KCL

$$7 + I_3 = I_1.$$

$$I_1 - I_3 = 7 \text{ --- } ③$$



From ① ②, ③

$$I_1 = 9$$

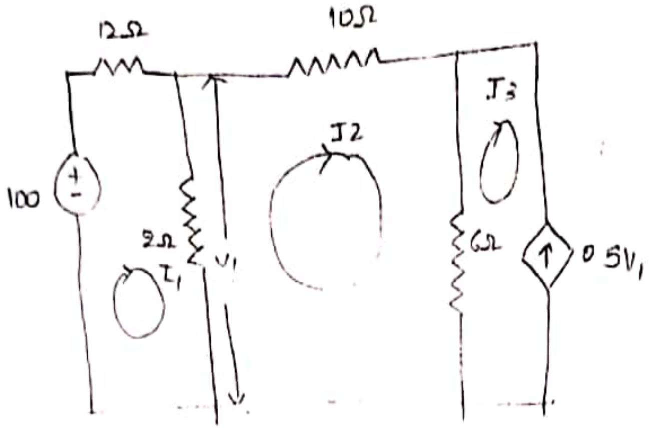
$$I_2 = \frac{5}{2}$$

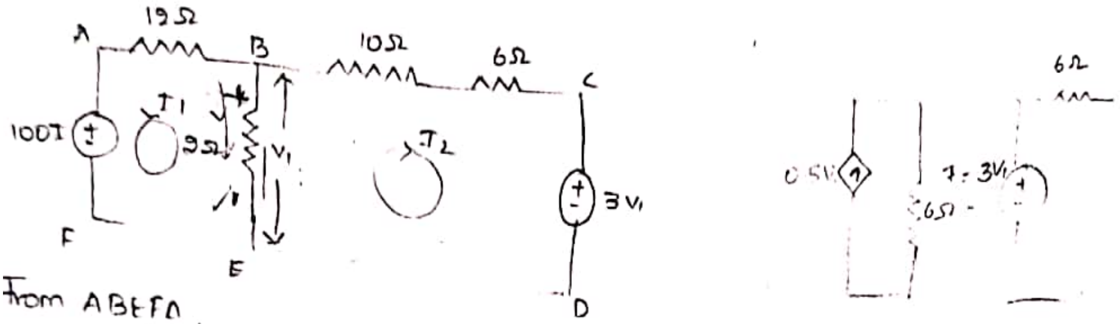
$$I_3 = 2.$$

$$V_x = 3(I_1 - I_2)$$
$$= 3(-1.08 + 1.32)$$

Problem-10:-

Find V_1





From ABEFA

$$100 - 12I_1 - 2(I_1 - I_2) = 0$$
$$100 - 12I_1 - 2I_1 + 2I_2 = 0$$
$$-14I_1 + 2I_2 = -100 \quad (1)$$

From BCDEB

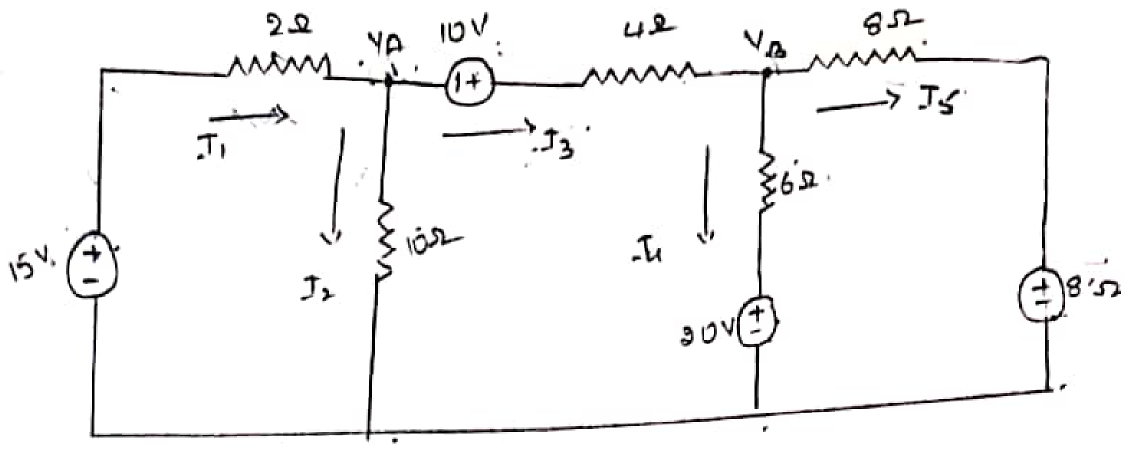
$$-10I_2 - 6I_2 - 2(I_2 - I_1) - 6(I_1 - I_2) = 0$$
$$-10I_2 - \cancel{6I_2} - 2I_2 + 2I_1 - 6I_1 + \cancel{6I_2} = 0$$
$$-4I_1 - 12I_2 = 0.$$
$$-2I_1 - 6I_2 = 0 \quad (2)$$

From (1) & (2)

$$I_1 = 6.81$$
$$I_2 = -2.27$$
$$V_1 = 2(I_1 - I_2)$$
$$= 18.16$$

NODAL ANALYSIS.

Problem-1:-



From Junction Law

$$I_1 = I_2 + I_3$$

$$I_3 = I_4 + I_5$$

$I_1 = \frac{15 - V_A}{2}$ $\qquad$ $I_4 = \frac{V_B - 20}{6}$

$I_2 = \frac{V_A}{10}$ $\qquad$ $I_5 = \frac{V_B - 8}{8}$

$I_3 = \frac{V_A - V_B + 10}{4}$

$$I_1 = I_2 + I_3$$

$$\frac{15 - V_A}{2} = \frac{V_A}{10} + \frac{V_A - V_B + 10}{4} \Rightarrow \frac{15 - V_A}{\cancel{2}} = \frac{4V_A + 10V_A - 10V_B + 100}{\cancel{40}\ 20}$$

$$300 - 20V_A - 100 - 14V_A + 10V_B = 0$$

$$-34V_A + 10V_B = -200$$

$$-17V_A + 5V_B = -100 \quad (1)$$

$$I_3 = I_4 + I_5$$

$$\frac{V_A - V_B + 10}{4} = \frac{V_B - 20}{6} + \frac{V_B - 8}{8} \Rightarrow \frac{8V_B - 160 + 6V_B - 48}{\cancel{48}\ 12} = \frac{V_A - V_B + 10}{4\ 1}$$

$$8V_B - 160 + 6V_B - 48 = 12V_A - 12V_B + 120$$

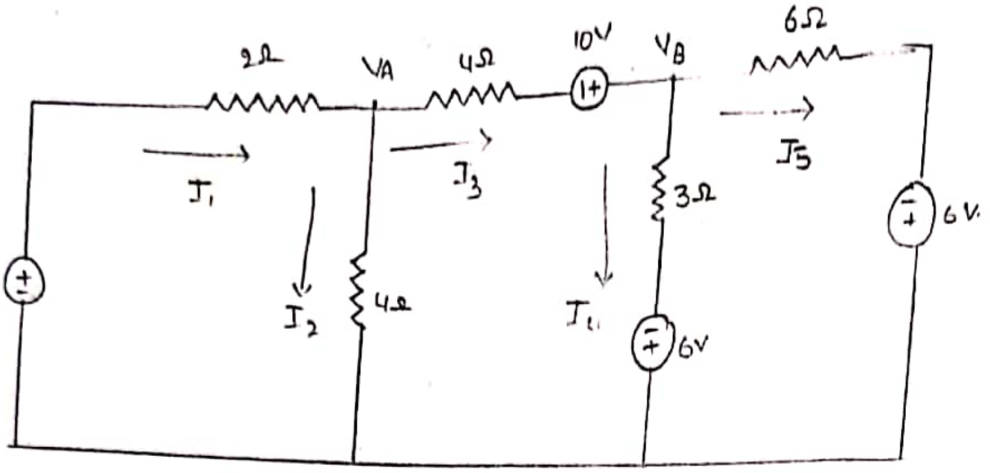
$$14V_B + 12V_B - 208 - 12V_A - 120 = 0$$

$$6V_A - 13V_B = -164 \quad \text{--- (2)}$$

$$V_A = 11.39V$$
$$V_B = 17.23V.$$

Problem-2:-

Obtain the node currents for the network shown below.



At junction V_A

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

$$I_1 = \frac{15 - V_A}{2} \qquad I_4 = \frac{V_B + 6}{3}$$

$$I_2 = \frac{V_A}{4} \qquad I_5 = \frac{V_B + 6}{6}.$$

$$I_3 = \frac{V_A - V_B + 10}{4}$$

$$I_1 = I_2 + I_3. \qquad\qquad I_3 = I_4 + I_5$$

$$\frac{15 - V_A}{2} = \frac{V_A}{4} + \frac{V_A - V_B + 10}{4} \qquad\qquad \frac{V_A - V_B + 10}{4} = \frac{V_B + 6}{3} + \frac{V_B + 6}{6}$$

$$2(15 - V_A) = 2V_A - V_B + 10 \qquad\qquad \frac{V_A - V_B + 10}{\cancel{4}\,2} = \frac{2V_B + 12 + V_B + 6}{\cancel{6}\,3}.$$

$$30 - 2V_A - 2V_A + V_B - 10 = 0$$

$$3V_A - 3V_B + 30 - 4V_B - 24 - 12 - 2V_B = 0$$

$$-4V_A + V_B = -20 \quad \text{--- (1)}$$

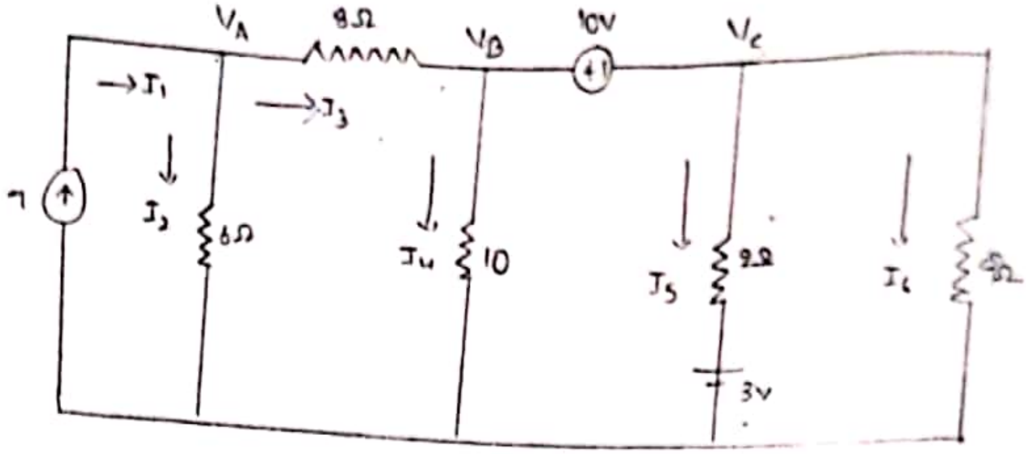
$$3V_A - 9V_B = 6 \quad \text{--- (2)}$$

$$V_A = 5.27$$
$$V_B = 1.09$$

$$I_1 = 4.865 \qquad I_2 = 1.3175 \qquad I_3 = 3.545$$

Problem-2:-

Find the current in 2Ω resistor.



$I_1 = I_2 + I_3$

$I_3 = I_4 + I_5 + I_6$

$I_1 = 7A.$

$I_2 = \frac{V_A}{6}$

$I_3 = \frac{V_A - V_B}{8}$

$I_4 = \frac{V_B}{10}$

$I_5 = \frac{V_C - 3}{2}$

$I_6 = \frac{V_C}{9}$

$7 = \frac{V_A}{6} + \frac{V_A - V_B}{8}$

$7 = \frac{8V_A + 6V_A - 6V_B}{48}$

$7 \times 48 = 14V_A - 6V_B$

$336 = 14V_A - 6V_B$

$168 = 7V_A - 3V_B$ —①

$\frac{V_A - V_B}{8} = \frac{V_B}{10} + \frac{V_C - 3}{2} + \frac{V_C}{9}$

$\frac{V_A - V_B}{8} = \frac{V_B + 5V_C - 15}{10} + \frac{V_C}{9}$

$\frac{V_A - V_B}{8_4} = \frac{9V_B + 45V_C - 135 + 10V_C}{90\ 45}$

$45V_A - 45V_B = 36V_B + 180V_C - 540 + 40V_C$

$45V_A - 81V_B - 220V_C = -540$ —②

$V_B - V_C - 10 = 0$

$V_A = 29.8$

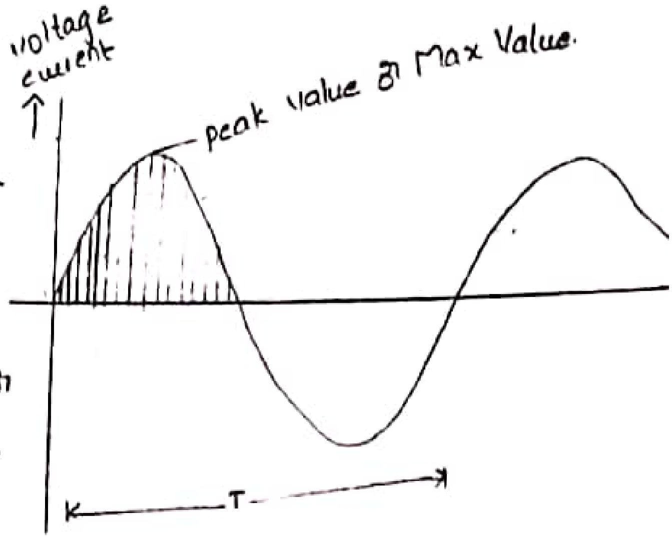
$V_B = 13.55$

$V_C = 3.55$

$I_5 = 0.275$

AC Fundamentals:.

AC quantities are valid only for instantaneous values only. We can't generate DC supply directly. In a DC Generator AC power is generated first and then it is converted into DC power by means of a commutator(mechanical rectifier).



Definitions:-

Wave Form:-
The Shape of the curve obtained by plotting the instantaneous values of voltage or current on y-axis (ordinate) and time on x-axis (absicae) forms a wave shape.

Instantaneous Value:-
The Value of a alternating quantity yet at a particular instant of time is known as instantaneous value.

Cycle:-
One complete set of positive and negative values (half cycles) of an alternating quantity is known as cycle.

Alteration:-
The positive or negative. half cycle of a alternating quantity.

Time Period:-
Time Required to complete one oscillation or cycle of an alternating quantity.

Frequency:-

Number of oscillations/cycles per one second of an alternating quantity.

Angular Velocity(ω):-

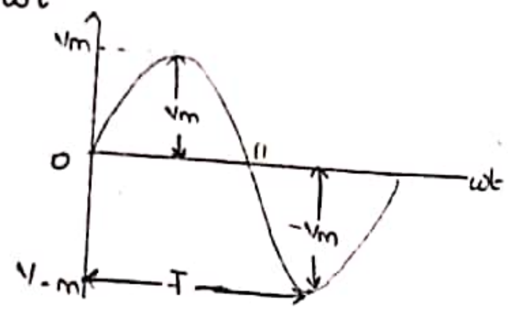
$$\text{Angular Velocity} = \frac{\text{Angular distance}}{\text{time}}$$

$$\text{Angular distance} = \text{Angular Velocity} \times \text{time}$$

$$= \omega t$$

Mathematical Representation of Sinusoidal Quantities:-

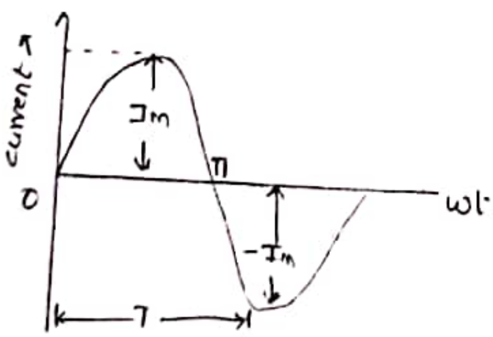
1. $v = V_m \sin \omega t$



Dc - capital
Ac - small

2 Current:-

$I = I_m \sin \omega t$



Peak Value or Maximum Value:-

The maximum value attained by an alternating quantity is known as peak value.

Peak-to-Peak Value:-

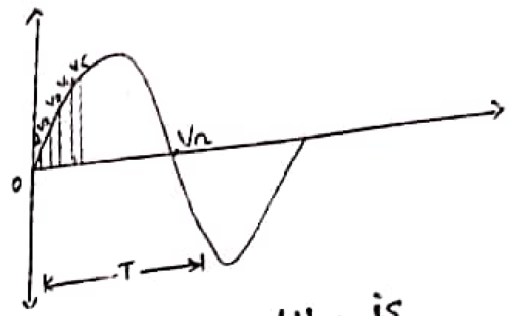
The Maximum Value from positive peak to negative peak.

Average Value:-

The average value of an alternating quantity is the average of all the instantaneous values during one alteration.

$$V_{avg} = \frac{V_1+V_2+V_3+ \cdots V_n}{n} = \frac{1}{T}\int_0^t v(t)\,dt$$

$$V_{avg} = \frac{\text{Area of one alteration}}{\text{Wave length of one alteration.}}$$



Average Value of an alternating quantity is expressed by that DC current which transfers across any point of circuit, the same charge as is transferred by the AC current, for the same time.

$$V_{avg} = \frac{1}{\pi}\int_0^{\pi} V_m \sin\omega t\,(d\omega t)$$

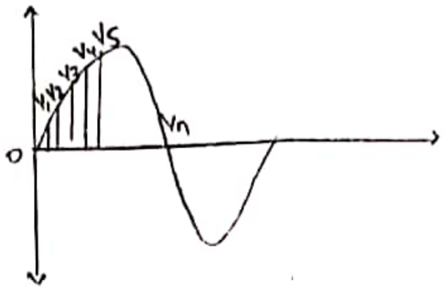
$$= \frac{V_m}{\pi}\left[-\cos\omega t\right]_0^{\pi}$$

$$= \frac{-V_m}{\pi}\left[-1-1\right] = \frac{+2V_m}{\pi} = \frac{2V_m}{\pi} = 0.637V_m$$

Rms Value:- Dc equivalent Ac value
Dc quantity

Rms value of an alternating quantity is defined as the steady or Dc current which when flowing through a circuit for a given period of time, produces, the same heat as produced by the Ac current flowing through the same circuit for the same period.

$$V_{rms} = \sqrt{\frac{V_1^2+V_2^2+V_3^2+\dots V_n^2}{n}}$$



$$V_{rms} = \sqrt{\frac{\text{Area of one alteration}}{\text{Wavelength of one alteration.}}}$$

$$V_{rms} = \left(\frac{\int_0^t [v(t)]^2\, dt}{T}\right)^{1/2}.$$

$$V_{rms} = \sqrt{\frac{1}{\pi}\int_0^{\pi} V_m^2 \sin^2\omega t \, d\omega t}$$

$$= \sqrt{\frac{V_m^2}{\pi}\int_0^{\pi} \frac{1-\cos 2\omega t}{2}\, d\omega t.}$$

$$= \sqrt{\frac{V_m^2}{2\pi}\left[\omega t - \frac{\sin 2\omega t}{2}\right]_0^{\pi}}$$

$$= \sqrt{\frac{V_m^2}{2\pi}\left[\pi - \frac{1}{2}(0)\right]}$$

$$= \frac{V_m}{\sqrt{2}} = 0.707 V_m$$

For Calculating Average Value or rms value of any symmetric alternating quantity, we consider half cycle only. For calculating average or rms values of any unsymmetrical alternating quantity, we consider full cycle.

Form Factor:-

It is defined as the ratio of rms value to average value.

$$\text{Form Factor} = \frac{\text{Rms value}}{\text{Average value}}$$

$$= \frac{\frac{V_m}{\sqrt{2}}}{\frac{2V_m}{\pi}} = \frac{\pi}{2\sqrt{2}} = 1.110$$

Peak factor:-

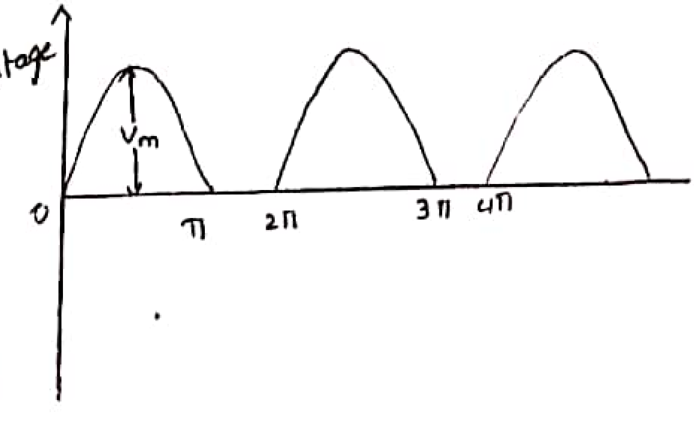
It is defined as the ratio of peak value to rms value.

$$\text{Peak factor} = \frac{\text{Peak value}}{\text{rms value}} = \frac{V_m}{\frac{V_m}{\sqrt{2}}} = \frac{\sqrt{2}}{1} = \sqrt{2} = 1.414.$$

Problem-1:-

Calculate the form factor for the given signal.

$$f(t) = \begin{cases} V_m \sin \omega t & 0 \text{ to } \pi \\ 0 & \pi \text{ to } 2\pi \end{cases}$$



$$V_{avg} = \frac{1}{2\pi}\int_0^{\pi} V_m \sin\omega t \, d(\omega t)$$

$$= \frac{V_m}{2\pi}\left[-\cos\omega t\right]_0^{\pi} = \frac{-V_m}{2\pi} \times 2 = \frac{V_m}{\pi} = 0.318 V_m$$

Branch:-

Each linesegment in a graph or figure.

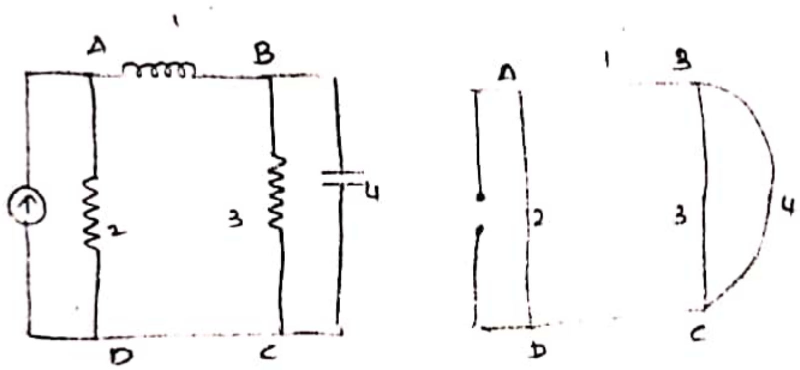
Node:-

The Interconnection between two or more elements.

Graph:-

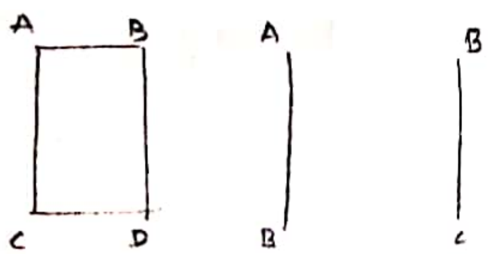
It is defined as set of nodes, along with set of edges (branches) with each end terminating at one of the vertices.

All elements LCR etc are replaced by linesegments joined together at various nodes. Voltage sources are replaced by short circuits and current sources are replaced by open circuits.



Sub Graph:-

A subgraph is obtained by removing some elements i.e., some branches from the main graph.



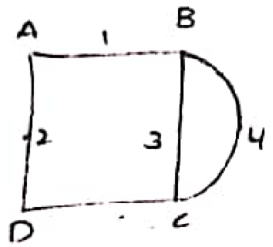
Path:-

It is defined as traversal from one node to another of a graph along the branches, such that no node is encoun twice.

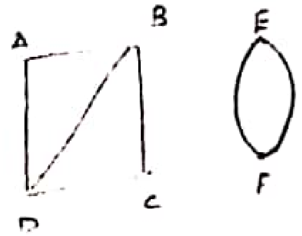
Connected Graph and Unconnected Graph:-

A graph is connected graph, i there exists atleast one path between any two vertices of the network is a connected graph, otherwise it is said to be unconnected graph.

Connected Graph:-

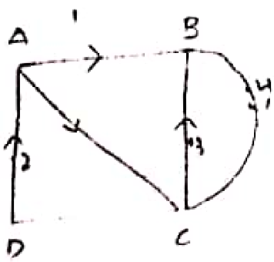


Unconnected Graph



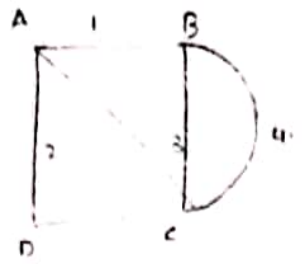
Oriented Graph:-

When each branch in a graph is given, an arbitrary direction, then it is known as oriented graph.



Planar and Non-Planar Graph:-

If a graph can be drawn on a plane, then it is called as planar graph, if not it is a non planar graph.



Planar Graph

Non-planar graph

Rank:-

Rank of a connected graph is (n-1). Where n is number of nodes.

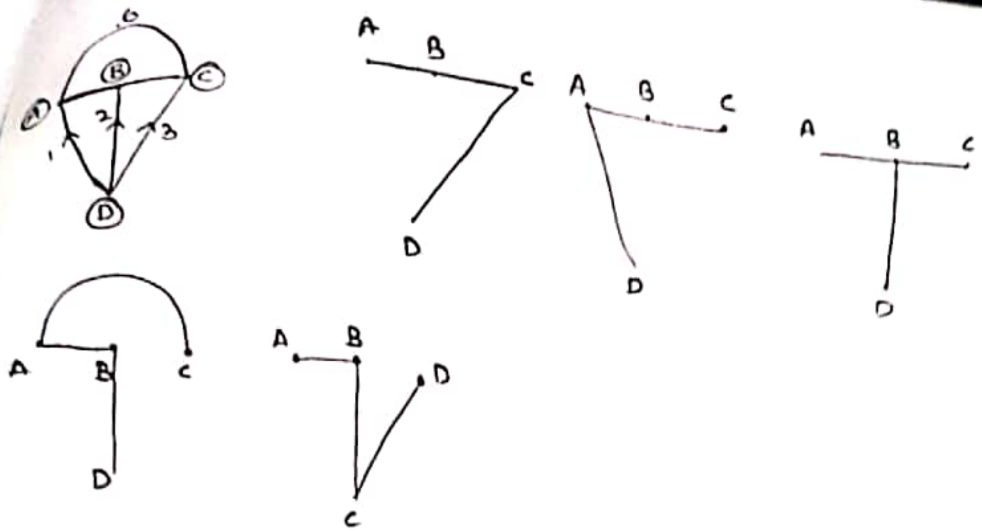
Tree:-

The tree of a graph contains all the nodes as in the main graph with (n-1) number of branches without any closed loop.

Conditions for drawing a tree:-

1. It should be a connected graph.
2. It should contain all nodes.
3. It should not contain closed loops.
4. Have only one p/o path between any two nodes.
5. Should have (n-1) branches
6. If there are n nodes and v branches, we need (n-1) branches to draw a tree.
7. The branches of a tree are known as Twigs & Links

$L =$ Links $= (V-n)+1$



Chord (or) Links:-

Branches which are removed in a graph are called as chord (or) links. The set of branches which are not in tree is called co-tree.

Incidence Matrix [A]:-

→ This matrix gives analytical description of oriented graphs.

→ This is a systematic representation of KVL and KCL applied to a network.

→ Order is $n \times b$.

where
n represents nodes. (rows)
b represents branches (columns)

Procedure for obtaining incident Matrix [A]:-

→ Graph with branches and nodes is drawn.

→ Make Oriented graph by giving arbitrary directions in each branch.

→ Construct incidence matrix with branch numbers horizontally node numbers vertically.

→ Entries are made as follows;

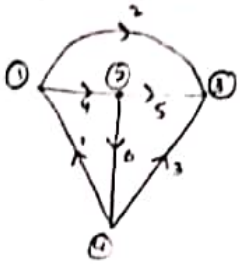
$$a_{ij} = \begin{cases} +1 \text{ if branch "j" is incident at node "i" and is directly away from it.} \\ -1 \text{ if branch "j" is incident at node "i" and is directed towards it.} \\ 0 \text{ if branch "j" is not connected to node "i".} \end{cases}$$

Properties of Matrix [A].

→ Addition of each column matrix is zero.

→ Determinant of complete matrix is zero.

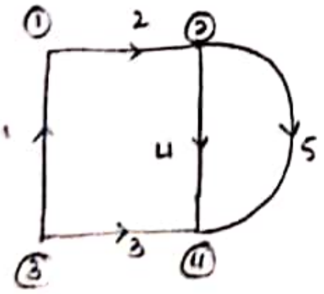
Problem-1:- Find the incident matrix.



	1	2	3	4	5	6
1	-1	+1	0	+1	0	0
2	0	0	0	-1	+1	1
3	0	-1	-1	0	-1	0
4	1	0	1	0	0	-1

Problem-2:-

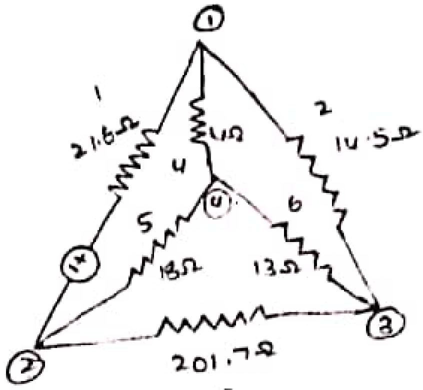
Find the Incident Matrix.



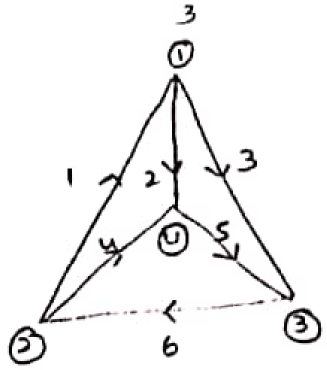
	1	2	3	4	5
1	-1	1	0	0	0
2	0	-1	0	1	1
3	1	0	1	0	0
4	0.	0	-1	-1	-1

Problem-3:-

	1	2	3	4	5	6
①	21.6	14.5	0	4	0	0
②	21.6	0	201.7	0	18	0
③	0	14.5	201.7	0	0	13
④	0	0	0	4	18	13.



	1	2	3	4	5	6
①	-1	1	1	0	0	0
②	1	0	0	1	0	-1
③	0	0	-1	0	-1	1
④	0	-1	0	-1	1	0



Tie-Set Matrix (or) Circuit Matrix (B):-

It is completely based on trees. It gives the relationship between branch currents and loop currents. The tie set of a graph with respect to tree is a root formed from fundamental loop. The number of loops is equal to number of links. where links = b-n+1.

Procedure:-

1. Draw the graph and make it oriented
2. From the graph, select a tree which consists of (n-1) branches.
3. By adding one link to the tree at a time a closed lopp should be form.
4. The closed loop current direction is link current direction.
5. Entries of matrix is given by

$$b_{ij} = \begin{cases} +1 & \text{branch } j \text{ is in fundamental loop } i \text{ and its reference direction same as link.} \\ -1 & \\ 0 & \end{cases}$$

$$b_{ij} = \begin{cases} +1 & \text{When branch } j \text{ is in fundamental loop and its reference direction is same as link.} \\ -1 & \text{when branch } j \text{ is in fundamental loop } l \text{ and its reference direction is opposite to the linked correction} \\ 0 & \text{when } j \text{ is not associated with } i. \end{cases}$$

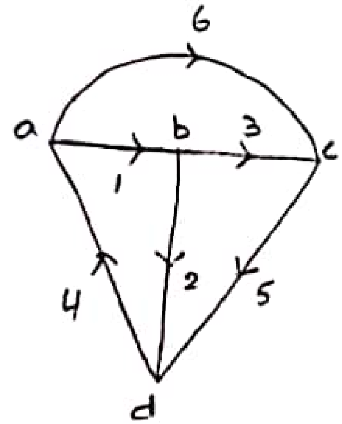
→ After writing the tie-set matrix, the equations which analyze the circuit are written.

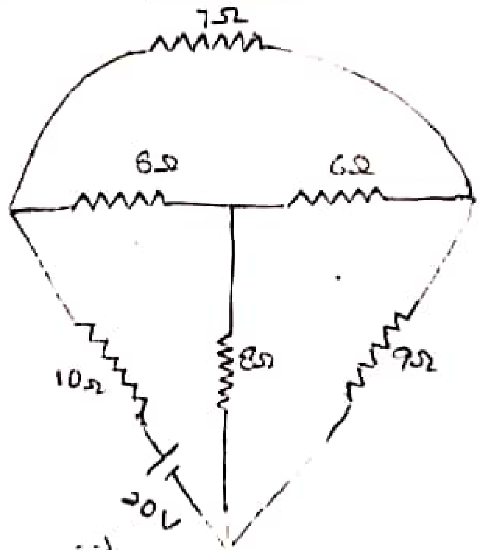
→ The branch currents are written in terms of loop currents in a column wise.

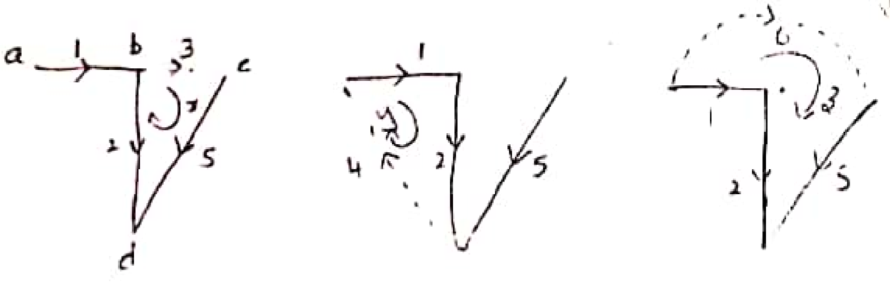
→ The Voltages (Branch Voltages) are written in terms of row wise.

Problem-1:-

Find the branch currents in the circuit







$i_1 = y - z$

$i_2 = -x + y - z$

$i_3 = x$

$i_4 = y$

$i_5 = x + z$

$i_6 = z$ —①

$-V_2 + V_3 + V_5 = 0$

$V_1 + V_2 + V_4 = 0$

$-V_1 - V_2 + V_5 + V_6 = 0$ —②

	1	2	3	4	5	6
x	0	-1	1	0	1	0
y	1	1	0	+1	0	0
z	-1	-1	0	0	1	1.

Considering coloumb wise entries branch current can be written as ①

Considering row wise entries branch voltages can be written as ②

From the circuit, we can write the branch voltages as

$V_1 = 5i_1$ $\quad V_3 = 6i_3$ $\quad V_5 = 9i_5$

$V_2 = 8i_2$ $\quad V_4 = -20 + 10i_4$ $\quad V_6 = 7i_6$ —③

The relationship between branch currents and loop current are shown in equation ① substituting eq ① in eq ③

$V_1 = 5y - 5z$

$V_2 = -8x + 8y - z$

$V_3 = 6x$

$V_4 = 10y - 20$

$V_5 = 9x + 9z$

$V_6 = 7z.$ —④

From ② & ④

$8x - 8y + 8z + 6x + 9x + 9z = 0$

$23x - 8y + 17z = 0$

$5y - 5z - 8x + 8y - 8z - 10y - 20 = 0$

$-8x + 3y - 13z = 20$

$-5y + 5z + 8x - 8y + 8z + 9x + 9z + 7z = 0.$

$17x - 13y + 29z = 0$

$x = 0.33 \quad y = 1.165 \quad z = 0.502$

$I_1 = 0.663 \quad I_4 = 1.16$

$I_2 = 1.634 \quad I_5 = 0.536$

$I_3 = 0.03 \quad I_6 = 0.502$

Another method of obtaining the analysis of the given network:-

A cut set Matrix (Q) consists of minimum set of elements such that the graph is divided into two parts.

Procedure:-

1. Draw a graph and make it oriented.
2. Select a tree
3. Select minimum number of elements and draw the cut-set-line along the selected elements such that graph is divided into two parts.
4. It is better, when elements are selected such that node is separated.
5. Cut set orientation is same as element orientation. i.e., direction of cut-set is same as direction of branch
6. The entries of cut-set matrix are

$$Q_{ij} = \begin{cases} +1 & \text{if } j \text{ branch belongs to } i \text{ cut set and has same direction.} \\ -1 & \text{if } j \text{ branch belongs to } i \text{ cut set and has opposite direction} \\ 0 & \text{if } j \text{ branch doesn't belongs to } i \text{ cut set} \end{cases}$$

After constructing cut set matrix, equations are forma

→ Column wise → Branch voltages interms of node voltage

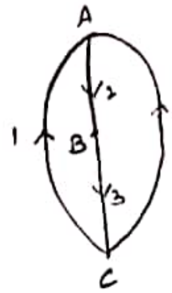
→ Row wise → Summation of branch currents.

→ The voltage and currents of various branches in the main circuit are also considered.

→ Number of links = b-n+1.

Problem-1:-

Form a cut-set matrix from the given oriented graph.



No. of links = b-n+1

= 4-3+1

= 5-3 = 2..

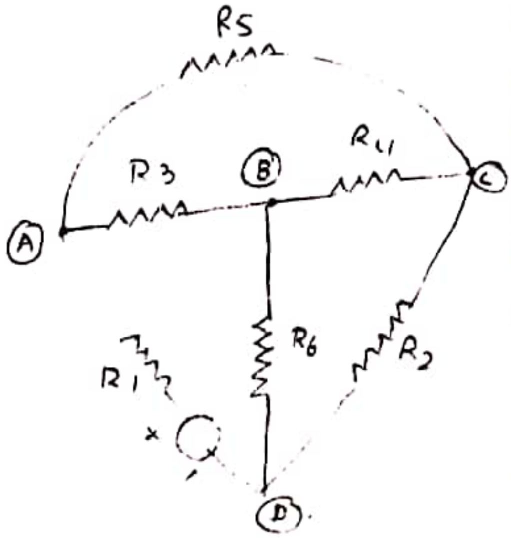
1 branch & any no. of link.

Cut-set Matrix.

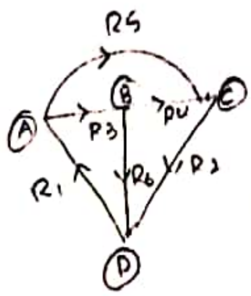
	1	2	3	4
c1	-1	1	0	1
c2	-1	0	1	-1

$$Q = \begin{pmatrix} -1 & 1 & 0 & -1 \\ -1 & 0 & 1 & -1 \end{pmatrix}$$

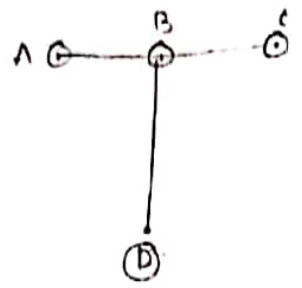
Problem-2:-



Step-1 -



Step-2:-



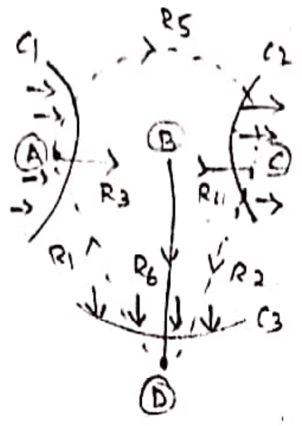
step-3:-

No. of links = b-n+1

= 6-4+1

= 7-4 = 3

Step-4:-



Step-5:- Cut-set-Matrix.

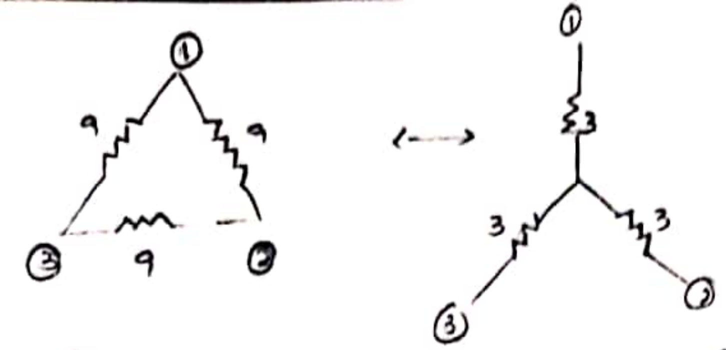
	1	2	3	4	5	6
c_1	-1	0	1	0	1	0
c_2	0	-1	0	1	1	0
c_3	-1	1	0	0	0	1

step-6:-

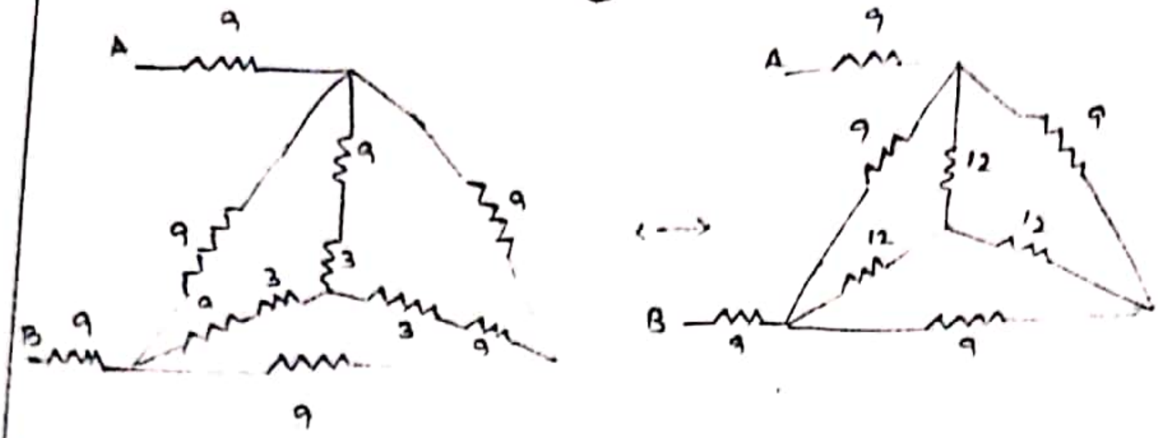
$$Q = \begin{bmatrix} -1 & 0 & 1 & 0 & 1 & 0 \\ 0 & -1 & 0 & 1 & 1 & 0 \\ -1 & 1 & 0 & 0 & 0 & 1 \end{bmatrix}$$

Δ - λ	λ - Δ
$R_1 = \dfrac{R_{12}R_{31}}{R_{12}+R_{31}+R_{23}}$	$R_{12} = R_1 + R_2 + \dfrac{R_1R_2}{R_3}$
$R_2 = \dfrac{R_{12}R_{23}}{R_{12}+R_{31}+R_{23}}$	$R_{23} = R_2 + R_3 + \dfrac{R_3R_2}{R_1}$
$R_3 = \dfrac{R_{13}R_{23}}{R_{12}+R_{31}+R_{23}}$	$R_{31} = \dfrac{R_1R_3}{R_2} + R_1 + R_3$

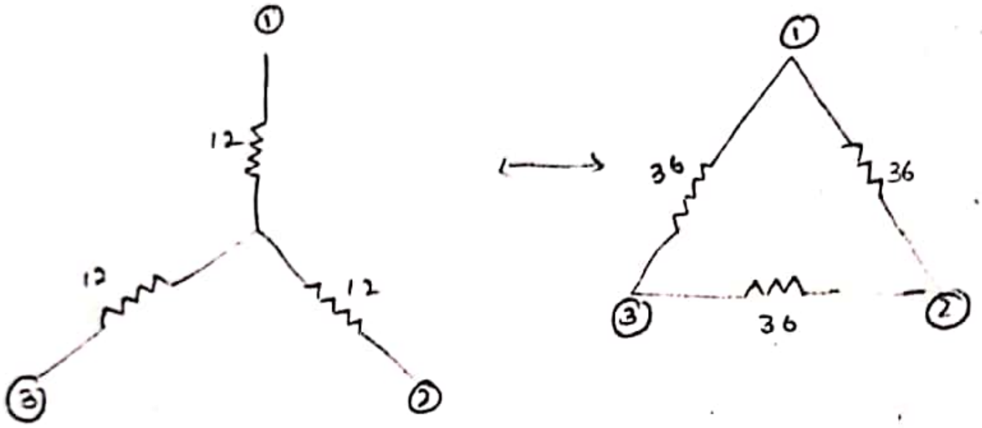
Problem-1:- Find the equivalent resistance between A & B.



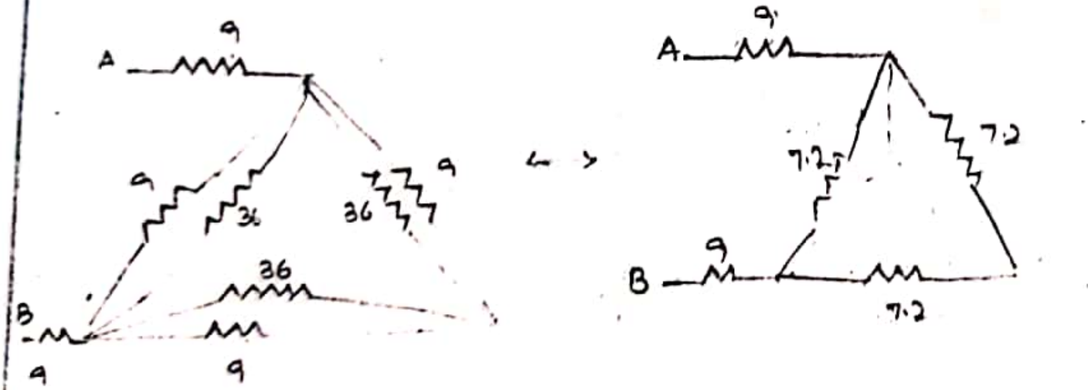
1
9
9
3
9
2
1
3
3
3
3
2



A
9
9
9
9
9
3
3
B
9
9
9
A
9
9
9
12
12
12
B
9
9



1
12
12
12
3
2
1
36
36
36
3
2



A
9
9
36
36
9
36
B
9
9
A
9
7.2
7.2
B
9
7.2

= 22.79.