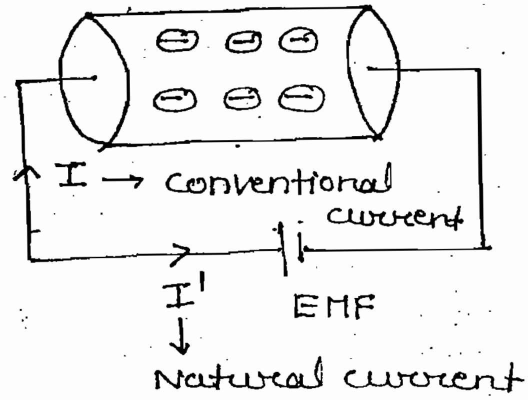
Lecture-1

Charge :-

→ The basic quantity in the electric circuit is charge

→ The charge on the electron is given $(-1.6 \times 10^{-19} C)$

→ The flow of $\bar{e}$'s is called as current



OR

The time rate of charge is also called as current.

$$\boxed{I = \frac{dQ}{dt}} \quad C/s \text{ or } A$$

→ By using conventional current direction KVL and KCL equations are developed

→ To move the $\bar{e}$ from one point to other point in particular direction external force is required In electric ckt external force is provided by EMF and it is given by

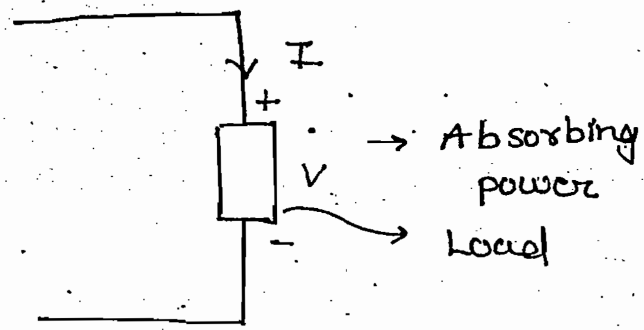
$$\boxed{V = \frac{dW}{dQ}} \quad J/C \text{ or volts}$$

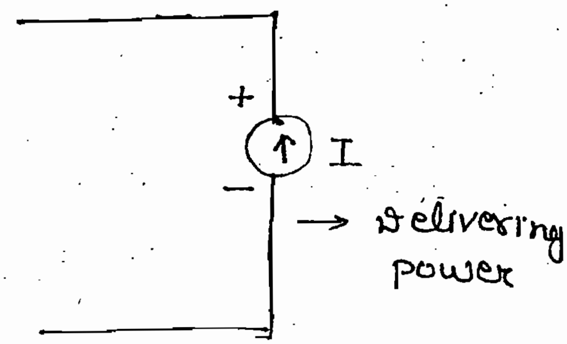
→ The time rate of energy is called as power

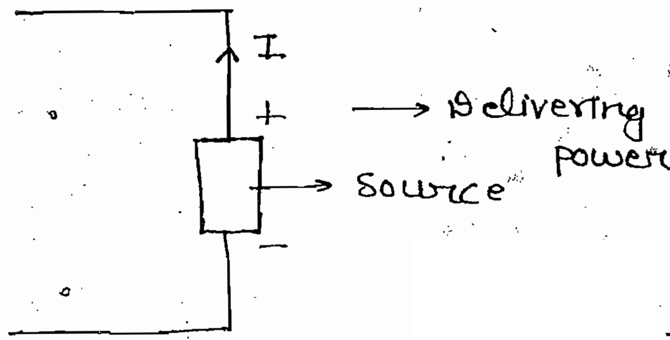
$$P = \frac{dW}{dt} \quad J/s \text{ or Watts}$$

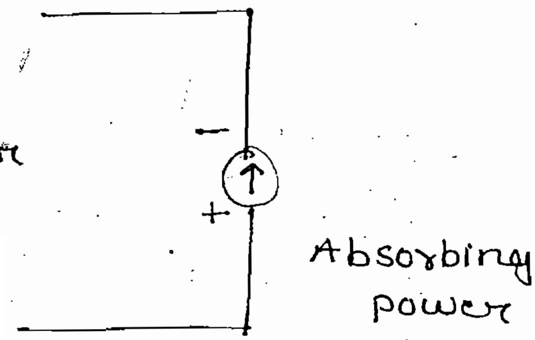
$$P = \frac{dW}{dQ} \cdot \frac{dQ}{dt}$$

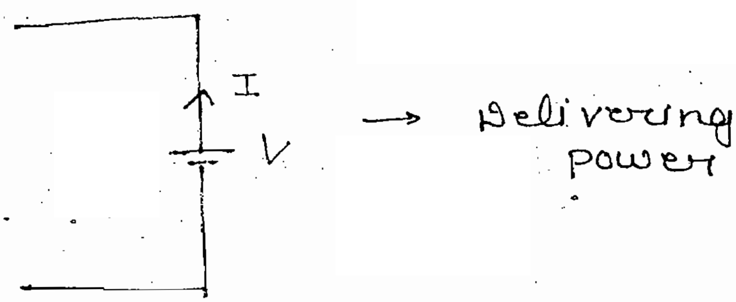
$$\boxed{P = V \cdot I}$$

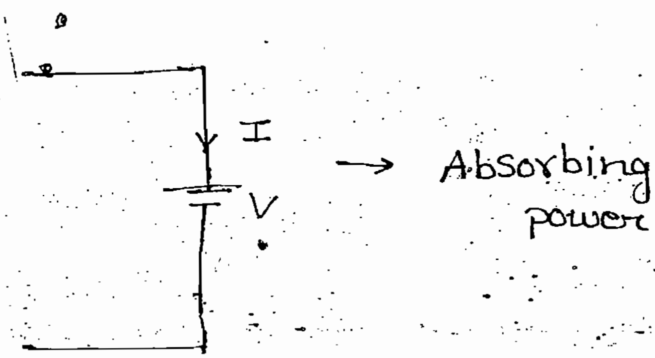










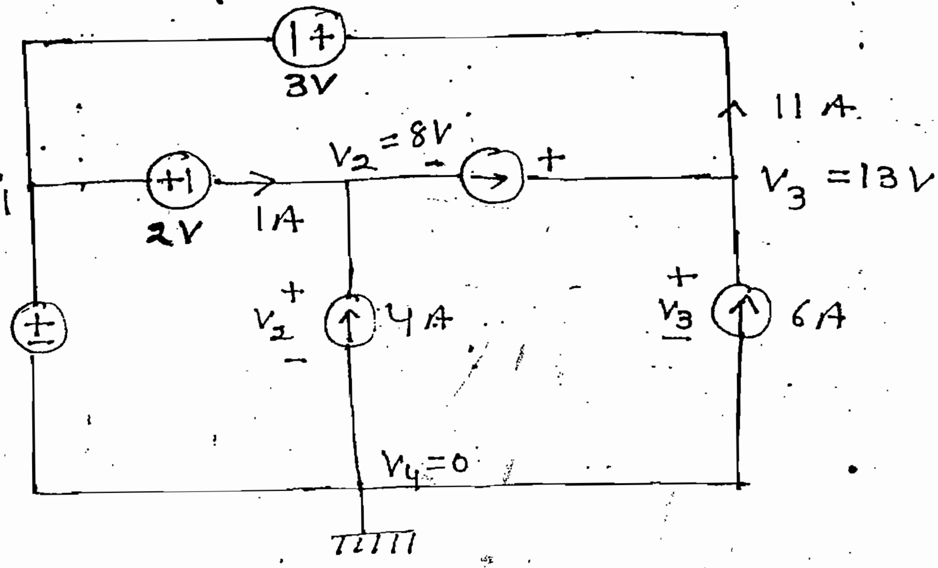


Note :-

→ When current is entering into the terminal element is absorbing power

→ When current is leaving from the terminal element is delivering power

Ques:- Find power of each element of the circuit shown



Soln:- $V_1 - V_2 = 2 \Rightarrow V_2 = 8V$

$V_3 - V_1 = 3 \Rightarrow V_3 = 13 \ V$

$P_4 = 4 \times 8 = 32W$ (Delivering Power)

$P_6 = 13 \times 6 = 78W$ (" ")

$P_5 = 5 \times 5 = 25W$ (" ")

$P_{10} = 10 \times 10 = 100W$ (Absorbing Power)

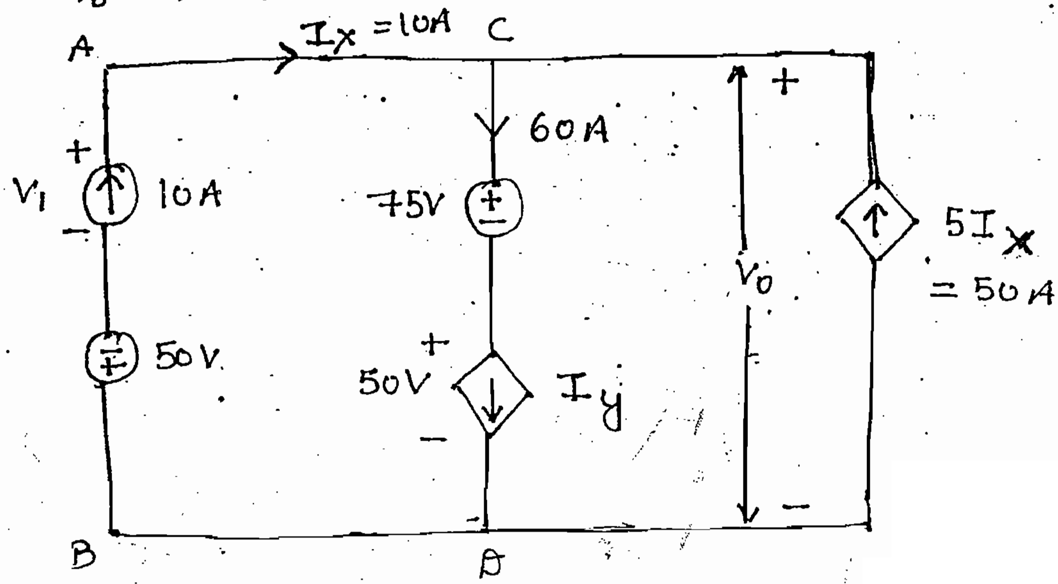
$P_3 = 3 \times 11 = 33W$ (" ")

$P_2 = 1 \times 2 = 2W$ (" ")

$(P_T)_{Absorbing} = (P_T)_{Delivering}$

$\Rightarrow 135W = 135W$

Ques:- Find power developed in a ckt when $V_0 =$
$V_0 = 125\,V$



Soln:- $V_{AB} = V_1 - 50$

$\Rightarrow 125 = V_1 - 50 \quad \Rightarrow V_1 = 175$

$P_{5I_x} = 125 \times 50 = 6250\,W$

$P_{10} = 175 \times 10 = 1750\,W$

$P_T = 6250 + 1750 = 8000\,W$

Classification of elements :-

(I) Active and Passive

(II) Linear and Non-linear

(III) Uni-direction and Bi-direction

(IV) Time varient and invarient

(V) Lumped and Distributed

Active & Passive Element :-

Active Element :-

When the element is capable of delivering energy for long time (approximately ∞ time) → A.E

OR

When the element is having property of internal amplification then the element is called as active element

transistor

Elements

- Active
  - Independent
    - Ideal
      - V
      - I
    - Practial
      - V
      - I
  - Dependent
    - VCVS
    - CCVS
    - CCCS
    - VCCS
- Passive
  - R
    - LR
    - NLR
  - C
    - LC
    - NLC
  - L
    - LL
    - NLL

Voltage source, current source → Independen

Transient, op-amp → Dependent

→ During discharging capacitor (inductor) can deliver energy independtly for a short time and capacitor (inductor) is not having property of internal amplification

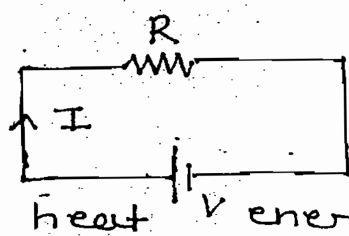
Passive Elements :-

When the element is not capable of delivering energy independtly then the element is called as passive element.

eg:- Resistor, bulb, transformer
$\downarrow$
It can't step-up or down power

Resistor :-

→ Resistance is a property of resistor. It always opposes the current. By doing so it converts electric energy to heat energy



→ Resistance is nothing but a friction to flow of $\bar{e}$'s

$$P = I^2 R$$

$$\underset{\substack{\downarrow \\ \text{Heat}}}{W} = I^2 R t$$

$$R = \rho \frac{l}{a} \quad \Omega$$

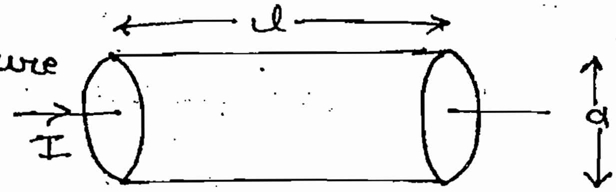
ρ
- → Ω-m
- → conductors
- → semi-conductors
- → Insulators

$$\boxed{\begin{array}{c}\text{Super conductor} \\ \rho = 0 \\ \text{eg:- Mercury} \\ \text{at } 4 \cdot 15\,K\end{array}}$$

$$R_1 = R_0 (1 + \alpha_0 t)$$

where R_0 = Resistance at $0°C$
t = Change in tempt.

Ohm's Law :-



→ At constant temperature current density is directly proportional to electric field intensity

→ At constant tempt. potential diff. across the element is directly proportional to current flowing into element.

$$J = \frac{I}{a} \quad A/m^2$$

$$E = \frac{V}{l} \quad Volts/m$$

$$\sigma = \frac{1}{\rho} \quad mho/m$$

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

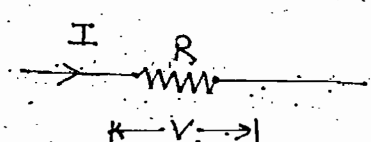
$$J \propto E$$

$$\Rightarrow J = \sigma E$$

$$\Rightarrow \frac{I}{a} = \frac{1}{\rho}\frac{V}{l}$$

$$\Rightarrow \boxed{\frac{V}{I} = \rho\frac{l}{a} = R}$$

$$V \propto I$$



$$V = RI$$

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

Different forms of Ohm's law :—

$$J = \sigma E \quad —(I)$$

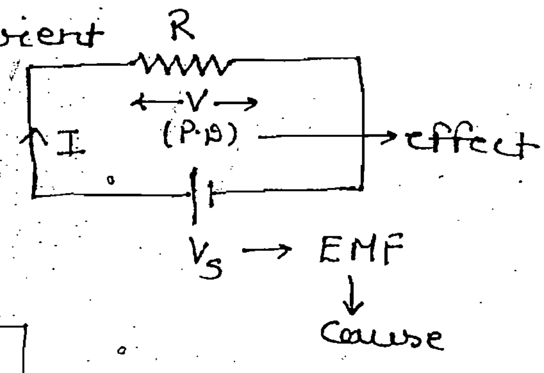
$$V = RI \quad —(II)$$

$$I = GV \quad —(III) \qquad \boxed{G = \frac{1}{R}} \text{ mho}$$

$$V = R\frac{dq}{dt} \quad —(IV)$$

→ EMF is independent on current and resistance magnitude

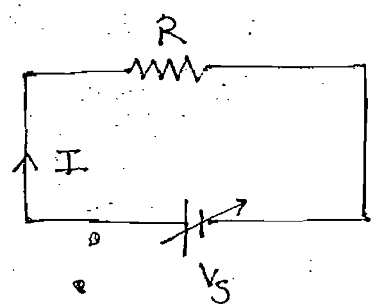
→ Potential difference depends on current and resistance magnitude



$\boxed{I \propto V_S}$ → EMF

$\boxed{V \propto I}$ → P.D / Voltage drop

→ When element properties and characteristics independent on the direction of current then the element is called as bidirectional element (bilateral)

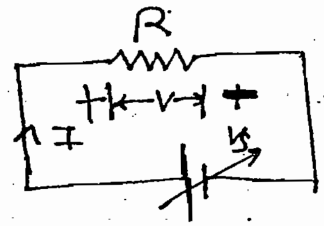


→ When element obeys ohm's law then the element is called as linear resistor

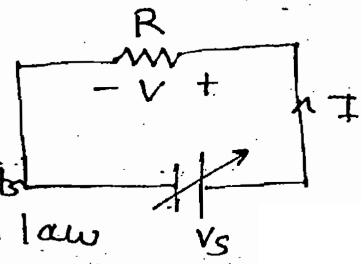
→ Every linear element should obey the bidirectional properties but not vice-versa

$I \uparrow 10\%$, $V \uparrow 10\%$

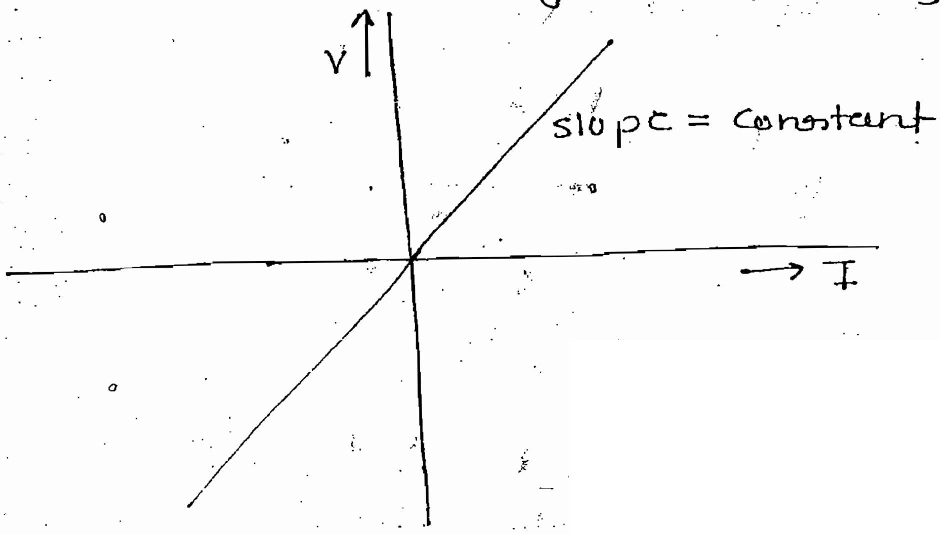
$I \uparrow 90\%$ $V \uparrow 10\%$



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

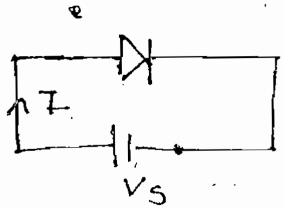


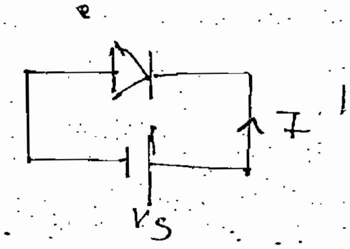
$\frac{V}{I}$ = constant then elements obey ohm's law



→ When element properties and characteristics depends on the direction of current then element is called as unidirectional element

→ When element does not obeys the ohm's law then the element is called as non-linear resistor

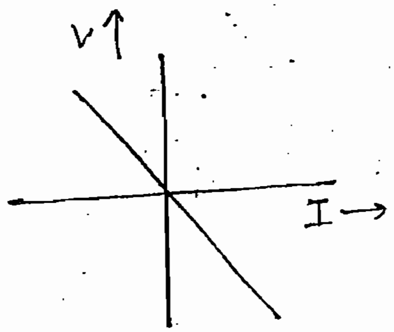




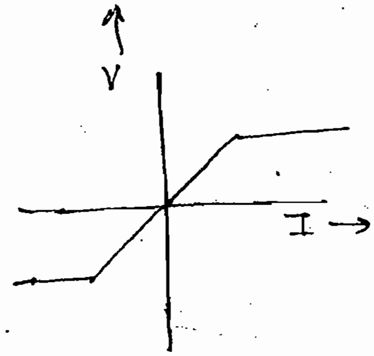
$$|I| \neq |I'|$$

Note :-

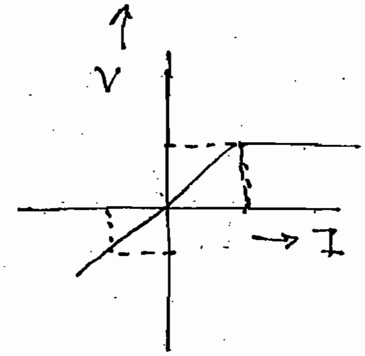
→ $\boxed{\frac{V}{I} = +ve}$ then element is passive



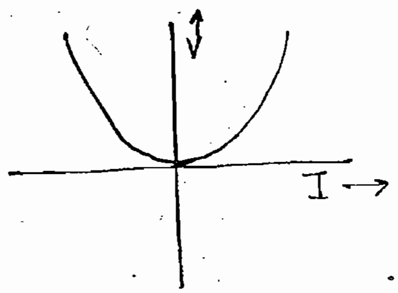
→ Linear
→ Bi-directional
→ Active



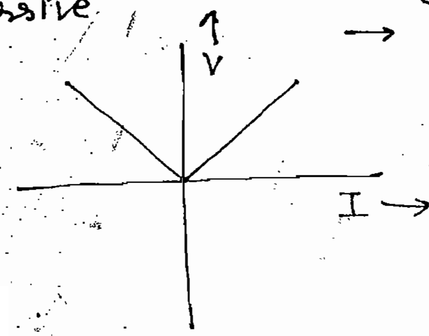
→ ~~Non~~ Linear
→ Bi-directional
→ Passive



→ Non-linear
→ Unidirectional
→ Passive



→ Non-linear
→ Uni-directional
→ Active



→ Non-linear
→ Uni-directional
→ Active

Note :-

→ If in any of the quadrant $\frac{V}{I}$ = -ve then the element is active

→ Every linear element should obey the bidirectional property but not vice-versa

→ If $\frac{V}{I}$ = +ve in both coordinates then the element is passive — (I)

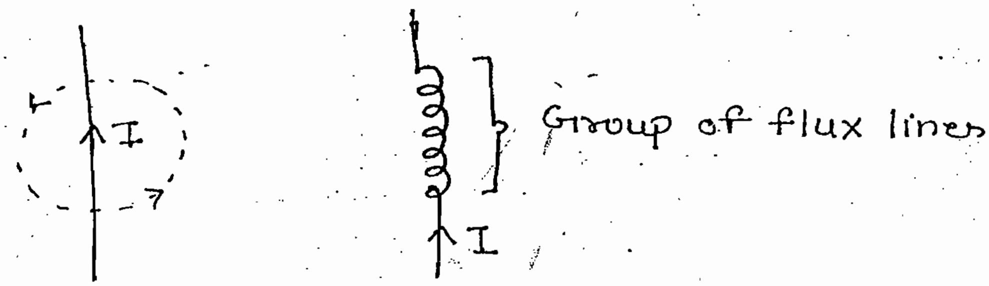
→ ~~In the~~ above

→ If $\frac{V}{I}$ = -ve either in any of the coordinates or both the coordinates then the element is active — (II)

→ In the above two cases waveform should passes through origin

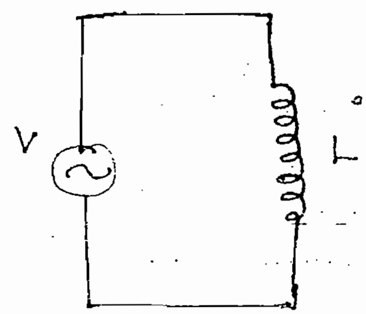
→ When the element obeys the bi-directional property characteristic should be identical in the opposite coordinates but not in the adjacent coordinates

Inductor (L) :—



Weak Magnetic Field — Strong magnetic field.

→



Faraday's Laws :—

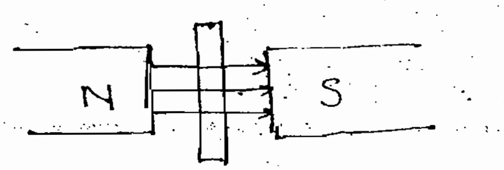
1st Law :—

When conductor cuts a magnetic lines of force an emf induced in the conductor

Second Law :—

An emf induced in the conductor is directly proportional to rate of change of flux

$e = B\,l\,v\sin\theta$, $e \propto \frac{d\phi}{dt}$

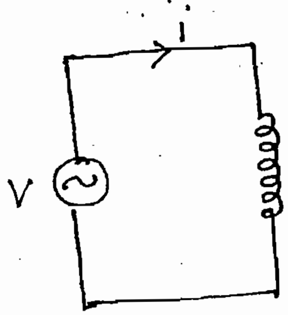


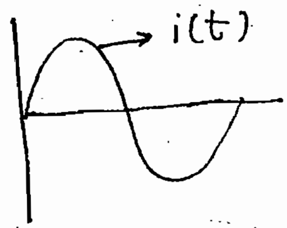
where

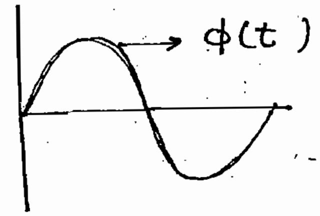
- B = flux density
- l = length of conductor
- V = velocity of conductor
- ϕ = Phase displacement b/w conductor & magnetic field
- e = dynamically induced emf (eg:— generator

L

Inductor (L) :-







$$e \propto \frac{d\phi}{dt}$$

$$\Rightarrow \boxed{e = -N\frac{d\phi}{dt}} \longrightarrow \text{Lenz's Law}$$

$\rightarrow$ V, i, ϕ, e — Lenz's Law $\Rightarrow$ $V = N\dfrac{d\phi}{dt}$

$\rightarrow$ $\psi = N\phi$

(Flux linkage)

$$V = \frac{d\psi}{dt}$$

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

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

$\psi \propto \phi$
$\psi \propto i$

$\psi \propto i$

$$\boxed{\psi = Li}$$

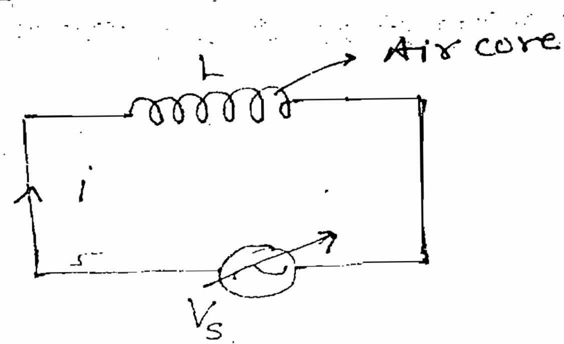
$\psi = N\phi$
$\psi = Li$

$$\boxed{L = \frac{N\phi}{i}} \quad \text{Henry}$$

$$L = \frac{N\phi}{i} = \text{Constant}$$

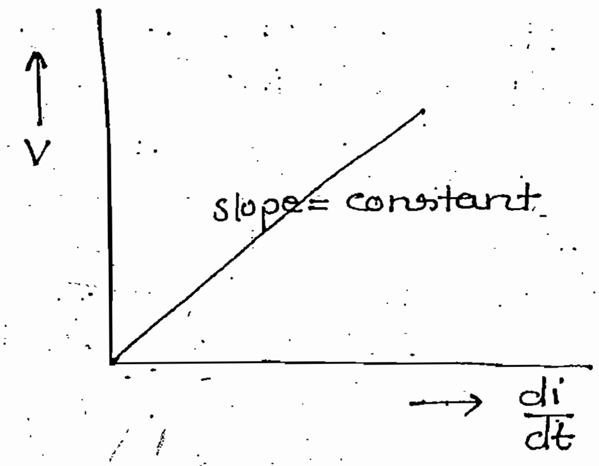
$i \uparrow 10\%$, $\phi \uparrow 10\%$

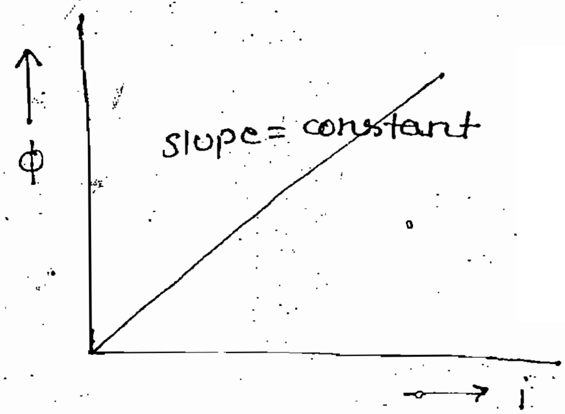
$i \uparrow 90\%$, $\phi \uparrow 90\%$

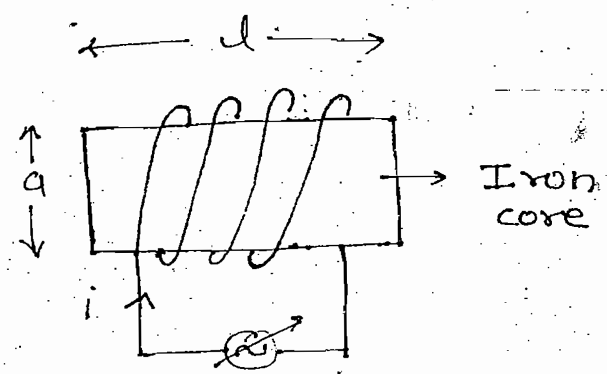


$$V = L\frac{di}{dt}$$

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







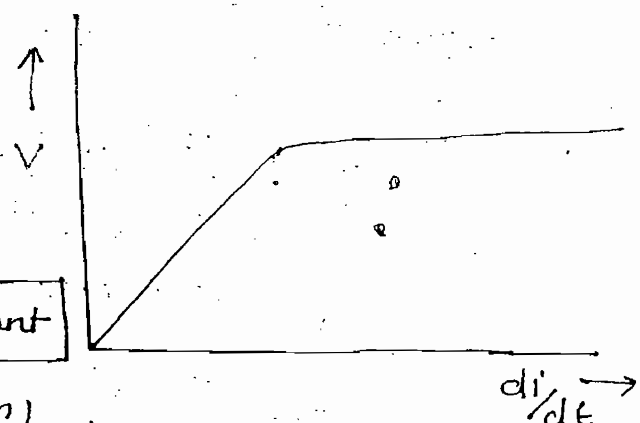
$$L = \frac{N\phi}{i} \quad \text{---(1)}$$

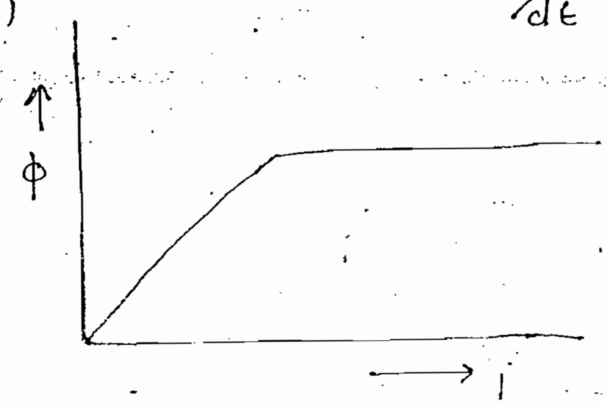
If $i \uparrow 10\%$, $\phi \uparrow 10\%$

If $i \uparrow 60\%$, $\phi \uparrow 60\%$

If $i \uparrow 90\%$, $\boxed{\phi = \text{constant}}$

(saturation)





→ The flux linked with iron-core is upto a certain limit.

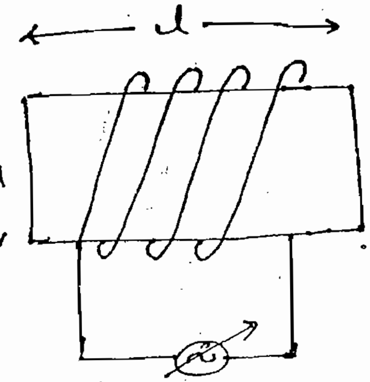
→ When inductance of a inductor is independent on the current magnitude then inductor is called as linear inductor

eg:- Air core inductor

→ When inductance of a inductor depends on current magnitude then inductor is called as non-linear inductor

eg:- iron core inductor

Electric Circuit	Magnetic Circuit
1. $i = \frac{EMF}{R}$	$\phi = \frac{MMF}{S(\text{Reluctance})}$
2. $i = \frac{EMF}{\frac{\rho l}{a}}$	$\phi = \frac{NI}{\frac{l}{a\mu_0\mu_r}}$ —(II)



Substitute eq-(II) in eq-(I)

** $$\boxed{L = \frac{N^2 \mu_0 \mu_r a}{l}}$$

where $\mu_0 = 4\pi \times 10^{-7}$ H/m

μ_r = Relative permeability

a = Area of cross-section of core

$$L = \frac{N^2}{\frac{l}{a\mu_0\mu_r}} \Rightarrow \boxed{L = \frac{N^2}{S}}$$

→ $\boxed{V = L\frac{di}{dt}} \Rightarrow \boxed{i = \frac{1}{L}\int_{-\infty}^{t} V dt}$

shows ohm's law 5th form & 6th form

→ The above formula is only applicable for linear inductor.

$$P = Vi$$

$$\boxed{P = L\frac{di}{dt}\, i}$$ → Instantaneous Power

$$W = \int P\,dt$$

$$\Rightarrow \boxed{W = \int L \frac{di}{\cancel{dt}}\, i \cdot \cancel{dt} = \frac{1}{2} L i^2}$$

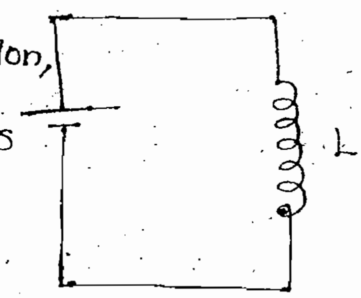
→ Power dissipation in ideal ~~capacitor~~ inductor is zero since internal resistance is zero

→ Inductor stores energy in the form of magnetic field (K·E)

→ Due to energy storage property inductor is also called as dynamic element

Conclusions :-

1. Under steady state condition, for a dc source inductor behave as a short circuit



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

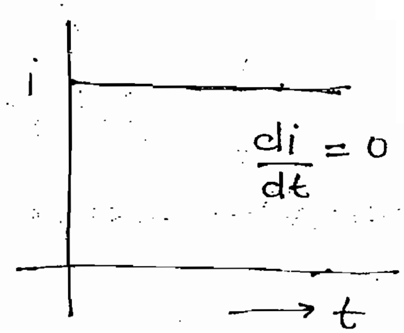
For dc, $\frac{di}{dt} = 0$

↓

$V = 0$

↓

S.C



2 Inductor does not allow sudden change of current since

(a) For sudden change of current infinite voltage is required but practically it is not possible

(b) Practical inductive circuit having finite value of time constant i.e. $\tau = \frac{L}{R}$

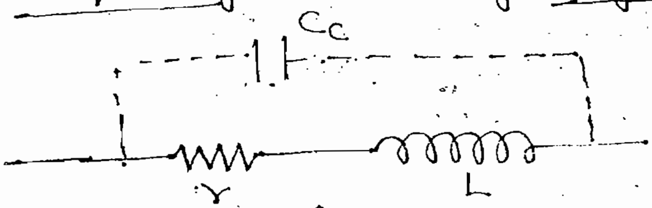
$$V = L\frac{di}{dt}$$

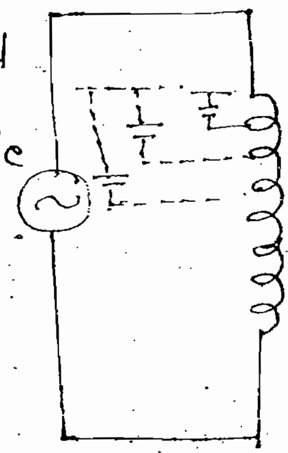
$$dt \longrightarrow 0 \quad \Rightarrow \quad V = \infty$$

3.

$r \simeq m\Omega$

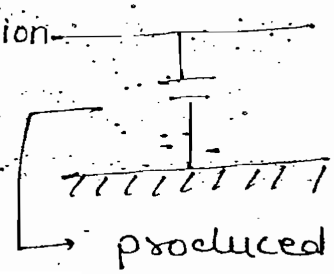
Inter-turn capacitance is present when inductor is operated at either at very high frequency or very high voltage





where C_c = inter-turn capacitance or self capacitance

Transmission line



produced due to high potential diff.

$$X_L = 2\pi f L$$

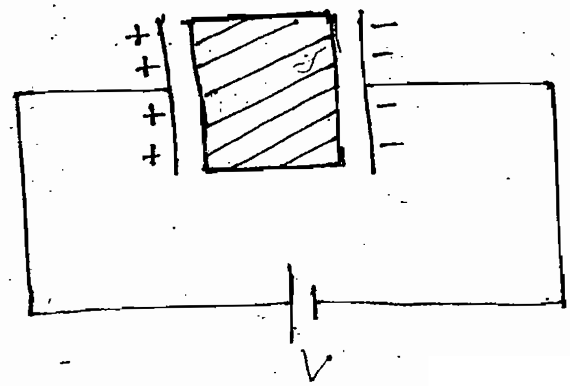
$$X_C = \frac{1}{2\pi f C}$$

Capacitor :-

$Q \propto V$

$\Rightarrow Q = CV$

$\Rightarrow \boxed{C = \frac{Q}{V}}$ C/Volt or F



Again $Q = CV$

$\Rightarrow \frac{dQ}{dt} = C\frac{dV}{dt}$

$\Rightarrow i = C\frac{dV}{dt}$

$\Rightarrow \boxed{C = \frac{i}{\frac{dV}{dt}}}$

→ Capacitor opposes rate of change of voltage

$\boxed{i = C\frac{dV}{dt}}$ → Ohm's law 7th form

$\boxed{V = \frac{1}{C}\int_{-\infty}^{t} i\,dt}$ → Ohm's law 8th form

$P = Vi$

$\Rightarrow \boxed{P = VC\frac{dV}{dt}}$ → Instantaneous power

$W = \int P\,dt$

$W = \int V.C\frac{dV}{dt}\,dt$

$\Rightarrow \boxed{W = \frac{1}{2}CV^2}$ → Potential Energy

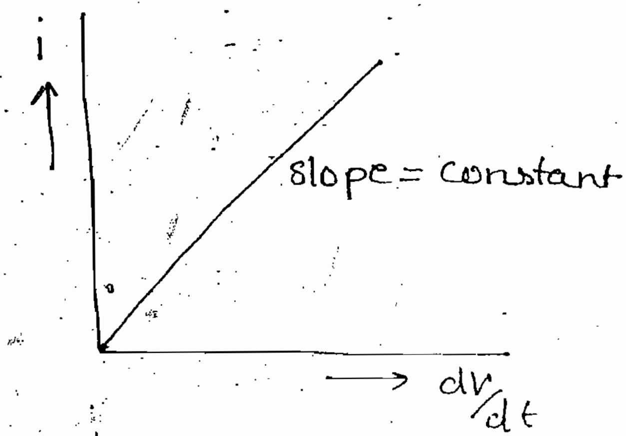
→ Power dissipation in ideal capacitor = 0

→ Capacitor stores energy in the form of electric field (Potential Energy)

→ Due to energy storage property capacitor is also called as dynamic element

→

$C = \frac{Q}{V}$ = constant

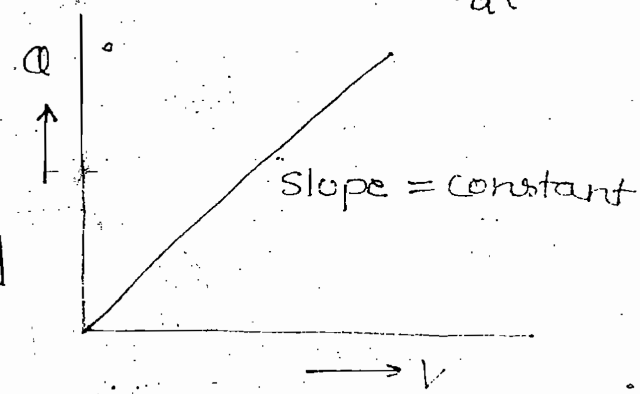


$V\uparrow 10\%$, $Q\uparrow 10\%$

$V\uparrow 90\%$, $Q\uparrow 90\%$

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

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



$\boxed{C = \frac{Q}{V} = \text{Variable}}$

↓

Non-linear

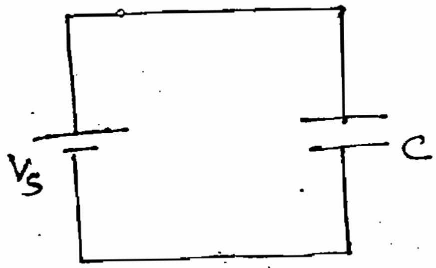
→ When capacitance of a capacitor independent on the voltage magnitude then the capacitor is called as linear capacitor.

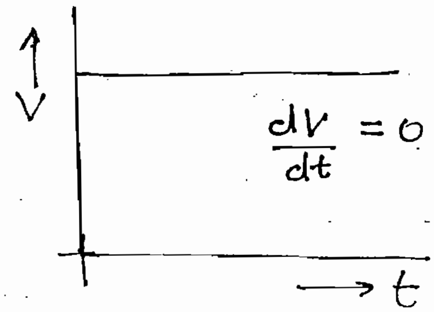
→ When capacitance of a capacitor depends on the voltage magnitude then capacitor is called as non-linear capacitor

eg:- Varactor diode

<u>Conclusion</u>:-

1. Under steady state condition for a dc source capacitor behaves as an open circuit





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

$$\frac{dV}{dt} = 0 \longrightarrow i = 0 \Rightarrow O \cdot C$$

2. Capacitor does not allow sudden change of voltages since

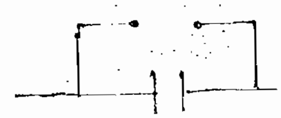
(a) For sudden change of voltages infinite current is required but practically it is not possible

(b) Practical capacitive circuit has finite value of time constant

$$(a)\quad i = C\frac{dV}{dt} = \infty \qquad dt \to 0$$

$$(b)\quad T = RC$$

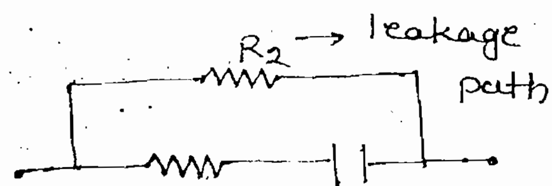
3. For ideal capacitor :-



(Ideal)

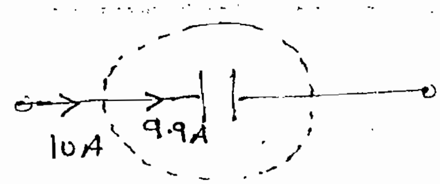
$$\boxed{\begin{aligned} R_1 &= 0 \\ R_2 &= \infty \end{aligned}}$$

For Practical capacitor :-



$R_1 \simeq$ very less
$R_2 \simeq$ very high.

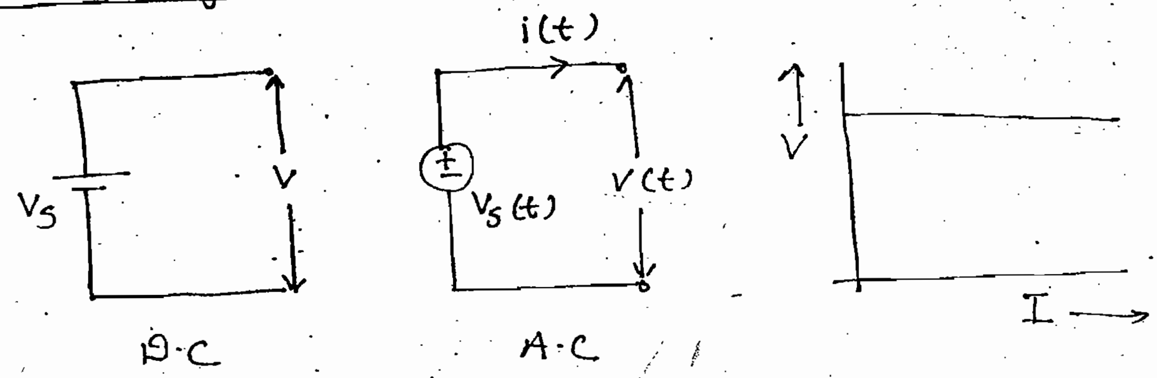
Dielectric loss ← (Power loss) (Practical)



R_2 = leakage path

Lecture - 2

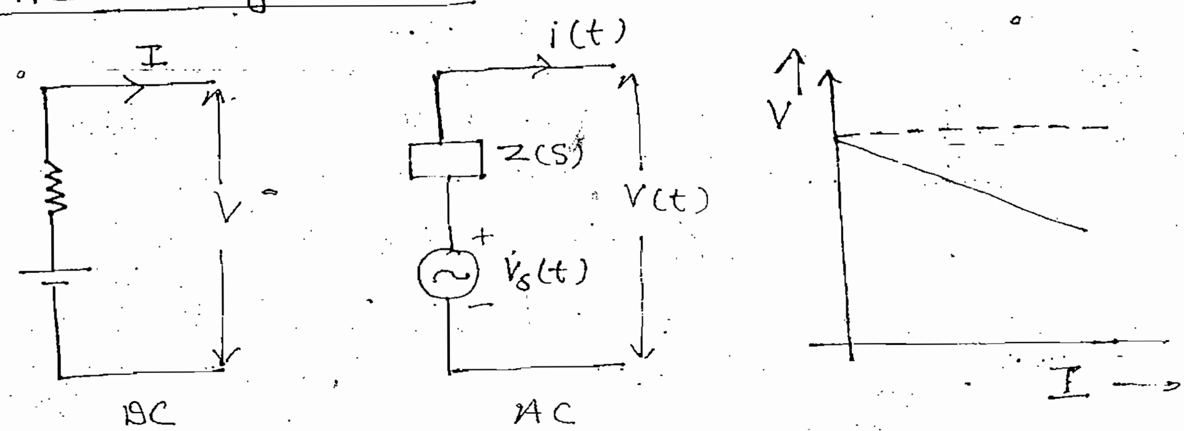
Ideal Voltage Source :-



→ $R_S = 0$

→ $V_S(t)$ → either AC or DC if t → specify then AC

Practical Voltage Source :-



$$V_S = V + IR_S$$

$$V = V_S - IR_S$$

→ Ideal voltage source delivers energy at specify voltage (V) it is independent on current deliver by a source

→ Internal resistance of ideal voltage source is zero

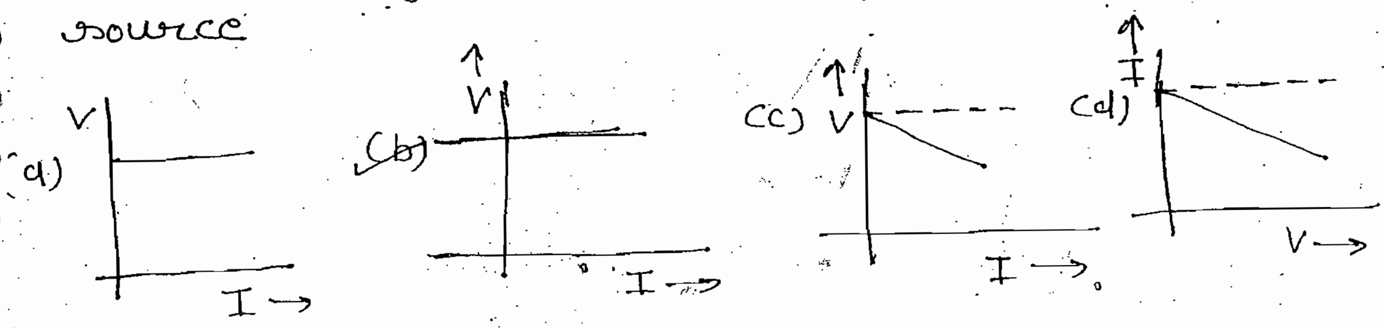
→ Practical voltage source delivers energy at specified voltage (V) which depends on current deliver by the source.

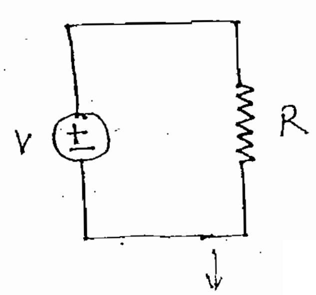
11

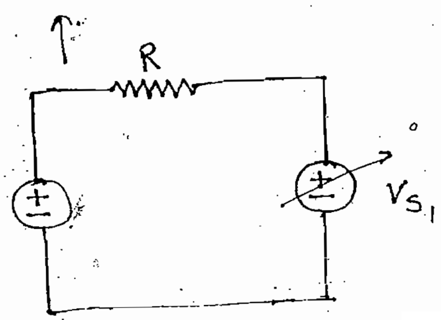
→ Linear → characteristic passes through origin and inc. linearly

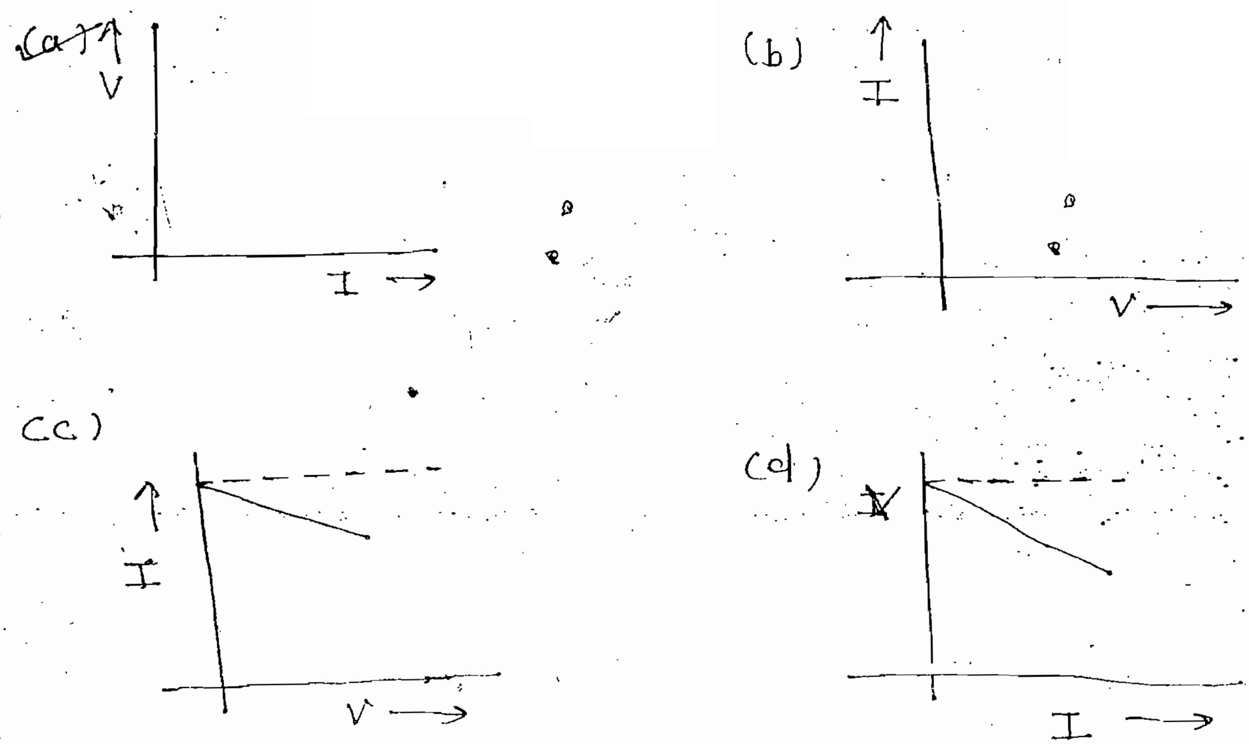
→ Independent voltage source does not obey the ohm's law since V-I characteristic is non-linear.

Ques:- Identify V-I characteristic of ideal voltage source



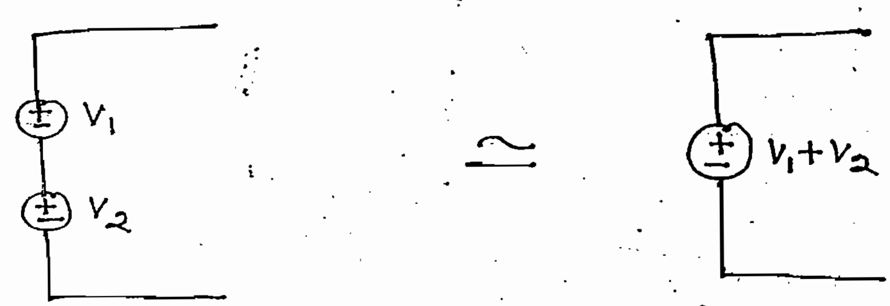




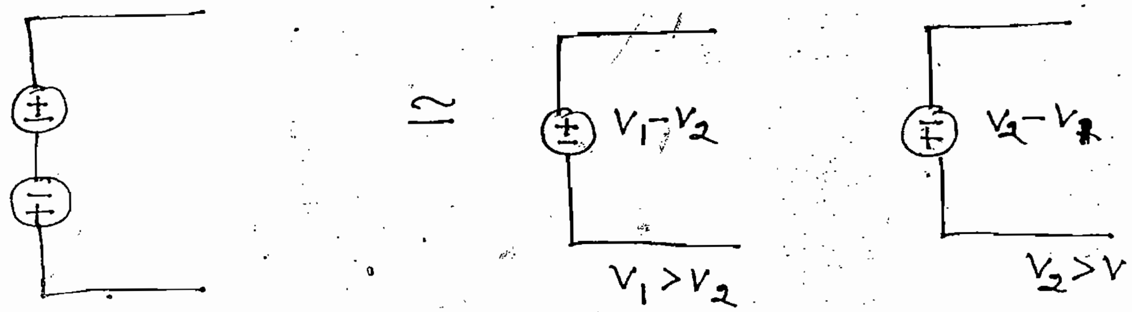


Note :—

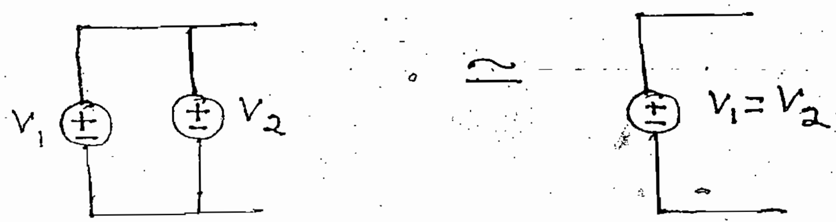
(I)



(II)

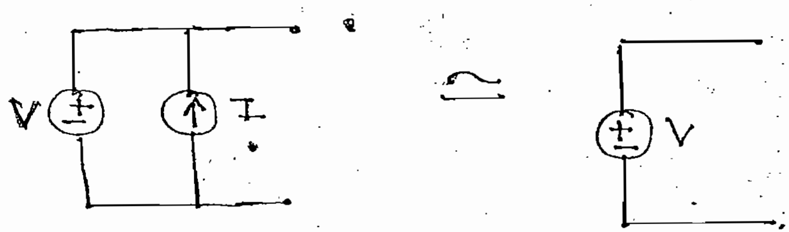


(III)



(IV)

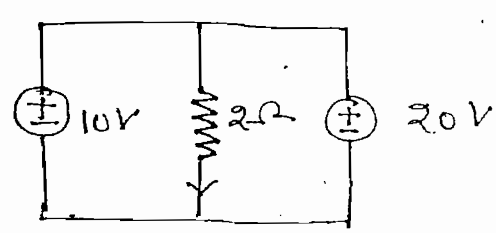
(V)



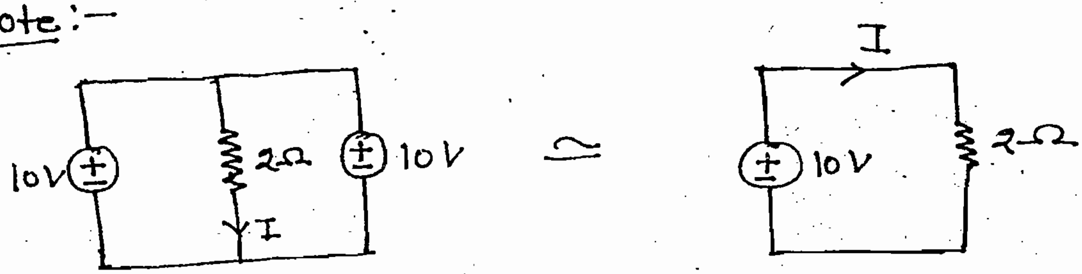
Ques :- Find current in the 2Ω resistor

(a) 5A (b) 10A

(c) 15A) (d) None or Not satisfying KVL



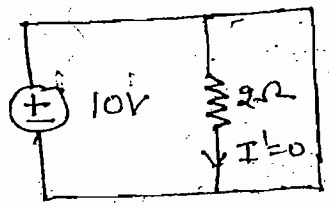
Note:-



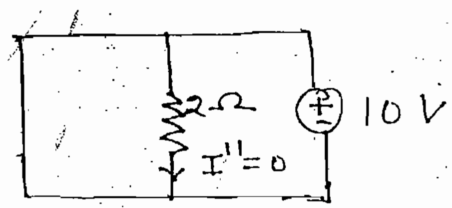
$I = 5A$

By using superposition theorem

Case - I



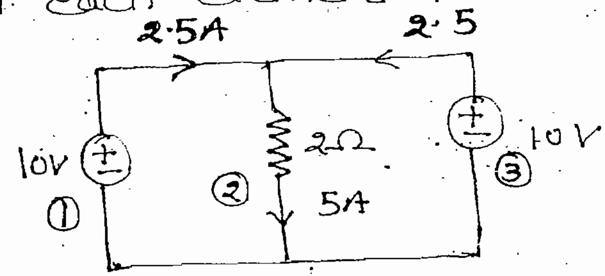
Case - II



$$I = I' + I'' = 0$$

→ For the above circuit superposition theorem can't be applied since case-(I) & case-(II) circuits are not satisfying KVL

Ques:- Find power of each element in the circuit given below



Soln:-

$P_1 = 10 \times 2.5 = 25\ W$ (Delivering)

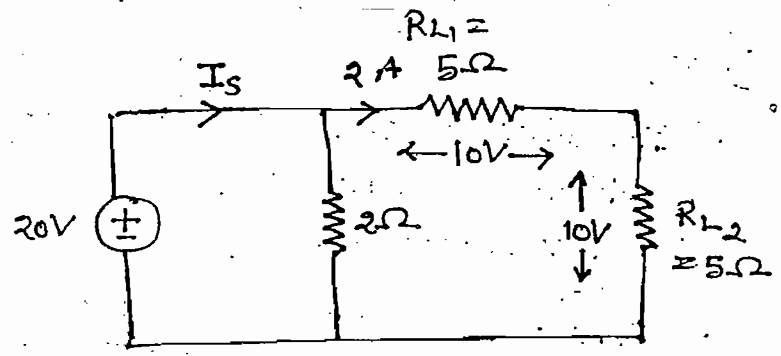
$P_3 = 10 \times 2.5 = 25\ W$ (Del.)

$P_2 = I^2 R = 5^2 \times 2 = 50\ W$ (Absorbing)

Note:-

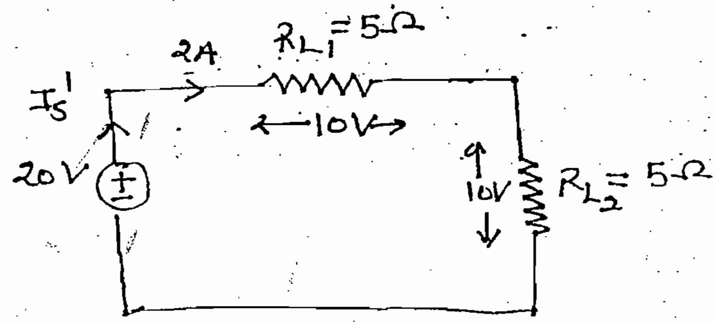
$I_S = 10+2 = 12A$

$P_S = 20 \times 12 = 240W$



$I_S' = 2A$

$P_S' = 20 \times 2 = 40W$



→ In the above circuit 2Ω resistance can be neglected while calculating either load current or load voltages

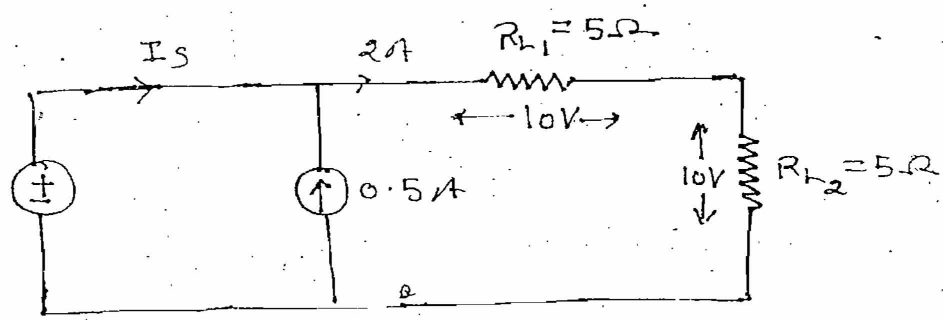
→ In the above circuit 2Ω resistance can't be neglected while calculating either source current or source power

$I_S + 0.5 = 2$

$\Rightarrow I_S = 1.5A$

$P_S = 20 \times 1.5$

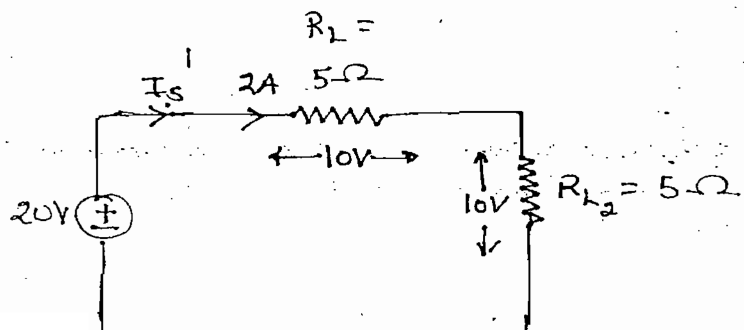
$= 30W$



$I_S' = 2A$

$P_S' = 20 \times 2$

$= 40W$

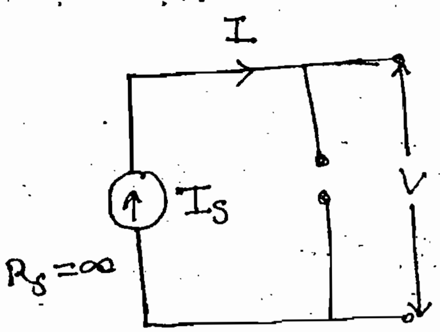


Note:-

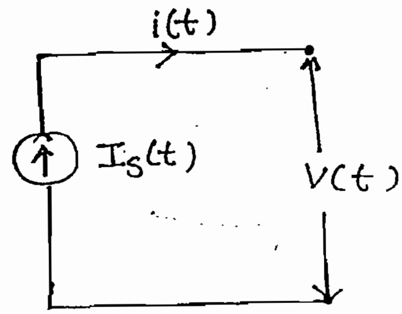
- In the above circuit current source can be neglected while calculating either load current or load voltage.

- In the above circuit current source can't be neglected while calculating either voltage source current or voltage source power

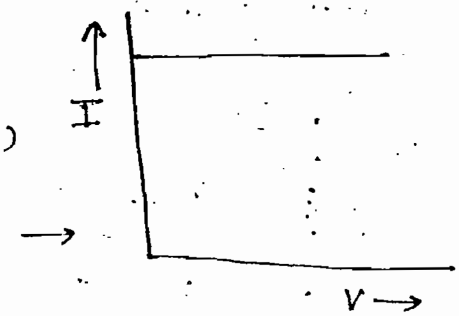
Current (I):-



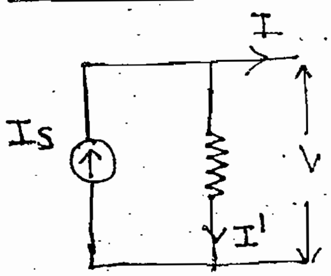
Ideal DC current source

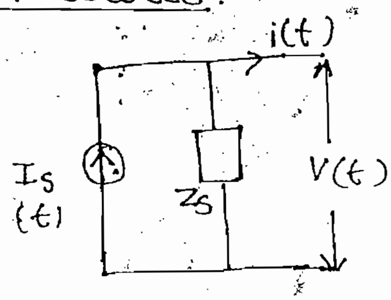


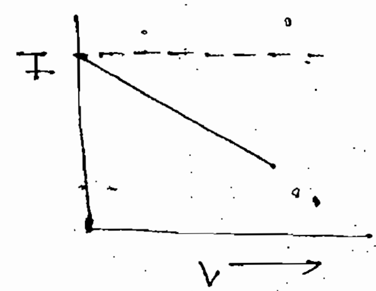
Ideal AC current source



Practical current source:-







$$I_S = I + I'$$

$$I = I_S - I'$$

$$I = I_S - \frac{V}{R_S}$$

→ Ideal current source deliver energy at specified current (I) which is independent on voltag across source

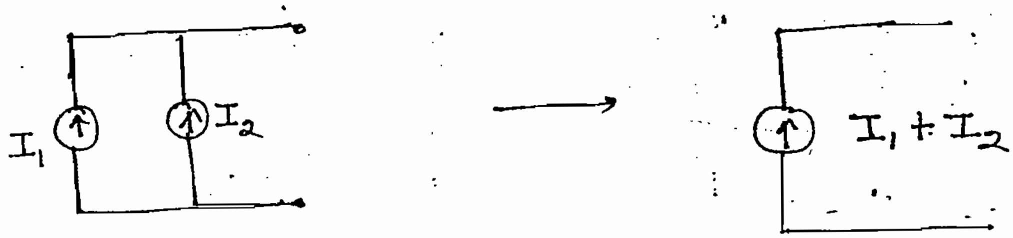
→ Internal resistance of ideal current source = ∞

→ Practical current source deliver energy at specified current (I) which depends on voltage across source

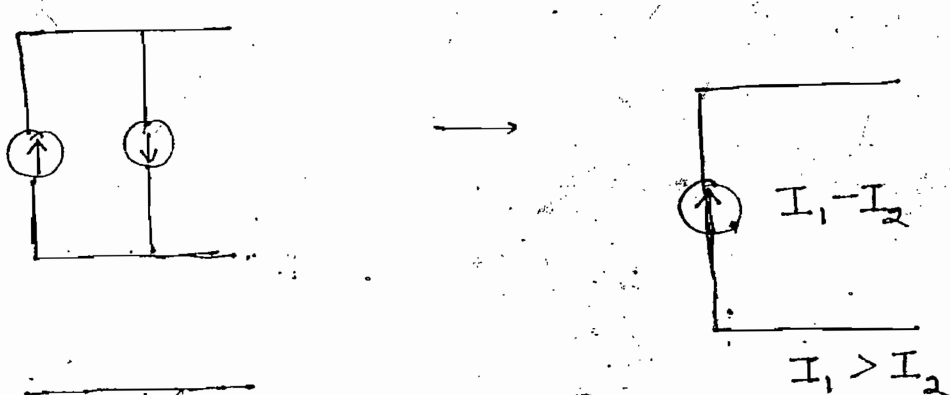
→ Independent current source doesn't obey the ohm's law since ∵ V-I characteristics are non-linear

→ In the practical system no independent current source are exist but dependent current source are exist.

(I)

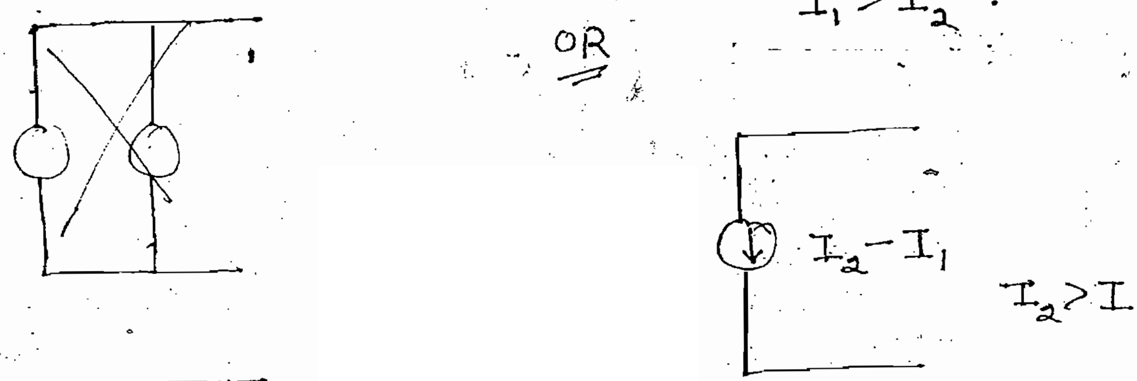


(II)

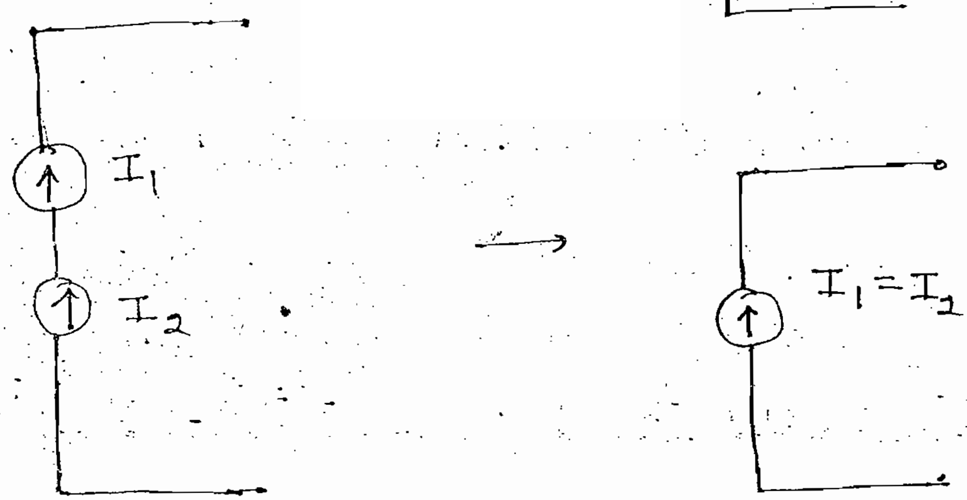


OR

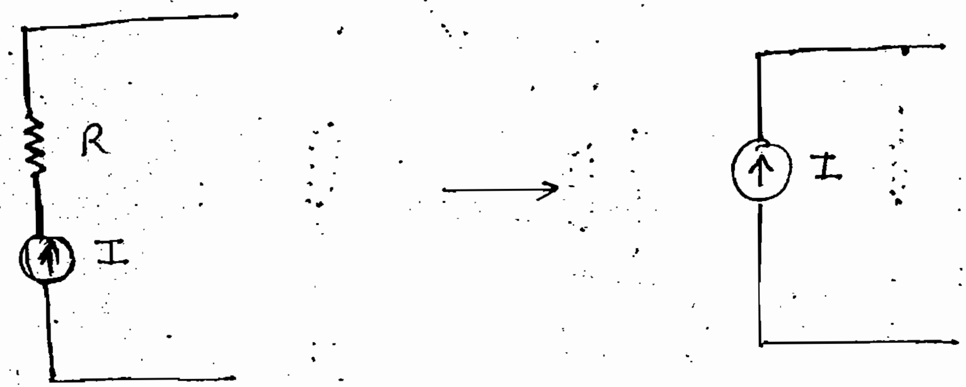
(III)



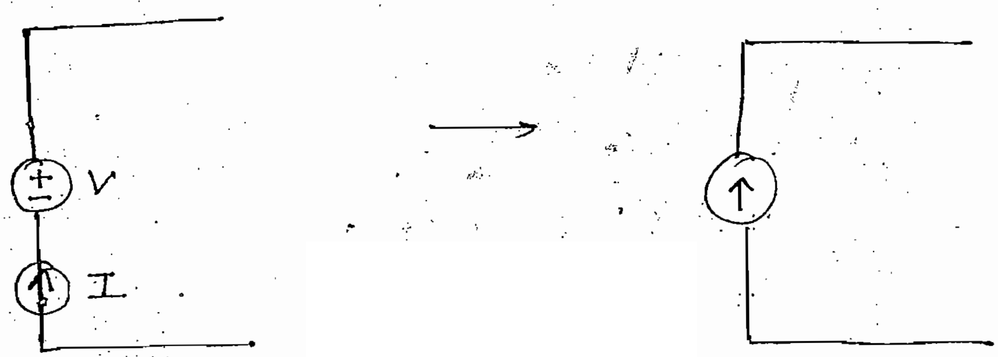
(III)



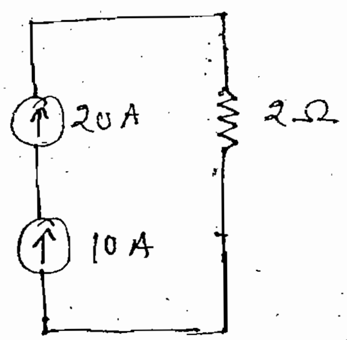
(IV)



(V)



Ques:–



(a) 10 A

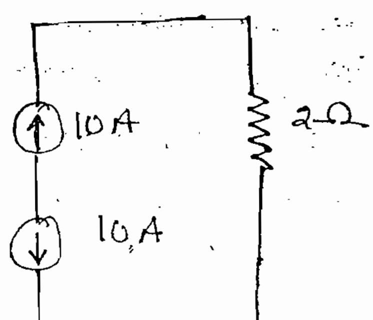
(b) 20 A

(c) 30 A

(d) None of these
OR Not satisfied KCL

Note:–
With respect to KCL current flowing through all the series element should be equal

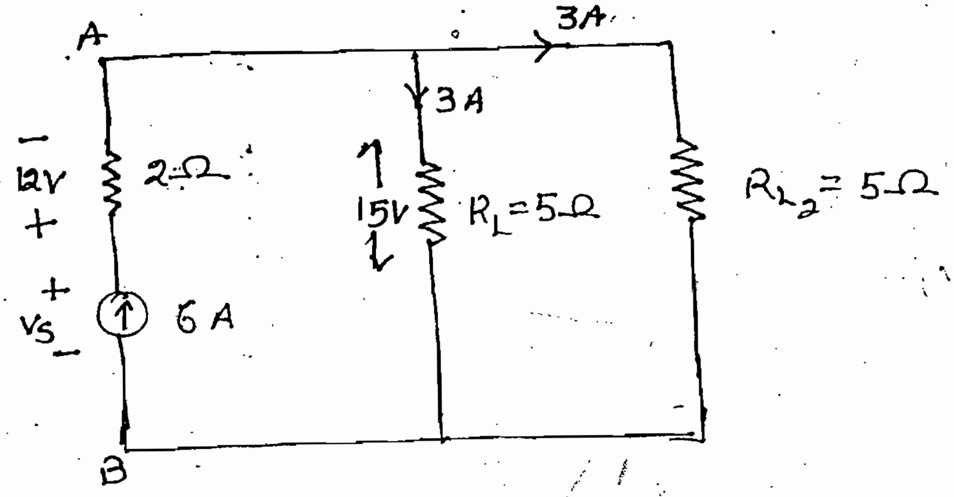
Ques:–



What is the current through 2Ω resistor?

Soln:– Not satisfied KCL bec. polarities are opposite.

→

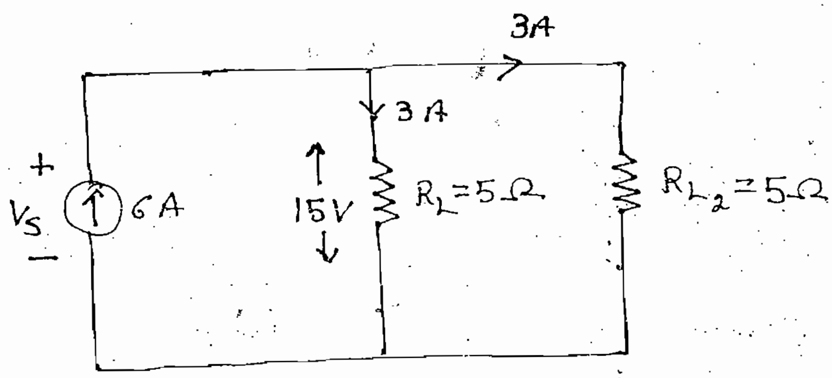


$$V_{AB} = V_S - 12$$

$$\Rightarrow 15 = V_S - 12$$

$$\Rightarrow V_S = 27$$

$$\& \quad P_S = 27 \times 6 = 162\,W$$



$V_S' = 15\,V$ $\qquad P_S' = 15 \times 6 = 90\,W.$

Note:-

→ In the above circuit 2Ω resistance can be neglecting either by calculating load current or load voltage.

→ In the above circuit 2Ω resistance cann't be neglected by calculating either voltage across current source or power of the current source.

Note:-

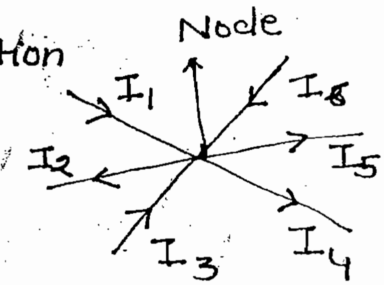
→ In above circuit voltage source can be neglected by calculating either load current or load voltage

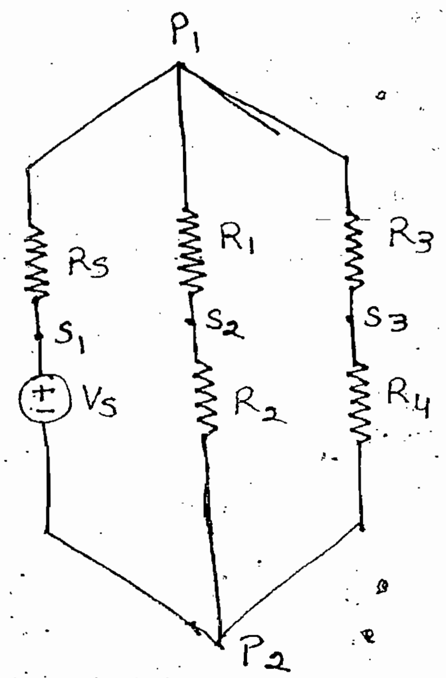
→ In the above circuit voltage source cannot be neglected either calculating voltage across current source or power of the current source

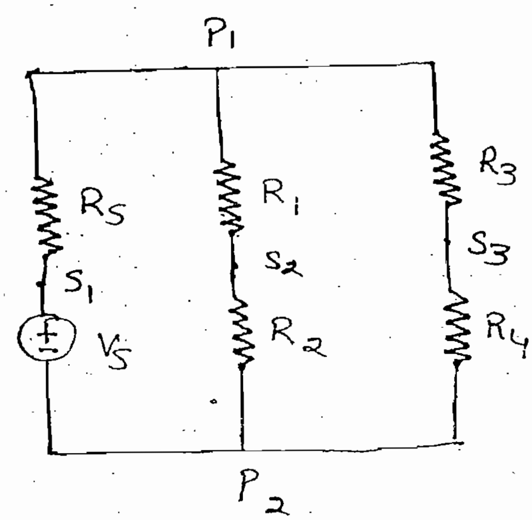
KCL:-

→ Based on law of conservation of charge

$$I_1 + I_3 + I_6 = I_2 + I_4 + I_5$$







→ KCL states that algebraic sum of currents meeting at a point is equal to zero.

→ When two elements are connected together then common point is called as simple node

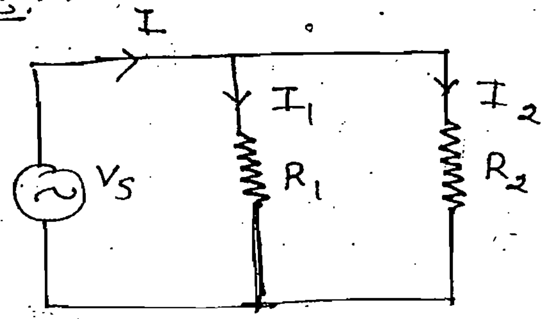
→ When more than two elements are connected together then common point is called as principal node.

Current division technique:-

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

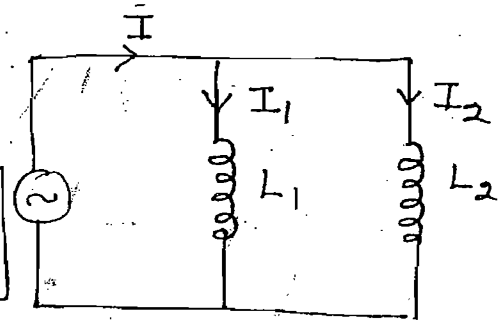
$$\boxed{I_1 = I \frac{R_2}{R_1+R_2}}$$

$$\boxed{I_2 = I \frac{R_1}{R_1+R_2}}$$



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

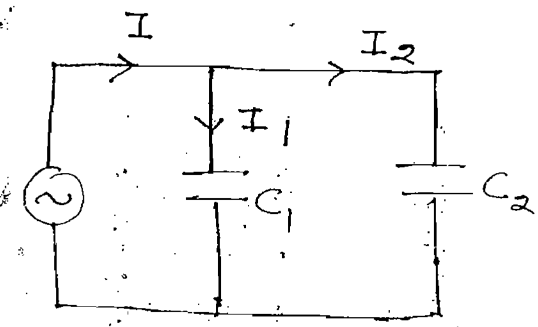
$$\boxed{I_1 = I \frac{L_2}{L_1+L_2}} \quad \boxed{I_2 = I \frac{L_1}{L_1+L_2}}$$



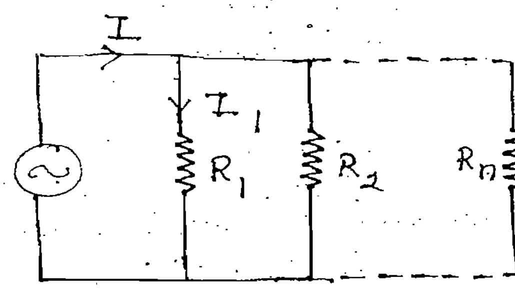
$$C_{eq} = C_1 + C_2$$

$$\boxed{I_1 = I \frac{C_1}{C_1+C_2}}$$

$$\boxed{I_2 = I \frac{C_2}{C_1+C_2}}$$



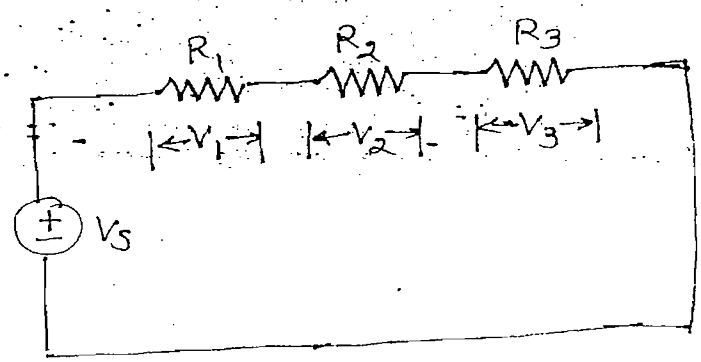
$$\boxed{I_1 = I \frac{1/R_1}{\frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n}}}$$



KVL:-

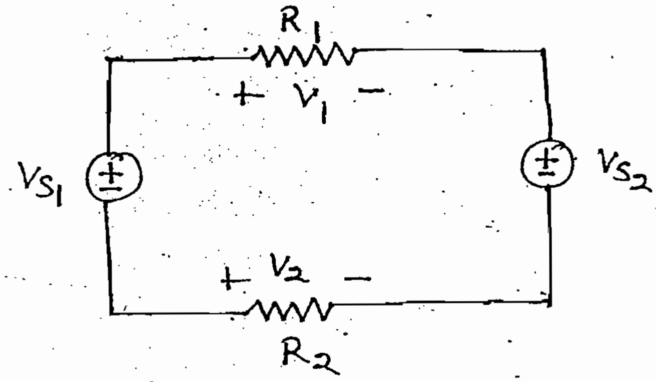
→ KVL works based on the principle of law of conservation of energy

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



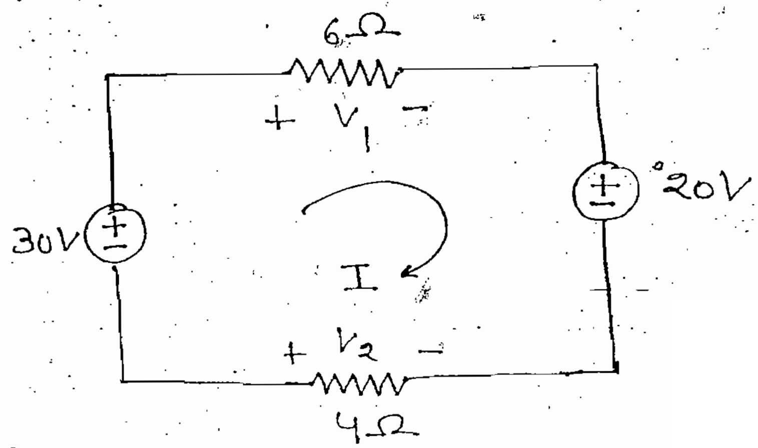
$$V_{S_1} - V_1 - V_{S_3} + V_2 = 0$$

$$V_{S_1} + V_2 = V_1 + V_{S_3}$$



→ KVL states that algebraic sum of voltages in a closed loop is equal to zero

Ques:- Find V_1 & V_2 of the circuit shown



Soln:-
$$V_1 = 6I \qquad V_2 = -4I$$

$$30 - V_1 + 20 - V_2 = 0$$

$$\Rightarrow -30 + 6I + 20 - (-4I) = 0$$

$$\Rightarrow I = 1A$$

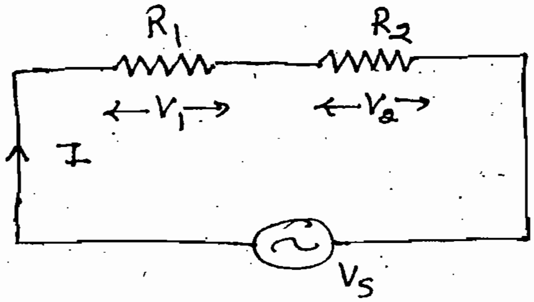
$$V_1 = 6V \quad \& \quad V_2 = -4V$$

Voltage Division Technique:-

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

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

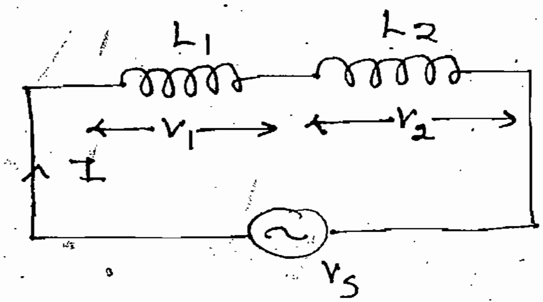
$$\boxed{V_2 = V_S \frac{R_2}{R_1+R_2}}$$



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

$$\boxed{V_1 = V_S \frac{L_1}{L_1+L_2}}$$

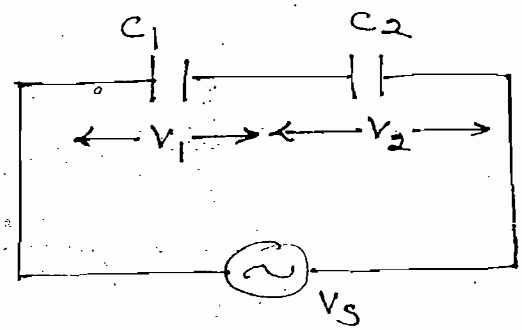
$$\boxed{V_2 = V_S \frac{L_2}{L_1+L_2}}$$



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

$$\boxed{V_1 = V_S \frac{C_2}{C_1+C_2}}$$

$$\boxed{V_2 = V_S \frac{C_1}{C_1+C_2}}$$



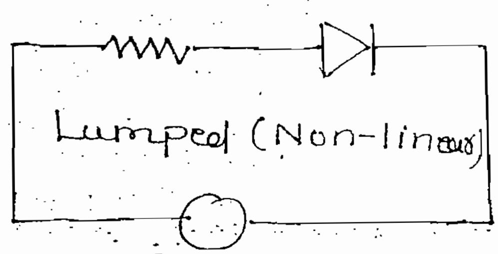
Conclusions :-

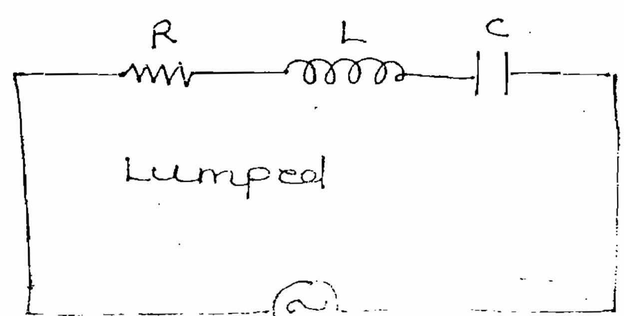
Field Theory → Low frequency

Field Theory → High frequency

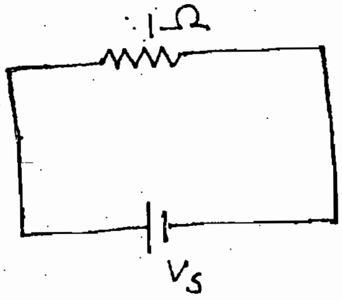
Network Theory → Low frequency

- → Field theory can be applied for low or high frequency application
- → In field theory accurate results are obtain. but developing mathematical equation is complex
- → Network theory is applied only for low frequency applications
- → In the network theory approximate results are obtained and developing mathematical equation is simple
- → KVL and KCL fails for high frequencies application

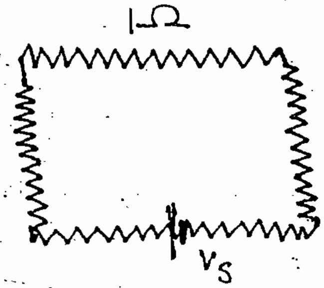




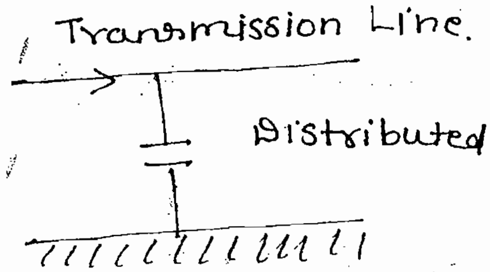
$$V_S = iR + L\frac{di}{dt} + \frac{1}{C}\int i\,dt$$



Lumped
(Linear)



Distributed



$J = \sigma E$
(Ohm's Law

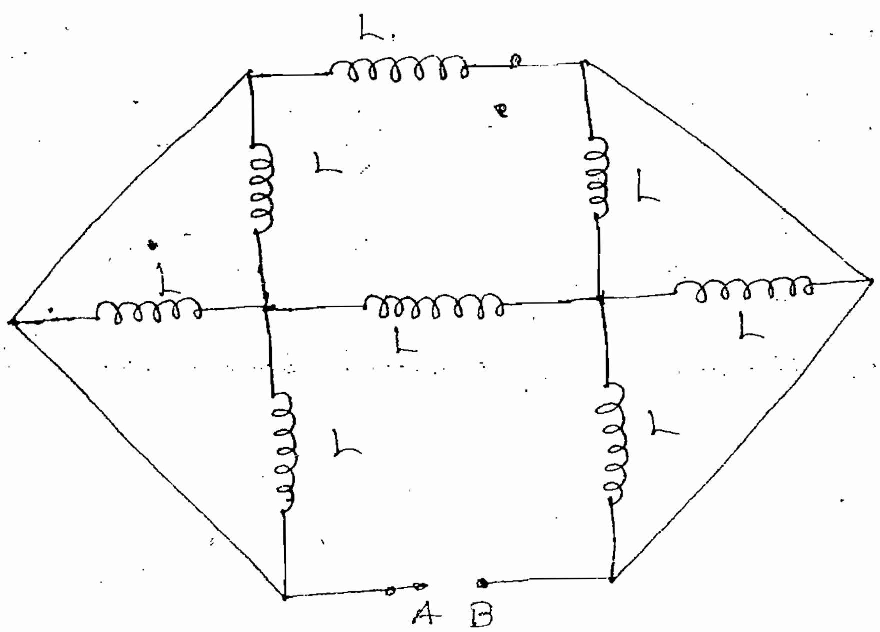
→ Ohm's law can be applied lumped (linear) and distributed parameters

→ KVL and KCL fails for distributed parameters since in the distributed parameters electrically it is not possible to separate resistance, inductance and capacitance effects

→ KVL and KCL are applied for lumped parameters (Linear, non-linear, uni-directional, bi-directional, time variant and invariant elements)

Ques:-

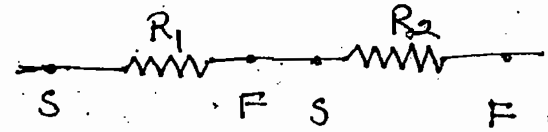
$L_{eq} = ?$



Note :-

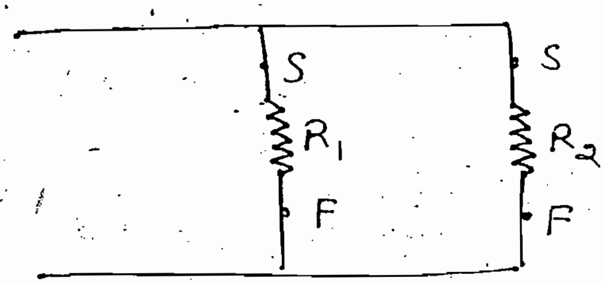
(I) one joint

(II) $I \rightarrow$ same

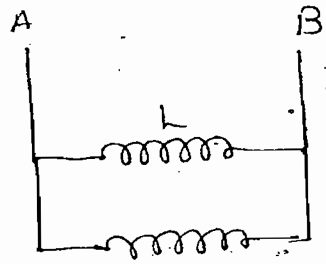


(I) Twice

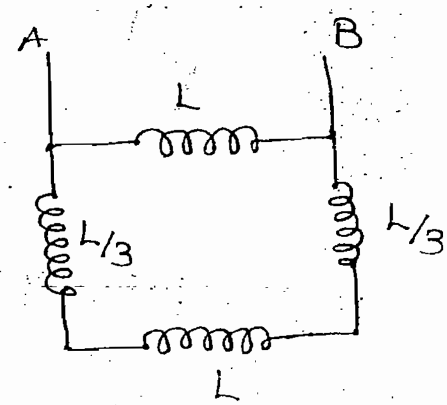
(II) $V \longrightarrow$ same



Soln:-



$$\frac{L}{3} + L + \frac{L}{3} = \frac{5L}{3}$$

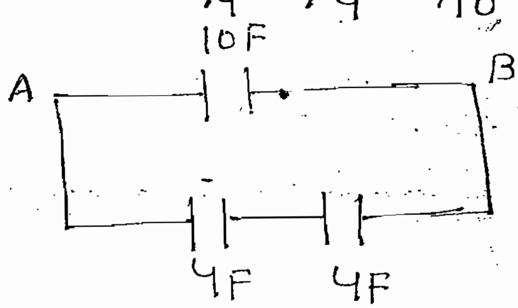


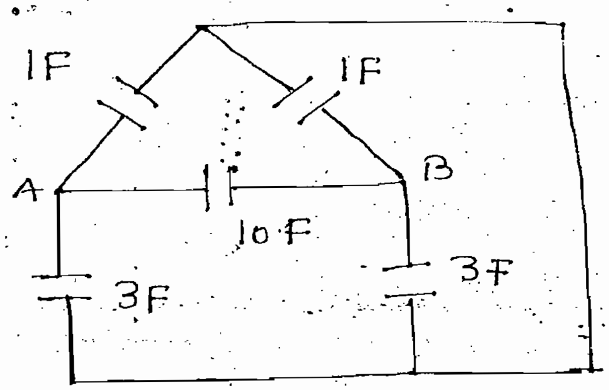
$$L_{eq} = \frac{L_1 L_2}{L_1 + L_2} = \frac{5L}{8} \text{, Ans}$$

Ques:- Find equivalent capacitance w.r.t A & B

Soln:-

$$\cancel{q_{eq}} = \frac{\cancel{1}}{\cancel{4}} + \frac{\cancel{1}}{\cancel{4}} + \frac{\cancel{1}}{\cancel{10}}$$

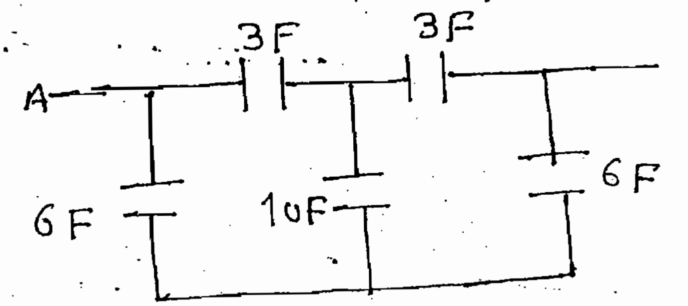




$$C_{eq} = 10 + 2 = 12F$$

μ_0

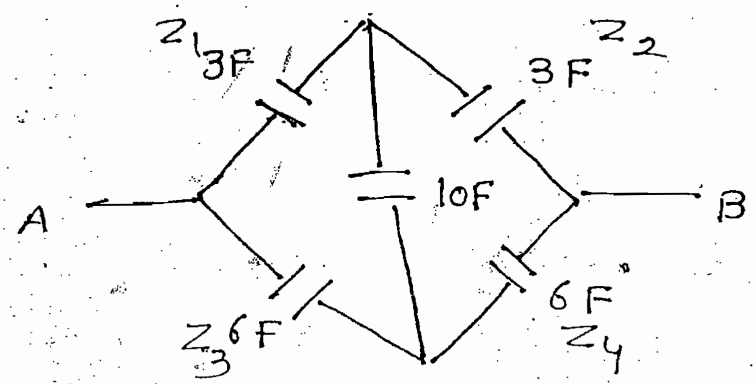
Ques:- Find equivalent capacitance w.r.t A & B



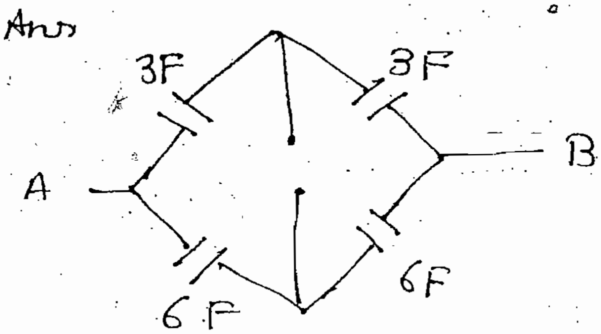
Soln:-

Balanced bridge

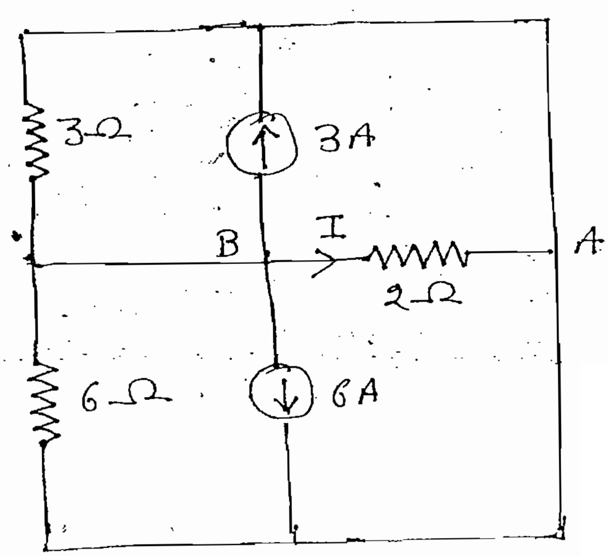
$Z_1 Z_4 = Z_2 Z_3$



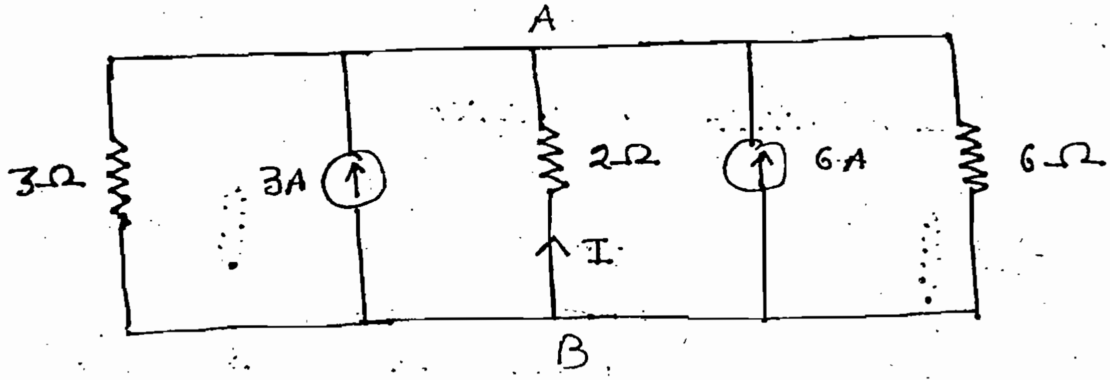
$C_{eq} = 3 + 1.5 = 4.5F$, Ans



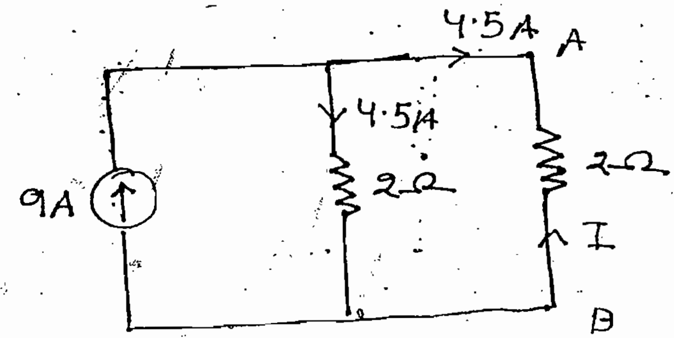
Ques:- Find I of the circuit shown



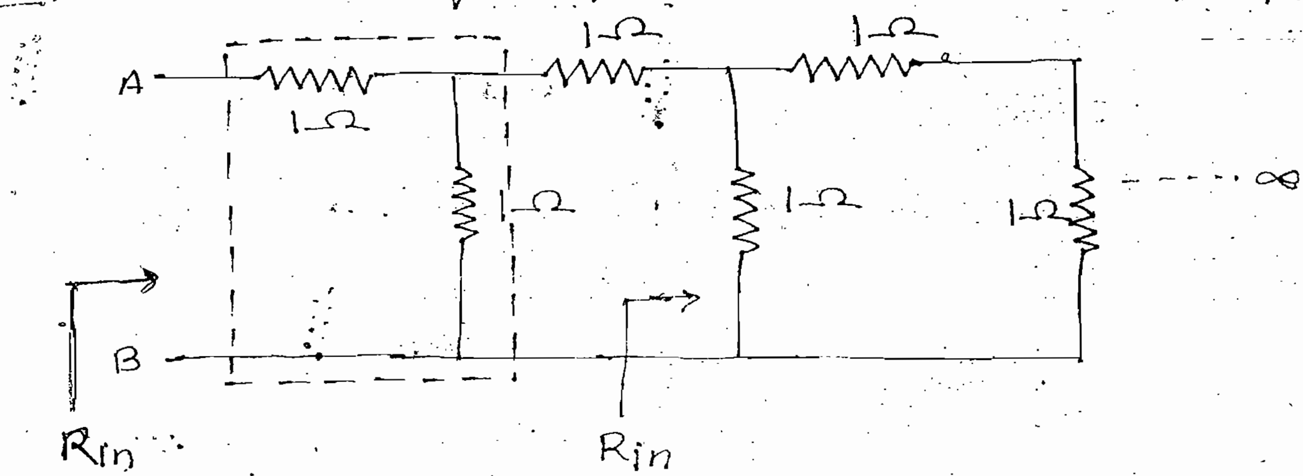
Soln :-



$$\boxed{I = -4.5\,A}$$

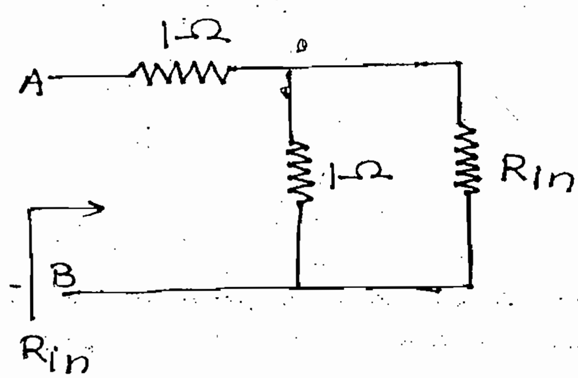


Ques:- Find the equivalent resistance w.r.t A & B



Soln:-

$$R_{in} = 1 + \frac{1 \times R_{in}}{1 + R_{in}}$$

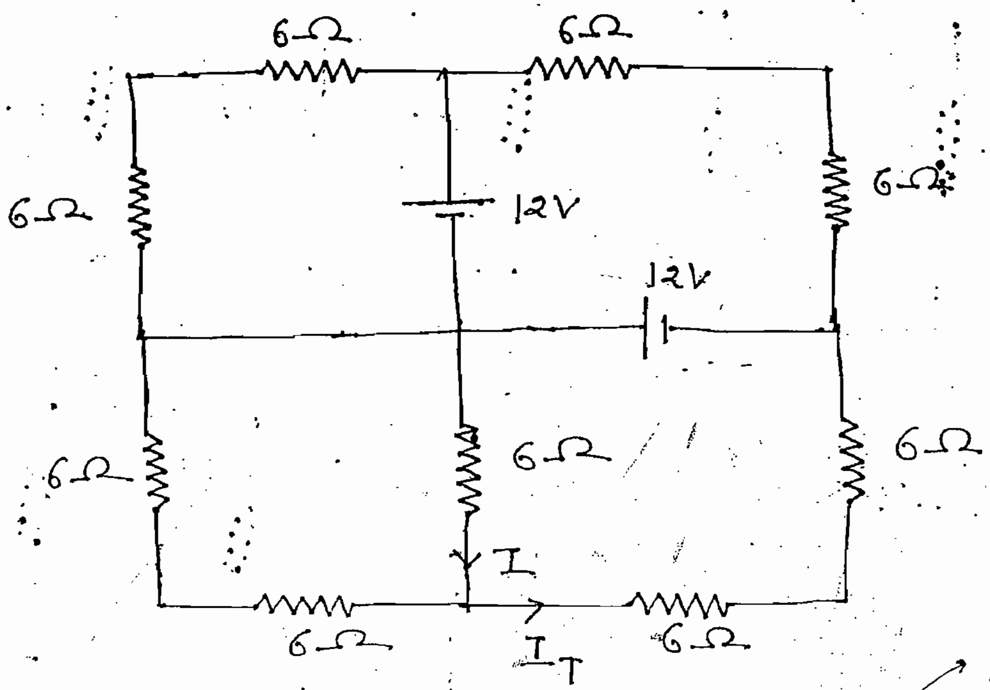


$$R_{in} = \frac{1 + R_{in} + R_{in}}{1 + R_{in}}$$

$$\Rightarrow \quad R_{in}^2 - R_{in} - 1 = 0$$

$$\boxed{R_{in} = \frac{1 + \sqrt{5}}{2}}$$, Ans

Ques:- Find I of the circuit shown



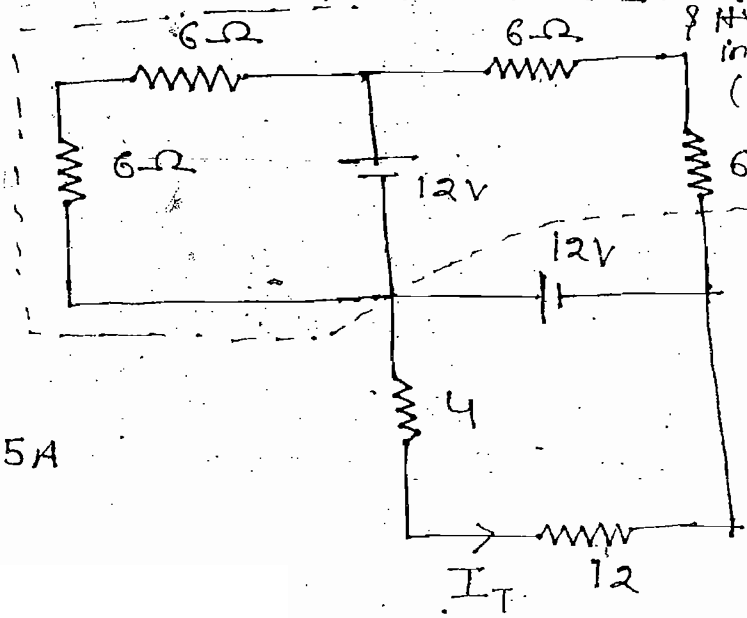
Soln:-

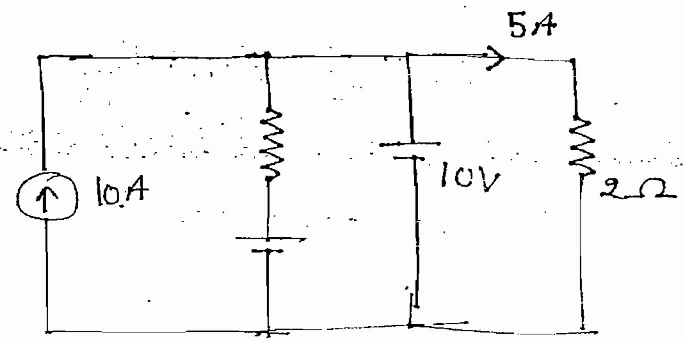
$$I_T = \frac{12}{4+12}$$

$$I = I_T \frac{12}{12+6}$$

$$= \frac{12}{16} \times \frac{12}{18} = 0.5A$$

Not effect in cal: I_T (∵ V → ideal) & H's in parallel (||)

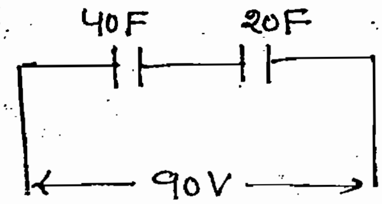




Ques:- When two capacitance 40F & 20F are connected in series with a source voltage 90V. When two capacitor charged fully then they are connected in parallel. Find voltage across capacitor in parallel branch.

(a) 40V (b) 60V (c) 45V (d) 30V

Soln:-

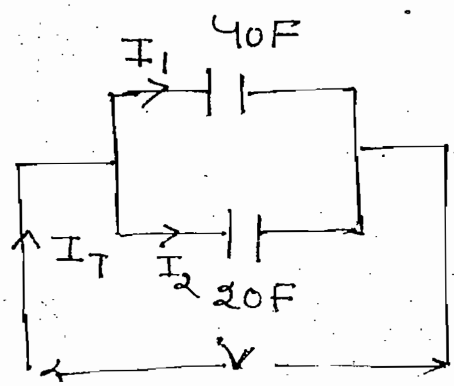


$$C_{eq} = \frac{40 \times 20}{40+20} = \frac{40}{3}$$

$$Q = C_{eq}V = \frac{40}{3} \times 90$$

$$= \cancel{90}\, 1200C$$

$$Q_T = 1200 + 1200 = 2400C$$



$$Q_T = 2400$$

$$C_{eq} = 40 + 20 = 60$$

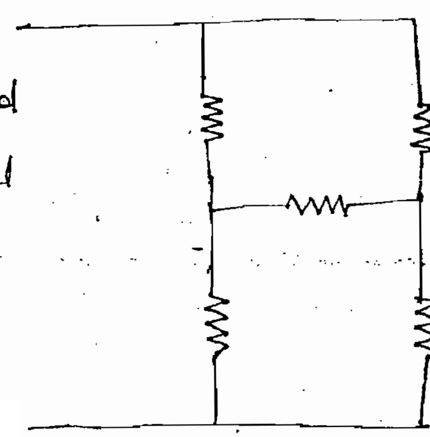
$$V = \frac{Q_T}{C_{eq}} = \frac{2400}{60}$$

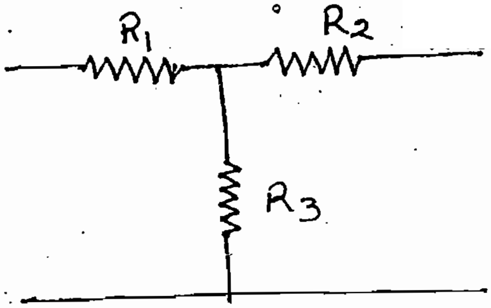
$$= 40V$$, Ans

~~Ques:-~~

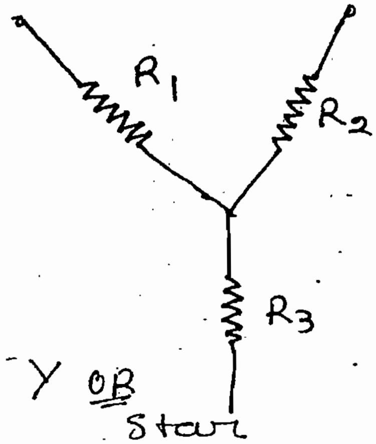
Note:-

When elements are connected not in series nor in parallel network is reduced by Star-delta transformation

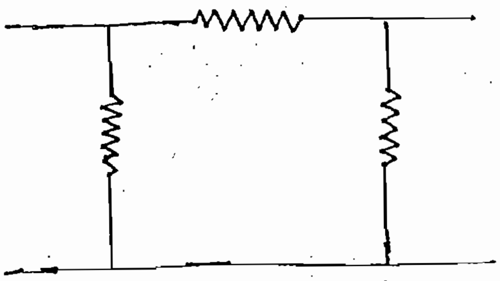




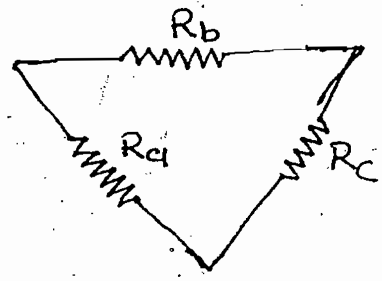
T



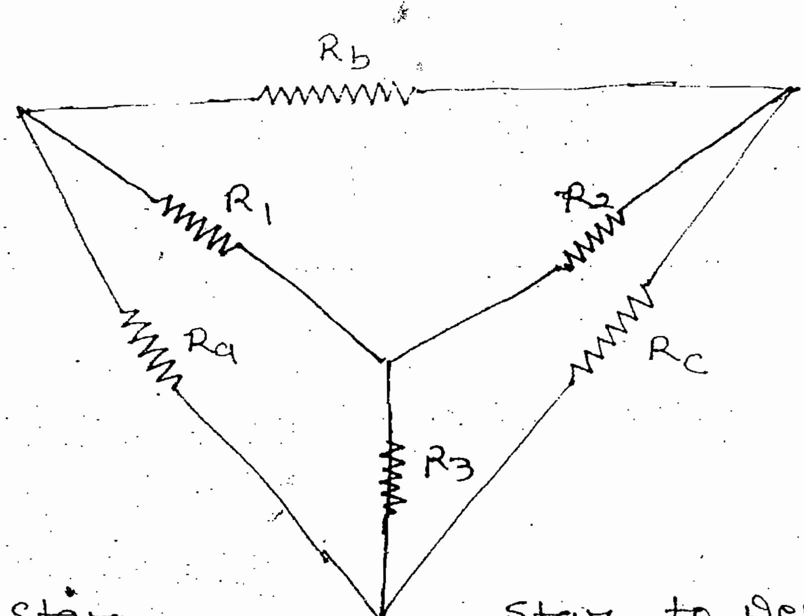
Y OR Star



π



Delta or Mesh



Delta to Star

$$R_1 = \frac{R_a R_b}{R_a + R_b + R_c}$$

$$R_2 = \frac{R_b R_c}{R_a + R_b + R_c}$$

$$R_3 = \frac{R_a R_c}{R_a + R_b + R_c}$$

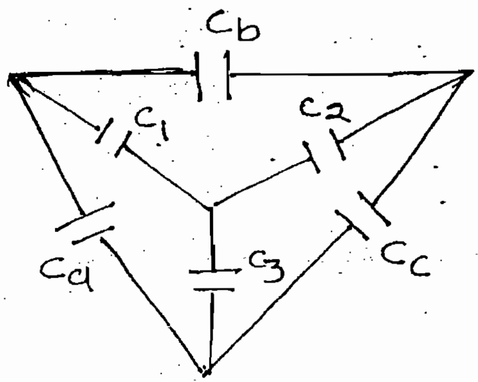
Star to Delta

$$R_a = \frac{R_1 R_2 + R_2 R_3 + R_3 R_1}{R_2}$$

$$R_b = \frac{R_1 R_2 + R_2 R_3 + R_3 R_1}{R_3}$$

$$R_c = \frac{R_1 R_2 + R_2 R_3 + R_3 R_1}{R_1}$$

→ The procedure of transformation either from delta to star or star to delta for the resistor, inductor and impedance is same



Delta to Star :—

$$\frac{1}{C_1} = \frac{\frac{1}{C_a} \cdot \frac{1}{C_b}}{\frac{1}{C_a} + \frac{1}{C_b} + \frac{1}{C_c}}$$

$$\frac{1}{C_2} = \frac{\frac{1}{C_b} \cdot \frac{1}{C_c}}{\frac{1}{C_a} + \frac{1}{C_b} + \frac{1}{C_c}}$$

$$\frac{1}{C_3} = \frac{\frac{1}{C_a} \cdot \frac{1}{C_c}}{\frac{1}{C_a} + \frac{1}{C_b} + \frac{1}{C_c}}$$

Star to Delta :—

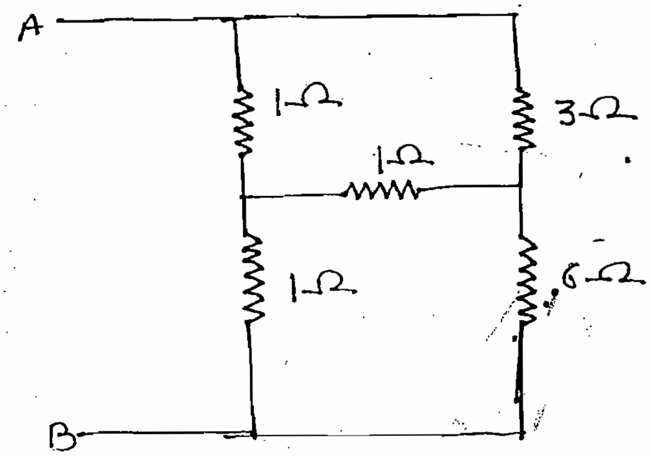
$$\frac{1}{C_a} = \frac{\frac{1}{C_1}\frac{1}{C_2} + \frac{1}{C_2}\frac{1}{C_3} + \frac{1}{C_3}\frac{1}{C_1}}{1/C_2}$$

$$\frac{1}{C_b} = \frac{\frac{1}{C_1}\frac{1}{C_2} + \frac{1}{C_2}\frac{1}{C_3} + \frac{1}{C_3}\frac{1}{C_1}}{1/C_3}$$

$$\frac{1}{C_c} = \frac{\frac{1}{C_1}\frac{1}{C_2} + \frac{1}{C_2}\frac{1}{C_3} + \frac{1}{C_3}\frac{1}{C_1}}{1/C_1}$$

Lecture - 3

Ques:- Find equivalent resistance w.r.t A & B



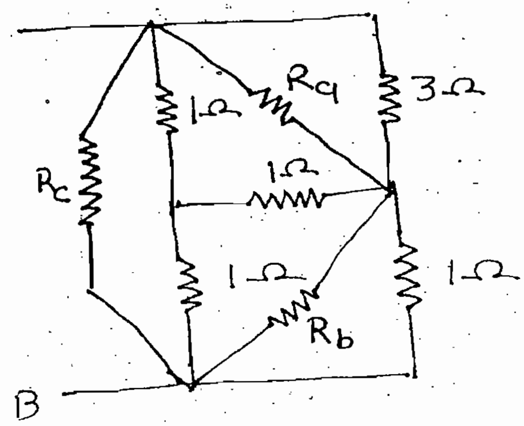
Soln:-

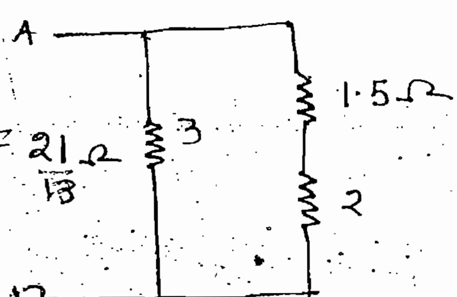
$$R_a = \frac{(1\times1)+(1\times1)+(1\times1)}{1}$$

$$= 3\,\Omega$$

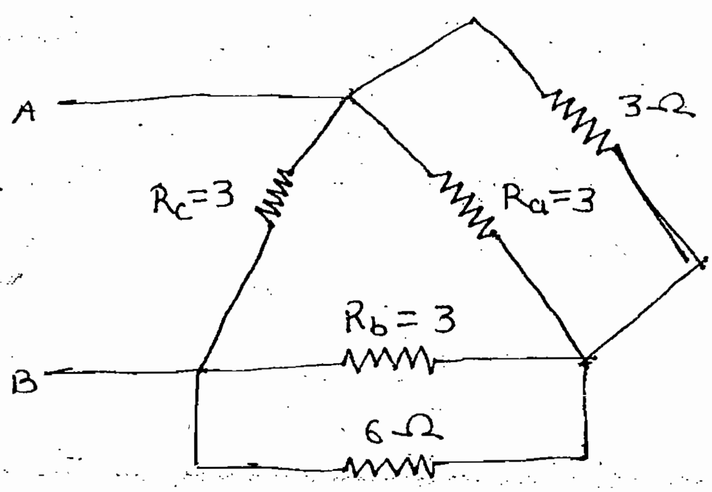
$R_b = 3$

$R_c = 3$





$R_{eq} = \frac{21}{13}\,\Omega$

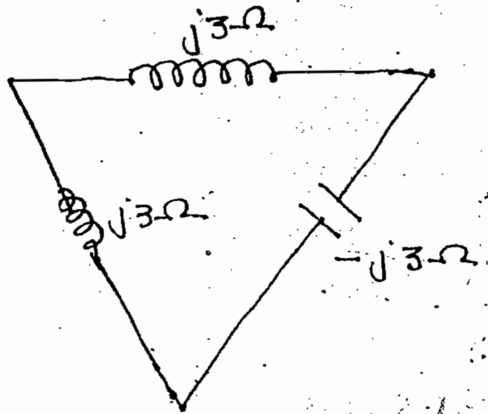


Note:-

When resistor of equal value transfer from star to delta resistance inc. by 3 times.

When capacitance of equal value transform from star to delta capacitance dec. by 3 times

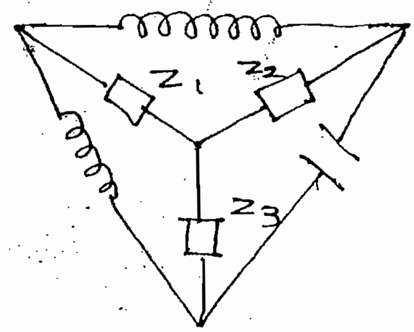
Ques:- Obtain equivalent star connection of the circuit shown



Soln:- $jX_L, -jX_C$

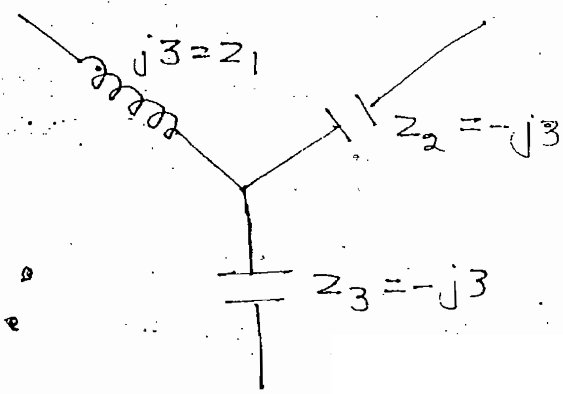
$$Z_1 = \frac{(j3)(j3)}{j3+j3-j3}$$

$$\boxed{Z_1 = j3}$$



$$Z_2 = \frac{(j3)(-j3)}{j3}$$

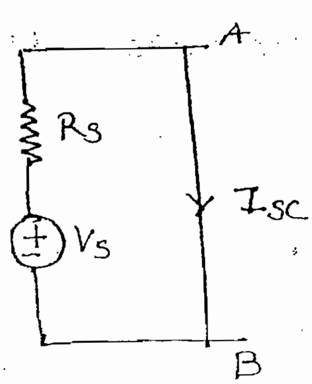
$$\Rightarrow \boxed{Z_2 = -j3}$$



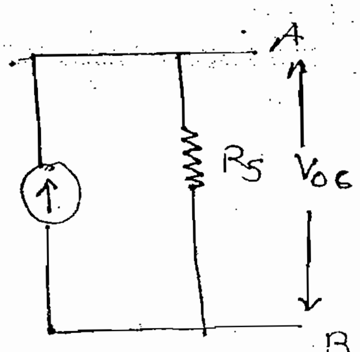
$$Z_3 = \frac{(j3)(-j3)}{j3}$$

$$\Rightarrow \boxed{Z_3 = -j3}$$

Source Transformation:-



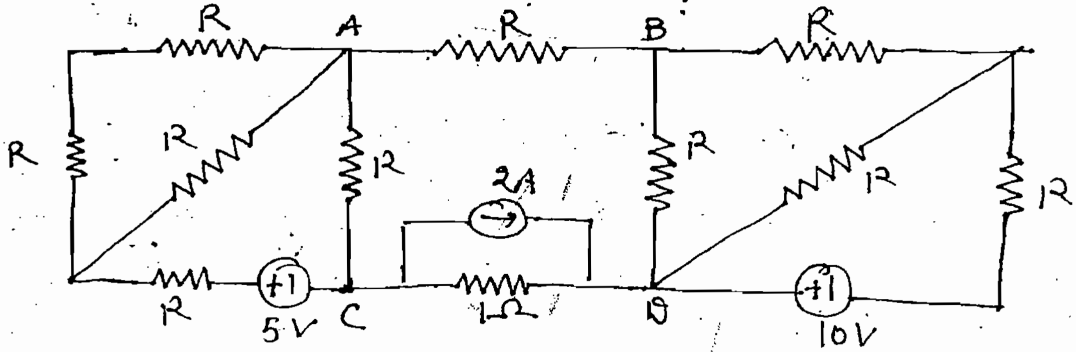
$\simeq$



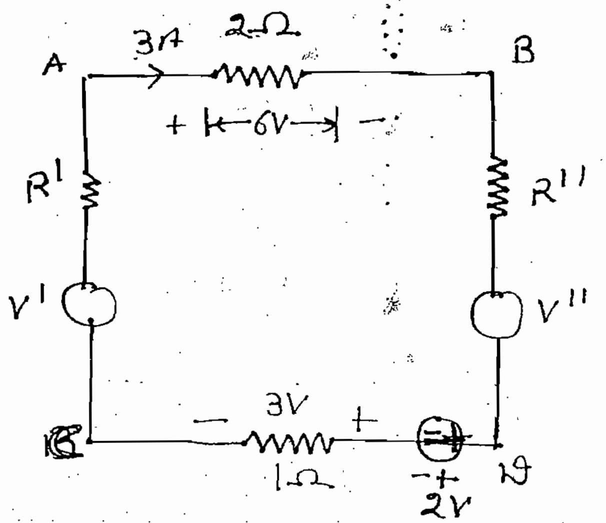
$$I_S = I_{SC} = \frac{V_S}{R_S} \quad \Rightarrow \quad R_S = R_S$$

$$V_S = V_{OC} = I_S R_S \qquad R_S = R_S$$

<u>Ques:</u>- In a circuit shown with $V_A - V_B = 6$ then find $V_C - V_D$

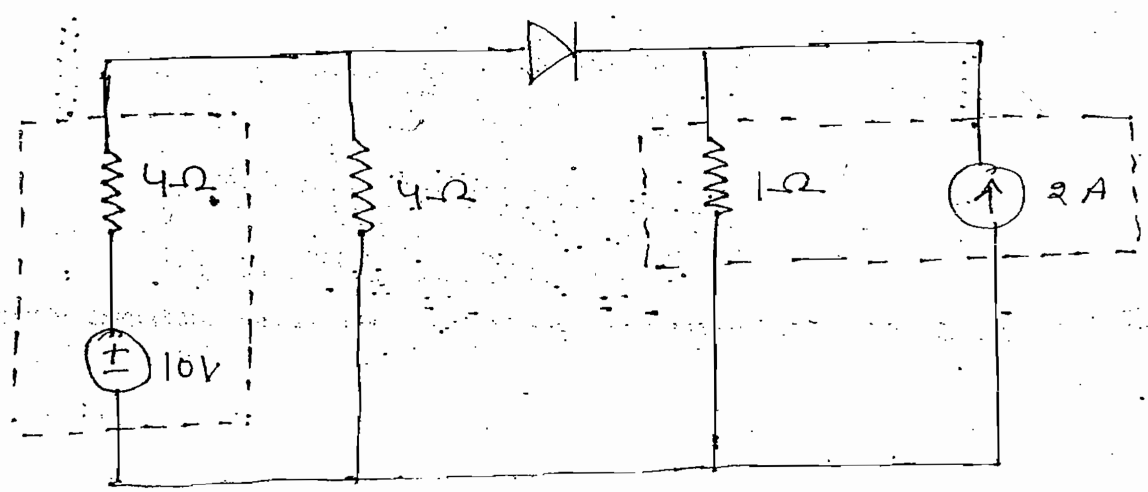


<u>Soln:</u>-

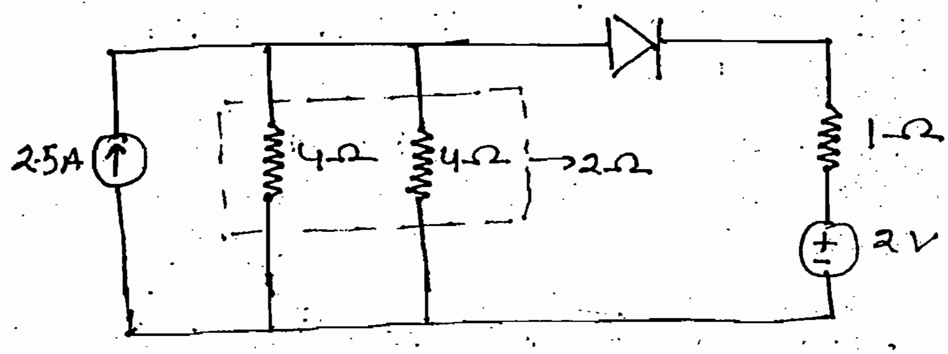


$V_C - V_D = -5\ V$

<u>Ques:</u>- Find current flown through ideal diode of the circuit



Soln:-

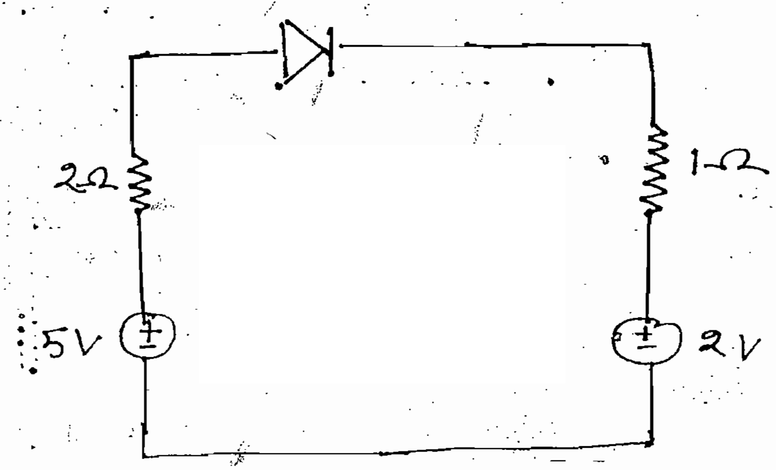


$$V_{S_1} = 2.5 \times 2 = 5V$$

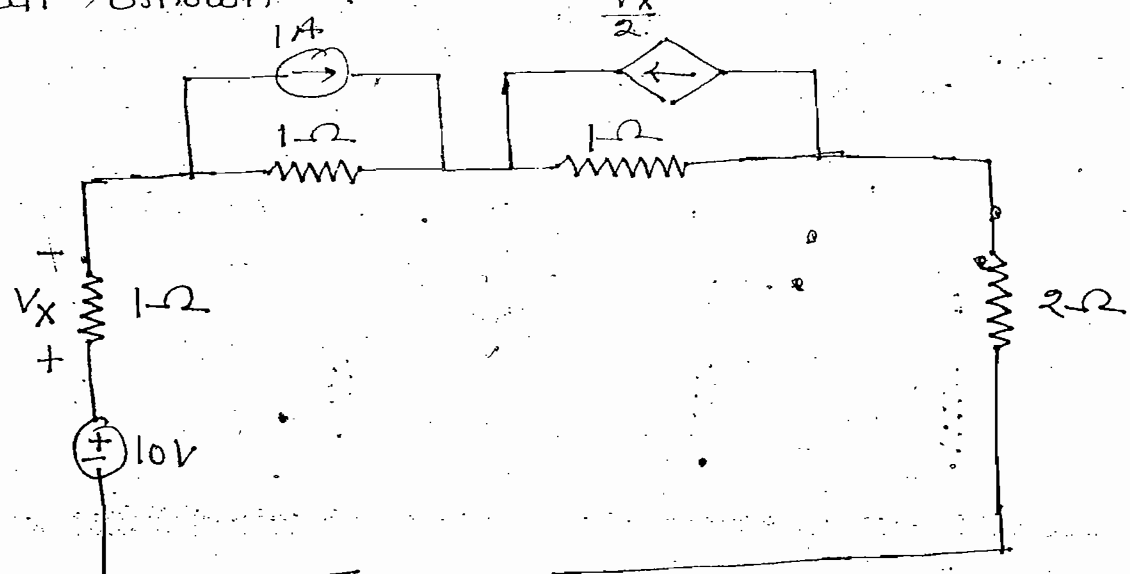
$$i = \frac{V_{eq}}{R_{eq}}$$

$$\Rightarrow i = \frac{5-2}{2+1}$$

$$i = 1A$$



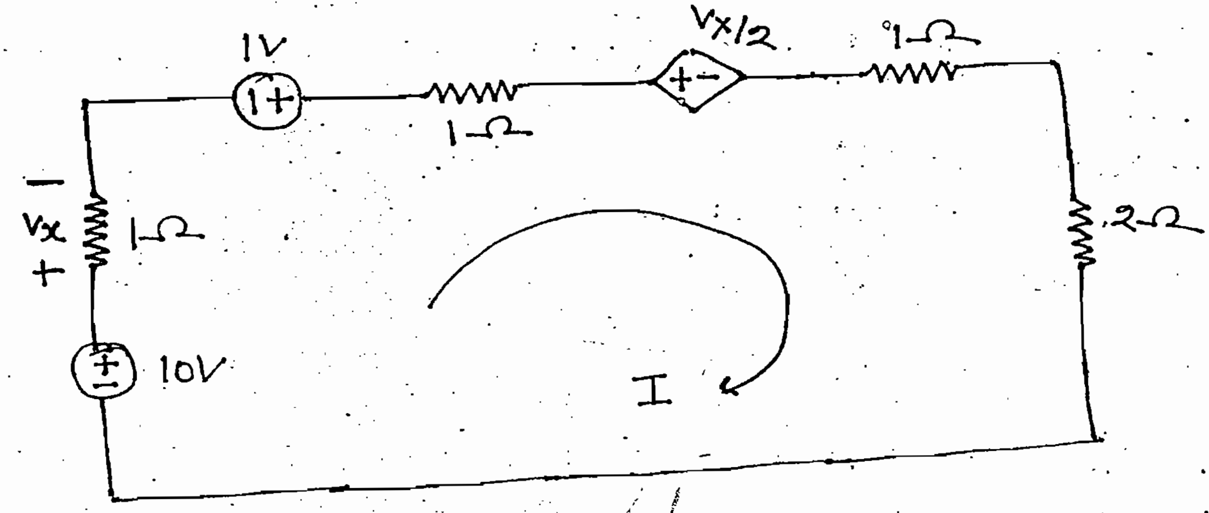
Ques:- Find current in 2Ω resistor for the circuit shown.



Note:-

While applying source transformation for dependent source wherever dependent source magnitude depends without disturbing an element transformation can be applied

Soln:-



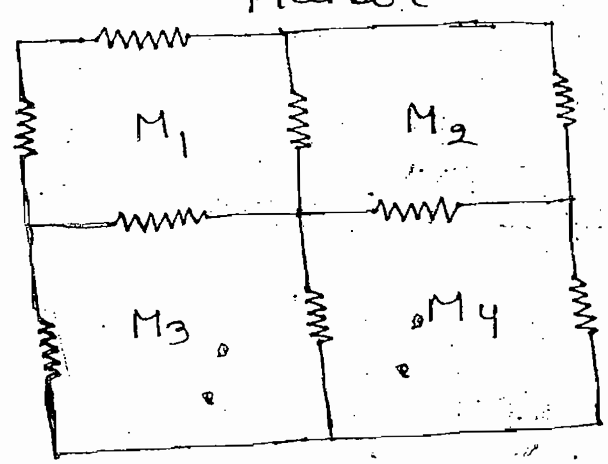
$$-10 + 5I - 1 + \frac{V_x}{2} = 0 \quad \text{— (I)}$$

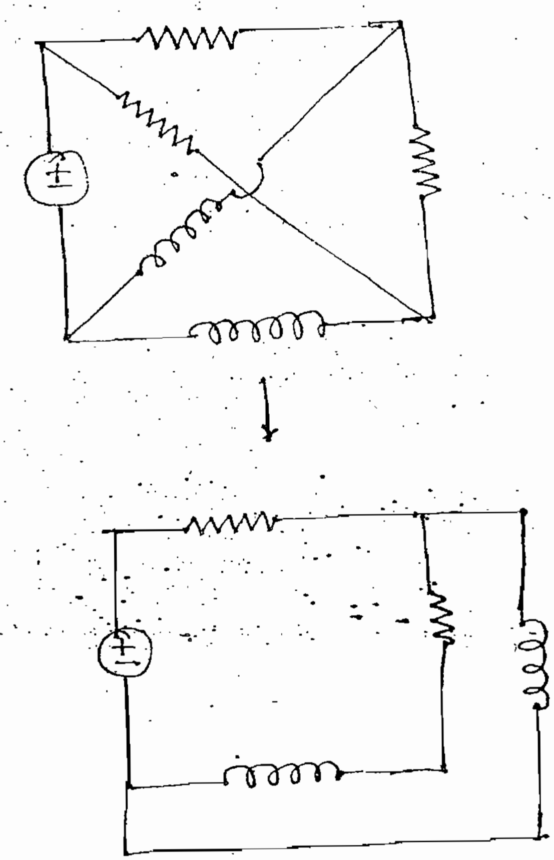
$$V_x = 1 \times I = I \quad \text{— (II)}$$

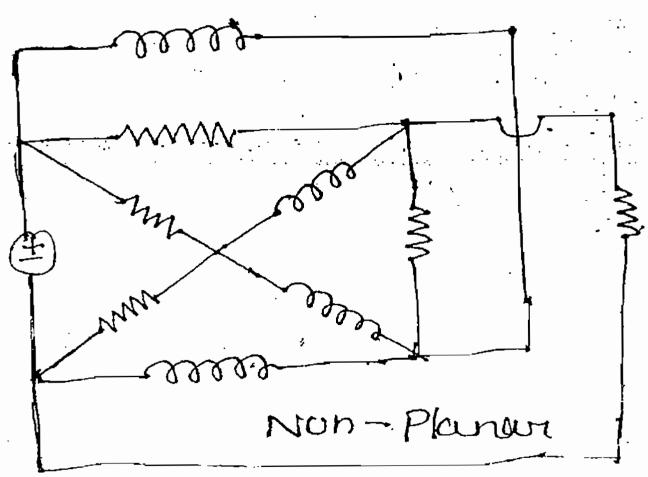
From (I) & (II)

$$\boxed{I = 2A}$$

Mesh Analysis :-





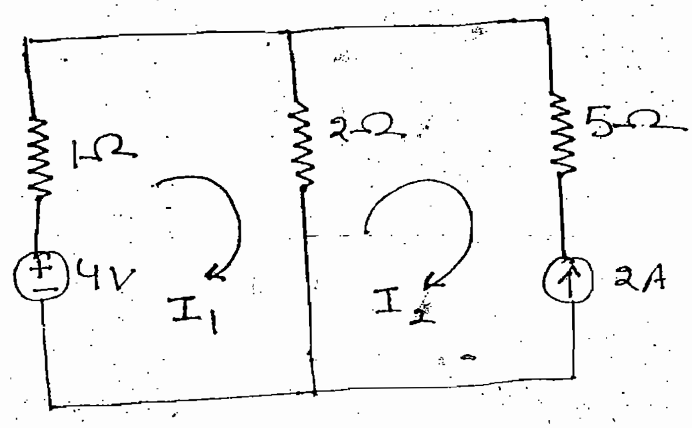


→ Mesh is a loop which does not consist of any loop

→ When the network is drawn on plane without any crossover then the network is called as planar network

Procedure of Mesh Analysis :—

1. Identify total no. of meshes in the given network
2. Assign the current direction for each mesh
3. Develop KVL equation for each mesh
4. By solving KVL equations find loop currents



$$-4 + 3I_1 - 2I_2 = 0$$
$$-4 + (1 \times I_1) + 2(I_1 - I_2) = 0$$
→ (I) (same)

$I_2 = -2$ —— (II) From (I) & (II)

$$\boxed{I_1 = 0}$$

Note :—

e = Mesh No b = total no. of branches

N = total no. of nodes

* $\boxed{e = b - (N-1)}$

In above ques

$e = 2$

$b = 3$

$N = 2$

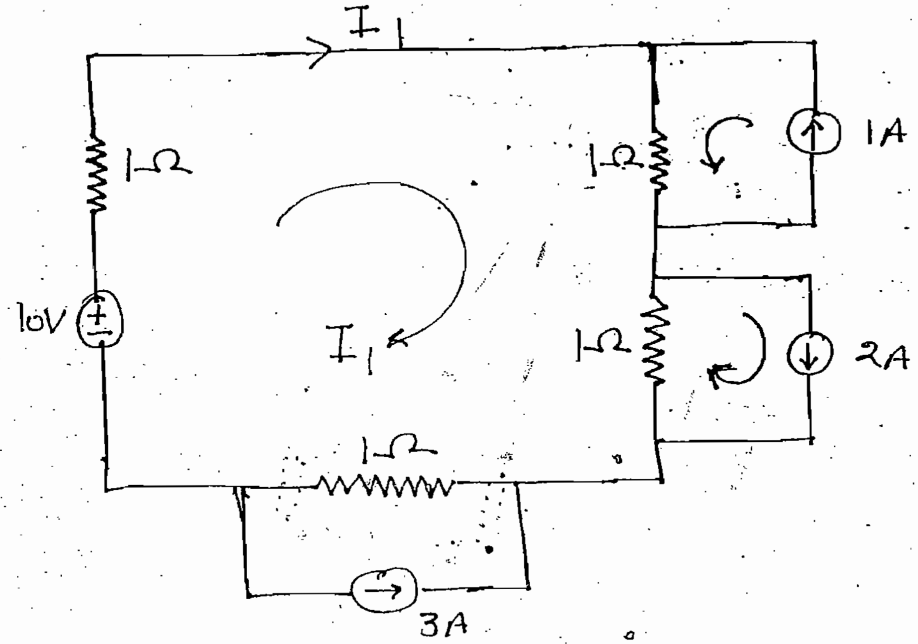
$e = 3 - (2-1)$

$\boxed{e = 2}$

~~e = 3 - (2~~

→ In above network to find loop current minimum one equation required

Ques:- Find I_1 of the circuit shown.

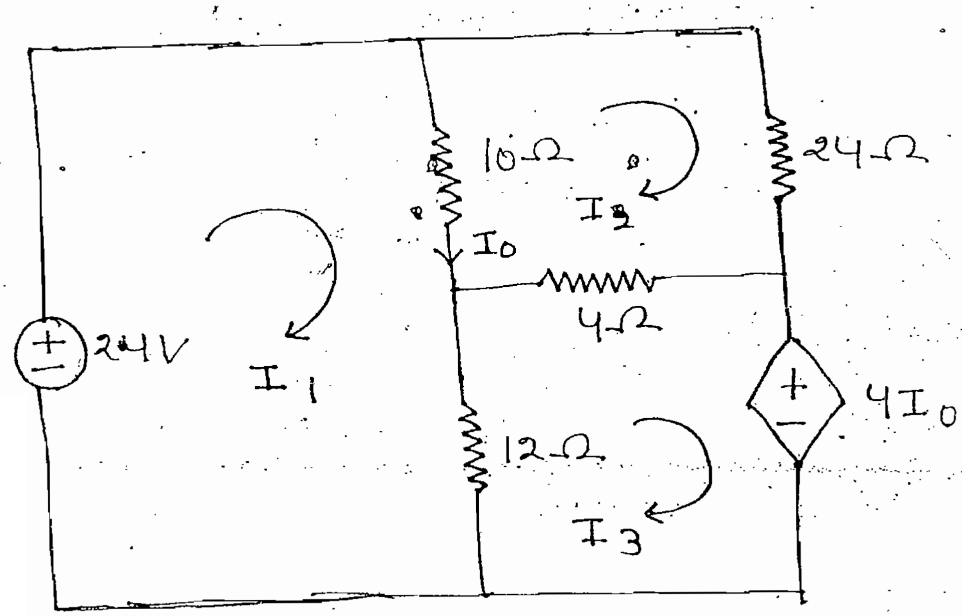


Soln:-

$$-10 + 4I + (1\times1) - (2\times1) + 3(\times1) = 0$$

$$\Rightarrow I = 2A \quad \& \quad I_1 = I$$

Ques:- Find I_o



Sol^n:-

$$24 = 22I_1 - 10I_2 - 12I_3 \quad \text{—(i)}$$

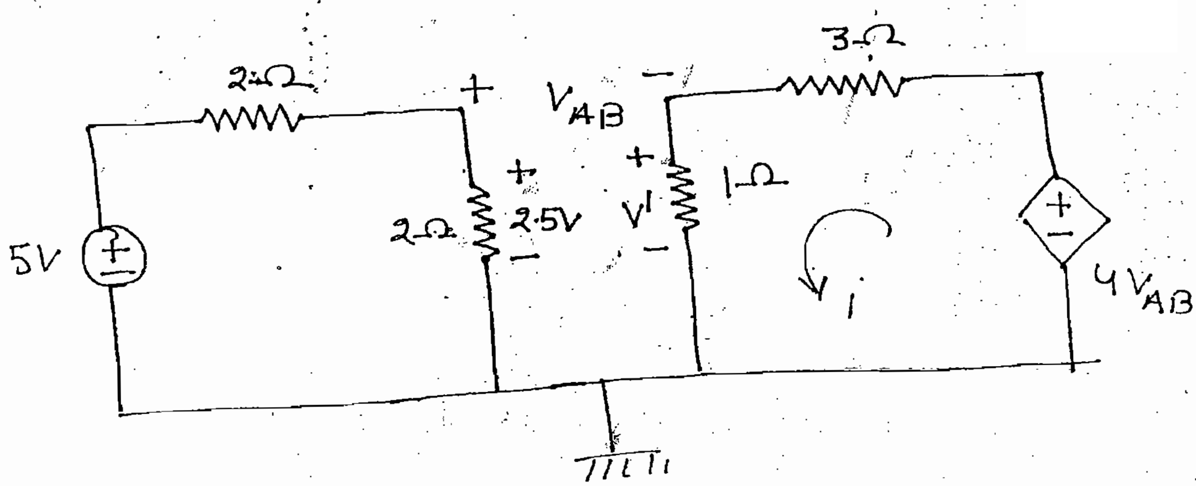
$$0 = -10I_1 + 38I_2 - 4I_3 \quad \text{—(ii)}$$

$$-4I_0 = -12I_1 - 4I_2 + 16I_3 \quad \text{—(iii)}$$

$$I_0 = I_1 - I_2$$

$$\boxed{I_0 = 1.5A}$$

Ques:- Find i of the ckt shown



Sol^n:-

$$i = \frac{4V_{AB}}{3+1} = V_{AB}$$

$$V' = i \times 1 = i$$

$$-2.5 + V_{AB} + V' = 0$$

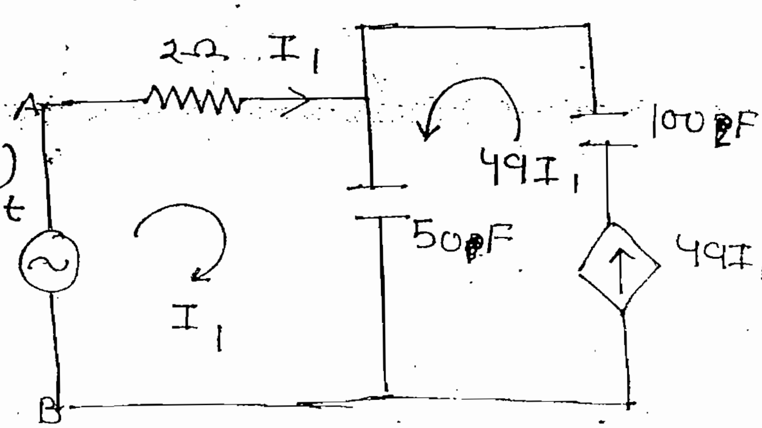
$$\Rightarrow \boxed{i = 2.5A} \quad \text{Ans}$$

Ques:- Find C_{eq} w.r.t A & B

Sol^n:-

$$V_s = 2I_1 + \frac{1}{50}\int (I_1 + 49I_1)\, dt$$

$$\Rightarrow V_s = 2I_1 + \frac{50}{50}\int I_1 dt \quad \text{—(1)}$$

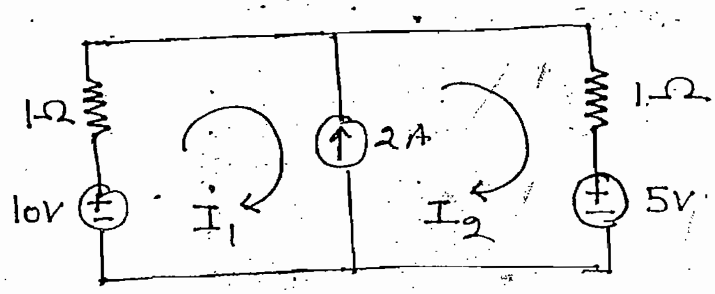


$$V_S = RI_1 + \frac{1}{C_{eq}} \int I_1 dt \quad -(II)$$

compare (I) & (II)

$$\boxed{C_{eq} = 1}$$, Ans

Ques:- Find I_1 and I_2 of the circuit shown



Note:-

When current source branch is common for two meshes it is possible to find solution using supermesh technique

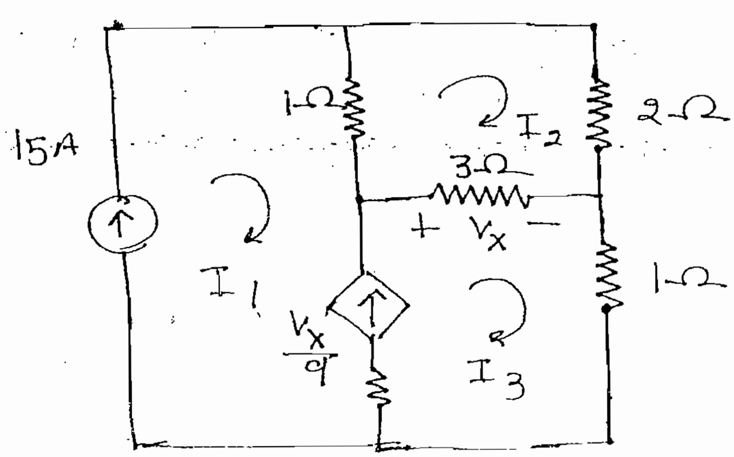
$$KVL \rightarrow -10 + (1 \times I_1) + (1 \times I_2) + 5 = 0 \quad -(I)$$

$$KCL \rightarrow \quad I_2 - I_1 = 2 \quad -(II)$$

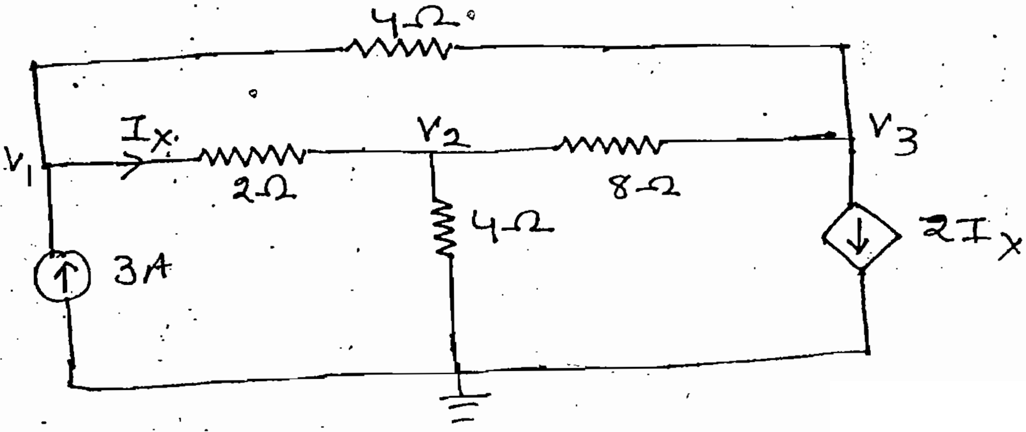
Mesh $\longrightarrow$	KVL + ohm's law
Super Mesh $\longrightarrow$	KVL + KCL + ohm's law

$$\Rightarrow \quad I_1 = 1.5 \quad I_2 = 3.5$$, Ans

Ques:- Find loop currents of the circuit shown!-



Ques:-



Find V_1, V_2 & V_3

Soln:- $\dfrac{V_1 - V_2}{2} + \dfrac{V_1 - V_3}{4} = 3$ — (I)

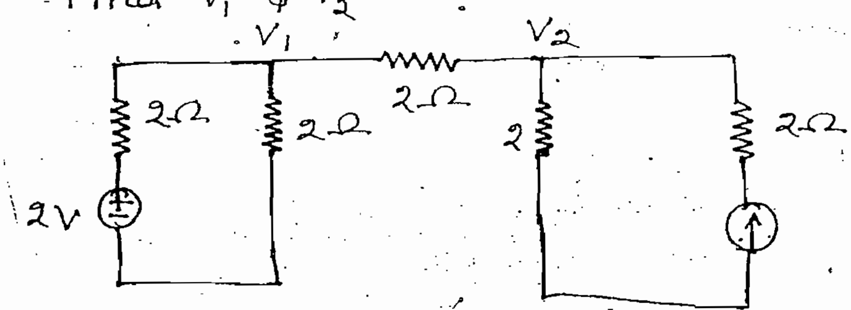
$$\frac{V_2}{4} + \frac{V_2 - V_1}{2} + \frac{V_2 - V_3}{8} = 0 \quad \text{— (II)}$$

$$\frac{V_3 - V_1}{4} + \frac{V_3 - V_2}{8} + 2I_x = 0 \quad \text{— (III)}$$

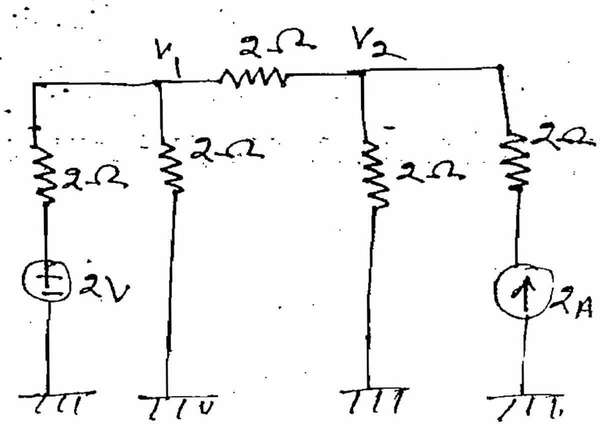
$$I_x = \frac{V_1 - V_2}{2} \quad \text{— (IV)}$$

$\underline{V_1 = 4.8}$, $\underline{V_2 = 2.4}$, $\underline{V_3 = -2.4}$, Ans

Ques:- Find V_1 & V_2



Soln:-

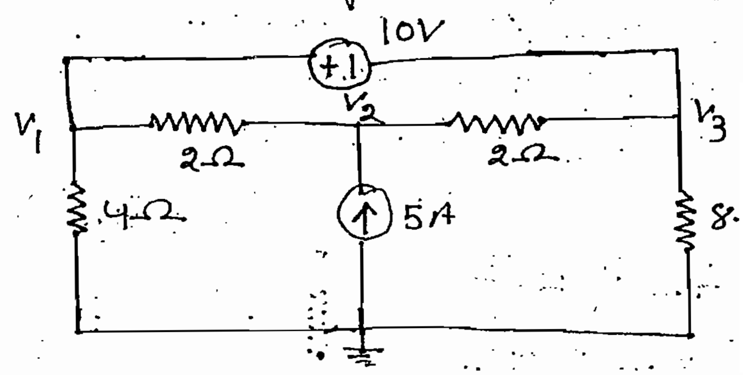


$$\frac{V_1 - 2}{2} + \frac{V_1}{2} + \frac{V_1 - V_2}{2} = 0 \quad \text{— (I)}$$

$$\frac{V_2}{\cancel{2}} + \frac{V_2 - V_1}{2} = 2 \quad \text{— (II)}$$

$$\boxed{\begin{aligned} V_1 &= 1.6\ V \\ V_2 &= 2.8\ V \end{aligned}}$$ Ans

Ques:- Find node voltages of the circuit shown.



Note:-

When ideal voltage source is connected b/w two non-reference node it is possible to find solution by using supernode technique

Solⁿ:-

$$\frac{V_1}{4} + \frac{V_1 - V_2}{2} + \frac{V_3}{8} + \frac{V_3 - V_2}{2} = 0 \quad \text{—(I)} \rightarrow \text{KCL}$$

$$V_1 - V_3 = 10 \quad \text{—(II)} \rightarrow \text{KVL}$$

$$-5 = \frac{V_2 - V_1}{2} + \frac{V_2 - V_3}{2} \quad \text{—(III)}$$

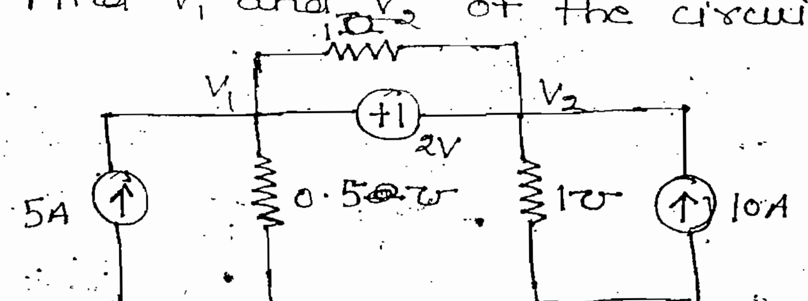
$V_1 = \cancel{16.6} \; 16.67\,V$ $\quad V_2 = 16.67$ $\quad V_3 = 6.67\,V$, Ans

Note:-

Nodal → KCL + ohm's law

Super Node → KCL + KVL + ohm's law

Ques:- Find V_1 and V_2 of the circuit shown

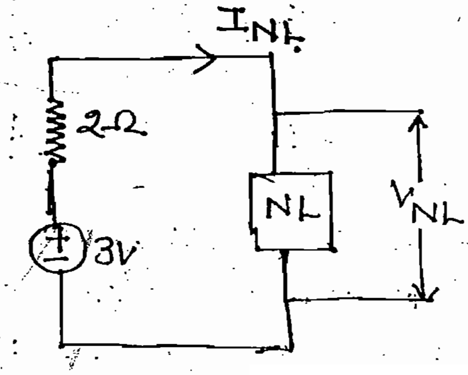


Solⁿ:- Resistance connected in parallel with voltage source does not influence

$$10 + 5 = (V_1 \times 0.5) + (V_2 \times 1) \rightarrow \text{KCL}$$

$$V_1 - V_2 = 2 \rightarrow \text{KVL}$$

Ques:- The practical source of 3V and internal resistance 2Ω connected to non-linear resistor. The characteristic of non-linear resistor is given by $V_{NL} = I_{NL}^2$. Find power dissipation in the non-linear resistor



Soln:-

$$-3 + 2I_{NL} + V_{NL} = 0$$

$$-3 + 2I_{NL} + I_{NL}^2 = 0$$

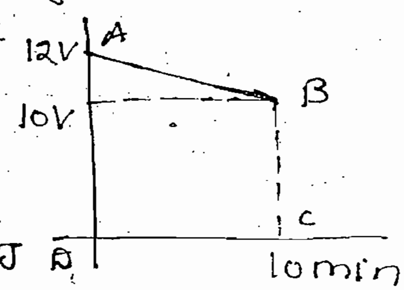
$$I_{NL}^2 + 2I_{NL} - 3 = 0$$

$$I_{NL} = 1$$

$$V_{NL} = I_{NL}^2 = (1)^2 = 1$$

$$P_{NL} = V_{NL} I_{NL} = 1 \times 1 = 1W$$

Ques:- A fully charged mobile phone is good for 10min talktime. During talktime battery delivers a constant current of 2A. The voltage characteristics of battery is as shown in figure. Find energy of battery during talk time



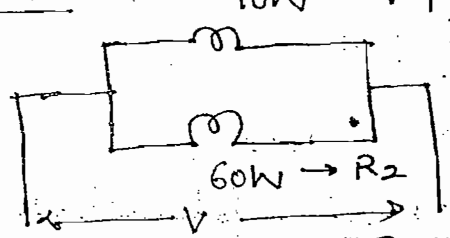
Soln:-

$$t = 10min = 10 \times 60 = 600s$$

$$V \times t = 6600$$

$$W = Vit = 6600 \times 2 = 13.2kJ$$

Note:-



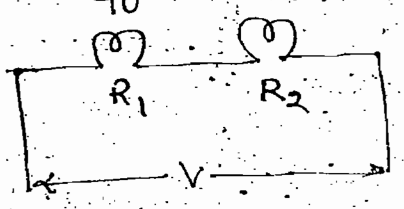
$\cancel{R_2 > R_1}$ $R_1 > R_2$

$$P_1 = \frac{V^2}{R_1} \qquad P_2 = \frac{V^2}{R_2}$$

$$P_1 < P_2$$

↓

More brightness



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

$$P_1 = i^2 R_1$$

$$P_2 = i^2 R_2$$

$R_1 > R_2$

$P_1 > P_2$

↓

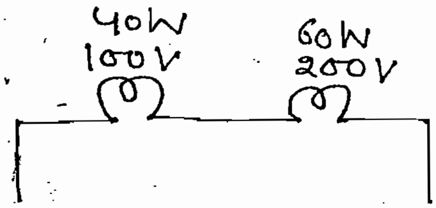
More brightness

→ When, the bulbs are connected in series low rating bulb used more brightness

→ When the bulbs are connected in parallel high rating bulb used more brightness

→ In the above two cases voltages reading of bulb are equal

Ques:- In the given connection which bulb glow brightly



Soln:- $R = \frac{V^2}{P}$

$R_1 = \frac{(100)^2}{40}$ $R_2 = \frac{(200)^2}{60}$

$R_2 > R_1$ $P = i^2R$

→ 60W bulb having more brightness