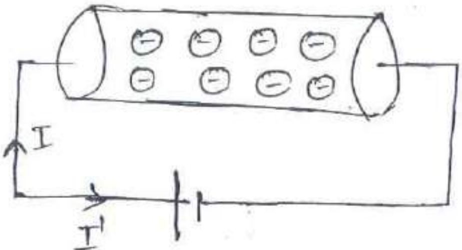
Fundamentals :-



where I' = Natural current
I = conventional current

* The Basic quantity in electric circuit is "charge", charge of the electron is given by $\underline{-1.602 \times 10^{-19}}$ C.
* The Flow of Electrons is called as "current" (or) the time rate of charge is also called as "current".
* By using conventional current only KVL & KCL eq's are developed. $I = (dQ/dt)$ C/s (or) Amps
* To move the electron from one point to another point in perticular Direction external force is required, In electric circuits external force is Provided by electro motive Force (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".

$$\boxed{P = \frac{dw}{dt}}$$

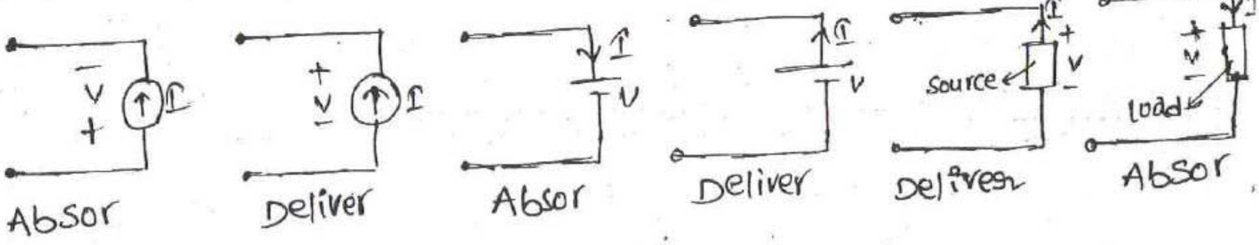
$$= \frac{dw}{dt} \times \frac{dQ}{dQ}$$

$$= \frac{dw}{dQ} \cdot \frac{dQ}{dt}$$

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

Now we will discuss some more conclusions on power from the following diagrams.

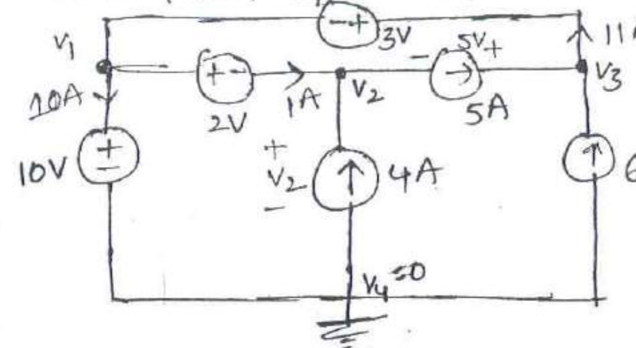
Ex:-



Note:- 1. current is Entering at +ve Terminal element is absorbing power.

2. when current is leaving from +ve terminal, element is delivering power.

(Pb) find power of each elements of the N/W shown.



$\therefore \boxed{V_1 = 10V}$

$V_1 - V_2 = 2V$

$\Rightarrow \boxed{V_2 = 8V}$

$V_3 - V_1 = 3$

$\boxed{V_3 = 13V}$ //...

$P_2 = V_2 I = 8 \times 4 = 32W$ (Deliver)

$P_3 = 13 \times 6 = 78W$ (Deliver)

$P_{5A \text{ branch}} = 5 \times 5 = 25W$ (Deliver)

$P_{3V} = 3 \times 11 = 33W$ (absorb)

$P_{10V} = 10 \times 10 = 100W$ (Absorb)

$P_{2V} = 2 \times 1 = 2W$ (Absorb)

Note:- In any N/W
delivering = absorbing
135 W = 135 W
so our calculation is exactly correct.

ENERGY:-
The capacity to do the work is called as "energy".

$$\boxed{W = \int_0^t P\,dt}$$ watt-sec (or) Jouls

classification of elements:-
1) Active & Passive elements
2) linear & Non linear elements
3) unidirectional & Bidirectional elements
4) Time variant & Time Invarient elements
5) Lumped & Distributed elements

Elements

- Active
  - Independent sources
    - Ideal
      - voltage source
      - current source
    - Practical
      - voltage source
      - current source
  - Dependent
    - VCVS
    - CCVS
    - CCCS
    - VCCS
- Passive
  - R
    - linear
    - Non linear
  - L
    - linea
    - Nonlinear
  - C
    - linea
    - Non linear

Active Elements :-

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

(OR)

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

Ex :- voltage source, Current source, Transistor & op-amp.

$\boxed{V, I \text{ sources}}$ → independent

$\boxed{\text{op-amp, Transistor}}$ → Dependent

Note :-

During discharging capacitor [(or) inductor] can deliver energy independently for short time and capacitor (or inductor) is not having property of internal amplification.

Passive elements :-

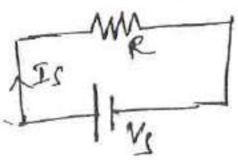
When the element is not capable of delivering energy independently then it is called as "passive element".

Ex:- (Resistor element) Bulb

Transformer → T/F only stepup (or) stepdown the voltage.
Not " " the power.
So there is no internal amplification.

Resistor :-

Resistance is a property of the resistor it opposes flow of current by doing so it converts electric energy to Heat energy.



$P = I^2R$

$\therefore W = P \times t = \underbrace{I^2Rt}_{\text{Heat energy}}$

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

Basically materials are classified into 3 types based on resistivity property.

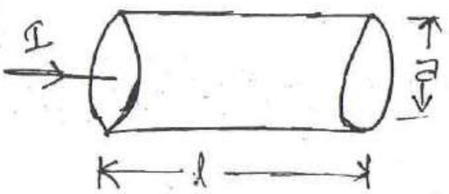
ρ (Ω-m)
- → conductors
- → semi-cond^u
- → Insulators

Super conductor
$\rho = 0$
Ex:- mercury at 4.15 K

$$\boxed{R_1 = R_0(1 + \alpha_0 t)}$$

R_0 = Resistance at $0^\circ C$
α_0 = Temp^n Co-Eff^n → conductors have the +ve Temp^n co-Eff^n.
Insulators " " -ve " ".
t = change in Temp^n

Ohm's law :-



Ohm's law states that at constant Temp^n current density is directly proportional electric field intensity.

$$J \propto E$$

$$\boxed{J = \sigma E}$$

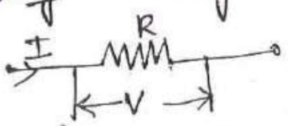
$$\frac{I}{a} = \frac{1}{\rho} \times \left(\frac{V}{l}\right)$$

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

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

$\because J = I/a$ A/m²
$E = \frac{V}{l}$ V/m
$\sigma = 1/\rho$ mho/m
$R = \frac{\rho l}{a}$

Ohm's law states that at constant Temp^n Potential difference across the elements is directly Proportinal to current flowing through element.



$V \propto I$
$V = RI$
$R = \frac{V}{I}$ = constant

note: $\frac{I}{a} = \frac{1}{\rho} \times \frac{V}{l}$

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

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

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

$\boxed{I \propto V}$

** note:- ohm's law is valid when Temp^n & conductivity of the material are constant.

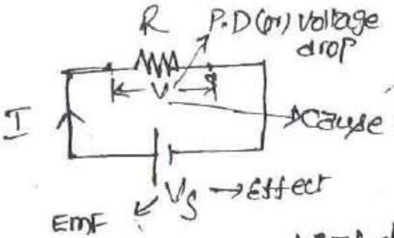
ohm's law 1st form → * $\boxed{J = \sigma E}$ → Basic formula

* $\boxed{V = RI}$ → 2nd form

* $\boxed{I = GV}$ → 3rd form $\left(\because G = \frac{1}{R}\right)$ mho (or) S

* $\boxed{V = R\frac{dQ}{dt}}$ → 4th Form

Note:-



which one is right?

$I \propto V_S$ ↓ EmF	$V \propto I$ ↓ Potential diff^n (or) voltagedrop

both are right.

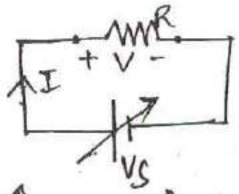
→ Diff^n b/w EmF & potential diff^n
↓ source voltage ↓ voltagedrop.

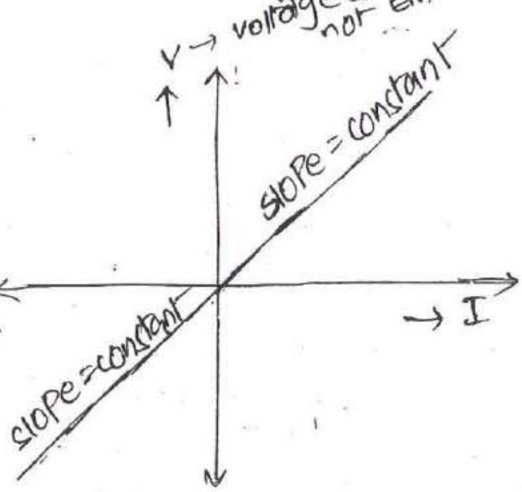
→ out of these Two Effect is EmF & cause is P.D (or) voltagedrop.

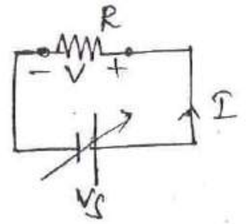
→ EmF is independent on current magnitude aswell as resistance.

but potential diff^n Depends " " " .

V-I Char^n :-







at $I \uparrow 10\% \Rightarrow V \uparrow 10\%$

$I \uparrow 90\% \Rightarrow V \uparrow 90\%$

so

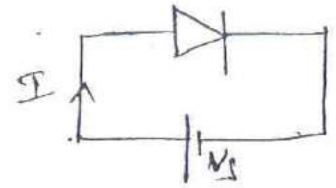
$\boxed{\frac{V}{I} = \text{constant} = R}$

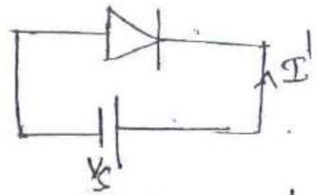
Here Just we are reversing the Polarities. Analysis is same.

* When element Properties and chara^n are independent on the Direction of the current then the element is called as "Bidirectional elements".

* when element obeys the ohm's law then the element is called as "linear resistor".

* Every linear element should obey the bidirectional Property but not viceversa.





$I \neq I'$

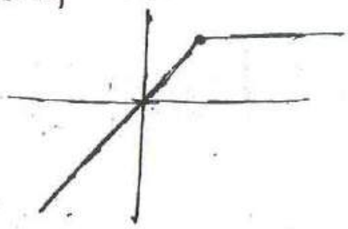
* When element properties and char" depends on the direction of the current then the element is called as "unidirectional element".

Ex:- Diode

* When Element doesnot obeys the ohm's law then the element is called as Non linear Resistor.

Let us consider the following V-I char" & conclude which type of Element it is?

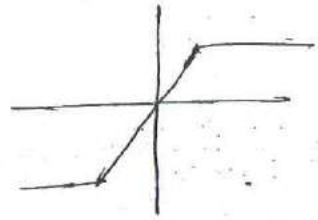
1)



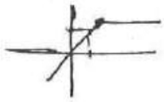
* Non linear
* unidirectional → If char" are identical then it is Bidirectional, otherwise unidirectional.

Active (or) passive = ?

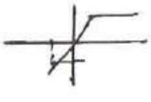
2)



* Non-linear
* Bidirectional
* Passive



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



$\frac{V}{I} = \frac{-ve}{-ve} = R = +ve$

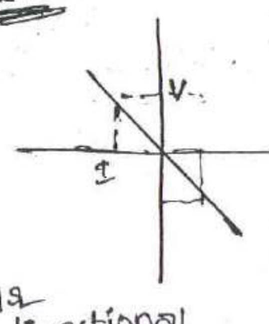
whenever $\frac{V}{I}$ ratio is +ve, then it is Passive. Always $R \geq 0$, $L \geq 0$, $C > 0$

-ve values doesn't exist.

when even $\frac{V}{I}$ ratio is -ve then it is a "Active Element".

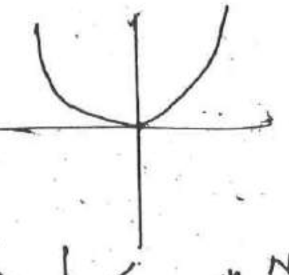
so Conclusion is
* passive

3)



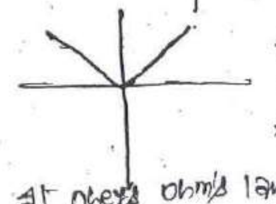
* linear
* Bi-directional
* Active

4)



* Nonlinear
* unidirell
* Active

5)



* Nonlinear
* unidirn
* Active

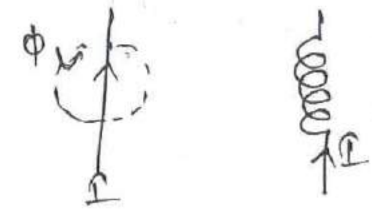
Here it obeys ohm's law, but unidirn. ~~but~~ Every Linear Element should be bidirn. so non linear.

Note:-

1. If $\frac{V}{I}$ is +ve in the both co-ordinates then the element is Passive.
2. When element obeys the bidirectional property charu are identical in the opposit co-ordinates. but not in the adjacent co-ordinates.
3. Every linear element should obey the bidirectional property but not viceversa.

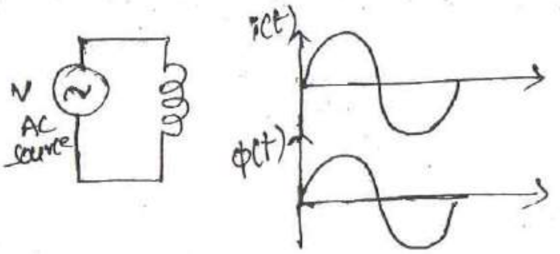
Inductor :-

Diff b/w plain conductor & inductor.



→ due to twisted arrangement group of magnetic fluxlinks are obtained. so strong mgticfld is obtained.

weak mgtic field



flux linkages.

$\psi = N\phi$

$v = \frac{d\psi}{dt} = e$

$\left.\begin{matrix}\phi \propto i \\ \psi \propto \phi\end{matrix}\right\}$

$\Rightarrow \psi \propto i$

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

$v = L\frac{di}{dt} \Rightarrow \boxed{L = \frac{v}{di/dt}}$

$\left.\begin{matrix}\psi = N\phi \\ \psi = Li\end{matrix}\right\} \Rightarrow \boxed{L = \frac{N\phi}{I}}$ #

Faraday's 1'st law:-

when conductor cuts a mgtic lines of the force an emf induced in the conductor.

Faraday's 2nd law:-

Emf induced in the conductor is directly proportional to rate of change flux.

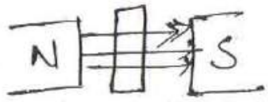
$e \propto \frac{d\phi}{dt}$

$\boxed{e = -N\frac{d\phi}{dt}}$

To satisfy lenz's law.

where e = statically induced emf

Practical ex:- Transformer



1) e
2) $e \propto \frac{d\phi}{dt}$
3) $\boxed{e = BlV\sin\theta}$

where B = flux density
l = active length of condu
V = linear velocity of conductor
θ = Phase displacement b/w conductor & flux line

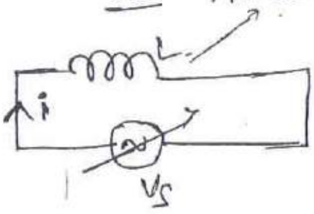
where e = dynamically induced emf

Ex: Generator

Networks...

1) When inductance of the inductor is independent on the current magnitude then the inductor is called as "linear inductor".

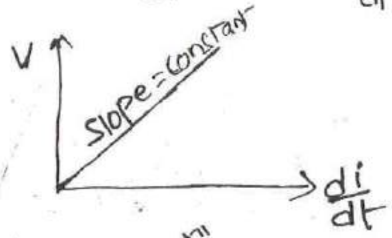
Ex:- Aircore inductor

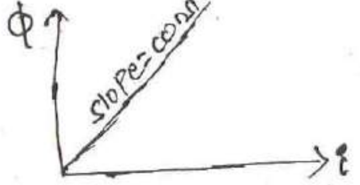


$i \uparrow 10\%$, $\phi \uparrow 10\%$

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

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

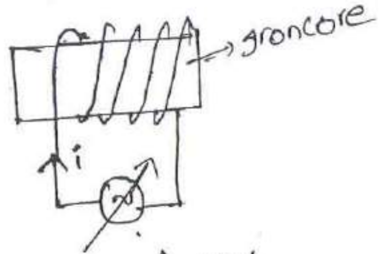




2) When inductance of inductor depends on current magnitude then the inductor is called as "Non linear inductor".

Ex:- Iron core inductor

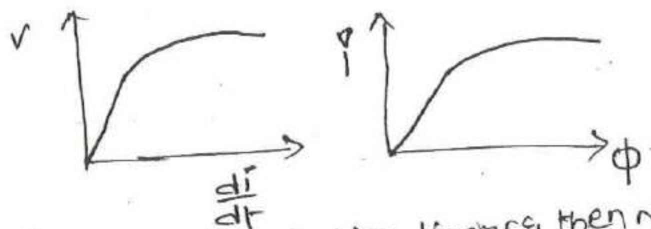
$\left[L = \frac{N\phi}{I}\right]$



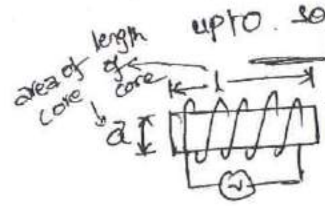
$i \uparrow 10\%$, $\phi \uparrow 10\%$

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

$i \uparrow 90\%$, ϕ = constant (∵ core is saturated)



upto some position linear & then nonlinear.



$L = \frac{N\phi}{I} \rightarrow ①$

Electric	Magnetic
1) $i = \frac{EMF}{R}$	1) $\phi = \frac{MMF}{S}$
2) $i = \frac{EMF}{\left(\frac{\rho l}{a}\right)}$	2) $\phi = \frac{NI}{\frac{l}{\mu_0 \mu_r a}} \rightarrow ②$

Now substitute eq② in eq①

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

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

μ_r = Relative permiability. (air $\mu_r = 1$)

permiability is the property of the medium in which magnitic field exist.

$$L = \frac{N^2 \mu_0 \mu_r a}{l} = \frac{N^2}{\left(\frac{l}{\mu_0 \mu_r a}\right)} = \frac{N^2}{S}$$

$$\boxed{\therefore L = \frac{N^2}{S}} \ ***$$

By knowing the No: of Turns and reluctance we can findout the reluctance.

Note:- $\boxed{v = L\frac{di}{dt}}$ → This formula valid only for linear inductor.

→ Here voltage and currents are related. So we can call this as "ohm's law 5th ~~tran~~ form.

$\boxed{i = \frac{1}{L}\int_{-\infty}^{t} v\,dt}$

→ This is also valid only For linear inductor.

→ Here ohm's law rep related to element like in resistor $i \propto v$. similarly $i \propto \int_{-\infty}^{t} v\,dt$ ...

Ohm's law 6th form

1. Power dissippation in ideal inductor is equal to zero since internal resistance = 0.
2. Inductor stores energy in the form of magnetic field (kinetic energy).

w.k.T $\boxed{W = \int P\,dt}$

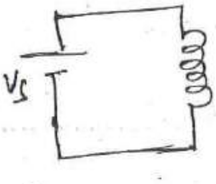
$\boxed{P = v.i = \cancel{v}.\left(L\frac{di}{dt}\right).i}$ → instantanious Power

$$W = \int P\,dt = \int L.\frac{di}{dt}.i\,dt = \frac{1}{2}Li^2 ....$$

$$\boxed{\therefore W = \frac{1}{2}Li^2} ...$$

3. Under steady state condition for DC source inductor acts as a short ckt.

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



$\frac{di}{dt} = 0$

$\Rightarrow v = 0$
↓
S.C

So for Constant Current

$\frac{di}{dt} = 0$.

Note:-

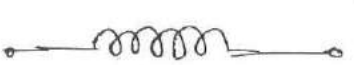
1) Inductor does not allow sudden change of currents since for sudden change of current infinite voltage is required.

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

As $dt \to 0$ $\Rightarrow$ $V = L\frac{di}{dt} = \infty$.

2) Inductor does not allow sudden change of currents since practical inductor ckt has finite value of Time constant.

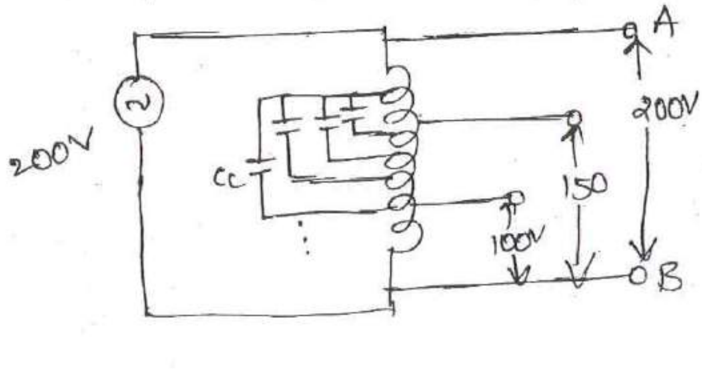
$\boxed{T = \frac{L}{R}}$ //...

3)  Ideal inductor $r=0$ → internal resistance

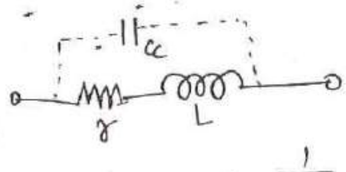
 Practical inductor

$\boxed{r \cong m\Omega}$ //...

4) Interturn capacitance is present when inductor is operated either at high frequency (or) high voltage.



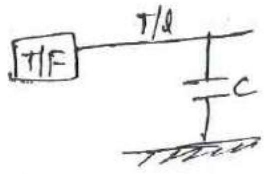
C_c = Interturn capⁿ
(or)
self capⁿ....



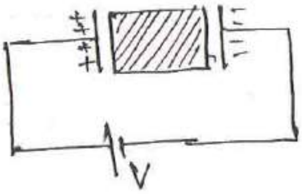
$X_L = 2\pi f L$; $X_C = \frac{1}{2\pi f C}$

So when f high ⇒ X_C = low. so entire current passes through self capⁿ.

→ self capⁿ is also present in the T/F.



→



$Q \propto V$

$\Rightarrow \boxed{Q = CV}$

$\Rightarrow \boxed{C = \frac{Q}{V}}$ coulombs/volt (or) farads

$Q = CV$

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

$\boxed{i = C\frac{dv}{dt}}$ → ohm's law 7th form //...

$\boxed{v = \frac{1}{C}\int_{-\infty}^{t} i\,dt}$ → 8th Form

$\boxed{C = \frac{i}{\frac{dv}{dt}}}$ ⇒ capn limits sudden changes in ~~current~~ Voltage.

$\boxed{P = vi = v \cdot C\frac{dv}{dt}}$ → instantanious Power

$w = \int P\,dt = \int v \cdot C\frac{dv}{\cancel{dt}} \cdot \cancel{dt} = \frac{1}{2}Cv^2$

$\boxed{w = \frac{1}{2}Cv^2}$ Jouls //..

note:-

$\frac{dv}{dt} = 0$ → under steady state condn.

$\frac{dv}{dt}$ → not zero under Transient.

$\frac{dQ}{dt} = C\frac{dv}{dt} = 0$ → only for steady state condn. for generalize the expression we are taking $\frac{dv}{dt}$ as it is.

* power dissipation in ideal capacitor is equal to zero.
* capacitor stores energy in the form of electric field (Potential Energy)
* $\boxed{C = \frac{\varepsilon A}{d}}$

$\varepsilon = \varepsilon_0 \varepsilon_r$

$\varepsilon_0 = 8.854 \times 10^{-12}$ F/m

ε_r = Relative permiability (air $\varepsilon_r = 1$)

* Permitivity is the property of the medium in which electric field exist.

A = Area of cross section of conduction plate

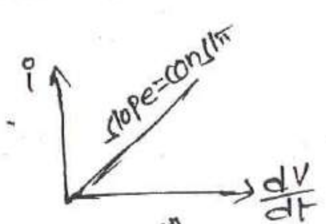
d = Distance b/w two conducting plates.

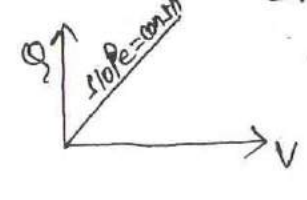
* $C = \frac{Q}{V}$

V ↑ 10%, Q ↑ 10%

V ↑ 90%, Q ↑ 90%

$i = C\frac{dv}{dt} \Rightarrow C = \frac{i}{\left(\frac{dv}{dt}\right)}$



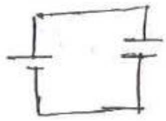


When capacitance of the capacitor is independent on the voltage magnitude then the capacitor is called as "linear capacitor"

* when capacitance of the capacitor is depends on the voltage magnitude then the capacitor is called as "Non linear capacitor"

Ex :- varactor diode

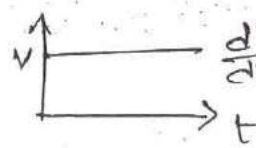
$\boxed{C = \frac{Q}{V} = \text{variable}}$ → for non linear capacitor.

*  As the capacitor is continuously charging, at a particular point $i=0$.

In otherwords at steadystate $\frac{dv}{dt}=0 \Rightarrow i=0$

→ under steady state cond" for DC source capacitor acts as a "open circuit".

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



$\frac{dv}{dt}=0$

$i=0 \quad (\because \frac{dv}{dt}=0)$
↓
O.C

Note :-

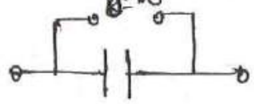
① $i = C\frac{dv}{dt}$

As $dt \to 0$; $i = C\frac{dv}{dt} = \infty$

capacitor doesn't allow sudden changes ~~in cur~~ ~~currents~~ of voltages, since for sudden change of voltages infinite current is required.

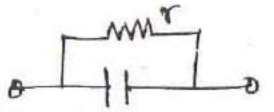
② capacitor does not allow sudden change of voltage since practical capacitor circuit has finite value of Time constant.

Note:-



$r=\infty$

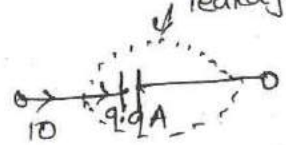
Ideal capacitor



r

$(r \cong M\Omega)$

practical capacitor



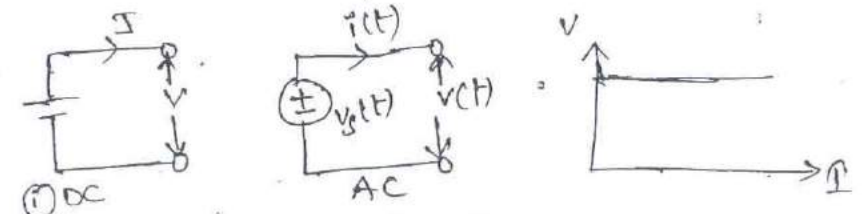
leakage path

10 9.9A

that's why we are connecting parallel.

r = leakage path res"

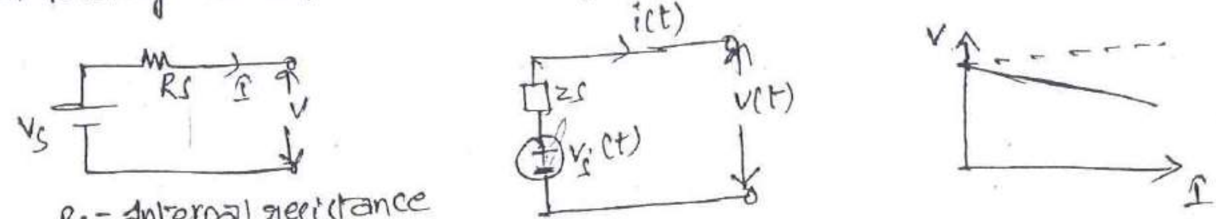
Air is the medium. Air offers high res". so it is order of Megaohms.



Ideal voltage source

→ V-I charⁿ nonlinear.
Any charⁿ which starts from origin are linear.
→ so doesn't obey's ohm's law.

→ Generally DC values represented by capital V, & I.



R_S = Internal resistance

DC AC

$V_s = V + I R_S$

$\Rightarrow V = V_S - I R_S$

practical voltage Sources

* Note:

* Ideal voltage source delivers energy at specified voltage (V). which is independent on current deliver by the source.

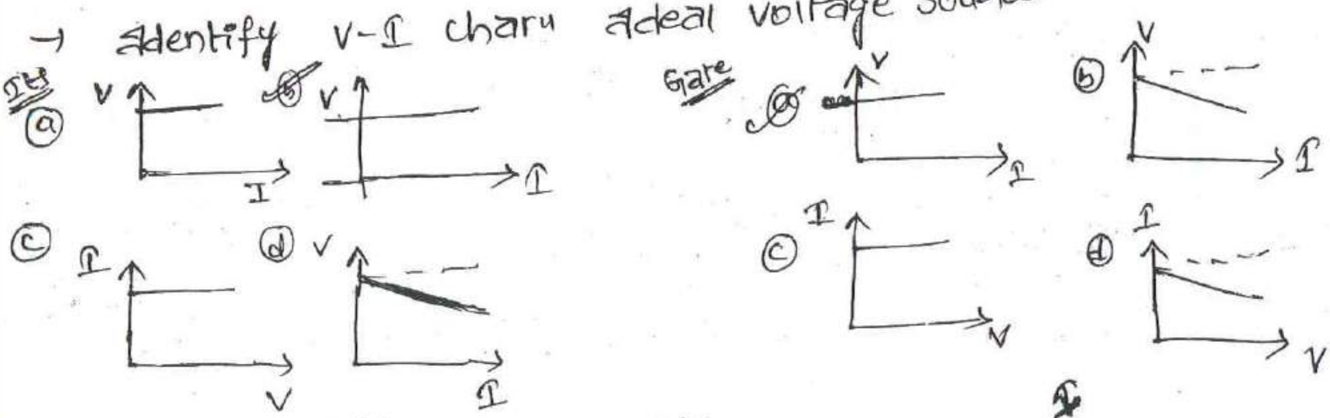
$\boxed{\text{Internal res}^{n}\text{ of ideal voltage source} = 0}$

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

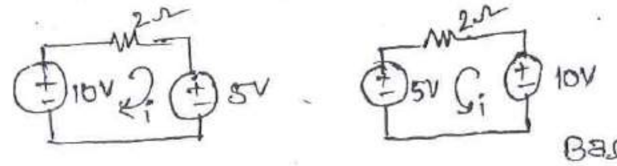
* Independent voltage source does not obey's the ohm's law since V-I charⁿ is Non linear.

* Independent voltage source is unidirectional & Non linear element.

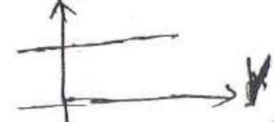
→ Identify V-I charⁿ ideal voltage source.



sol:



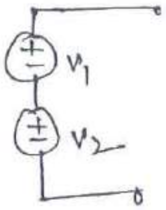
⇒



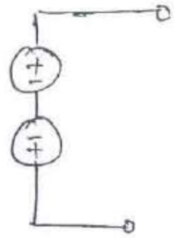
Based on options you have to select.

Note :- Reduction Techniques :-

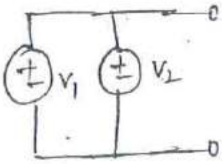
1)



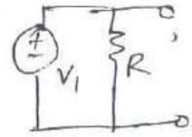
2)



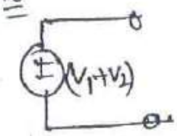
3)



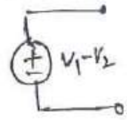
4)



sol :- ≅

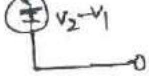


≅



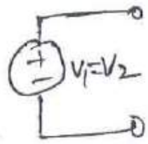
$(V_1 > V_2)$

≅

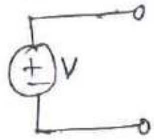


$(V_2 > V_1)$

≅

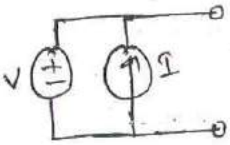


≅

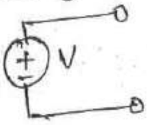


'R' neglected....

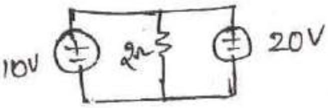
5)



sol :- ≅



(Pb) Find current in the '2Ω' resistor!

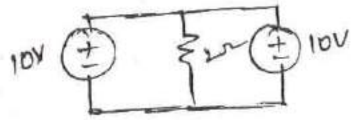


(a) 5A (b) 10 A (c) 15 (d) None (or) not satisfy KVL

Given N/W is not satisfy the KVL. So we can't apply the N/W Analysis.

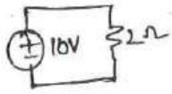
Note :- w.r.to KVL voltage across all the parallel branches should be equal.

(Pb)



Ans : 5A

by using above rules ≅



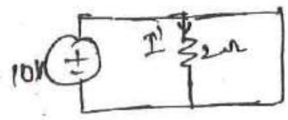
$\Rightarrow I = \frac{10}{2} = 5A$

(Pb)

Ans :- Not satisfy KVL.

We have one doubt. whenever two or more sources are present, we have to use super position theorem

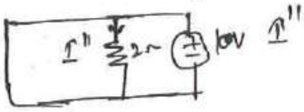
case (i) :-



$I' = 0$

$\therefore I = I' + I'' = 0 + 0 = 0.$

case (ii) :-

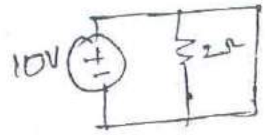


$I'' = 0$

w.r.to Super Position Theorem $I = 0$.
" reduction Technique " $I = 5A$.

that means superposition Theorem is wrong ?

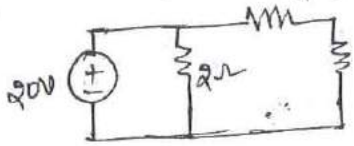
Let's consider case (i) or (ii)

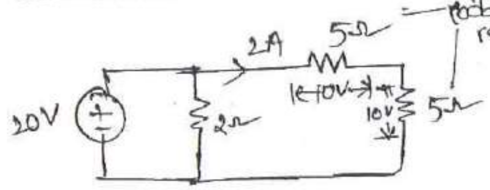


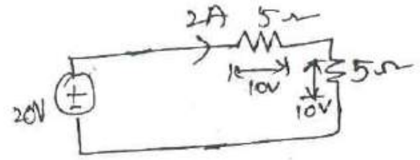
this ckt will not satisfy the KVL so we Never apply superposition Theorem to this ckt.

for the above circuit Super position theorem can not be applied. Since case (i) & case (ii) are not satisfy KVL.

$I = \frac{20 \times 12}{20}$ $I_S = \frac{12 \times 2}{12}$

(P) 

Sol:- 

$\cong$ 

With 2Ω resi & without 2Ω resi the load current is same. So while calculating the load current we can neglect the 2Ω resi.

Now for Ex if he asking the source current / source power.

$I_S = 10 + 2 = 12A$;

with 2Ω resi

$P_S = 12 \times 20 = 240W$

without 2Ω resi:-

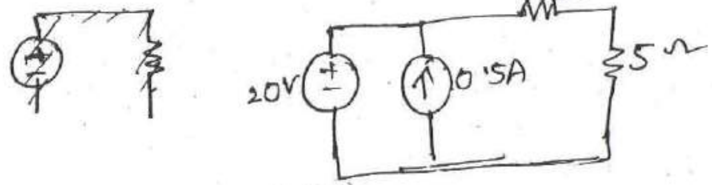
$I_S = 2A$

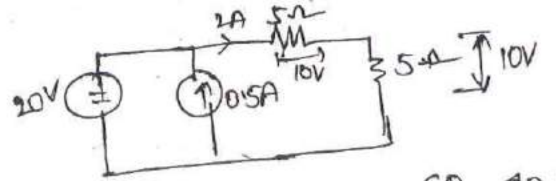
$P_S = 20 \times 2 = 40W$

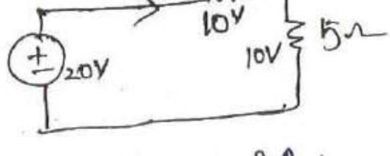
so I_S & P_S are not same. Therefore 2Ω resi should not be neglected while calculating the source current & source power.

NOTE:- 1) In the above circuit 2Ω resistance can be neglected while calculating either load currents (or) load voltage.

2) In the above circuit 2Ω resistance can not be neglected while calculating either Source current (or) source power.

(P) 

Sol:- 

$\cong$ 

So In both cases $I_{load} = 2A$.

Now I_S = ?

Without current source

$I_S = 2A$

$P_S = 20 \times 2 = 40W$

with current source

$I_S + 0.5 = 2$

$I_S = 1.5$

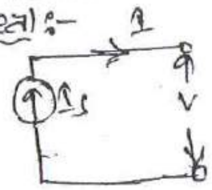
$P_S = 20 \times 1.5 = 30W$

so while calculating P_S, I_S don't remove current source.

Note:- 1) In the above circuit current source can be neglected while calculating either load current or load voltage.

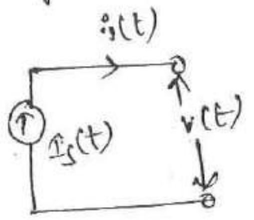
2) In the above circuit current source can not be neglected while calculating either voltage source current (or) voltage source power.

from Ideal:-

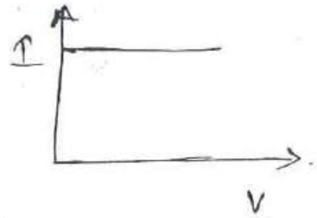


D.C

$i(t)$

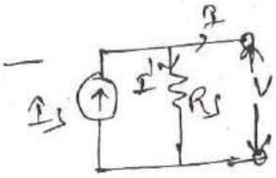


A.C

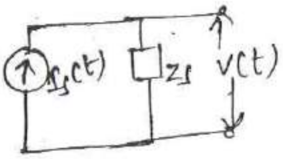


Since not Time function of

Practical :-



D.C

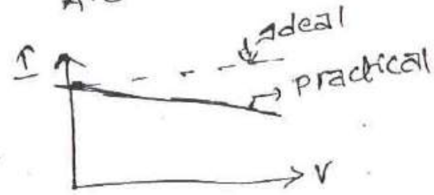


A.C

$I_S = I + I'$

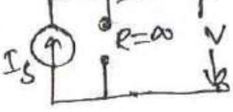
$I = I_S - I'$

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



Note:-

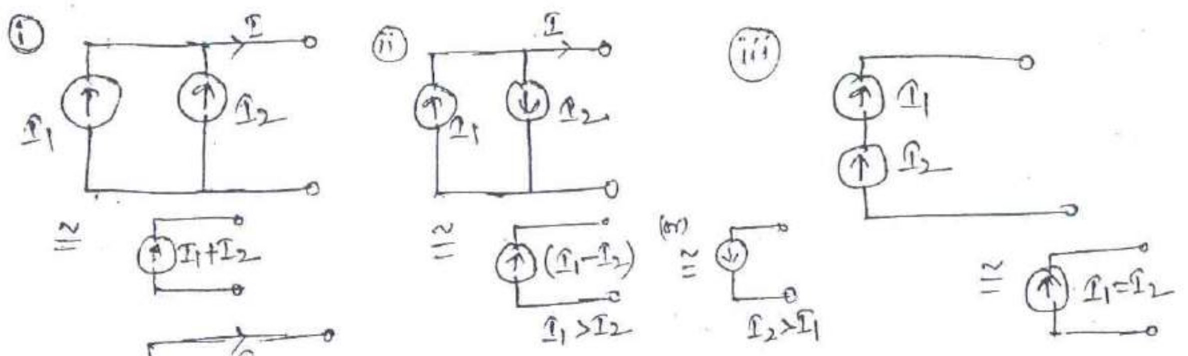
1. Ideal current source delivers energy at specified current (I) which is independent on voltage across the source.
2. Internal res^n of Ideal current source = ∞ →

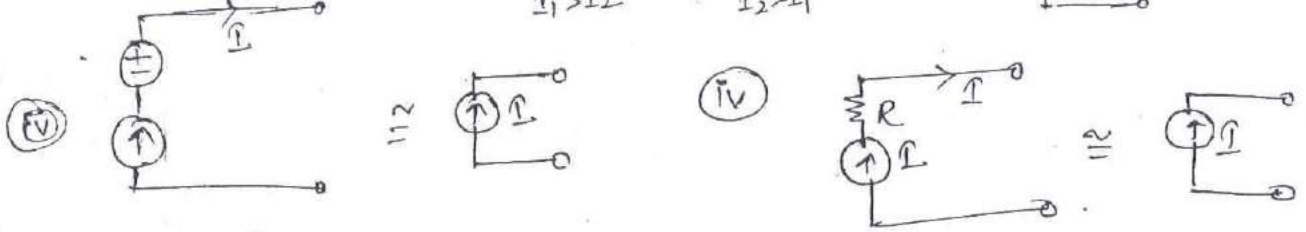


3. practical current source delivers energy at specified current (i) which depends on voltage across the source.
4. Independent current source does not obey's the ohm's law since V-I char^n is Non linear.

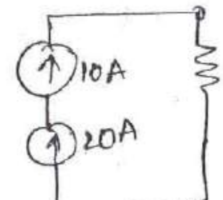
Note:- In Real Time applications (or system) No independent current source is exist. But dependent current source are exist.

(Just for convinence only we are taking (or) modifying the voltage source into current source)





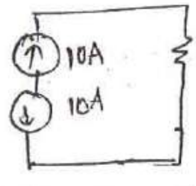
(Pb)



(a) 10A (b) 20A (c) 30A (d) None
(Not satisfy KCL)

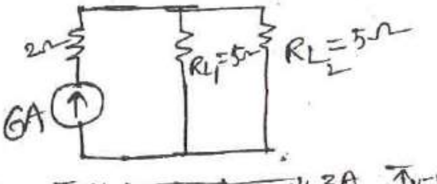
Sol:- w.r.to KCL current flowing through all the series elements should be equal.

(Pb)

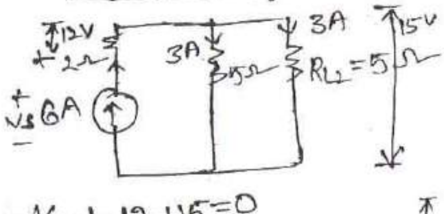


→ Not satisfies KCL....

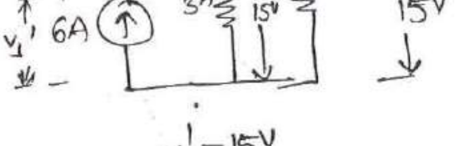
(Pb)



Sol:-



Based on Reduction Technique we can eliminate the resistance 2Ω.



$-V_s + 12 + 15 = 0$

$V_s = 27V$

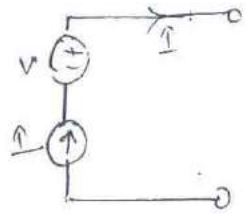
$P_s = 27\times6$

$V_s' = 15V$

$P_s = 15\times6$

Note:- 1) In the above circuit 2Ω resistance can be neglected while calculating either load current (or) load voltage....

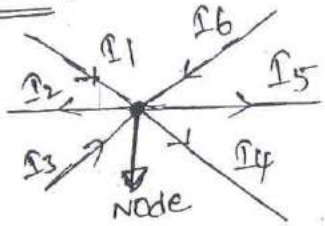
2) In the above circuit 2Ω resistance can not be neglected while calculating either voltage across current source (or) power of the current source.



Explanation :- 1. In the given circuit voltage source can be Neglected while calculating either load current or load voltage.

2. In the above circuit voltage source can not be Neglected while calculating either voltage across Current source (or) power of the current source.

KCL :-

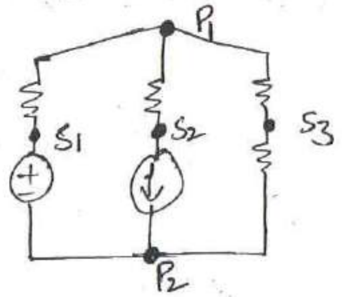


Mathematical Expression :-

$$I_1 - I_2 + I_3 - I_4 - I_5 + I_6 = 0$$

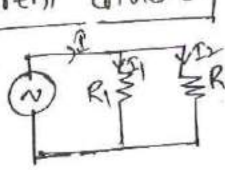
note :- node → simple node, → principle node

* KCL works based on the principle of "law of Conservation of charge"
* KCL states that algebraic sum of currents meeting at a point is equal to zero.
* When the two elements are connected together then the common point is called as "simple Node".
* When more than two elements are connected together then the common is called as "principle Node".

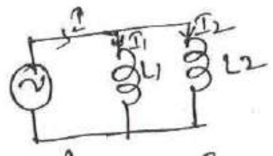


Where
S_1, S_2, S_3 are → Simple Nodes
P_1, P_2 → Principle Nodes

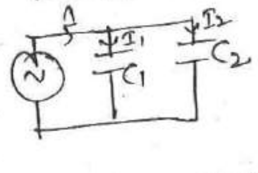
Current division Rule :-



$$I_1 = I \cdot \frac{R_2}{R_1+R_2} ; \quad I_2 = I \cdot \frac{R_1}{R_1+R_2} ; \quad \frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

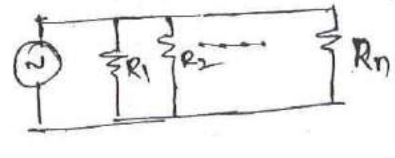


$$I_1 = I \cdot \frac{L_2}{L_1+L_2} ; \quad I_2 = I \cdot \frac{L_1}{L_1+L_2} ; \quad \frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2}$$



$$I_1' = I \cdot \frac{C_1}{C_1+C_2} ; \quad I_2 = I \cdot \frac{C_2}{C_1+C_2} ; \quad C_{eq} = C_1 + C_2 \ldots$$

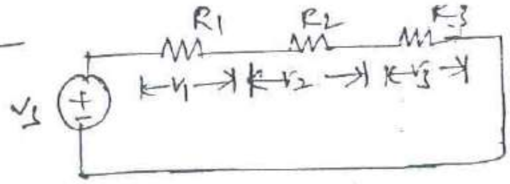
With 'n' branches :-



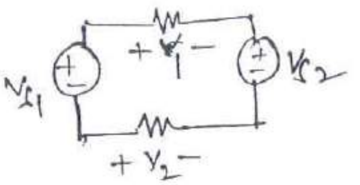
$$I_1 = I \frac{1/R_1}{\frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n}}$$

similarly for Inductor. & opposit to capacitor.

KVL:-



$V_1+V_2+V_3-V_s=0$

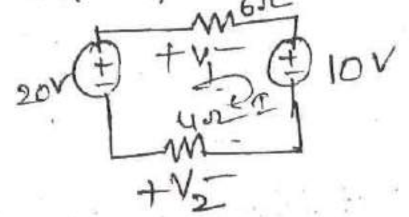


$-V_{s1}+V_1+V_{s2}-V_2=0$

$\Rightarrow V_2+V_{s1}=V_1+V_{s2}$

* KVL works based on the principle of law of conservation of energy.
* KVL states that Algebraic sum of the voltages in a closed loop is equal to zero.

(Pb) Find V_1 & V_2 of the ckt shown?



Sol:- $-20+V_1+10-V_2=0$

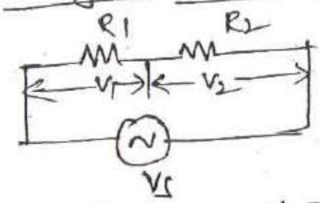
$V_1-V_2=10$

$-20+6I_1+10+4I_1=0$

$I_1=1A$

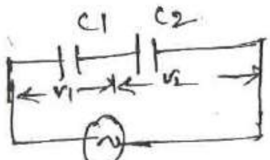
$\therefore$ $V_1=6V$, $V_2=-4V$

Voltage division Rule:-



$R_{eq}=R_1+R_2$

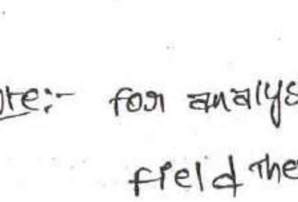
$V_1=V_s\cdot\frac{R_1}{R_1+R_2}$; $V_2=V_s\cdot\frac{R_2}{R_1+R_2}$



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

$V_1=\frac{C_2}{C_1+C_2}V_s$

$V_2=\frac{C_1}{C_1+C_2}V_s$



$L_{eq}=L_1+L_2$

$V_1=\frac{L_1}{L_1+L_2}\cdot V_s$; $V_2=V_s\cdot\frac{L_2}{L_1+L_2}$

note:- for analysis of any N/w

field theory ⟶ High freq^y, low freq^y — developing mathematical equ^s are complex.

N/w Theory ⟶ low freq^y — Dev^n " is simple. ↳ (KVL & KCL)

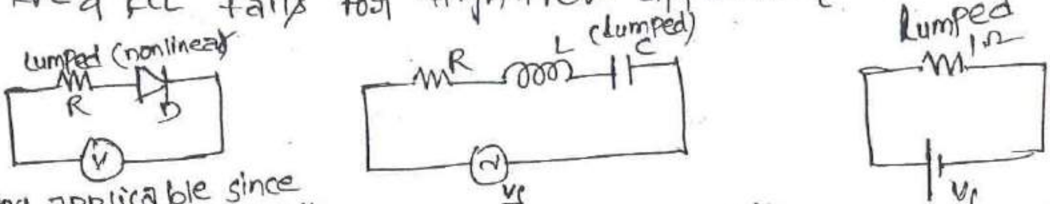
Always we obtain approximate results · Accurate results in KVL, KCL.

are possible in field theory, we use Gauss law, Ampere's law like that.

Ex:- wireless transmission can u write KVL, KCL?
we can't write.

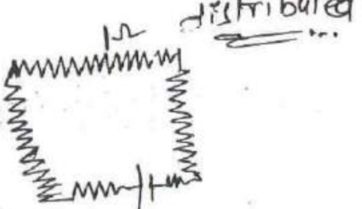
→ KVL & KCL fails for high freq".

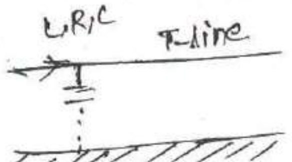
Conclusions:—
* Field theory can be obtain for low & High freq" applications.
* In the field theory accurate results are obtained. but developing mathematical eq"s are more complex.
* N/w theory is applied only for low freq" applications.
* In the N/w theory approximate results are obtained. and developing mathematical eq" is simple.
* KVL & KCL fails for High freq" applications.



KVL applicable since law of con" of energy.
ohm's law not applicable since nonlinear.

$V_s = Ri(t) + L\frac{di(t)}{dt} + \frac{1}{C}\int i(t)dt$
ohm's law applicable since linear.





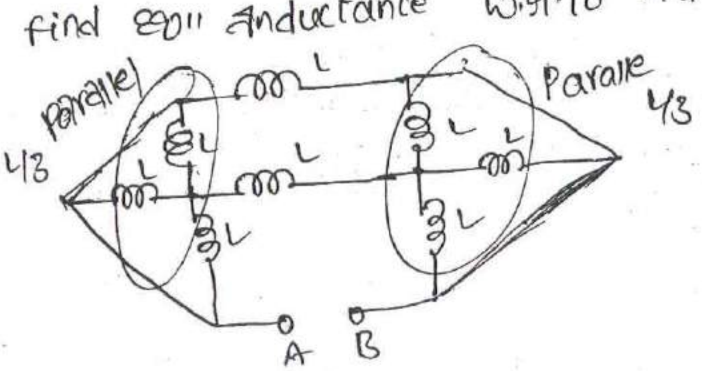
KVL, KCL not possible
ohm's is applicable. since $\boxed{J=\sigma E}$

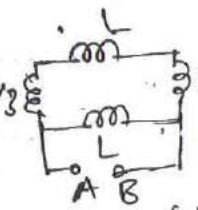
for the given T/L we can able to find J, σ, E.

$\boxed{J=\sigma E}$ //...

* KVL & KCL "fails for distributed parameters", since in the distributed parameters electrically it is not possible to isolate resistance, inductance and capacitance effects.
* Ohm's law can be applied for lumped (Linear) & distributed parameters.
* KVL & KCL are applied for lumped parameters. [Linear, Nonlinear unidirectional, bidirectional, Time varient & invarient elements].

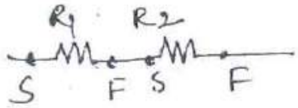
(pb) find eq" inductance w.r.to A & B.





$L_{AB} = (2L/3 + L) \,//\, L$

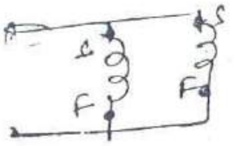
$= \frac{5L/3 \times L}{\frac{5L}{3}+L} = \frac{5L}{8}$ //...

series:- 

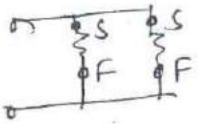
series

S→starting end
F→finishing end

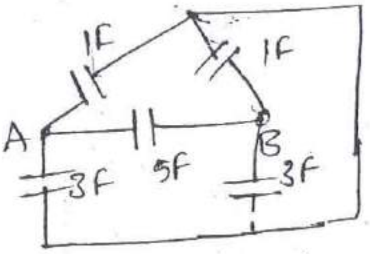
parallel:-



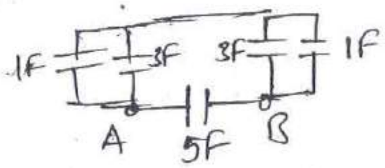
(or)

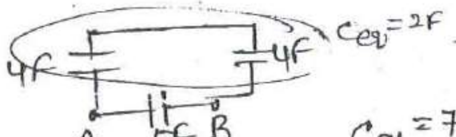


(Pb)
Find Eqn capn w.r.to A & B.



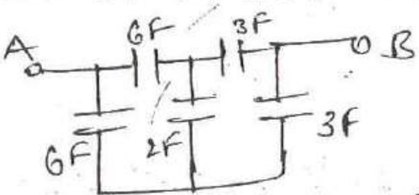
Sol:-



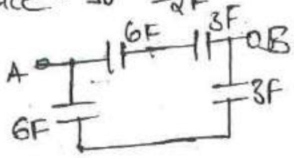


$C_{ab} = 7F$

(Pb) Find Eqn Cap w.r.to A & B?

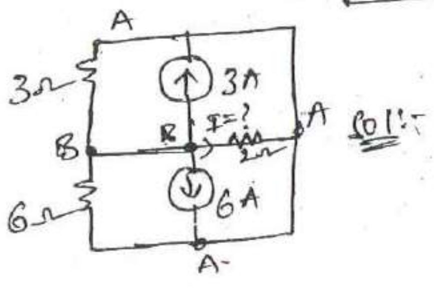


Sol:- bridge balance. So $I_{2F} = 0$.

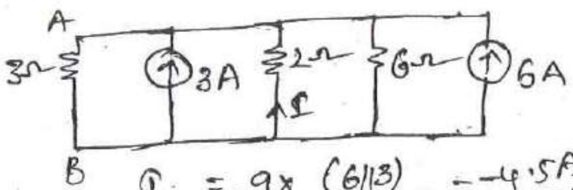
$\Rightarrow$ 

$\Rightarrow C_{AB} = 4F$

(Pb)

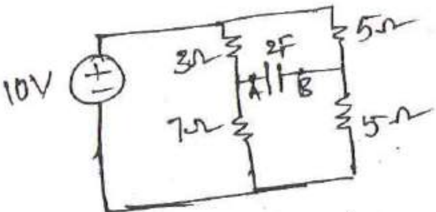


Sol:-



$I_{2\Omega} = -9 \times \frac{(6\|3)}{(6\|3)+2} = -4.5A$

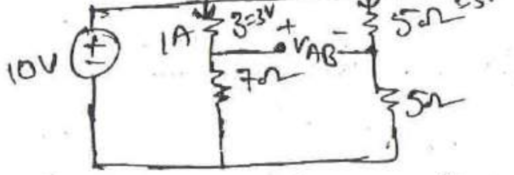
(Pb)



find energy of the capacitor of the circuit shown?

for DC capacitor openckt.

Sol:- Energy $= \frac{1}{2} CV^2$



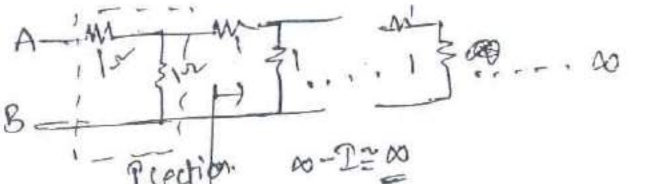
$V_{AB} = V_A - V_B = 3 - 5 = -2V$

$V_{AB} = -2V$

$\therefore E = \frac{1}{2}(2)(4)$

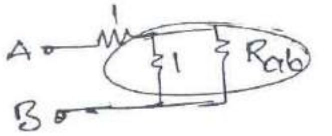
$= 4$ Joules

10 (Pb)



$R_{AB} = ?$

I section. $\infty - I \cong \infty$



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

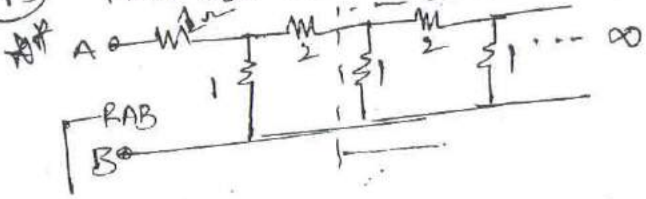
$$R_{ab}^2 + \cancel{R_{ab}} = R_{ab} + 1 + \cancel{R_{ab}}$$

$$R_{ab}^2 - R_{ab} - 1 = 0$$

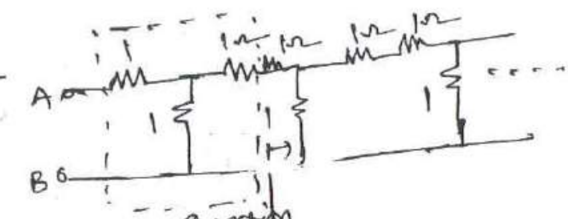
$$R_{ab} = \frac{1 \pm \sqrt{1 - 4(-1)}}{2}$$

$$= \frac{1 \pm \sqrt{5}}{2} \qquad \therefore R_{ab} = \frac{1+\sqrt{5}}{2} \,//\ldots$$

(Pb) Find Eqll res w.r.to A & B.

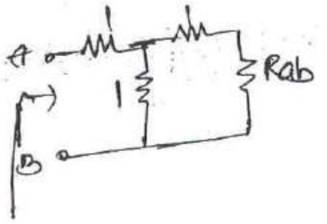


Sol:-



I section

$$\therefore R_{ab} = 1 + \frac{(R_{ab}+1)}{(R_{ab}+2)}$$



$$R_{ab}^2 + 2\cancel{R_{ab}} = 2\cancel{R_{ab}} + 3$$

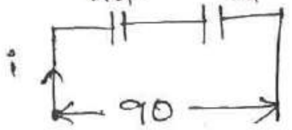
$$R_{ab} = \pm\sqrt{3}$$

$$R_{ab} = \sqrt{3}\ \Omega$$

(Pb) When two capacitors of 40F & 20F are connected in series to a source voltage of 90V. When two capacitors are charged fully they are connected in parallel. Find 'V' across capacitors in parallel connection.

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

Sol:-



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

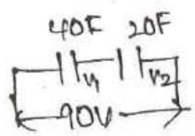
$$Q = C_{eq} \cdot V$$

$$Q = \frac{40}{3} \times 90 = 1200C$$

So charge on $c_1 = 1200C$

& " " $c_2 = 1200C$

(or)



$$V_1 = 90 \times \frac{20}{60} = 30V \ldots$$

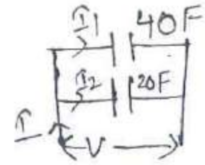
$$Q = CV = 30 \times 40 = 1200C$$

$$V_2 = 90 \times \frac{40}{60} = 60V$$

$$Q = CV = 60 \times 20 = 1200C$$

$\therefore Q_T = 1200 + 1200 = 2400$

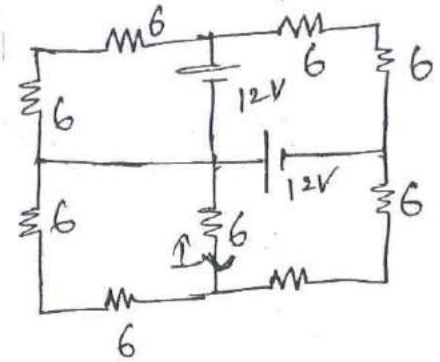
NOW



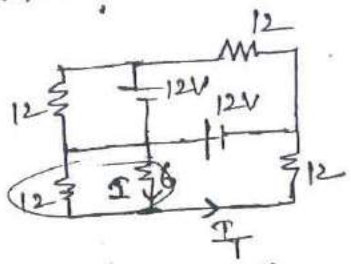
$C_{eq} = 40 + 20 = 60$

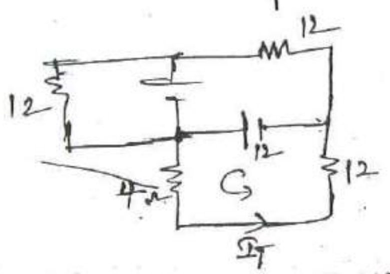
$\therefore V = \dfrac{Q_T}{C_{eq}} = \dfrac{2400}{60} = 40V$

→ Find the value of 'I' for the N/W shown?



Sol:-





$I_T = \dfrac{12}{12+4} = \cancel{0.75A} \; \dfrac{12}{16}$

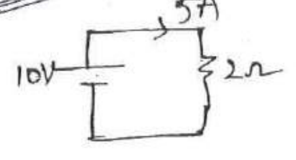
$\therefore$ Therefore $I_T = \cancel{0.75A} \; \dfrac{12}{16} A$

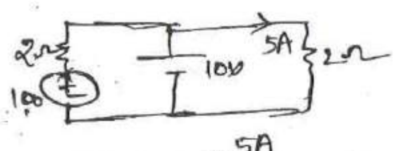
$\cancel{I_{6\Omega}} = 0.5 \times \dfrac{12}{18}$

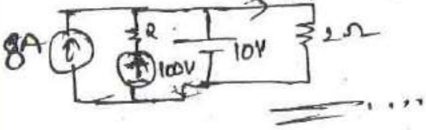
$= \dfrac{1}{3} = 0.33A \ldots$

$I_{6\Omega} = I = \dfrac{12}{16} \times \dfrac{12}{(12+6)} = 0.5A \ldots$

NOTE:-



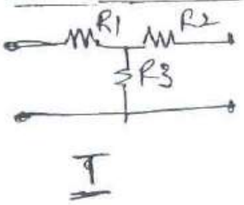




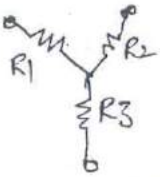
As the ~~ideal~~ sources (voltage source (or) current source) are connected in this manner there is no change in load current.

NOTE:- When elements are connected either in series nor in parallel to reduce the N/W star-delta transformation is used.

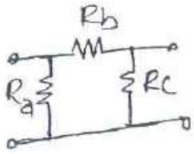
Star - Delta Transformations :-



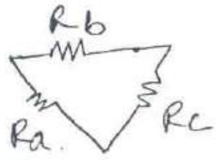
T



Star (or) Y



II



Delta

Delta to Star :-

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

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

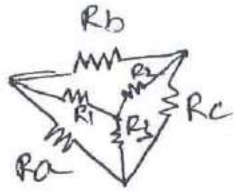
$$R_3 = \frac{R_a R_c}{R_a + R_b + R_c}$$

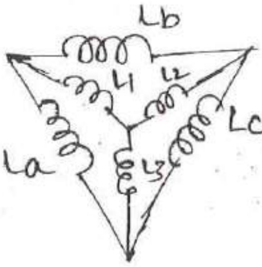
Star to Delta

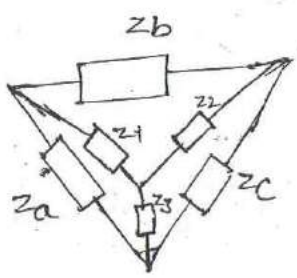
$$R_a = \frac{R_1 R_2 + R_2 R_3 + R_3 R_1}{R_2}$$

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

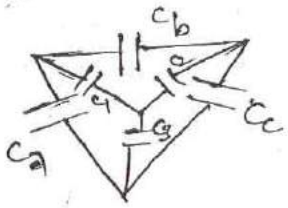
$$R_c = \frac{R_1 R_2 + R_2 R_3 + R_3 R_1}{R_1}$$







The procedure of during transformation either from Δ to Y (or) Y to Δ for the resistors, inductors and impedences is same.



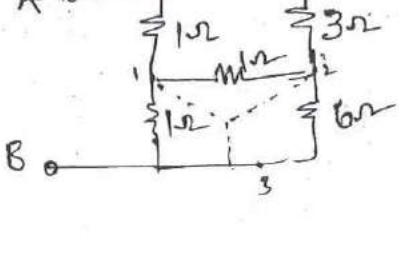
$$\frac{1}{C_1} = \frac{\frac{1}{C_a} \cdot \frac{1}{C_b}}{\frac{1}{C_a} + \frac{1}{C_b} + \frac{1}{C_c}} \; ; \quad \frac{1}{C_a} = \frac{\frac{1}{C_1}\frac{1}{C_2} + \frac{1}{C_2}\frac{1}{C_3} + \frac{1}{C_3}\frac{1}{C_1}}{\frac{1}{C_2}}$$

$$\frac{1}{C_2} = \frac{\frac{1}{C_b} \cdot \frac{1}{C_c}}{\frac{1}{C_a} + \frac{1}{C_b} + \frac{1}{C_c}} \; ; \quad \frac{1}{C_b} = \frac{\frac{1}{C_1}\cdot\frac{1}{C_2} + \frac{1}{C_2}\frac{1}{C_3} + \frac{1}{C_3}\frac{1}{C_1}}{\frac{1}{C_3}}$$

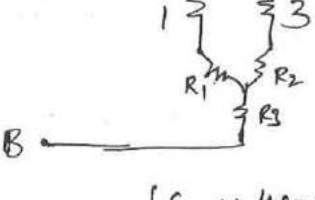
$$\frac{1}{C_3} = \frac{\frac{1}{C_a} \cdot \frac{1}{C_b}}{\frac{1}{C_a} + \frac{1}{C_b} + \frac{1}{C_c}} \; ; \quad \frac{1}{C_c} = \frac{\frac{1}{C_1}\frac{1}{C_2} + \frac{1}{C_2}\frac{1}{C_3} + \frac{1}{C_3}\frac{1}{C_1}}{\frac{1}{C_1}}$$

Star to delta   Delta to star

(Pb) Find equ. resn w.r.to A & B ?



Sol:-



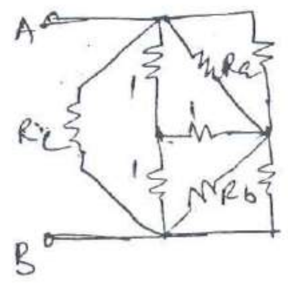
$$R_1 = \frac{1 \times 1}{1+1+6} = \frac{1}{8}$$

$$R_2 = \frac{6}{8}$$

$$R_3 = 6/8$$

$$\therefore R_{ab} = \left[\left(1+\tfrac{1}{8}\right) \| \left(3+6/8\right)\right] + (6/8)$$

$$= (1.125 \| 3.75) + (0.75)$$

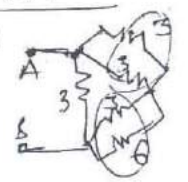


$R_a = \frac{1\times1+1\times1+1\times1}{1}$

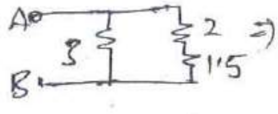
$= 3\Omega$

$R_b = 3\Omega$

$R_C = 3\Omega$



$\therefore$

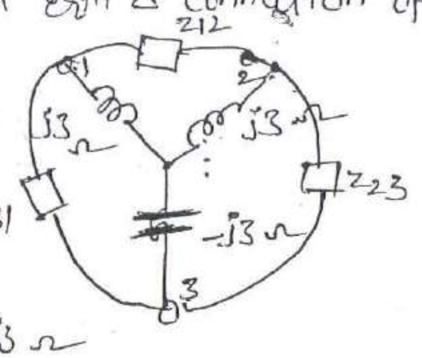


$\Rightarrow R_{AB} = 3 \| 3.5$

Note :- when resistances of equal values are Transformed from star to Delta resistance is increased by 3 times.

When capacitors of equal value Transformed from star to Delta capacitance decreased by 3 times.

(Pb) obtain Equ Δ connection of the N/w shown.



Sol:- $Z_{12} = \frac{Z_1Z_2 + Z_2Z_3 + Z_3Z_1}{Z_3}$

$= Z_1 + Z_2 + \frac{Z_1Z_2}{Z_3}$

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

$= \underline{j3}\ldots$

$Z_{23} = (Z_2) + Z_3 + \frac{Z_2Z_3}{Z_1} = j3 + (-j3) + \frac{(j3)(-j3)}{j3}$

$= -j3$

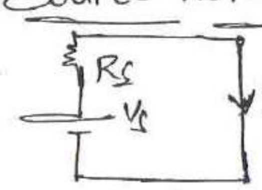
$Z_{31} = -j3 + j3 + \frac{(-j3)(j3)}{j3} = -j3$

$\therefore Z_{12} = j3\ \Omega$

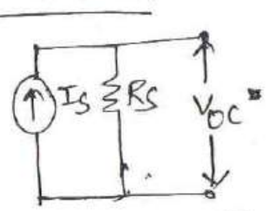
$\rightarrow Z_{23} = -j3\ \Omega$

$\rightarrow Z_{31} = -j3\ \Omega$

Source Transformation Theorem:-



$\cong$



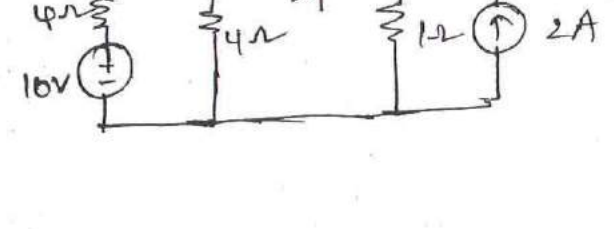
$I_S = I_{SC} = \frac{V_S}{R_S}$

$R_S = R_S$

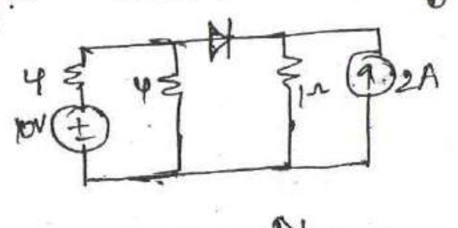
$V_S = V_{OC} = I_S R_S$

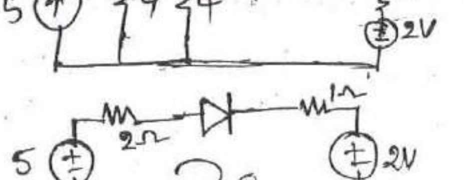
$R_S = R_S$

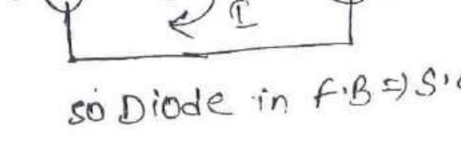
(Pb) Find current flowing through ideal diode of the ckt shown.



Sol:- Ideal diode → S.C in F.B, O.C in R.B

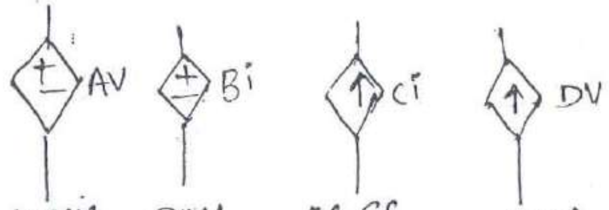






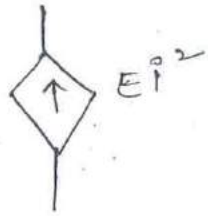
so Diode in F.B ⇒ S.C

$\therefore I_D = \frac{3}{3} = 1A$



VCVS　CCVS　CCCS　VCCS

$A \rightarrow$ No units　$V = Bi$, $B \rightarrow \Omega$　$C \rightarrow$ No units　$D \rightarrow$ mho, $\therefore i = \frac{V}{D}$



All sources are linear dependent Sources.

Nonlinear

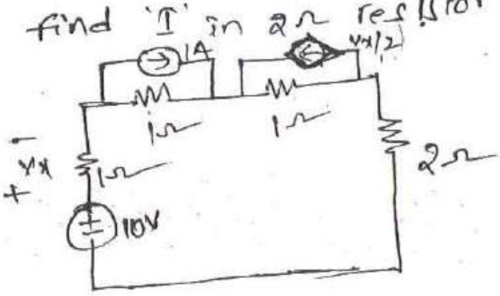
As $i \uparrow 10\% \Rightarrow I = 100\% \uparrow$

$V = Bi$

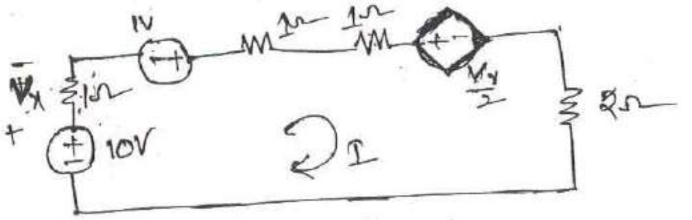
As $10\% \uparrow$ in 'i' $\Rightarrow$ $10\% \uparrow$ in 'V'

So linear....

(Pb) find 'I' in 2Ω resistor?



Sol:- while applying source transformation for dependent source whereever dependent source magnitude depends without disturbing that element Transformation can be applied.



$\Rightarrow -10 + 5I - 1 + \frac{V_x}{2} = 0$

$\Rightarrow$ ~~V_x~~

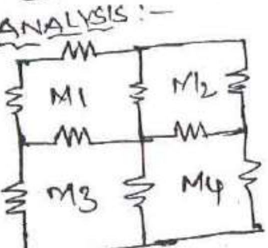
$\frac{V_x}{2} + 5I = 11 \rightarrow (1)$

$V_x = I \times 1 \rightarrow (2)$

from (1) & (2) $V_x = 2V$; $\therefore I = 2A$

MESH ANALYSIS :-

(Pb)



** Planar N/w:- when the N/w is drawn without crossover is called "Planar N/w".

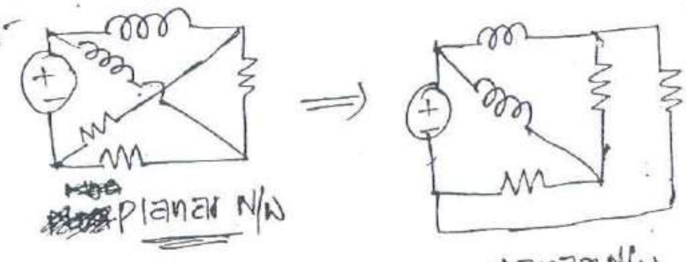
** Nonplanar N/w:- when the N/w is drawn with cross over is called "non planar N/w".

Mesh:- * Mesh is the loop it does not consists of any inner loop.
Mesh analysis can be applied only for planar N/w s.

* when the N/w is drawn on plane without any cross over then the N/w is called as "planar N/w".

The above N/w is a planar N/w.

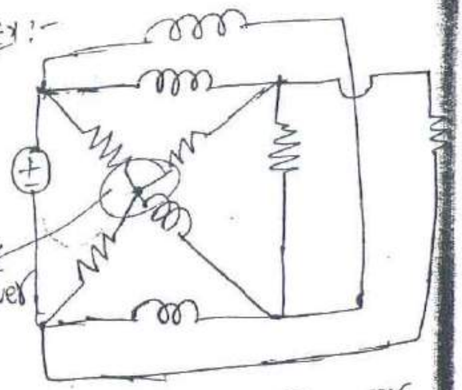
Ex:-



Planar N/W

Planar N/W

Ex:-



crossover

Non Planar.

Procedure of Mesh Analysis:-

1. Identify Total no: of meshes in the given N/w.
2. Assign the current direction for each mesh.
3. Develope KVL equation for each mesh.
4. By solving KVL equ's find loop currents.

(pb)

Mesh(1):- $-4+i_1+2(i_1-i_2)=0$

$-4+i_1+2i_1-2i_2=0$

$3i_1-2i_2=4 \rightarrow (1)$

Sol:- No: of meshes = 2.

Mesh(2):- $i_2=-2A$...

$(1) \Rightarrow 3i_1+(4)=4$

$\Rightarrow i_1=0$...

Note:-

Total No: of equ's = Total no: of meshes

$\boxed{e = M} = 2$...

$\boxed{\text{Total no: of meshes possible} = (b)-(n)+1}$...

$e = b-(N-1)$

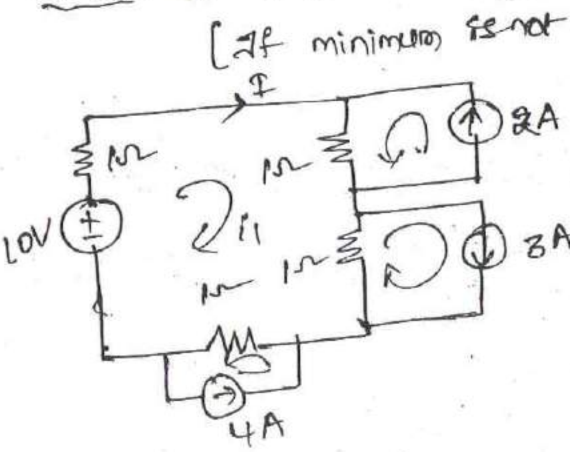
$= 3-(2-1)$

$= 2$...

Note:- In the above N/W to find the loop currents minimum 1 equ is required. [Since due to Current source $I_2=-2A$ can written directly].

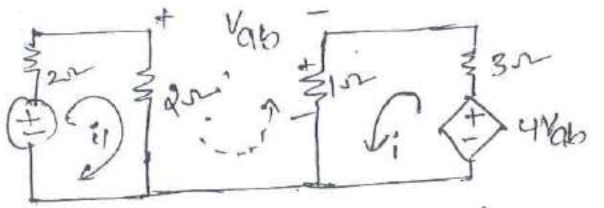
[If minimum is not there - Ans=2]

(pb)



Sol:- $-10V+(I)+(2\times 1)-(3\times 1)+(4\times 1)=0$

$\Rightarrow I=\frac{7}{4}$....

(Pb) 

Find 'i' in the ckt shown?

sol:- $i_1 = \frac{5}{4} = 1.25A$

$-V_{ab} + 2.5 - (1)i = 0$

$-V_{ab} + 2.5 - V_{ab} = 0$

$\Rightarrow V_{ab} = 1.25$

for mesh(2):-

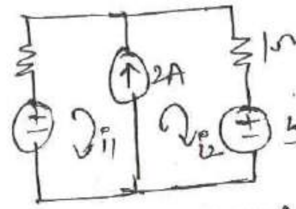
$-4V_{ab} + 3i + 1i = 0$

$-V_{ab} + i = 0$

$i = V_{ab}$

$\boxed{\therefore i = 1.25A}$

(Pb) Find I_1 & I_2 of the circuit shown?



Note:- When Current source branch is common for two meshes it is possible to find solution by using Super Mesh Technique.

sol: $-10 + i_1 + i_2 + 5 = 0 \rightarrow (1)$ (KVL)

$i_2 - i_1 = 2 \rightarrow (2)$ (KCL)

from (1) & (2) $i_1 = 1.5A$

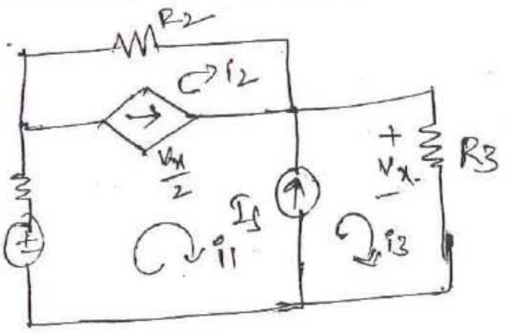
$i_2 = 3.5A$

Note:-

Mesh → KVL + ohm's law

Supermesh → KVL + KCL + ohm's law

(Pb) Develope mathematical eqn's of the N/W shown.



sol:- $-V_s + i_1R_1 + i_2R_2 + i_3R_3 = 0 \rightarrow (1)$

$i_1 - i_3 = \frac{V_x}{2} \rightarrow (2)$

$i_3 - i_1 = I_S \rightarrow (3)$

$V_x = i_3R_3 \rightarrow (4)$

from (2) $\Rightarrow i_1 - i_3 = \frac{i_3R_3}{2}$

$\Rightarrow 2i_1 - 2i_3 = i_3R_3$

$2i_1 - i_3(R_3+2) = 0 \rightarrow (5)$

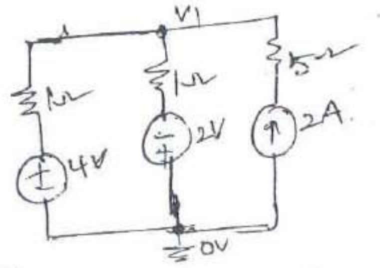
Nodal Analysis :-

* (For parallel ckts Nodal Analysis is better)
* Nodal Analysis can be applied for planar & Non Planar N/Ws.

Procedure of Nodal Analysis :-

1) Identify Total No. of nodes in the given N/W.
2) Assign the voltage at each node, one of the nodes is taken as a reference Node. And reference node potential should be equal to ground Potential (0V).
3) Develope KCL eqn at each non reference Node.
4) By solving KCL eqn's find Node voltages.

(Pb)

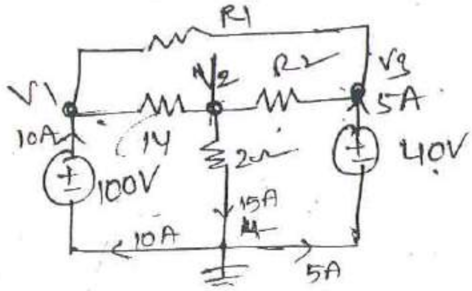


Sol:-

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

$$\Rightarrow V_1=\underline{2V}\ldots$$

(Pb) find R_1 & R_2 of the N/W shown?



Sol:

$V_1=100V$

$V_3=40V$

$$\frac{V_2-V_1}{14}+\frac{V_2}{2}+\frac{V_2-V_3}{R_2}=0\rightarrow(1)$$

$$\frac{V_3-V_1}{R_1}+\frac{V_3-V_2}{R_2}=5\rightarrow(2)$$

$$\frac{V_1-V_3}{R_1}+\frac{V_1-V_2}{14}=10\rightarrow(3)$$

$$\therefore (2)\Rightarrow \frac{40-100}{R_1}+\cancel{\frac{40-V_2}{R_2}=5}$$

$I_{2\Omega}=15A$.

$\underline{V_2=30\ V}$

$$(3)\Rightarrow \frac{60}{R_1}+\frac{70}{14}=10$$

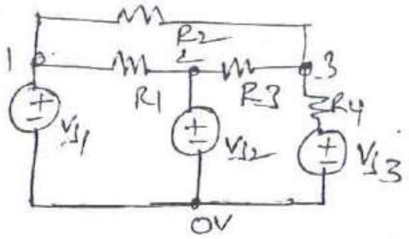
$$\Rightarrow R_1=\underline{12\Omega}$$

$$(2)\Rightarrow \underline{R_2=1\Omega}$$

Note:- In nodal Analysis total no: of eq^ns $=\underline{n-1}$

where n = no: of nodes.

APSPDCL



Sol:- no: of eq^ns $=n-1$

$=4-1$

$=\underline{3}\ldots$

from the ckt

$V_1=V_{s1}$

$V_2=V_{s2}$

Now at node (3)

$$\frac{V_3-V_{s3}}{R_4}+\frac{V_3-V_2}{R_3}+\frac{V_3-V_1}{R_2}=0$$

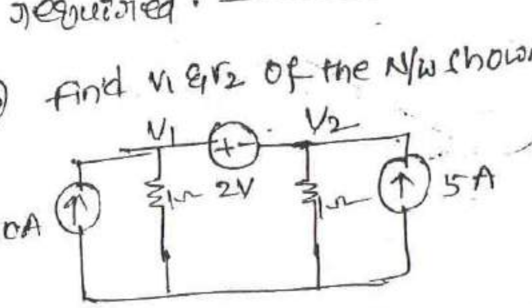
$$\Rightarrow V_3=\underline{\quad}\ldots$$

So we require only one equation.

Note:-

To Find the node voltages in the above n/w minimum one eq^n is required.

(Pb) Find V_1 & V_2 of the N/w shown?



Sol:- $\frac{V_1}{1}-10+\frac{V_2}{1}-5=0$

$V_1+V_2=15\rightarrow(1)$

$V_1-V_2=2\rightarrow(2)$

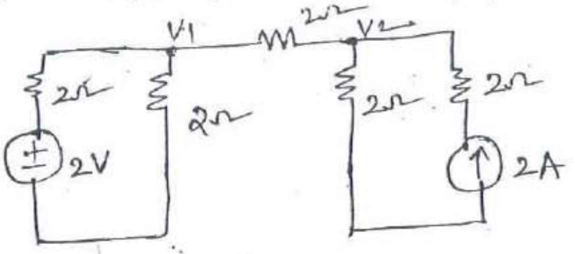
$\Rightarrow V_1=\underline{8.5V}$

$V_2=\underline{6.5}\ V$

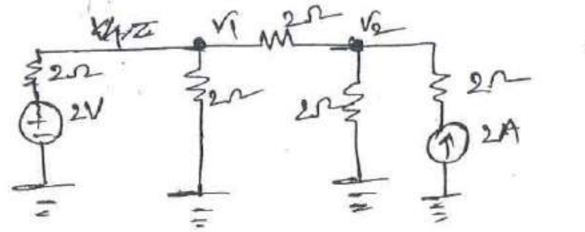
Note:- When Ideal voltage source is connected b/w two Non touching reference nodes, It is possible to find solution by using Super Node Technique.

Note:
Nodal → KCL + Ohm's law
Super Node → KCL + KVL + Ohm's law

(Pb) Find V_1 & V_2 of the ckt shown?



Sol:-



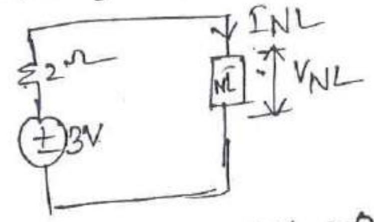
$$\frac{V_1}{2} + \frac{V_1 - 2}{2} + \frac{V_1 - V_2}{2} = 0 \rightarrow (1)$$

$$\frac{V_2}{2} + \frac{V_2 - V_1}{2} = 2 \rightarrow (2)$$

from (1) & (2) $V_1 = 1.6V$
$V_2 = 2.8V$

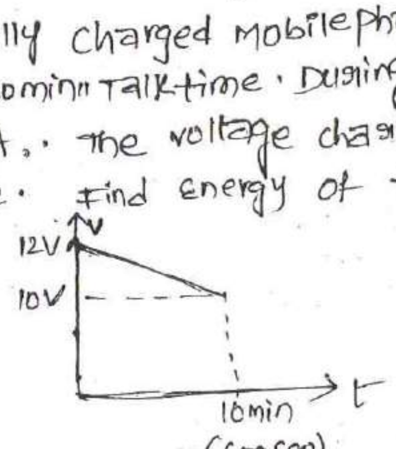
(Pb) A practical DC source of 3V with internal resn of 2Ω is connected to non linear resn. The charn of non linear resn is given by $V_{NL} = I_{NL}^2$. Find power dissipation in the non linear resistor?

Sol:-



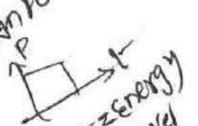
$$-3 + 2I_{NL} + V_{NL} = 0$$
$$-3 + 2I_{NL} + I_{NL}^2 = 0$$
$$\Rightarrow I_{NL} = 1, \cancel{-3}$$
$$\underline{I_{NL} = 1A}$$
$$V_{NL} = I_{NL}^2 = 1A$$
$$P_{NL} = V_{NL} \times I_{NL} = 1 \times 1 = 1W$$

(Pb) A fully charged mobile phone is good for 10 min talk time. During talk time battery delivers a constant current of 2A. The voltage charn during talk time is as shown in the figure. Find energy of the battery during talk time?



Sol:- =(600 sec)

Total Area = $\frac{1}{2}(600 \times 2) + (600 \times 10) = 6600 \Rightarrow \underline{V \times t}$ → since like an power systems



P × t = energy = Area over the curve

$$W = [(V \times t) \times I]$$
$$= 6600 \times 2$$
$$= 13.2 \text{ kJ}$$

1200
6000
7200