IES/GATE

Electronics & Telecommunication Engineering

VOLUME-III

Network Theory

Contents

Toppersnotes
Unleash the topper in you

NETWORK THEORY

1. Basics
2. Steady state A.C. Circuits [resonance]
3. Theorems
4. Transients } ** } Frequently asked
5. Two-port }
6. Graph Theory
7. Magnetic Coupled Circuits /* Not in Syll*/
8. Filters /*Not in Syll*/

- Fundamentals of Electric Circuits :- by Alexander & Sadiku | *only exercise*
- Engg Circuit Analysis :- Hayt & Kemmerly
- Network Analysis [Transients and two port ⇒ conventional] :- Van Valkenberg.

1] Gate — EC (Problems

2] IES < Memory (40% repeated) Problems

3] Workbook

4] Home work

5] IAS

6] Test series → old, new.

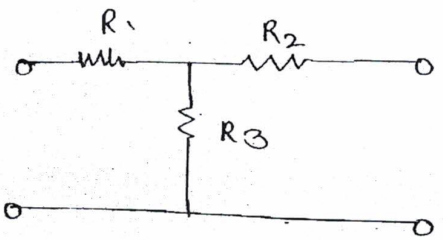
* goo.gl/2XhUx3 → sadiku → Textbook, soln

* goo.gl/HWKKZz → Home work (Nodal & Mesh analysis)

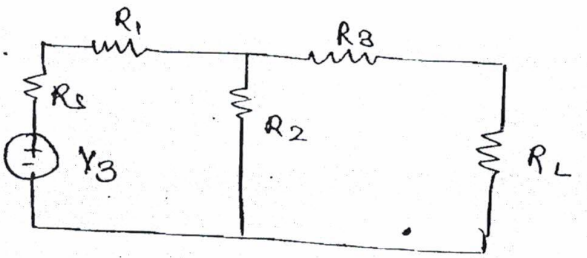
* goo.gl/6Fa34E → Steady state + Theorems

* goo.gl/dJnhu8 → RL, RC, RLC → conv.

- **Network vs Circuit :→**



T-Network



N/w or circuit

→ Network is a combination of elements, it may or may not consist of closed path

→ Circuit is a combination of elements and it should consist of closed path.

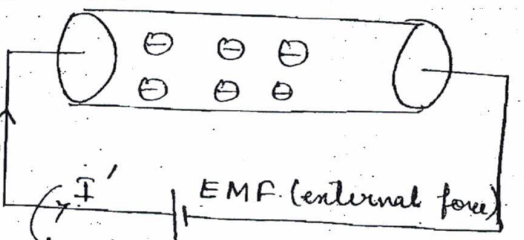
→ All circuits are N/w but all N/ws are not circuits.

- $q = -1.602 \times 10^{-19} C$

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

rate of flow of charge with time

$Q = \int I \cdot dt$

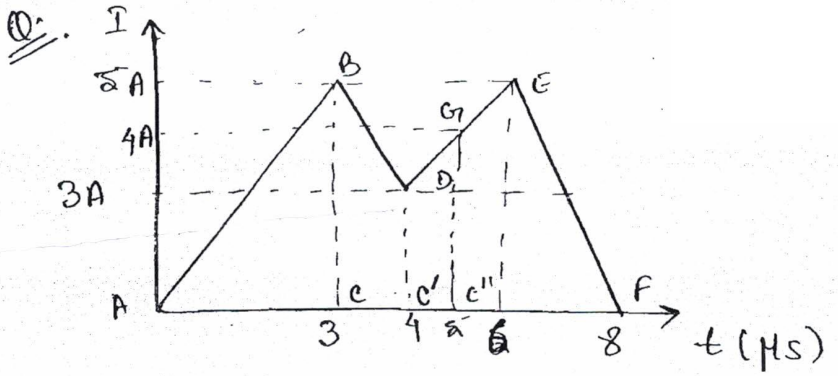


[higher pot → lower pot]

- In KCL, KVL we always use conventional direction
- $\boxed{|I| = I'}$ but opposite in direction.
- $Q = \int_{-\infty}^{t} I \cdot dt = \int_{-\infty}^{0} I \cdot dt + \int_{0}^{t} I \cdot dt$ or $\boxed{Q = Q_0 + \int_0^t I\, dt}$ (Q_0 → initial charge)
- $\boxed{V = \frac{dw}{dQ} = \frac{J}{C}}$ or Volt
- $\boxed{P = \frac{dw}{dt} \frac{J}{s}}$ or Watt → time rate of energy.

$= \frac{dw}{dQ} \times \frac{dQ}{dt}$ $\therefore \boxed{P = VI = I^2R = \frac{V^2}{R} = G V^2 = I^2/G}$

$\because \left[\frac{1}{R} = G\right]$

Q. 

Find charge acquired by cap in 5 μsec

:→ $Q = \int I\,dt$

2 methods: ① Developing mathematical eqn
② Finding area under curve.

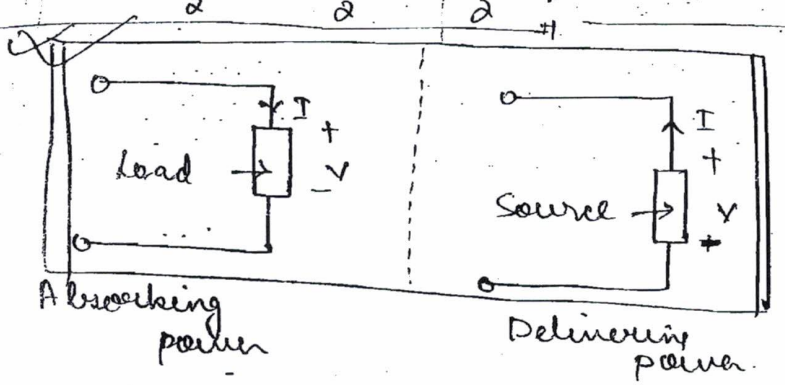
2. $Q = \int I\,dt$

$= \Delta ABC + \square BDC'C + \square C'DGC''$

$= \frac{1}{2}(3\times5) + \frac{1}{2}\times(3+5)\times1 + \frac{1}{2}\times(3+4)\times1$

(* Area of Trapezoid = $\frac{1}{2}$ × (sum of ht of 2 sides) × dist btw sides *)
(* DE - linear, slope constant $m = 1$ ∴ at 5 μs ; $I = 4A$ *)

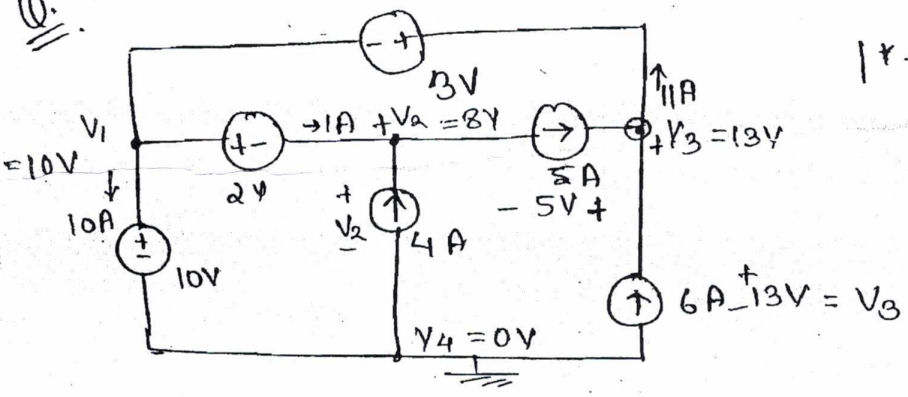
$= \frac{1}{2}\times15 + \frac{1}{2}\times8 + \frac{1}{2}\times7 = 7.5 + 4 + 3.5 = 15\ \mu C$



⇒ Absorbing & Delivering
Source | Load (elements)

* When the current is entering at the terminal element is absorbing power.
* When the current is leaving from the terminal element is delivering power

Q.



* To find power, find voltage & current of each element *

Find power of each element of the N/w shown.

:→ potential betwn V_1 + gnd = 10V ∴ $V_1 = 10$ V

at node V_1 & V_2 :- $V_1 - V_2 = 2V$ ∴ $V_2 = 8$ V

at node V_1 & V_3 :- $V_3 - V_1 = 3V$ $V_3 = 13$ V

In 4A :- P = 4 × 8 = 32 W (Delivering)
In 6A :- P = 6 × 13 = 78 W (Delivering)
In 5A :- P = 5 × 5 = 25 W (Delivering)

} current leaving +ve terminal

In 3V :- P = 11 × 3 = 33 W (Absorbing)
In 2V :- P = 1 × 2 = 2 W (Absorbing)
In 10V :- P = 10 × 10 = 100 W (Absorbing)

} I entering +ve terminal or going from lower to higher pot.

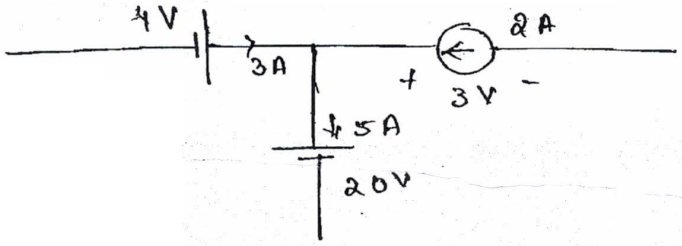
$$(P_T)_{Absorbing} = (P_T)_{Delivering}$$

$P_{T\,del} = 32 + 78 + 25 = 135$ W
$P_{T\,abs} = 33 + 2 + 100 = 135$ W

} verified.

Toppersnotes
Unleash the topper in you

Q:



Find total power absorbed in the figure shown.

In 4V :- $P = 4 \times 3 = 12W$ (Del) $= -12W$ (Abs)

In 2A :- $P = 2 \times 3 = 6W$ (Del) $= -6W$ (Abs)

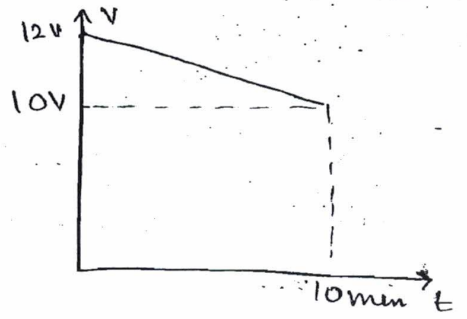
In 20V :- $P = 20 \times 5 = 100W$ (Absorbing)

$P_T = 82W$ (Absorbing)

- The capacity to do work is called **energy.**

$$W = \int_0^t P\,dt$$ watt-sec or Joule

Q. A fully charged mb. phone is good for 10 min talktime. During talktime battery delivers a constant current of 2A. Find energy on the battery during talktime.



$$\Rightarrow W = \int_0^t P\,dt = \int_0^t VI\,dt$$

$$= I \int_0^t V\,dt \qquad I = 2A \text{ (constant)}$$

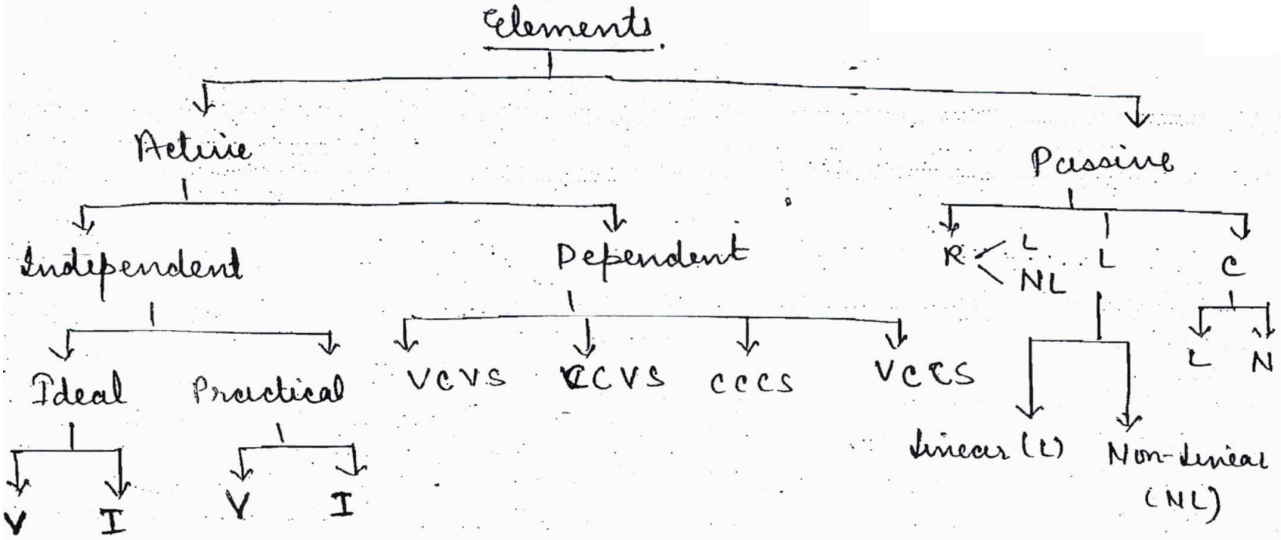
$$= 2 \times \frac{1}{2} \times (12+10) \times 600 \qquad = 600 \text{ sec.}$$

$$= 22 \times 600$$

$$= 13200 = 13.2 \text{ kJ}.$$

Classification of Elements :-

1. Active & Passive Elements :-
2. Linear and Non Linear Elements
3. Unidirectional and bi-directional elements
4. Time Variant and Invariant
5. Lumped & Distributed



- **ACTIVE ELEMENT:-** ○ When the element is capable of delivering energy independently for long time (approximately infinite time). or
- ○ When the element is having property of internal amplification.

eg :- Voltage source (V), Current source (I), } Independent.
Transistor & op-amp. } Dependent

* Cap vs independent sources :-

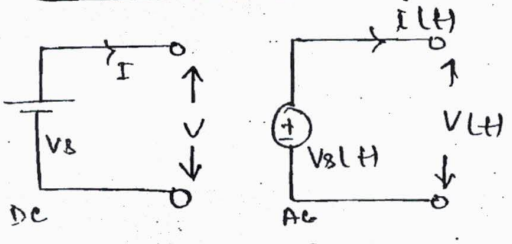
- During discharging capacitor can deliver the energy independently for short time (1) and capacitor is not having internal amplification (2) property

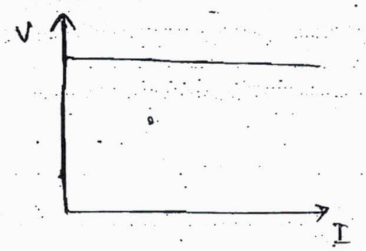
• **PASSIVE ELEMENT**:- When the element is not capable of delivering energy independently.

eg:- Resistor, bulb, transformer $(V_1I_1 = V_2I_2)$ ⇒ no internal amplification

$P_{in} = P_{out}$

• Ideal V source:





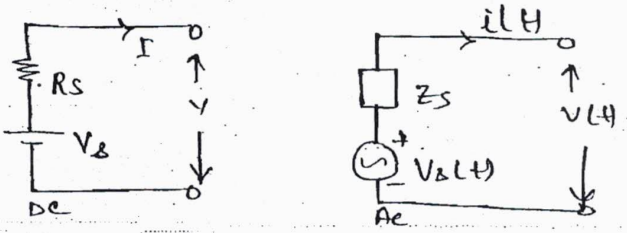
DC → no time mentioned
AC → time mentioned

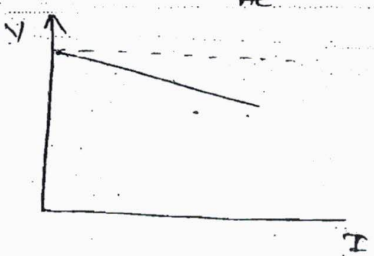
$R_s = 0$ $V = V_s$ $V \neq f(I)$

→ Ideal voltage source delivers energy at specified voltage (V) which is independent on current delivered by source.

→ Internal Resistance of ideal voltage source = 0.

• Practical V source:





For DC:- $V_s = V + IR_s$

$V = f(I)$ or $V = V_s - IR_s$ V ↓ as I ↑

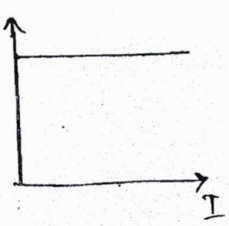
→ Practical voltage source delivers energy at specified voltage (V) which depends on current delivered by the source.

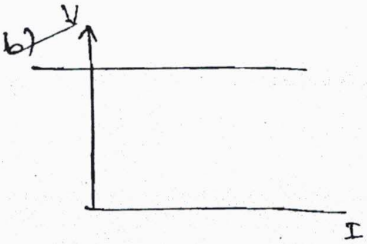
→ Internal Resistance of practical voltage source = R_s

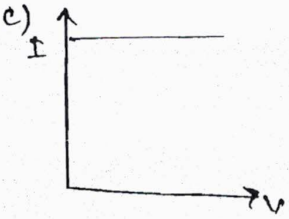
$R_s \neq 0$.

~~Independent voltage source~~ does not satisfy ohm's law since VI characteristics is not linear. (does not cross origin or not linearly ↑↓)

Q. Identify VI - characteristics of ideal voltage source

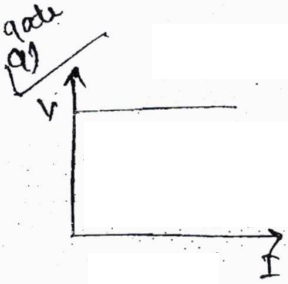
a) 

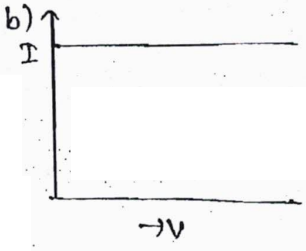
b) 

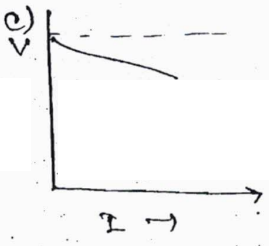
c) 

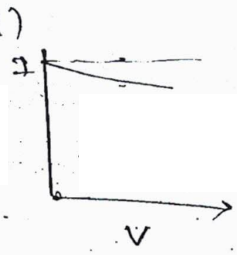
d) 

Q. Same - Identify VI charact of ideal volt source.

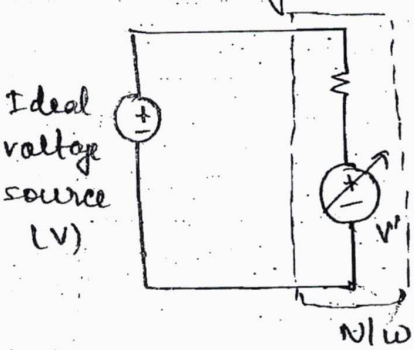
a) 

b) 

c) 

d) 

:→ Considering a simple example:-



if $V' > V \Rightarrow$ I = (clockwise)

$V' < V \Rightarrow$ I = (anticlockwise)

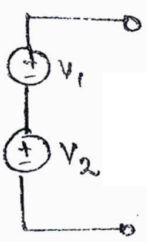
$V' = V \Rightarrow I = 0$

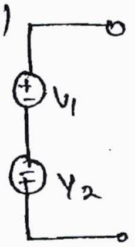
** for both directions of I, V is constant, hence I considers in both the +-ve direction **

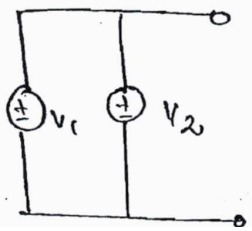
If both options Q_1 (a, b) → select b → most appropriate

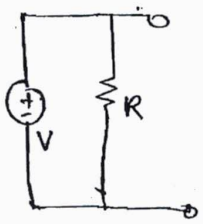
one option Q_2 (a) → select a.

Q: Find equivalent ckt corresponding to them:-

1) 

2) 

3) 

4) 

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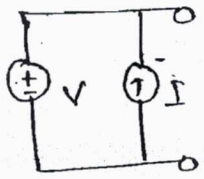

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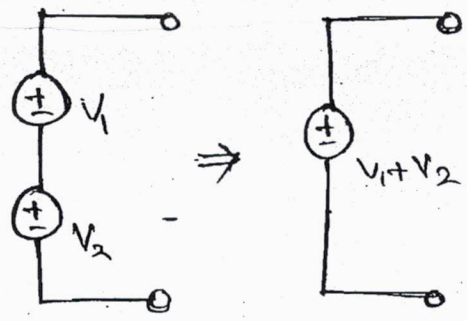

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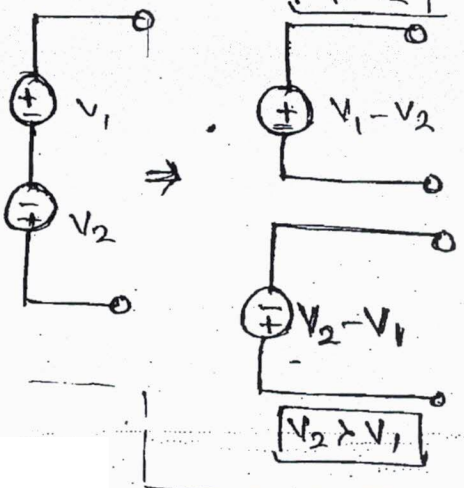

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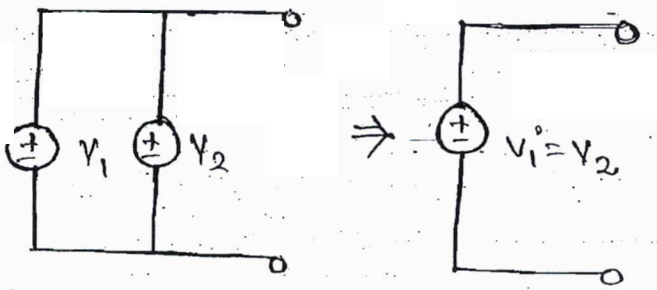

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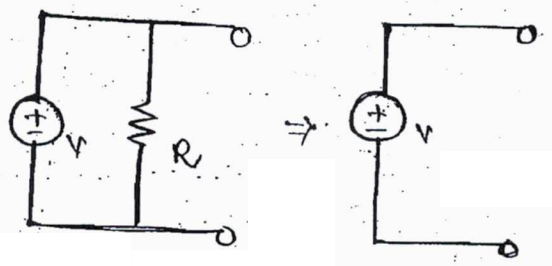

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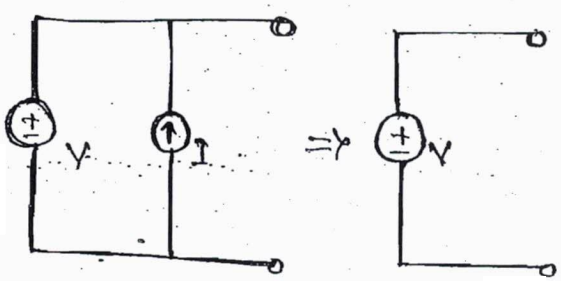
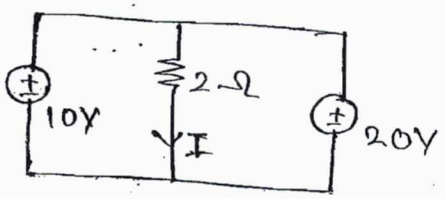


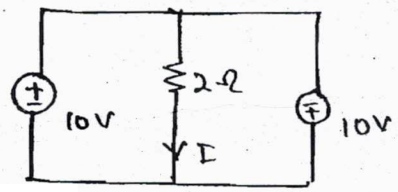
Q. Find current in the 2Ω resistance



a) 5A b) 10A

c) 15A d) None or (NOT satisfying KVL) or (0)

NOTE:- With respect to KVL, voltage across all the parallel branches should be equal.

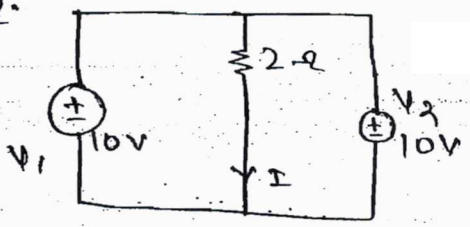


⇒ **polarity** as well as **magnitude** of voltages in parallel branches should be equal. Hence,

NOT satisfying KVL ∴ $I = 0$

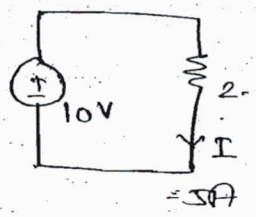
$\boxed{10V \neq -10V}$

Q.



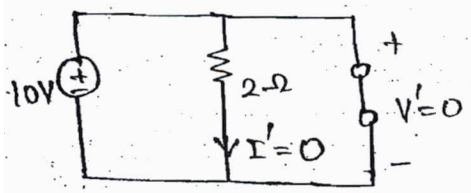
$10V = IR$

or $I = \frac{10V}{2} = \boxed{5A}$ ⇒

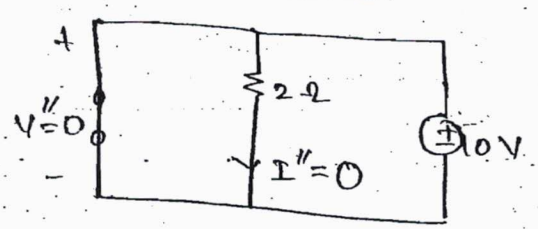


- verifying by using superposition Theorem:-

Case I due to V_1;



Case 2 due to V_2.



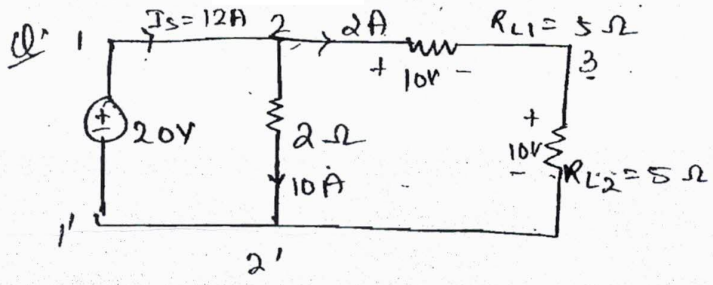
$I = I' + I'' = 0$

$10V \neq 10V$ → not satisfying KVL

$10V \neq V'$ ∴ KVL not satisfied ← ∴ The superposition does not apply.

NOTE:- For the above NW superposition theorem cannot be applied since Case 1 & Case 2 circuits are not satisfying KVL.

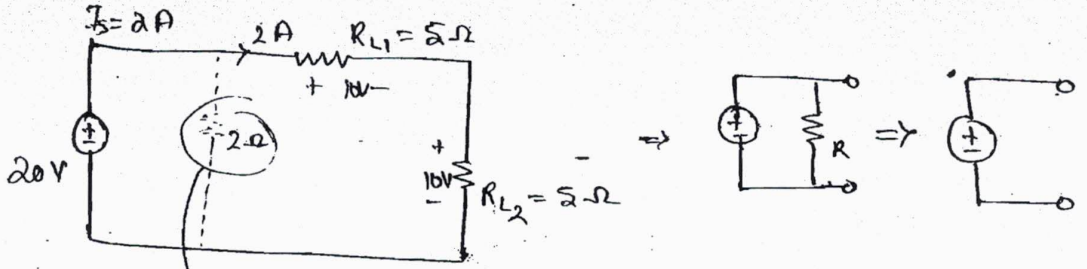
Q.



$V_{11'} = V_{22'} = V_{232'}$

↓

parallel branches



R ↓ not important/justifying ckt (4) from previous.

In 1st ckt; $P_s = 20 \times 12 = 240W$

In 2nd ckt; $P_s = 20 \times 2 = 40W$

} → not justifying ckt(4)

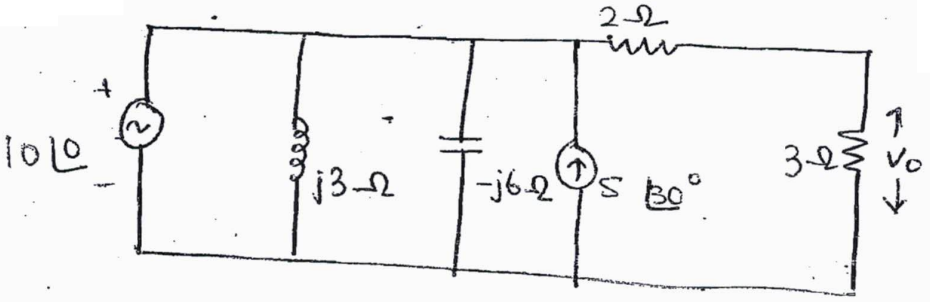
∴ Conclusion:→ R can be neglected wrt load calculations (V_R, I_L)

R cannot be neglected wrt source current & source power

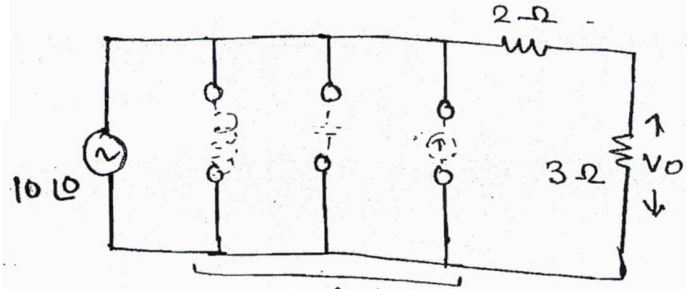
NOTE:- In above Nlw, 2Ω resistance (10A current) can be neglected to calculate as a load current or load voltage.

However, in above Nlw, 2Ω resistance (10A current) cannot be neglected to calculate either source current or source power.

Q. Find V_o on the nlw shown.



⇒ Equivalent ckt for solving can be reduced to

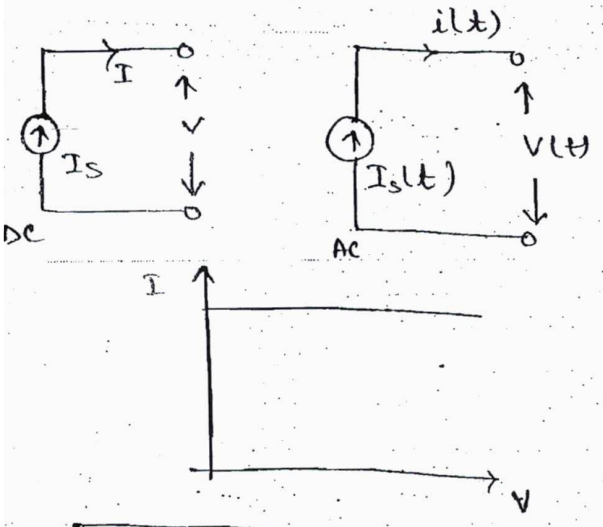


$I = \frac{10}{5} = 2\ A$

$V_o = I \times 3\ \Omega$

$\boxed{V_o = 6\ V}$ Ans

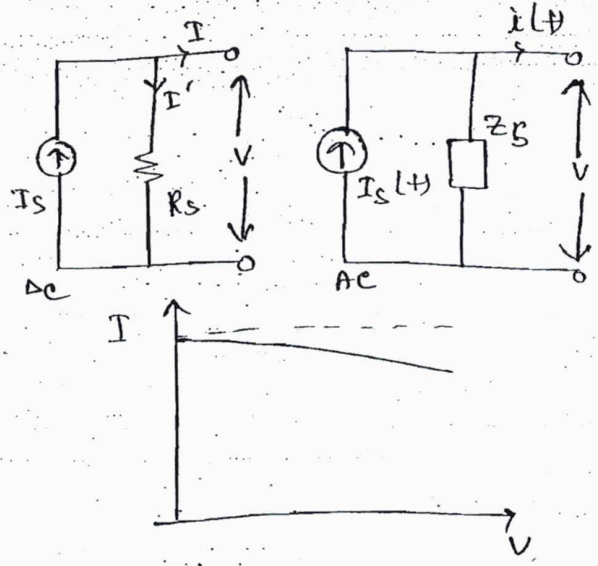
- Ideal Current Source -



$\boxed{R_s = \infty}$

- Ideal current source delivers energy at specified current (I) which is independent of voltage across the source.
- Internal resistance of ideal current source = ∞

- Practical Current Source -



- $I_s = I' + I$

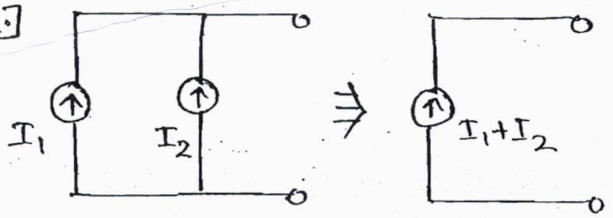
⇒ $I = I_s - I'$ or $\boxed{I = I_s - \frac{V}{R_s}}$

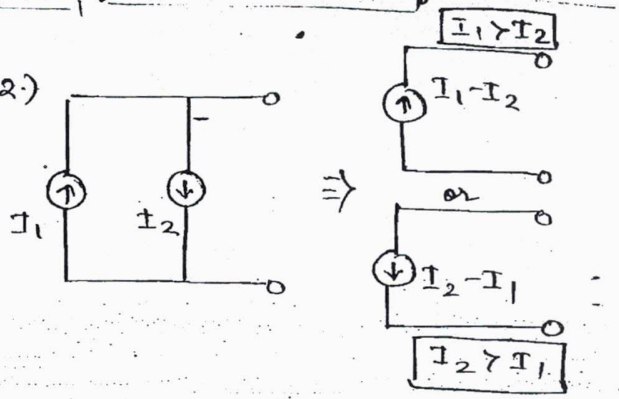
$\boxed{I \propto V}$

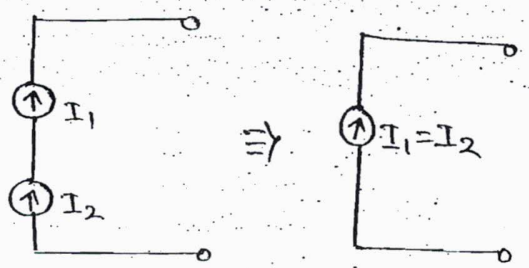
- Practical current source delivers energy at specified current (I) which depends on voltage across the source.

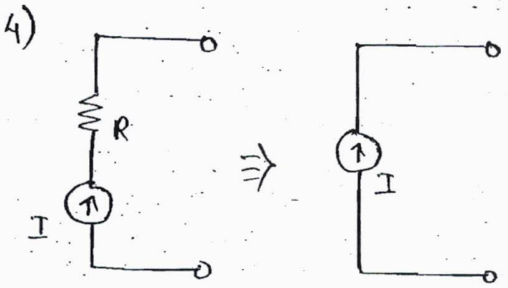
Conclusion:- Independent current source does not obey Ohm's law since VI characteristics is non-linear.

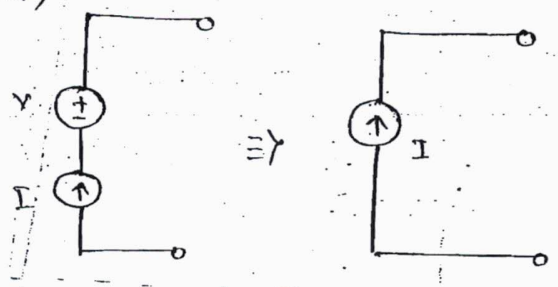
- Internal resistance of ideal voltmeter = ∞
- " " " ideal ammeter = 0 $\rightarrow R_s$ (ideal)
- In the practical system independent current source does not exist but dependent current source exists.
  eg:- Transistor → theoretical concept for source transformation.

1.] 

2.) 

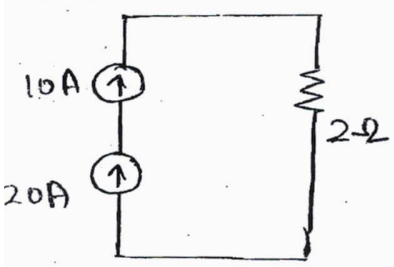
3.) 

4) 

5.) 

← Equivalent topologies for various N/Ws with ideal current source

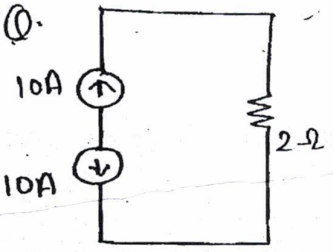
Q. Find equivalent current in 2Ω resistor.



a) 10A
b) 20A
c) 30A
d) None or Not satisfying KCL

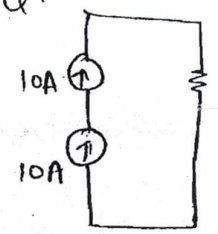
NOTE:- With respect to KCL, current flowing through all the series elements should be equal.

Q.

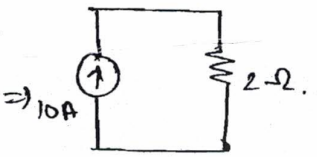


not satisfying KCL at both direction + magnitude should be same.

Q.



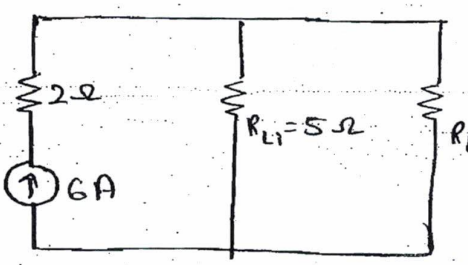
$\Rightarrow$



$\boxed{I = 10A.}$

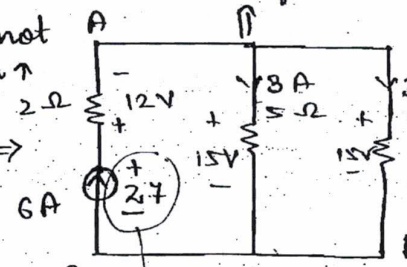
Property (4) for load cds verified (with without 2Ω)

Q.



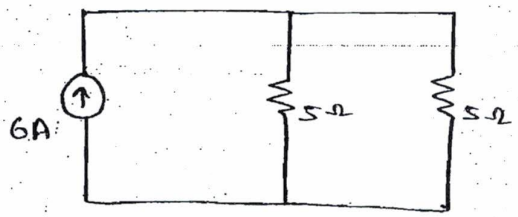
does not matter ↑

$\Rightarrow$

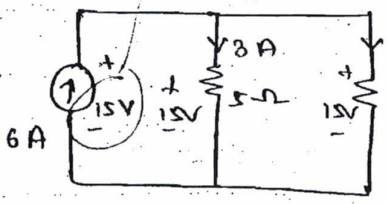


$P = 6 \times 2.7 = 14.2W$

$\Rightarrow$ MISMATCH



$\Rightarrow$



$P = 6 \times 15 = 90W$

Notations:- when current entering = +ve corresponding to arrow ↑ +V

$V_{AB} = V_s - 12 \Rightarrow 15 = V_s - 12 \Rightarrow V_s = 27$ $(V_s > 12) \rightarrow$ Considered as source volt is greater.

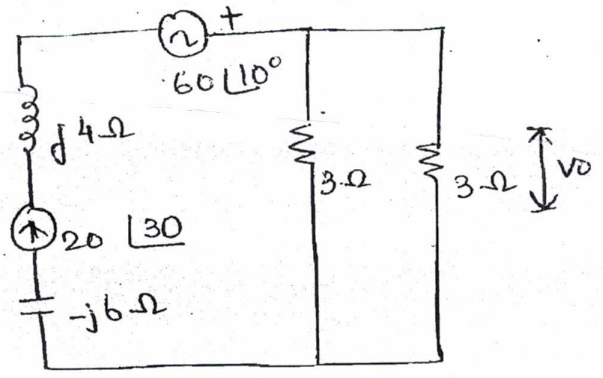
NOTE:- In above NW:-

2Ω resistance (12V voltage) • Can be neglected wrt load calculation $\|(V_L + I_L)\|$

• but it cannot be neglected wrt source calculations [current, source voltage or power of current source)

$\|(V_{Is}, P_{Is})\|$

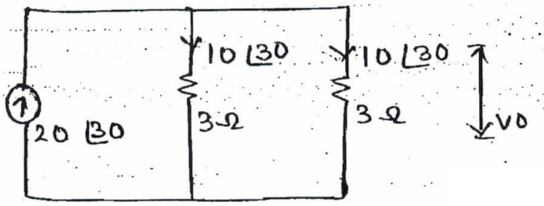
Q.



Find V_o.

** All elements in series to current source are neglected **

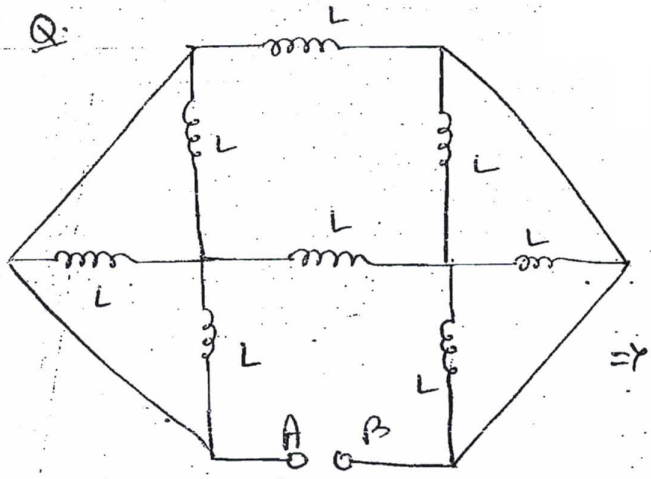
Equivalent ckt:→



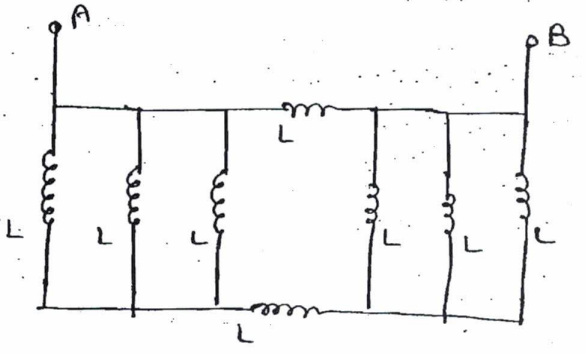
∴ $V_o = 3 \times 10 \angle 30°$

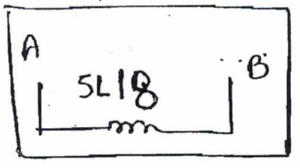
$$V_o = 30 \angle 30° \text{ V}$$

Q:

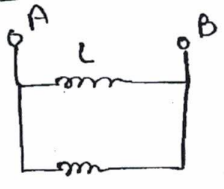


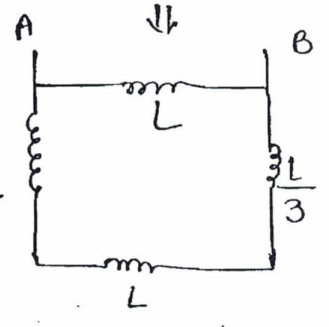
1) Find equivalent inductance wrt A+B.





$L_{eq} = \frac{5L}{8}$ ohm





$L \parallel \frac{5L}{3}$

$$\Rightarrow \frac{L \times \frac{5L}{3}}{L + \frac{5L}{3}} = \frac{L^2}{4L} \cdot \frac{5L}{8} \quad \left| \left(\frac{L}{8} + L + \frac{L}{3} \right) \right.$$