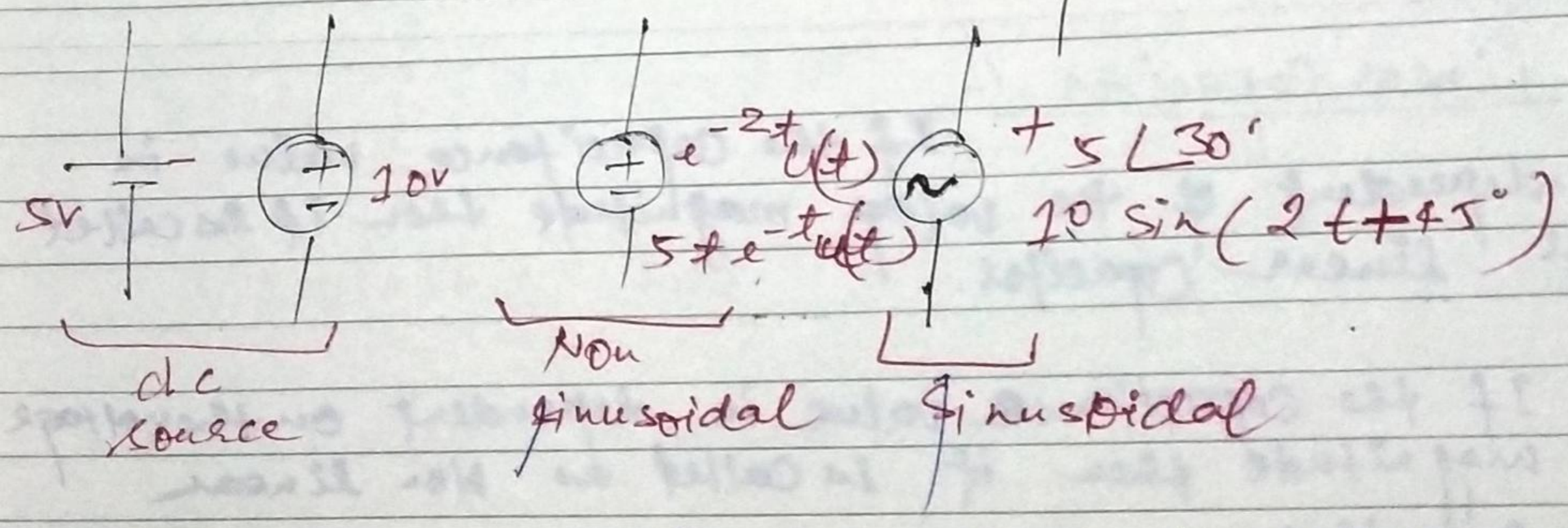
Sources :-

* If the terminal voltage is completely independent of current or current is completely independent of voltage then the element is called an independent source.

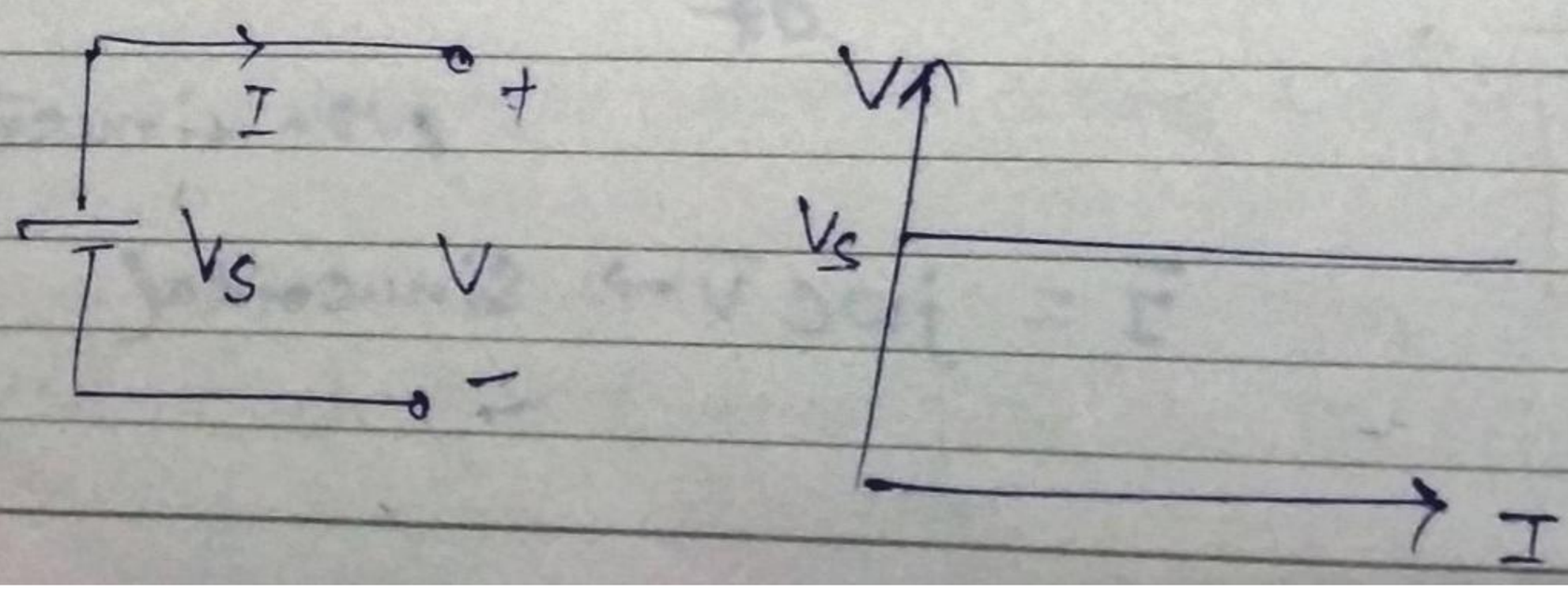
* the element for which either the current or voltage (some where else in the ckt) is called dependent source.

I st voltage sources

Representation of independent voltage source

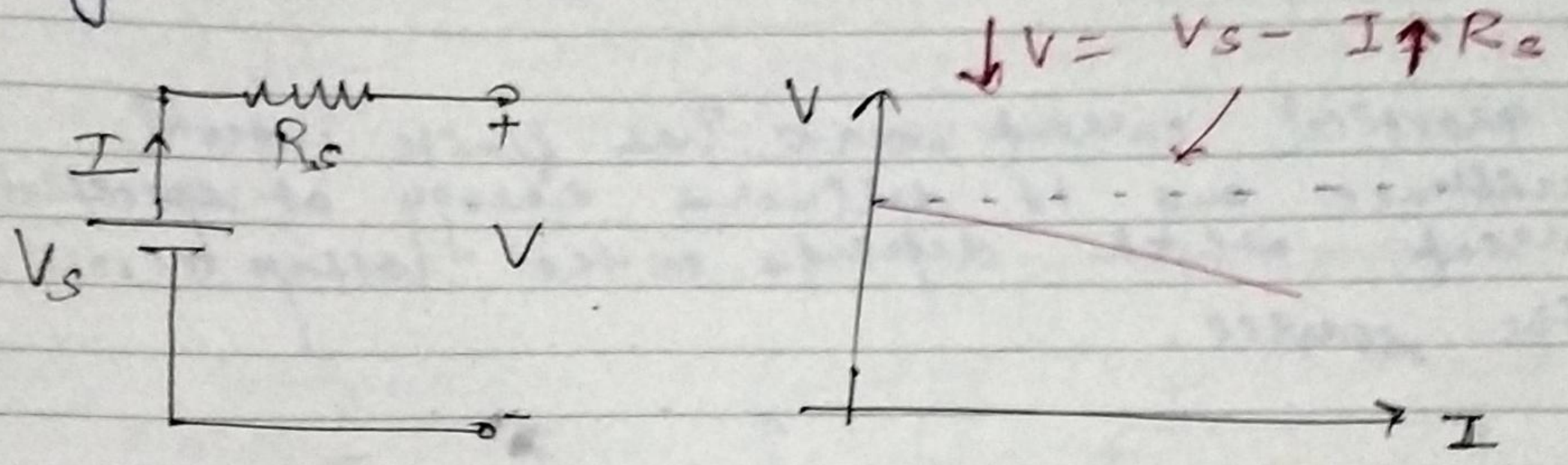


* Ideal voltage source has zero internal resistance and it delivers energy at specified voltage which is independent of the current delivers by the source.



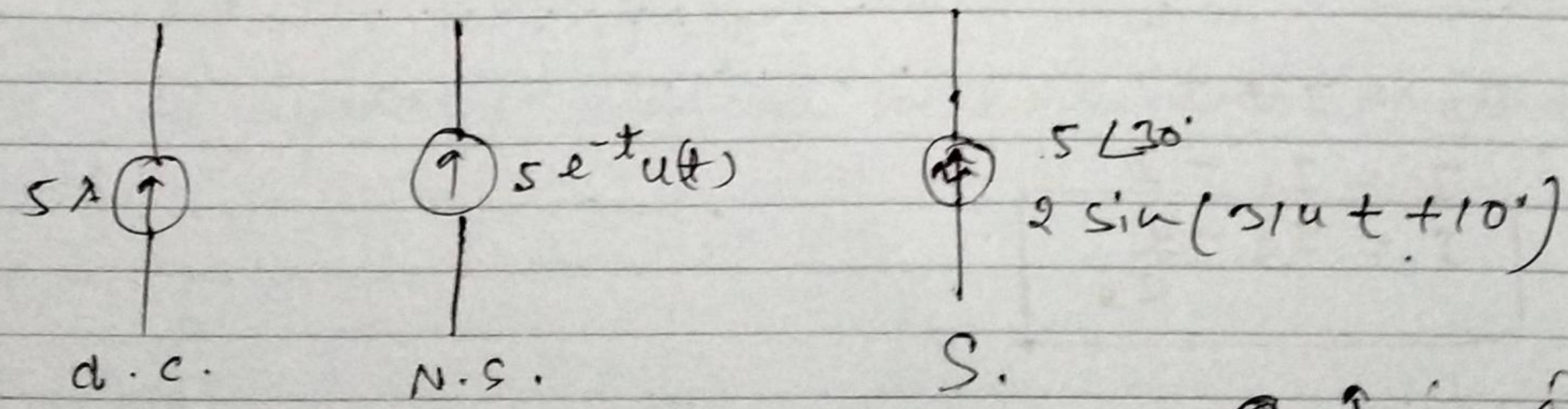
Scanned by TapScanner

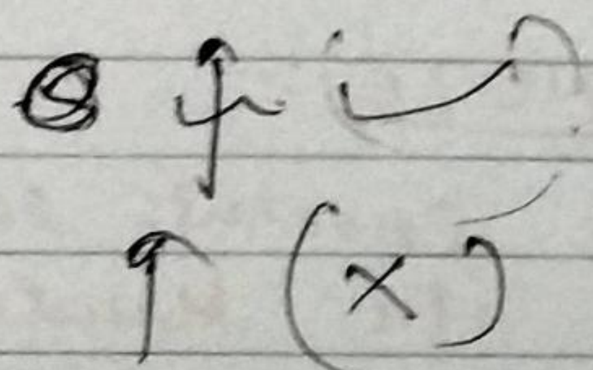
* practical voltage source has some finite internal resistance and it delivers energy at specified voltage which depends on the current delivered by the source.



Practical voltage source

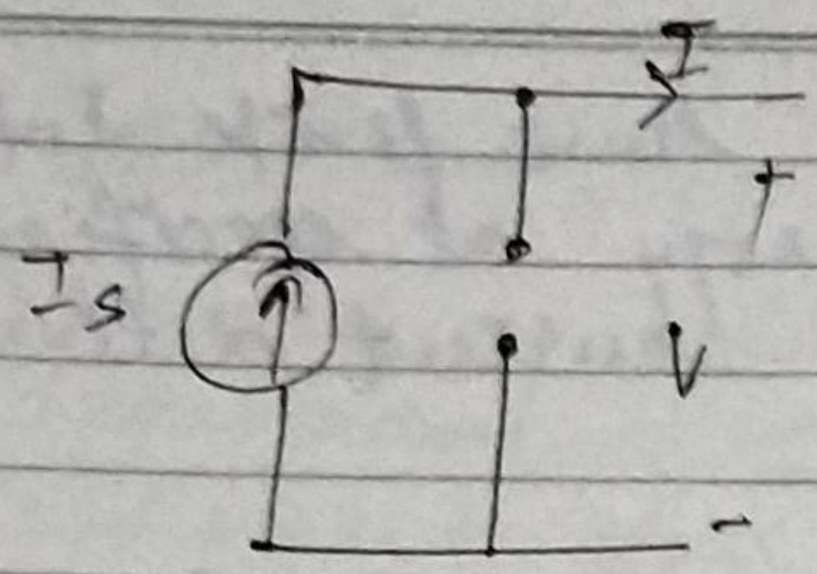
Current sources :-

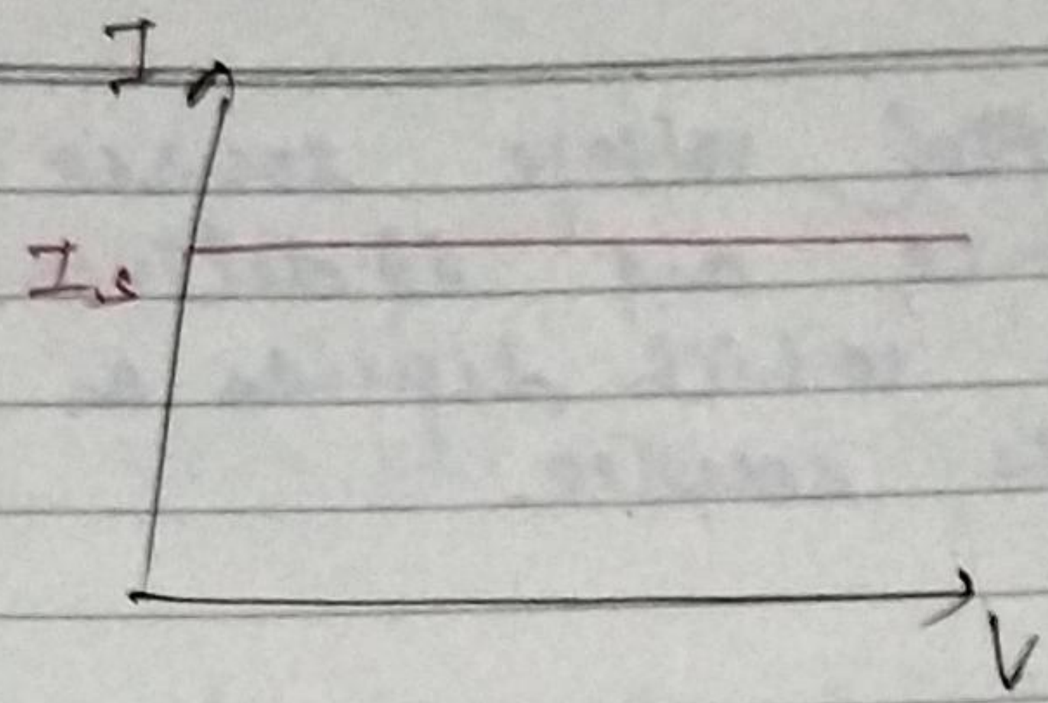




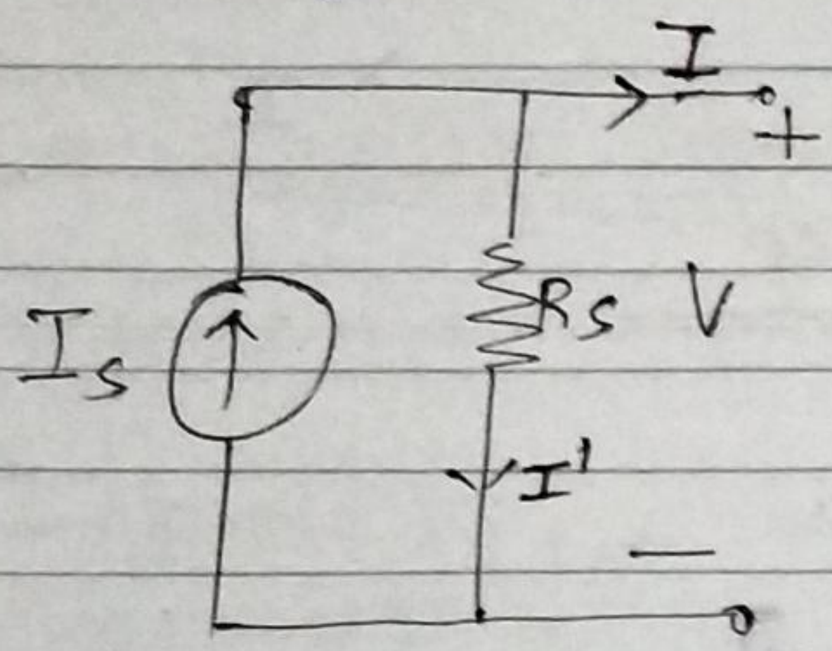
* for ideal current source internal resistance is infinite and it delivers energy at specified current which independent of the voltage across its terminals.

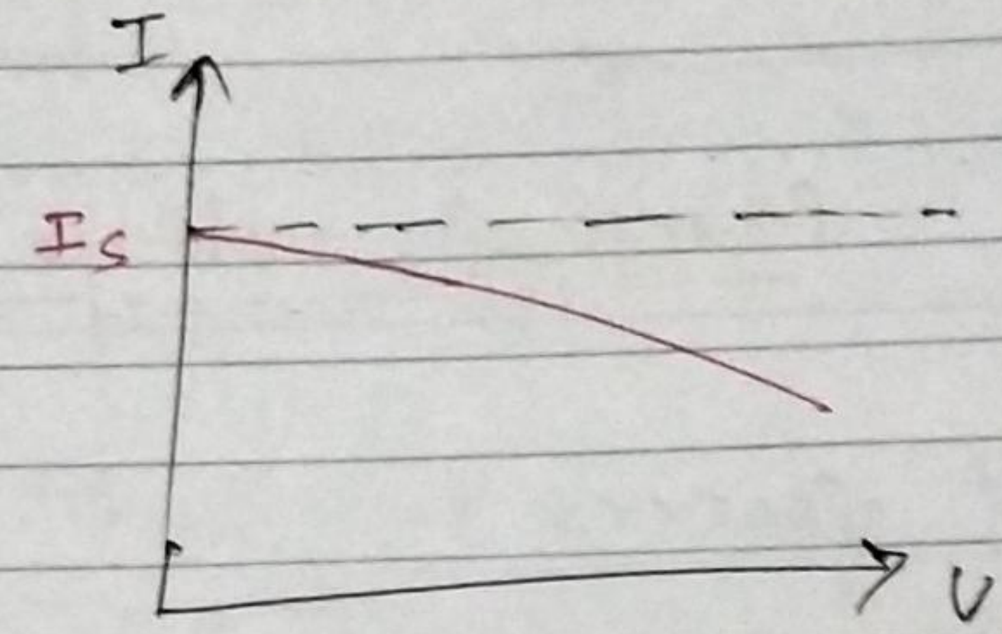
Scanned by TapScanner





* practical current source has finite internal resistance and it delivers energy at specified current which depends on the voltage across the source.





$$I_s = I + I'$$

$$I = I_s - I'$$

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

NOTE :-

(I.) Current source does not have zero voltage across its terminals while providing the fixed current, it depends entirely on the ckt in which it is connected.

(II) In the real time system only independent voltage source exist. To make calculation simple by source

Transformation Technique current source concept is introduced.

* By analysing an in electrical N/W using KVL and KCL equations the independent and dependent voltage and current sources are handled exactly in the same manner except in the following cases.

(I) Analysis of the ckt using superposition theorem

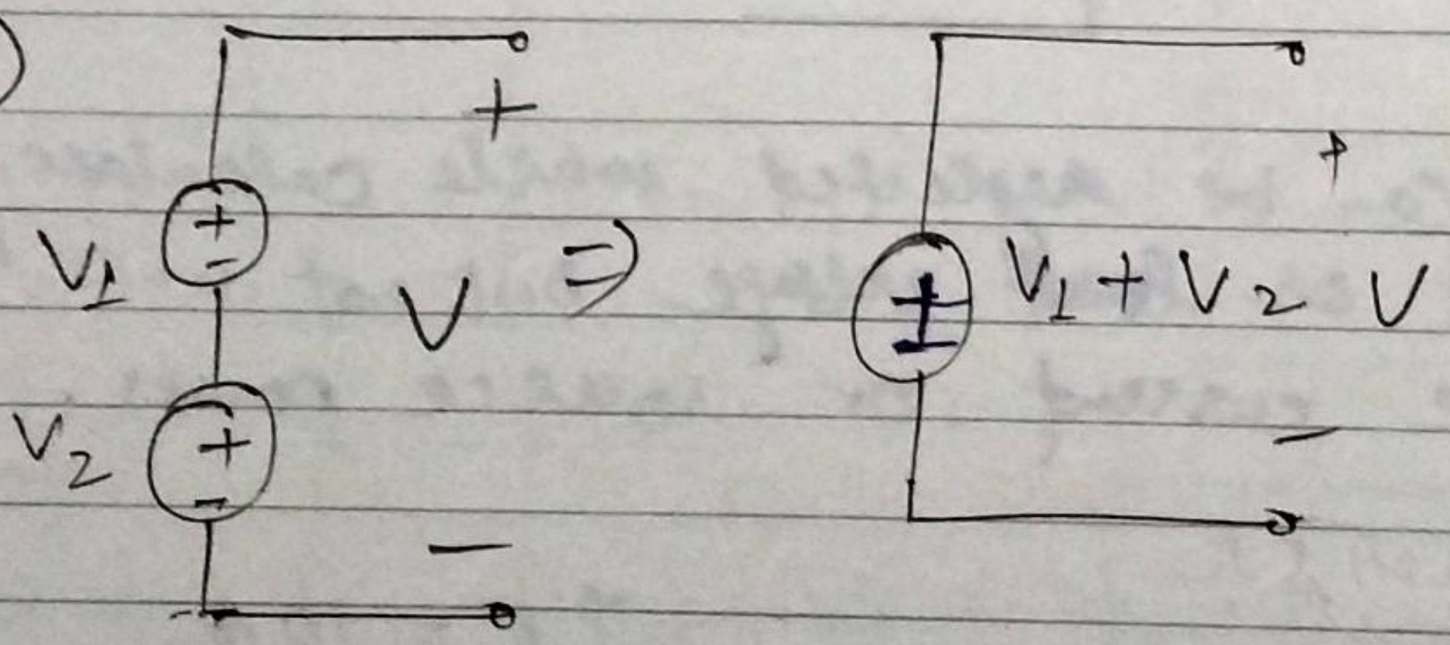
(II) Analysis of ckt using Thevenin's and Norton Theorem.

In such cases

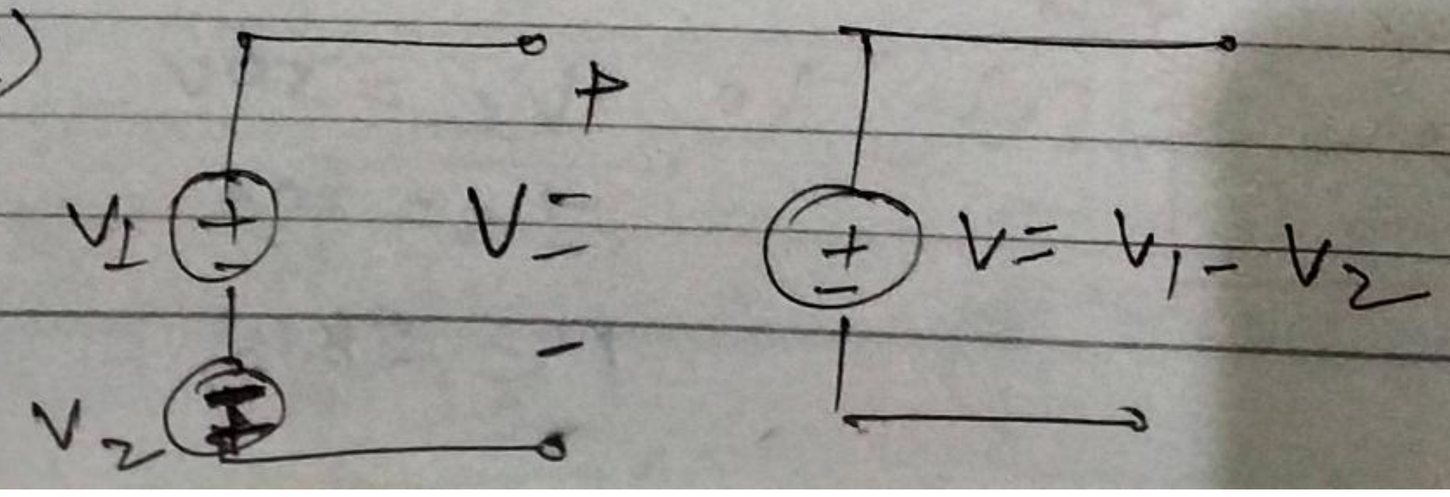
(I) All independent current and voltage sources are replaced by their internal resistances.

(II) All dependent sources will remain as they are.

1)

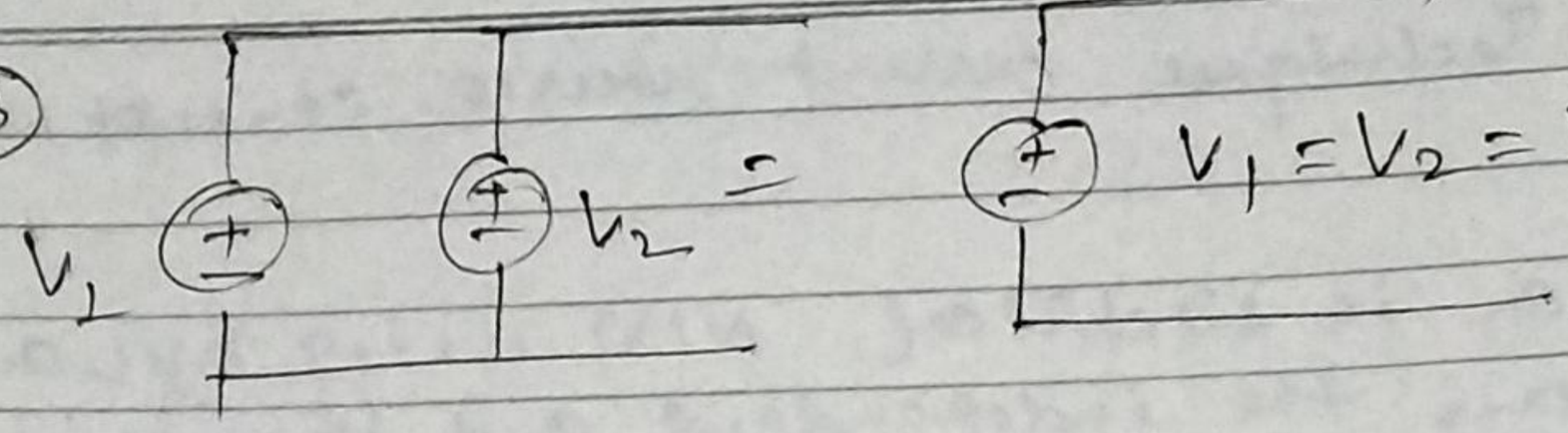


2)

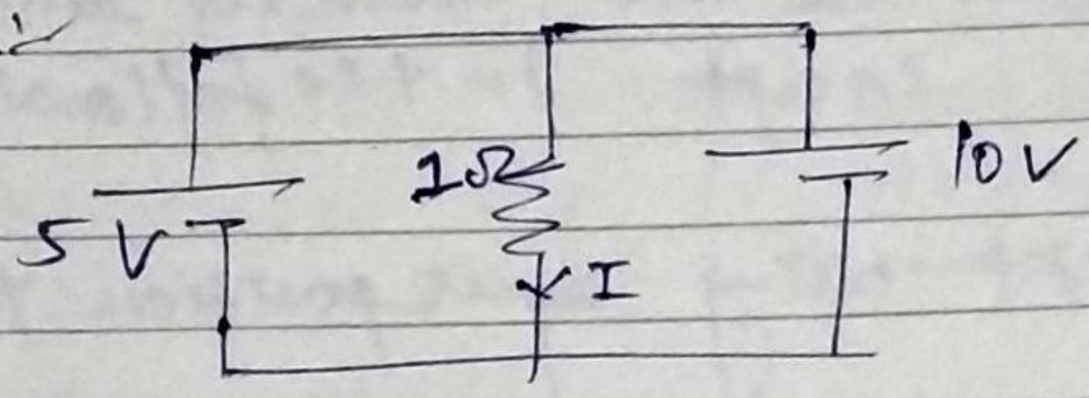


Scanned by TapScanner

③

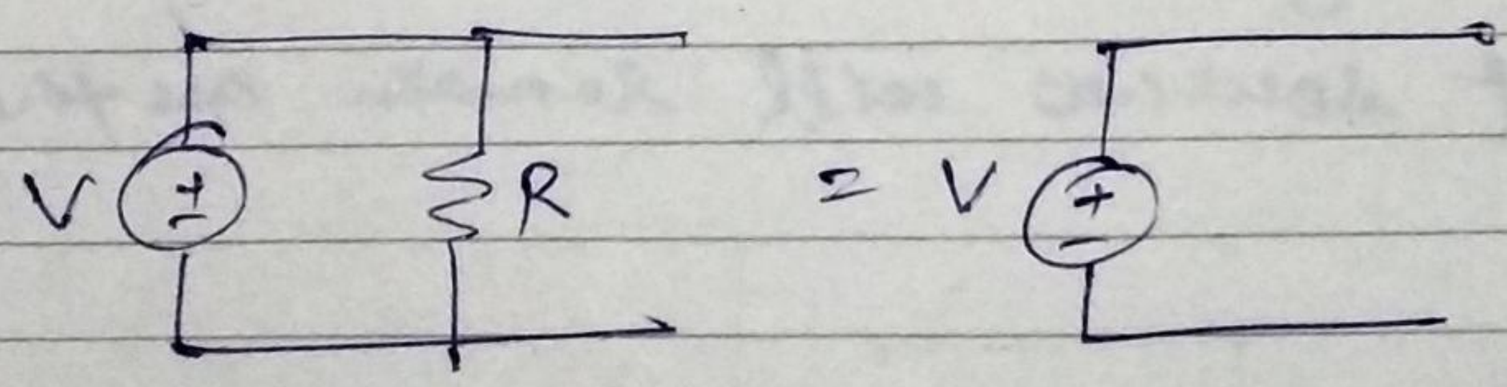


Eg:-



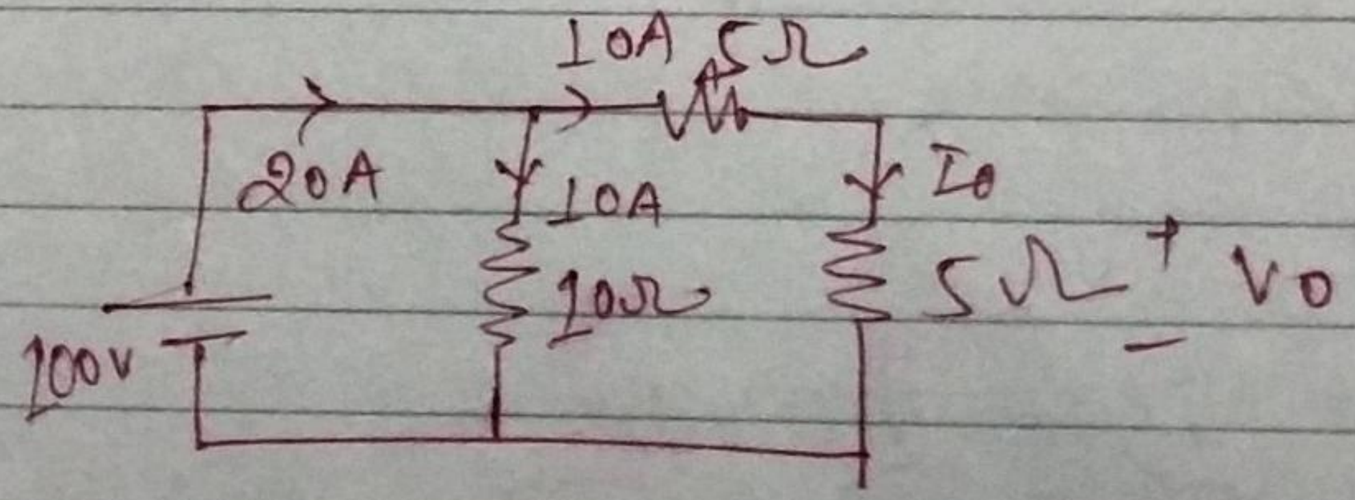
a) 5 A
b) 15 A
c) 10 A
d) None (✓) Bcz these voltage should be same for verifying KVL.

4)



The resistor R can be neglected while calculating either load current or load voltage but not while calculating source current or source power.

Eg:-



$I_L = 10A$

$V_L = 50V$

$I_S = 20A$

$P_S = 2kW$

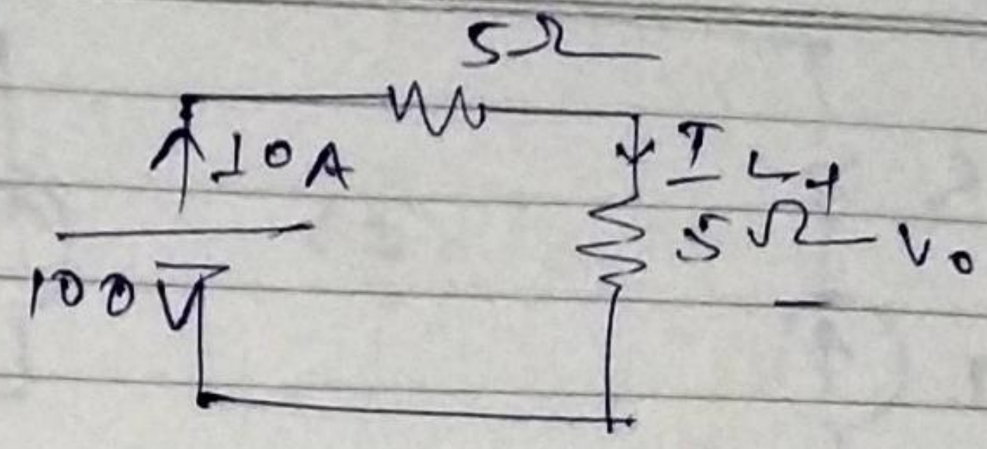
Scanned by TapScanner

$I_L = 10A$

$V_L = 50V$

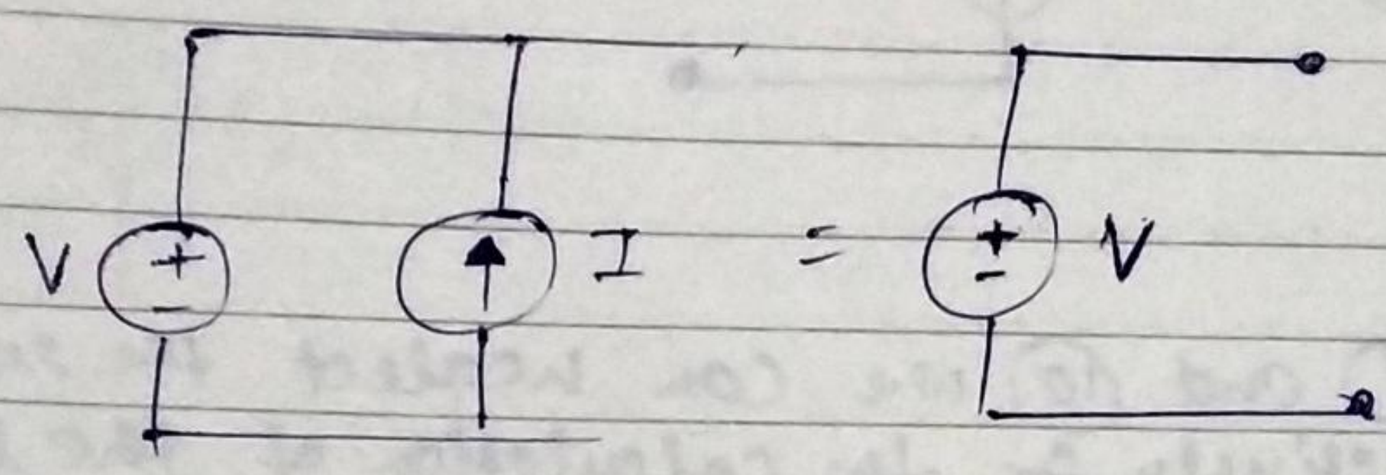
$I_s = 10A$

$P_s = 1kW$



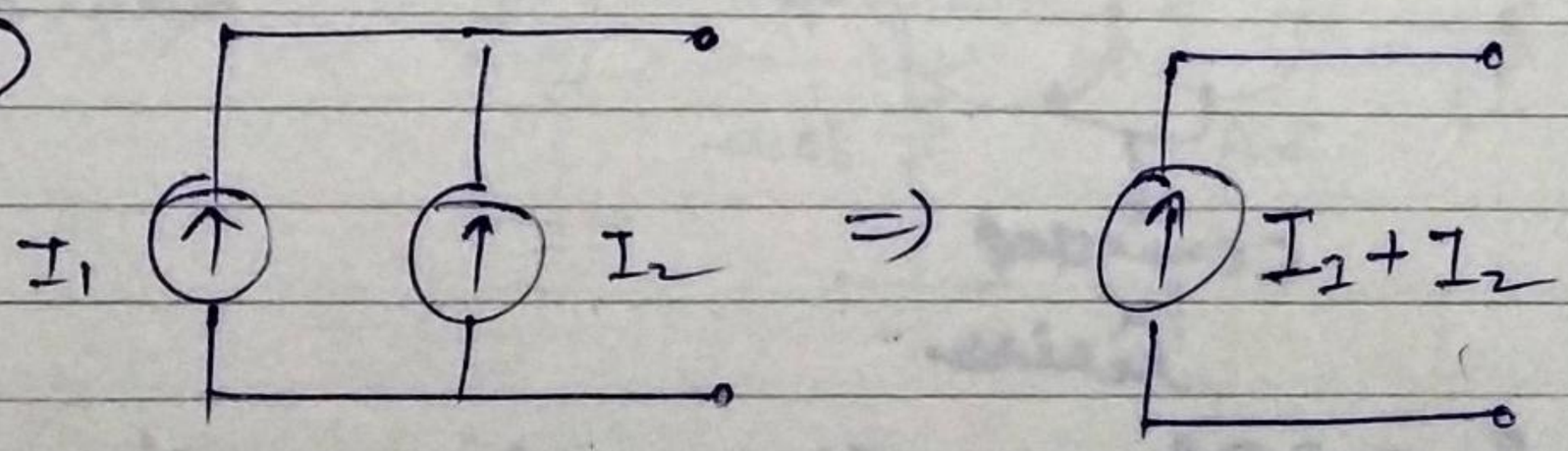
Hence when we neglect 10Ω then load side calculation remains same but source side calculation will change.

5)

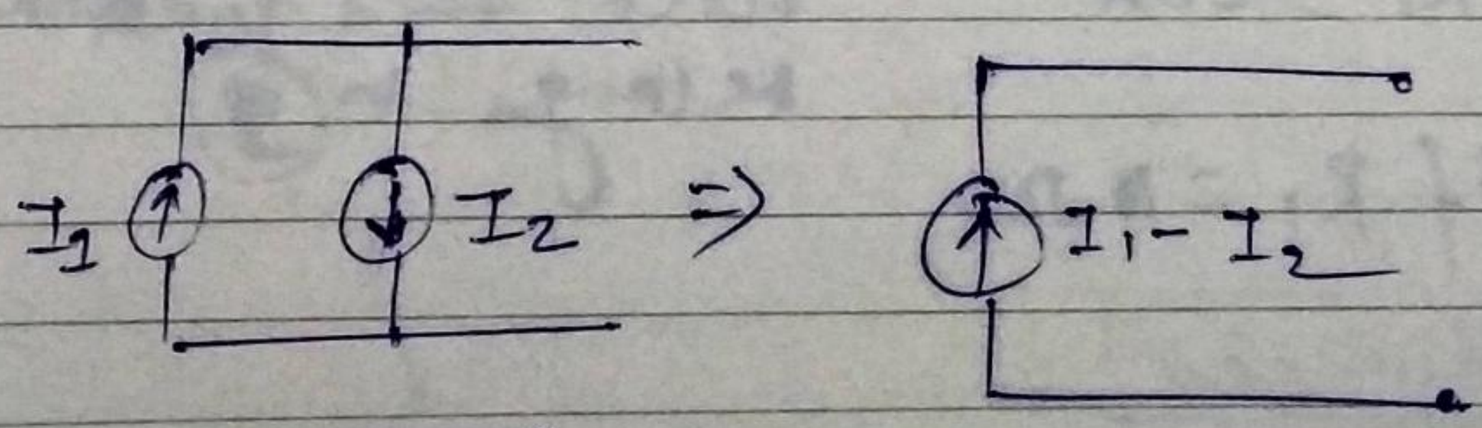


In the above ckt current source can be neglected while calculating either load current or load voltage but not for the calculation of source current or source power.

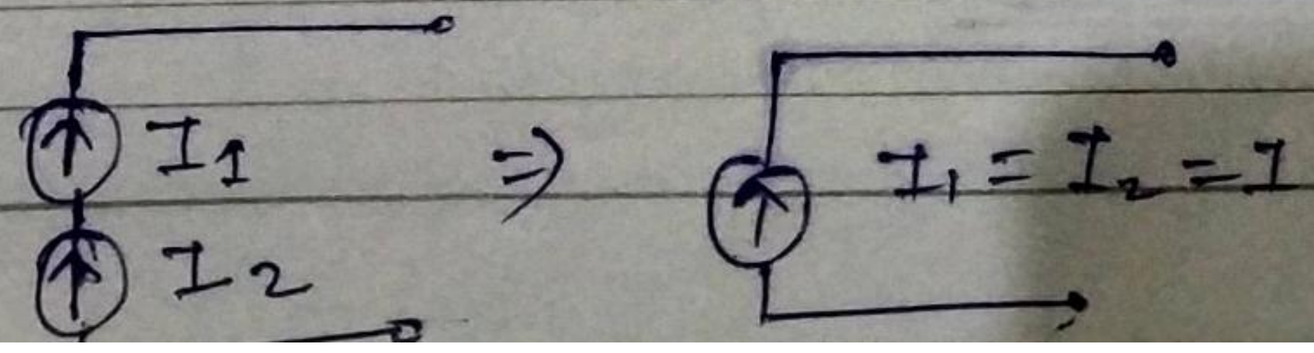
6)



7)

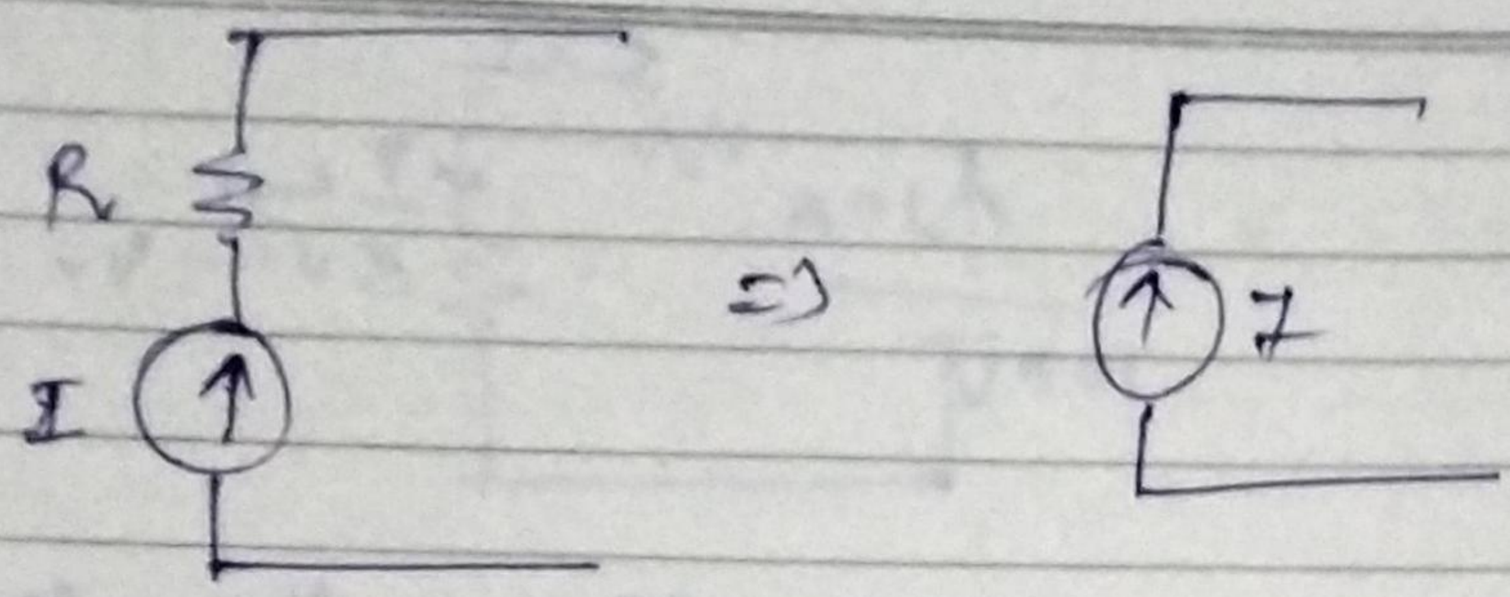


8)

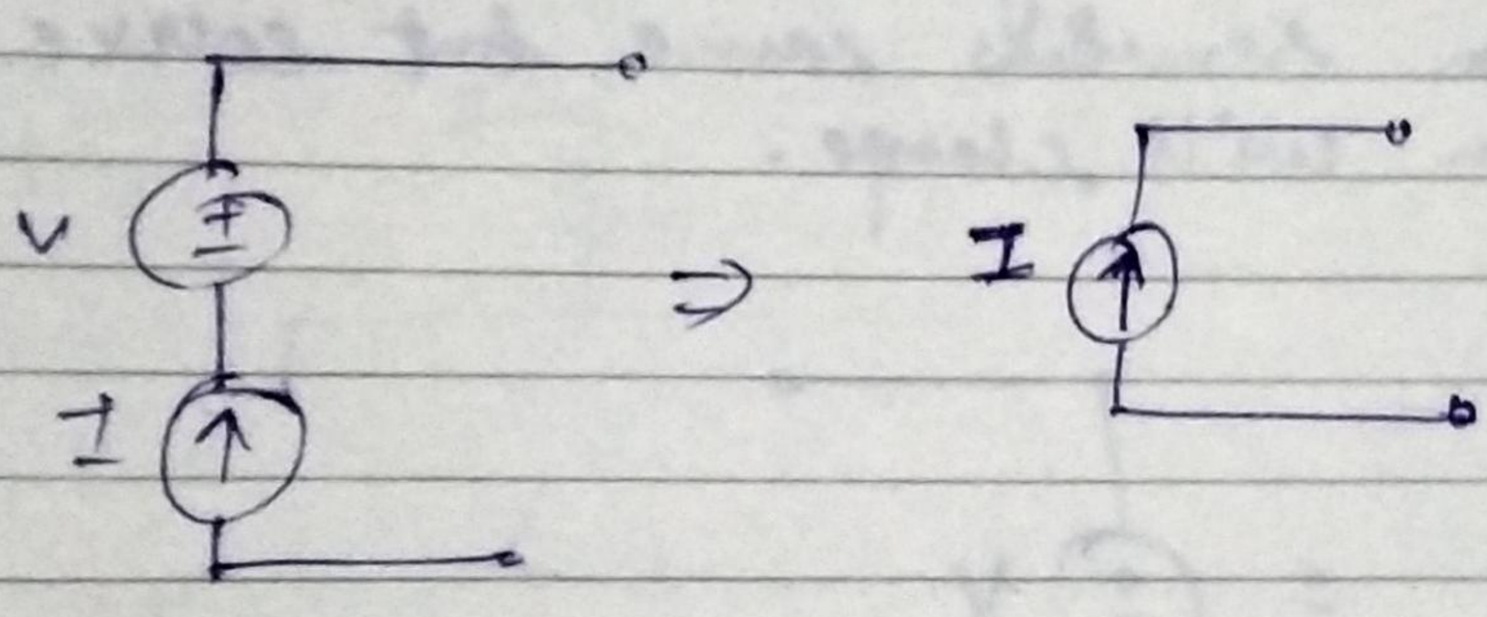


Scanned by TapScanner

(9)



(10)



In the point (9) and (10) we can neglect the resistance and voltage respectively for the calculation of the load current or load voltage but not for the calculation of the voltage across the source or the power of the source.

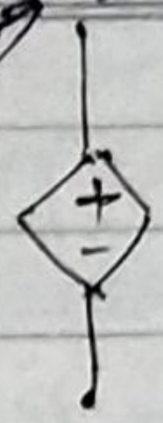
Scanned by TapScanner

Linearly dependent sources bcz NO Nonlinear operator.

$v_x = Ai$

CCVS

$\boxed{A = \Omega}$



$v_x = BV$

VCVS

B = unit less

$i_x = Ci$

CCCS

C → unit less

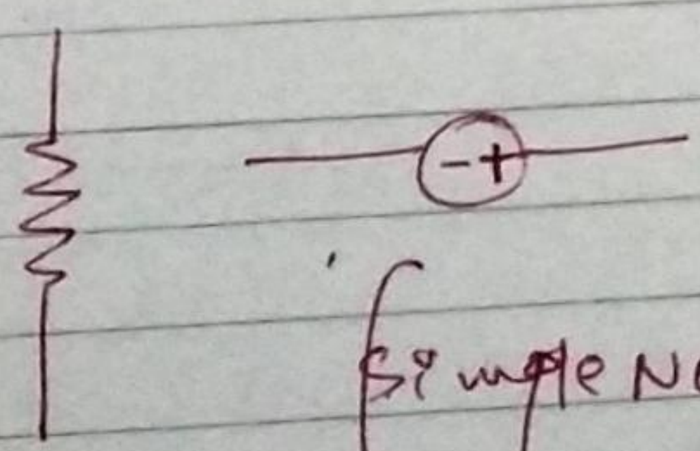
$i_x = Dv$

VCCS

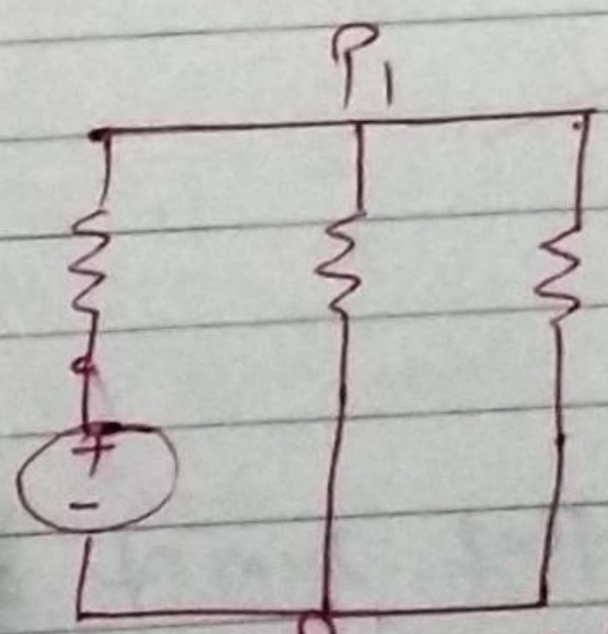
D = ℧ siemens

01.09.15

Branch: Branch is a single element or component in a ckt. If several element carry the same current they can also be referred as single branch.



(Simple Node)S



P_2 → Principal Node

$e = b - (N-1)$

Scanned by TapScanner

Node: when two or more than two element are connected together in a common point then the common point is called as ~~principle~~ Node.

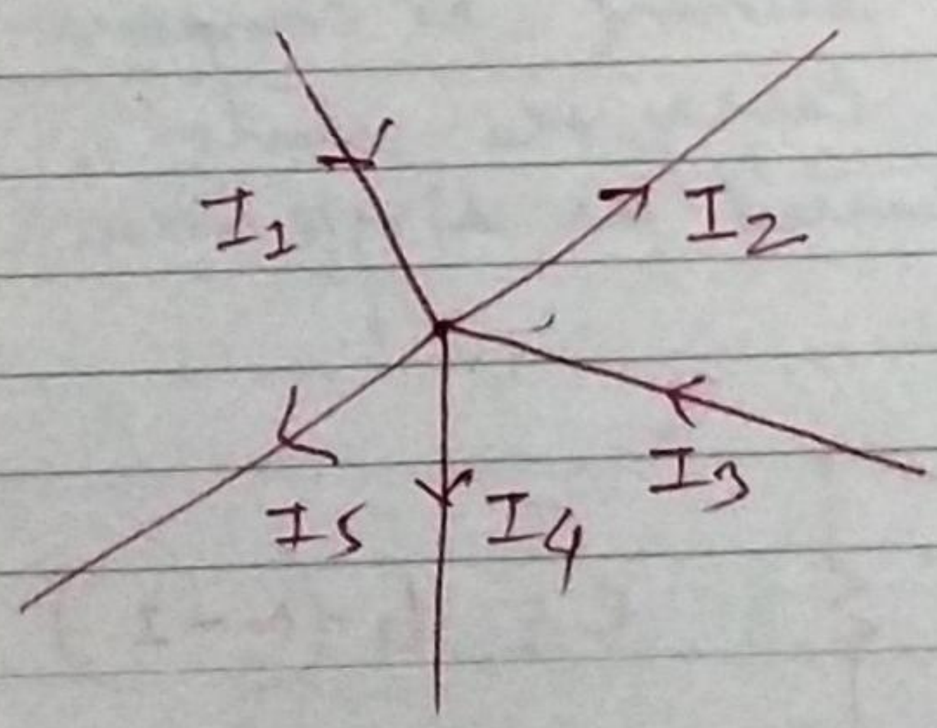
* When two elements are connected together then the common points it is called as ~~single~~ simple Node.

* When more than two element are connected together then the common point is called as principal Node and at this Node current division takes place.

KCL:

KCL states that algebric sum of the current entering a node (or meeting at the point) is zero.

* Outgoing current is considered as -ve and incomming current is considered as +ve.
* It is based on the Law of conservation of charge.



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

KVL:-

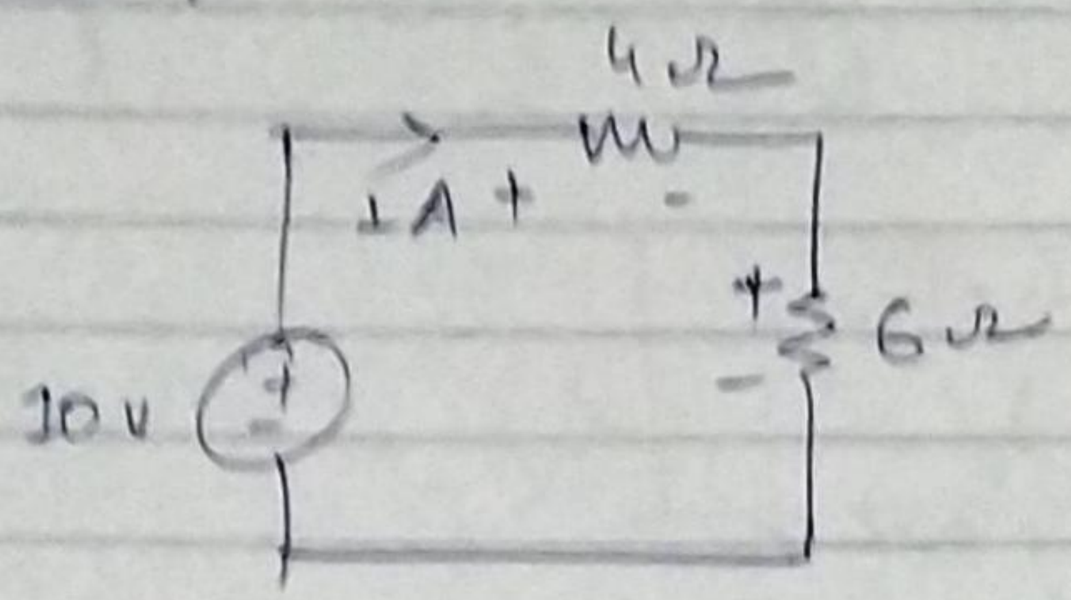
It states that sum of all the voltages in a closed loop is zero.

* It is based on the law of Conservation of energy.

Scanned by TapScanner

Standard Notation :-

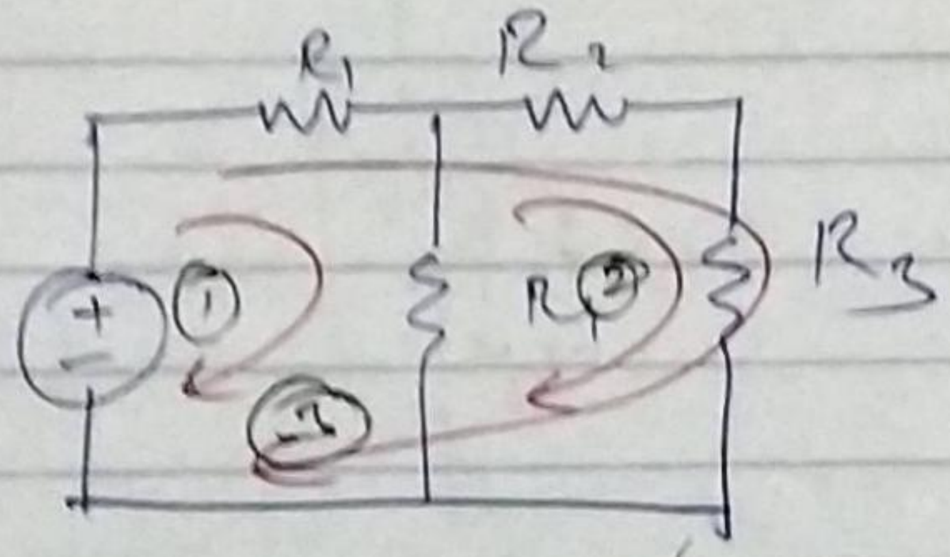
Q. a loop rise in potential is considered is (-ve) and drop in potential is considered (+ve).



$-10+4+6=0$

Mesh Analysis :-

* Mesh is a loop which does not contain any inner loop.
* It is applicable only for the planar N/ws and planar N/w is one that can be drawn in a plane with no branches crossing one another.



Loops
1 2 3

Mesh
1 2

Procedure

* Identify total no of mesh.
* Assign mesh current
* Develop KVL eqn for each mesh.
* Solve eqn to solve loop current.

Scanned by TapScanner

Note :

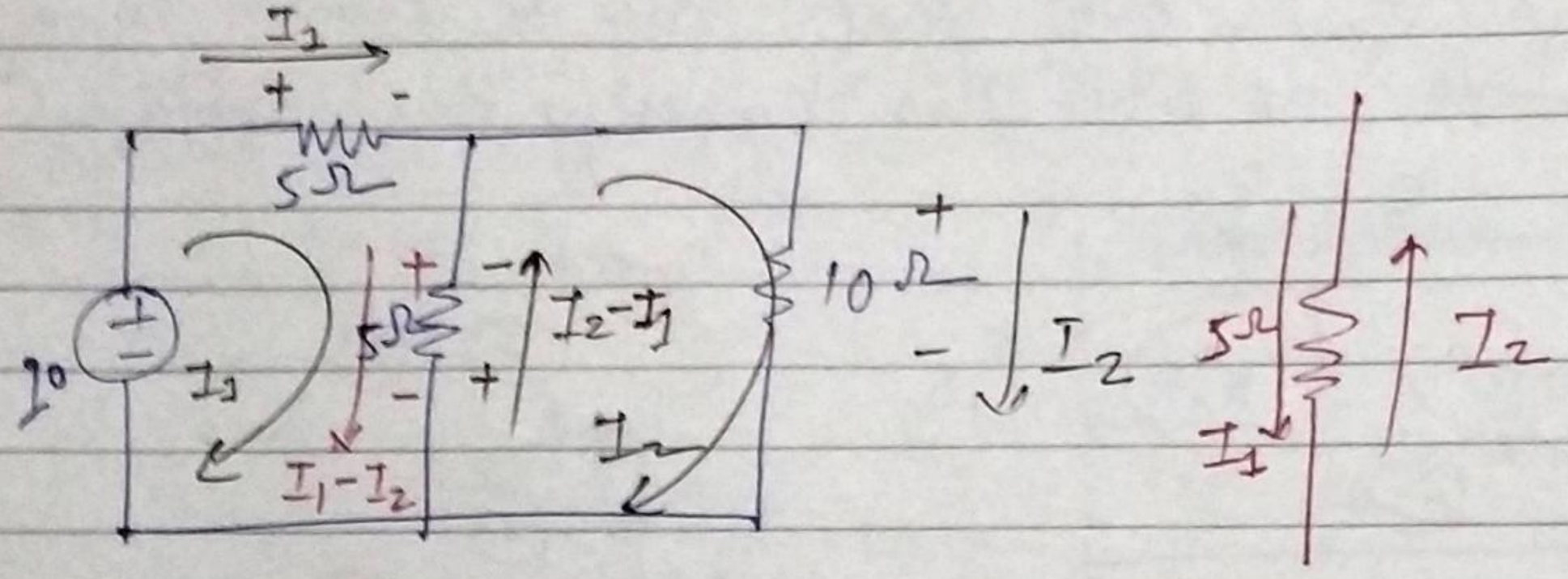
The direction of mesh current can be taken in any direction clk wise or anticlk wise. But taking clk wise direction gives the simpler analysis.

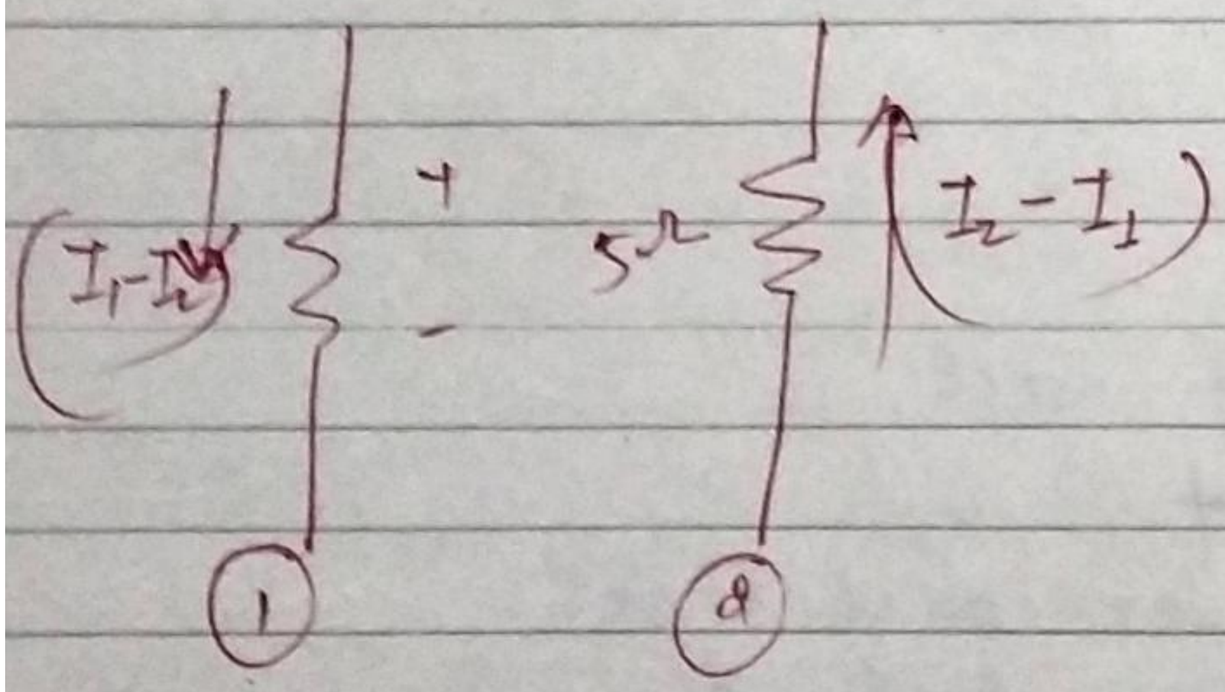
$$\boxed{\begin{aligned} \text{No of eq}^n &= \text{No of Meshes} \\ &= b-(N-1) \end{aligned}}$$

$b \rightarrow$ Total No of Branches

$N \rightarrow$ Total no of nodes

Ques :- Using Mesh analysis find the power loss in the 10 Ω resistor.





loop 1 :-

$$-10 + 5I_1 + 5(I_1 - I_2) = 0$$

$$10I_1 - 5I_2 = 10$$

$$2I_1 - I_2 = 2 \quad \text{--- (1)}$$

loop 2 :-

$$10I_2 + 5(I_2 - I_1) = 0$$

Scanned by TapScanner

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

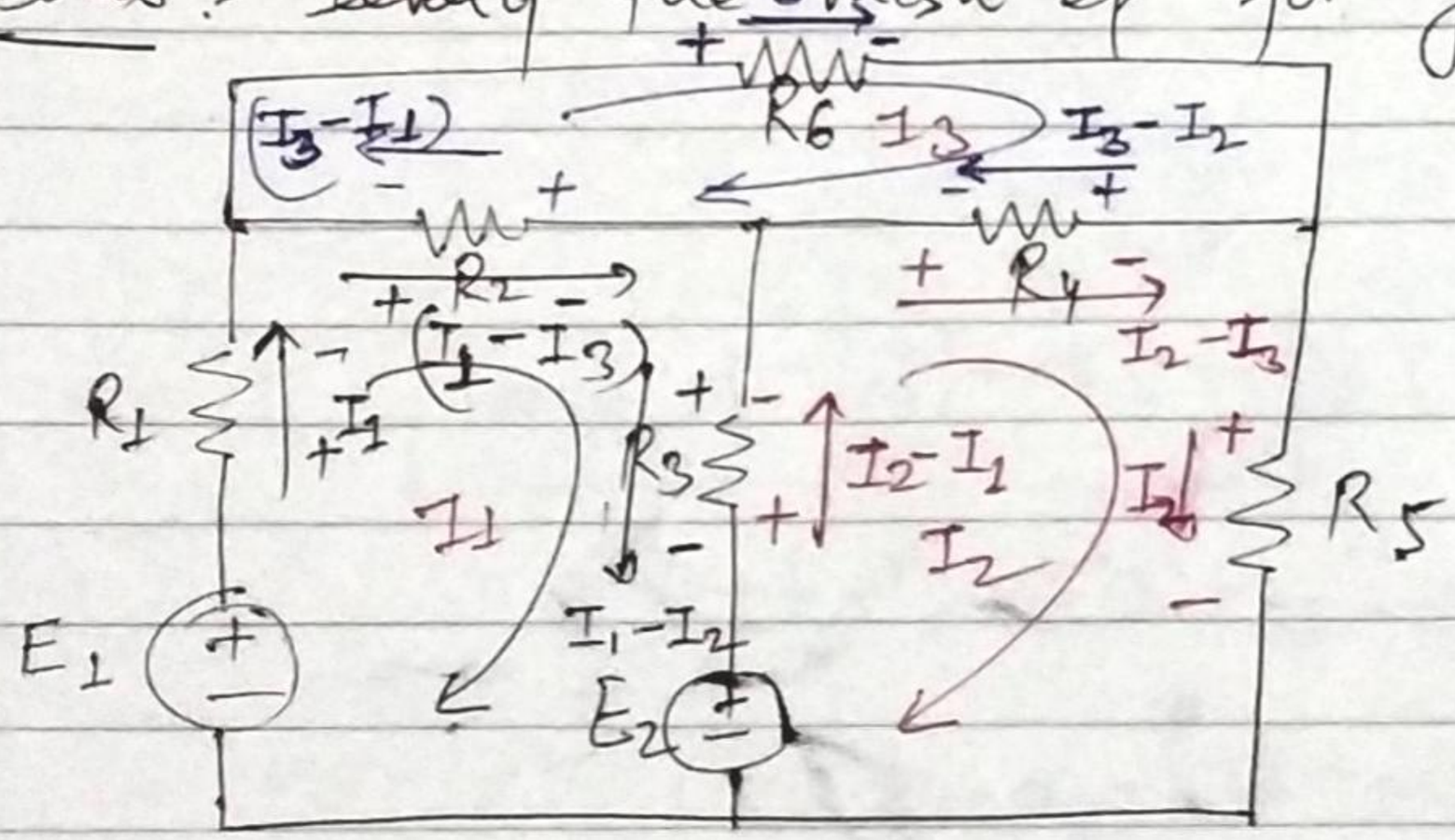
$$-I_1 + 3I_2 = 0 \quad \text{—— (2)}$$

(1) + 2 × (2)

$$5I_2 = 2 \qquad \boxed{I_2 = \frac{2}{5}\,A}$$

$$P_{10} = I_2^2 \cdot (10) = \frac{4}{25} \times 10 \boxed{= \frac{40}{25}\,W}$$

Ques :- Develop the mesh eqn for given N/W :-



loop 1 :-

$$-E_1 + I_1R_1 + (I_1 - I_3)R_2 + (I_1 - I_2)R_3 + E_2 = 0$$

loop 2 :-

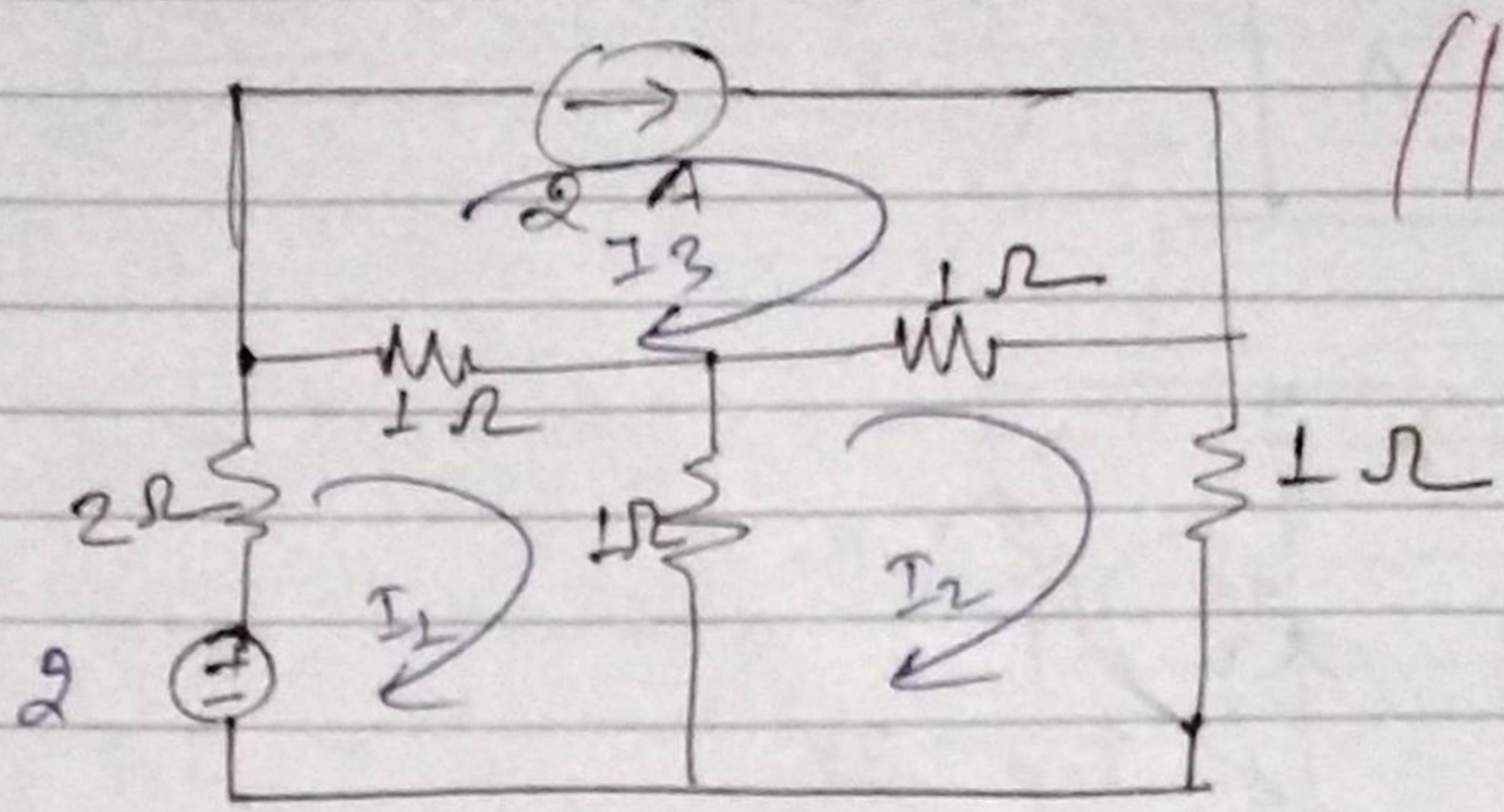
$$I_2R_5 - E_2 + (I_2 - I_1)R_3 + (I_2 - I_3)R_4 = 0$$

loop 3 :-

$$I_3R_6 + (I_3 - I_2)R_4 + (I_3 - I_1)R_2 = 0$$

Scanned by TapScanner

Ques. Find the mesh current in the below N/W –



// Single mesh bcz current source is only in one mesh. //

(1) :-

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

$$4I_1 - I_2 - I_3 = 2 \quad \text{—— (1)}$$

(2) :-

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

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

(3) :- $I_3 = 2A$ —— (3)

(3) in (1) & (2) :-

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

Scanned by TapScanner

$-I_1 + 3I_2 = 2$ —— (5)

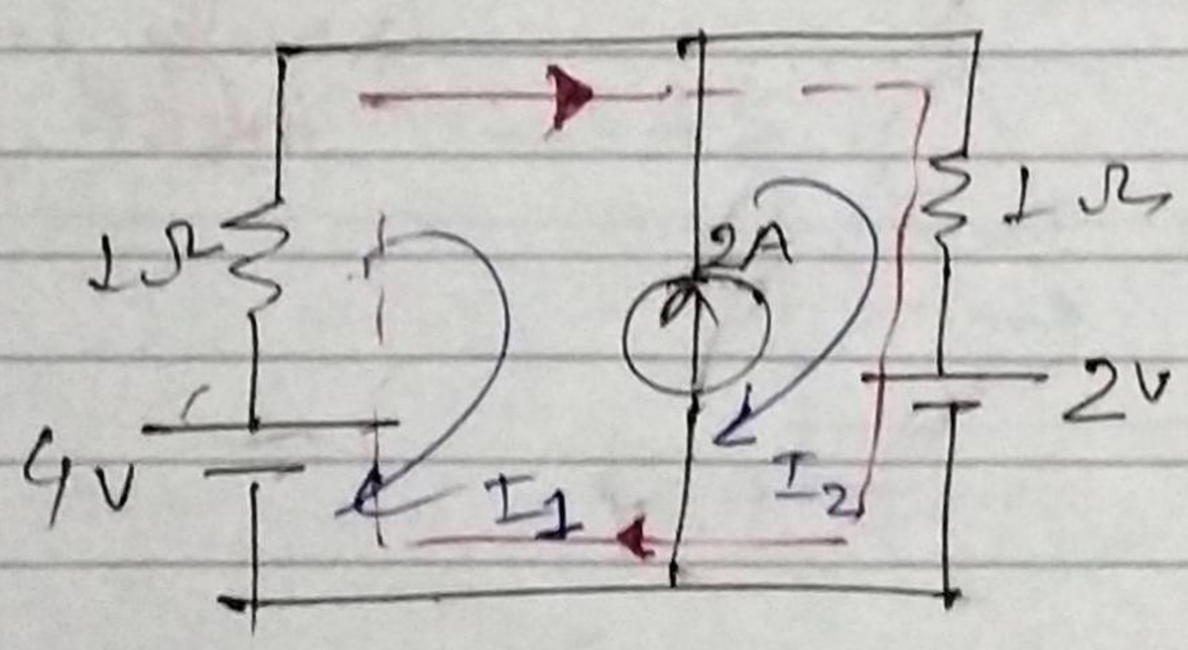
$3 \times (4) + (5) \div$

$11 I_1 = 14$ $\boxed{I_1 = \frac{14}{11} A}$

$-\frac{14}{11} + 3I_2 = 2 \Rightarrow 3I_2 = 2 + \frac{14}{11}$

$\boxed{I_2 = \frac{12}{11} A}$

Que :-



Super mesh :- $-4 + I_1 + I_2 + 2 = 0$

$I_1 + I_2 = 2$ —— (1)

$-I_1 + I_2 = 2$ —— (2)

(1) + (2) $2I_2 = 4$ $\boxed{I_2 = 2A}$ $\boxed{I_1 = 0 A}$

Scanned by TapScanner

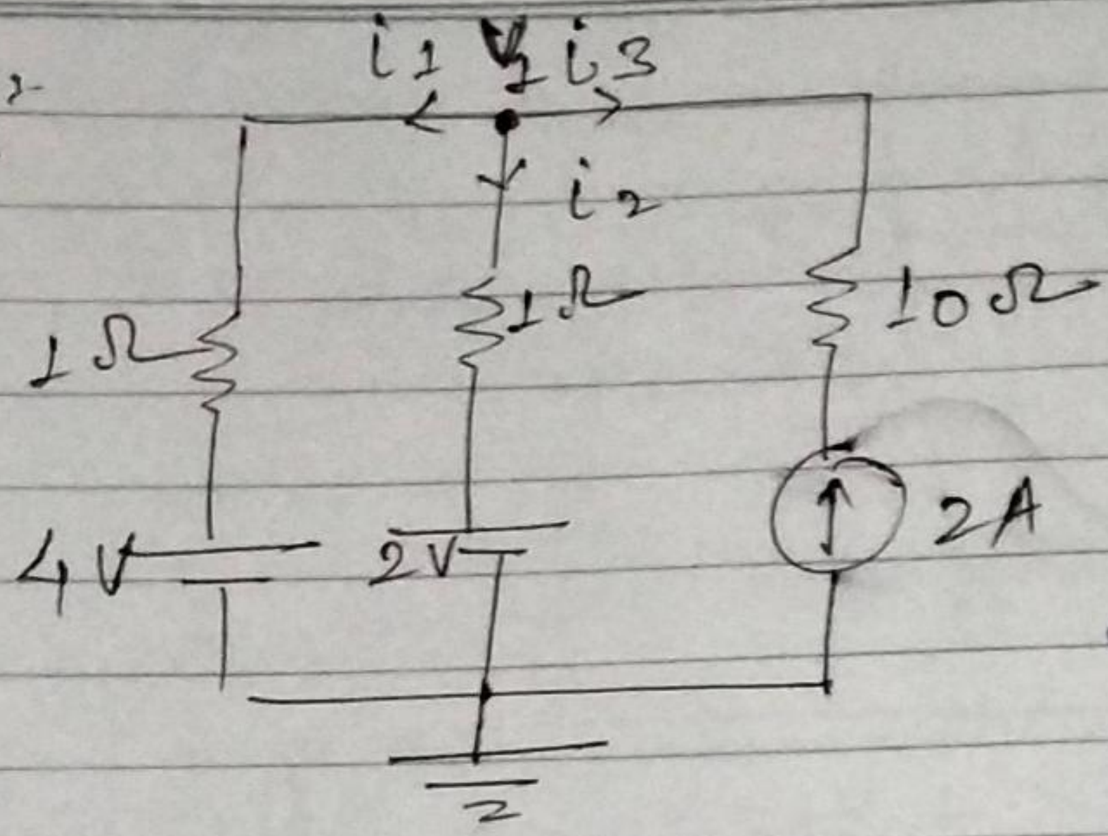
Nodal Analysis :-

Procedure :-

* Identify total no of nodes.
* Asign the voltage at each node, one of the node is taken as the reference Node. (OR datum) And the reference Node Potential should be equal to the ground potential.
* Develop KCL eqns for each non reference node.
* By solving KCL eqns find node voltages.

Scanned by TapScanner

Ques :-



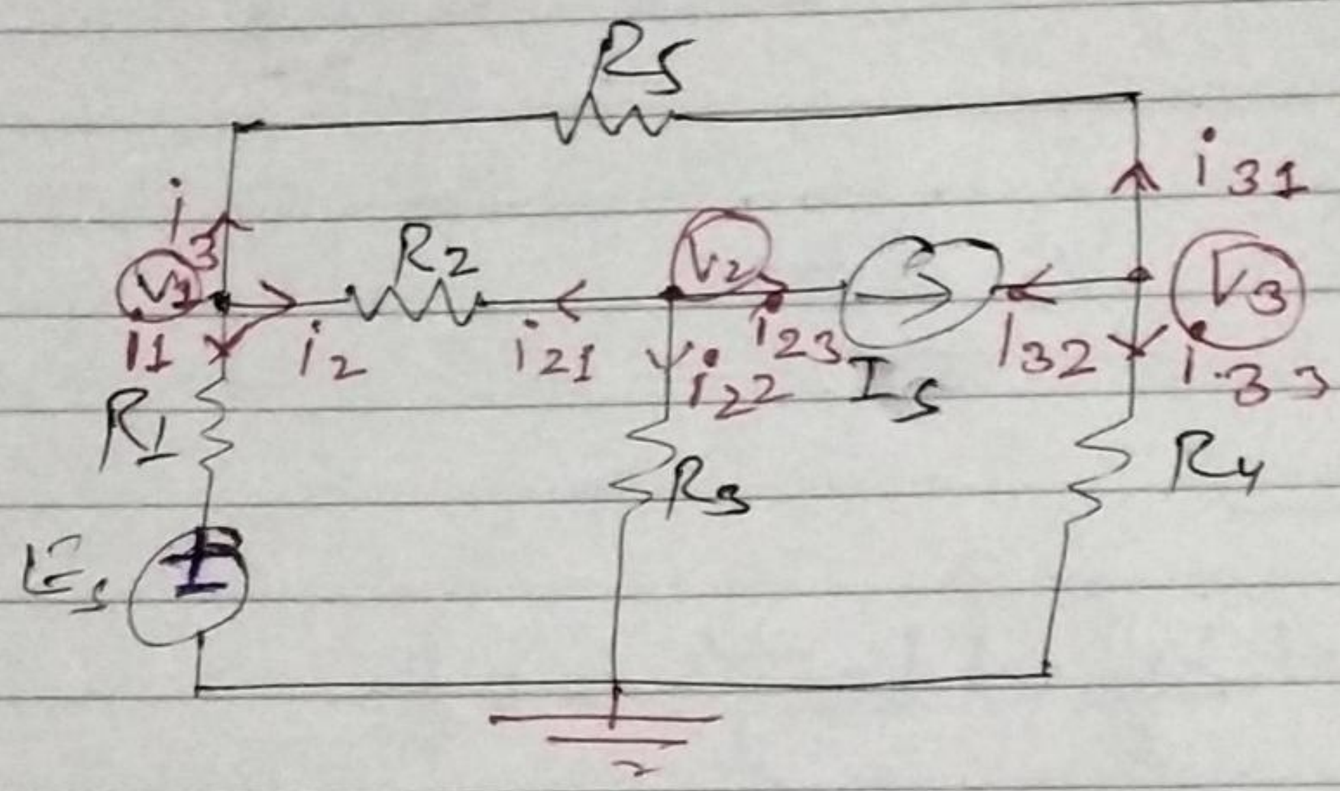
$$i_1 + i_2 + i_3 = 0$$

$$\frac{(V_1 - 0) - 4}{1} + \frac{(V_1 - 0) - 2}{1} - 2 = 0$$

$$2V_1 - 4 - 2 - 2 = 0$$

$$\boxed{V_1 = 4V}$$

Ques :-



Node 1 :-

$$i_1 + i_2 + i_3 = 0$$

$$\frac{(V_1 - 0) - E_s}{R_1} + \frac{(V_1 - V_2)}{R_2} + \frac{V_1 - V_3}{R_5} = 0$$

Node 2 :-

$$i_{21} + i_{22} + i_{23} = 0$$

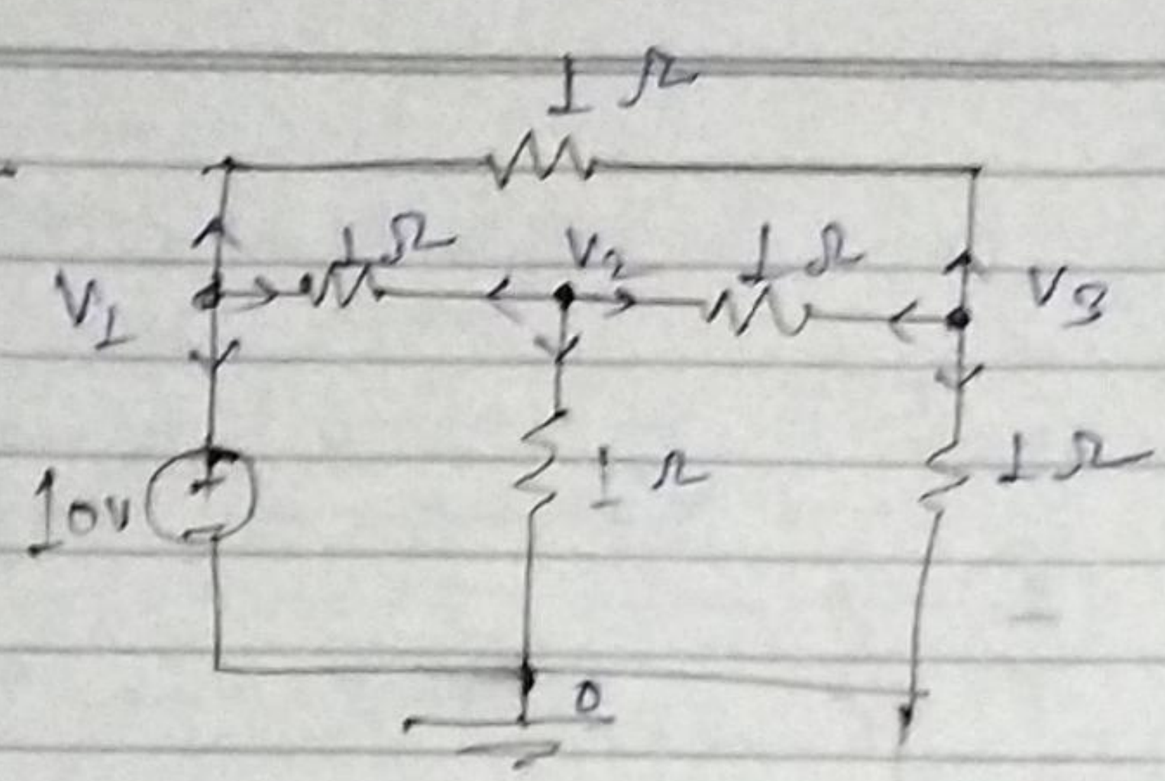
$$\frac{V_2 - V_1}{R_2} + \frac{V_2 - 0}{R_3} + I_s = 0$$

Node 3 :- $i_{31} + i_{32} + i_{33} = 0$

$$\frac{V_3 - V_1}{R_5} - I_s + \frac{V_3 - 0}{R_4} = 0$$

Scanned by TapScanner

Ques



$$\cancel{\frac{(V_1 - 0) - 10}{1} + \frac{V_1 - V_2}{1} + \frac{V_1 - V_3}{1} = 0}$$

At Node ① :- $V_1 = 10V$

At Node ② :-

$$\frac{V_2 - 10}{1} + \frac{V_2}{1} + \frac{V_2 - V_3}{1} = 0$$

$$3V_2 - V_3 = 10 \quad \text{—— ①}$$

At Node ③ :-

$$\frac{V_3 - 10}{1} + \frac{V_3 - V_2}{1} + \frac{V_3}{1} = 0$$

$$-V_2 + 3V_3 = 10 \quad \text{—— ②}$$

① × 3 + ②

$8V_2 = 40V$

$\boxed{V_2 = 5V}$

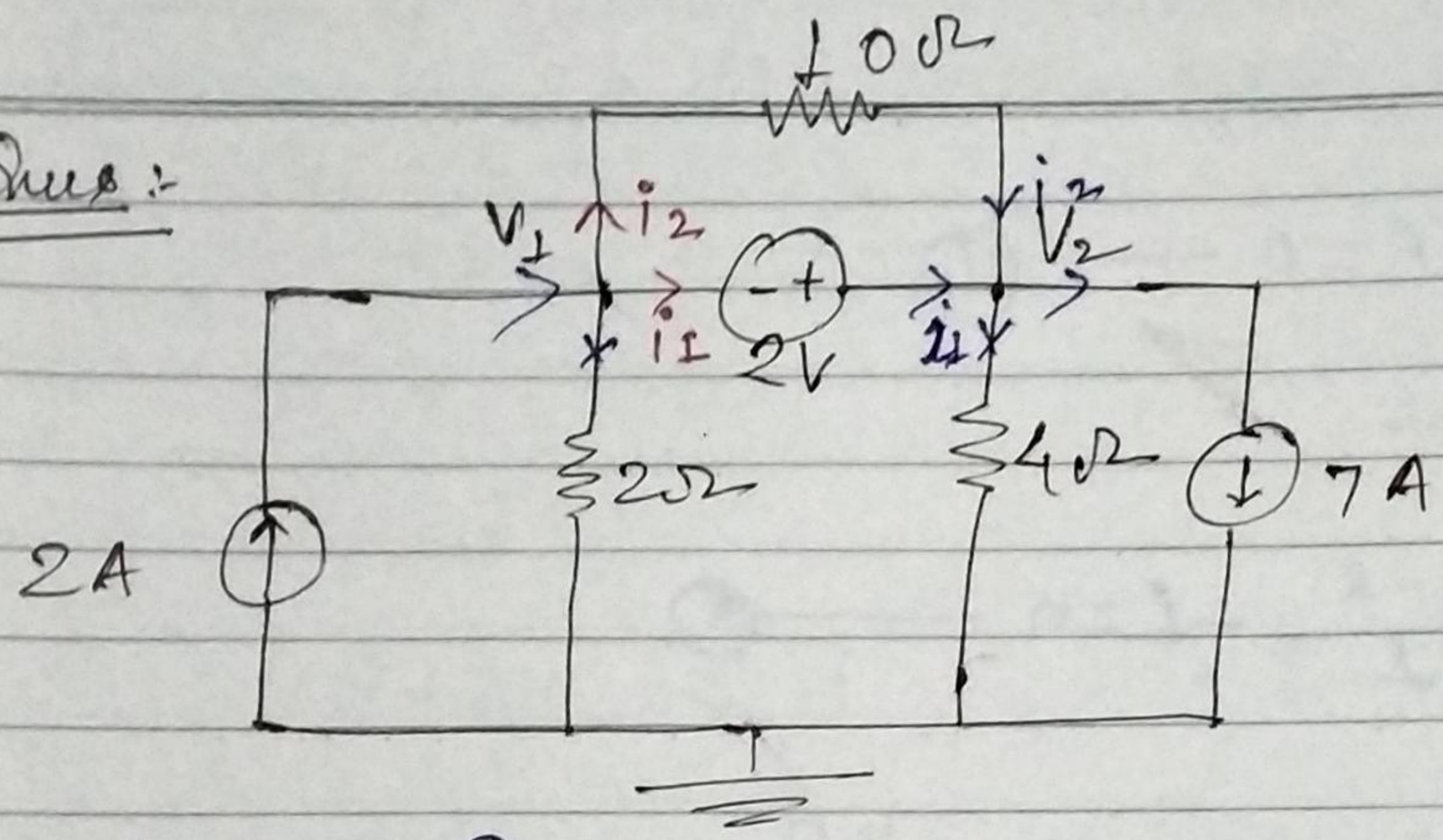
$-5 + 3V_3 = 10$

$3V_3 = 15$

$\boxed{V_3 = 5V}$

Scanned by TapScanner

Ques :-



At Node ① :-

$$-2 + \frac{V_1}{2} + i_1 + i_2 = 0 \quad \text{——} \; ①$$

At Node ② :-

$$-i_2 - i_1 + \frac{V_2}{4} + 7 = 0 \quad \text{——} \; ②$$

① + ②

$$\underbrace{-2 + \frac{V_1}{2}}_{\text{From first Node}} + \underbrace{\frac{V_2}{4} + 7}_{\text{from second Node}} = 0 \rightarrow \text{Super Node eq}^n \; ①$$

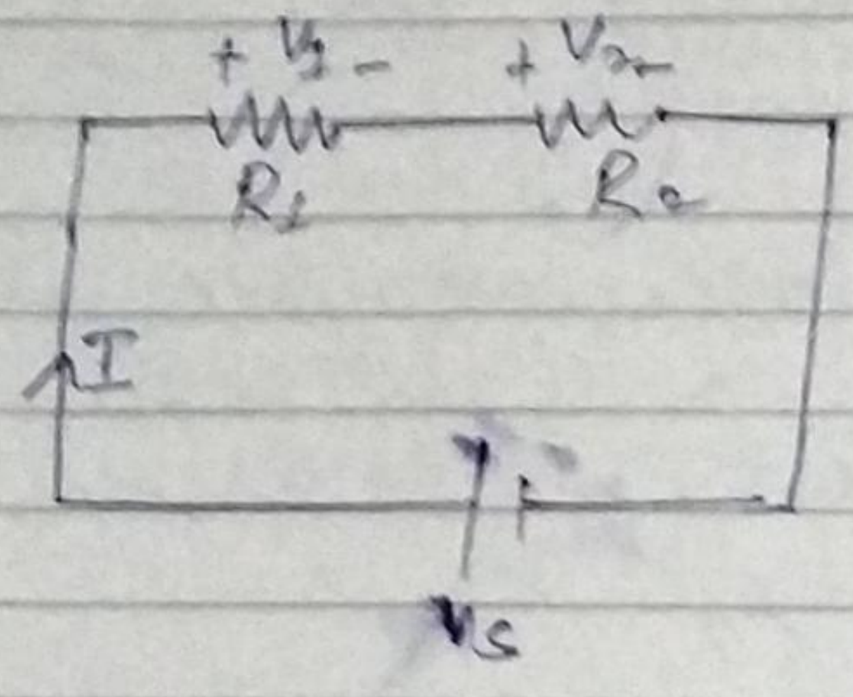
and from the ckt —

$$V_2 - V_1 = 2 \quad \text{——} \; ③$$

$$\therefore \; V_1 = -7.33V \qquad V_2 = -5.33V$$

Scanned by TapScanner

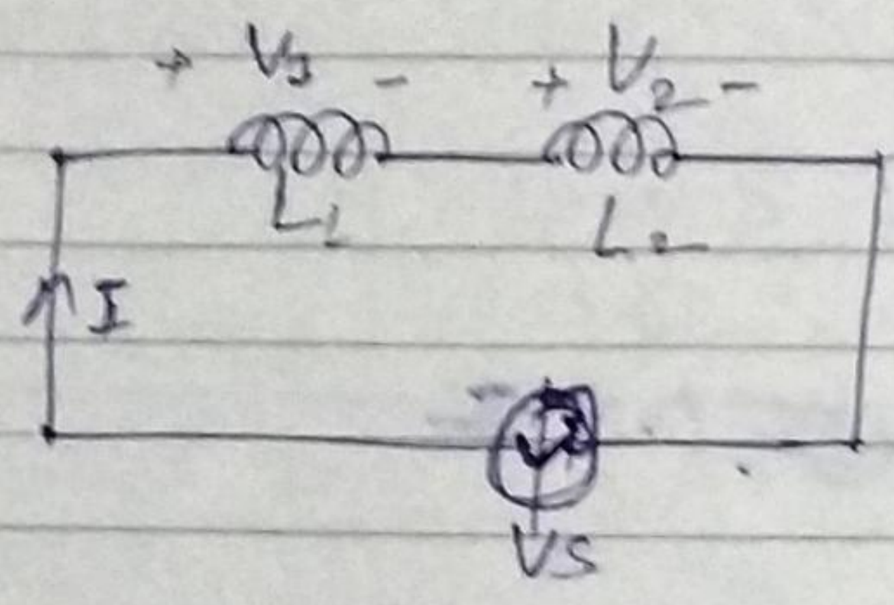
Voltage Division in Series Combination :-



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

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

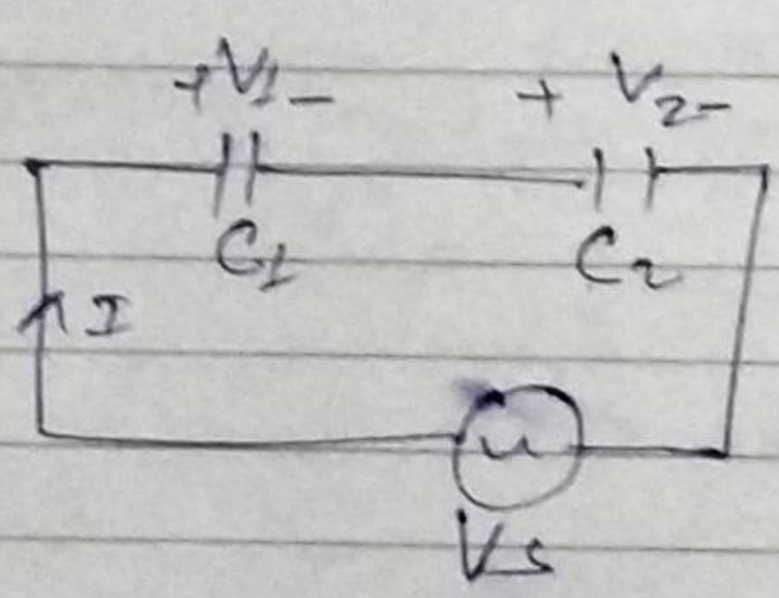
$$V_2 = V_s \cdot \frac{R_2}{R_1 + R_2}$$



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

$$V_1 = V_s \left(\frac{L_1}{L_1 + L_2} \right)$$

$$V_2 = V_s \left(\frac{L_2}{L_1 + L_2} \right)$$



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

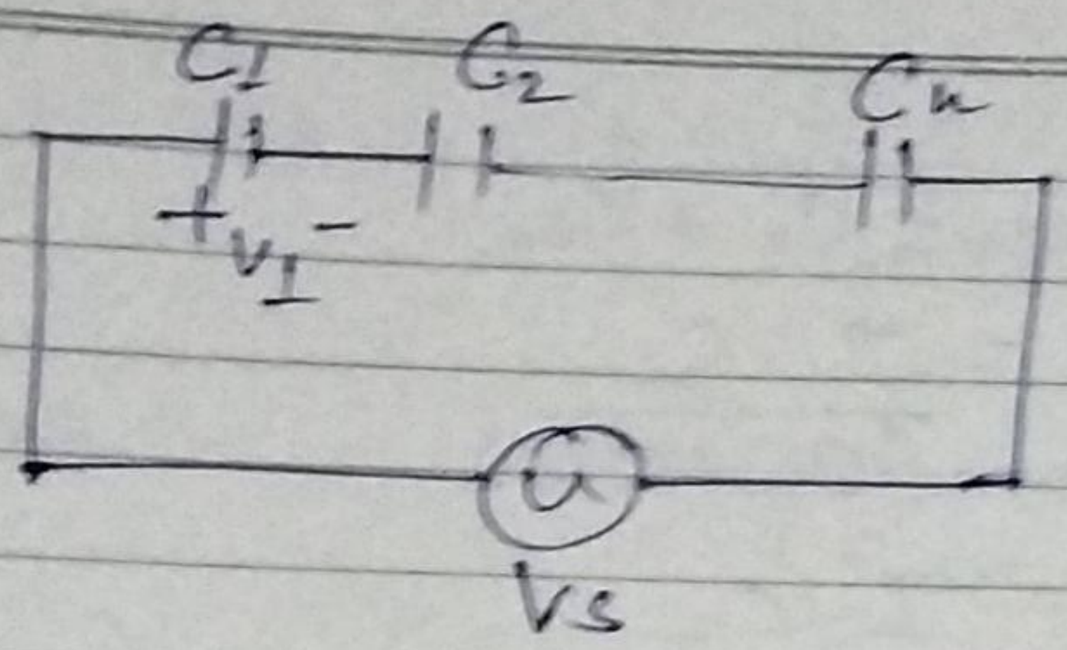
$$V_1 = V_s \cdot \frac{C_2}{C_1 + C_2}$$

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

$$V_1 = V_s \cdot \frac{\frac{1}{j\omega C_1}}{\frac{1}{j\omega C_1} + \frac{1}{j\omega C_2}} = \frac{V_s \, C_1 C_2}{C_1 + C_2} \left(\frac{1}{C_1} \right)$$

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

Scanned by TapScanner

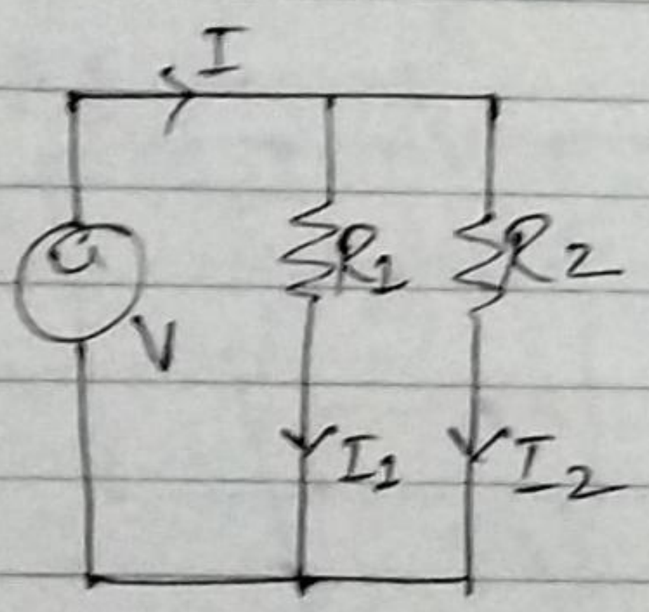


$$V_1 = V_s \cdot \frac{\frac{1}{C_1}}{\left[\frac{1}{C_1} + \frac{1}{C_2} + \cdots + \frac{1}{C_n}\right]}$$

$$V_1 = \frac{V_s}{\left(\frac{1}{j\omega C_1} + \frac{1}{j\omega C_2} + \cdots \frac{1}{j\omega C_n}\right)} \times \frac{1}{j\omega C_1}$$

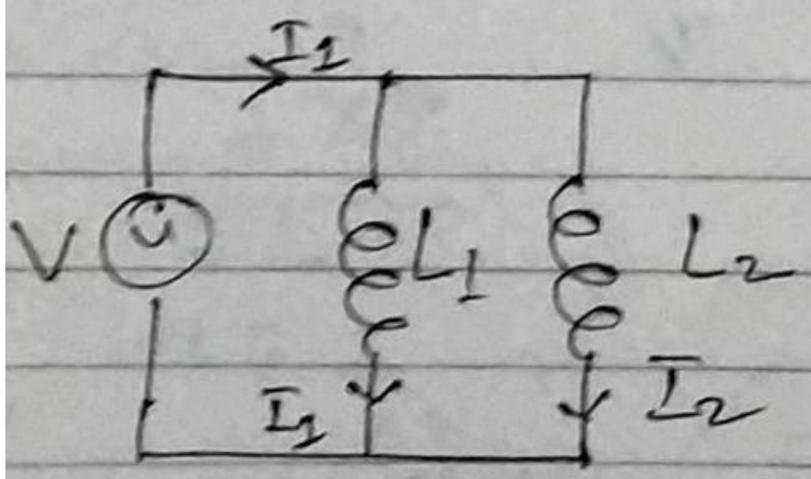
$$\boxed{\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots \frac{1}{C_n}}$$

Parallel Combination in Current Division:-



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

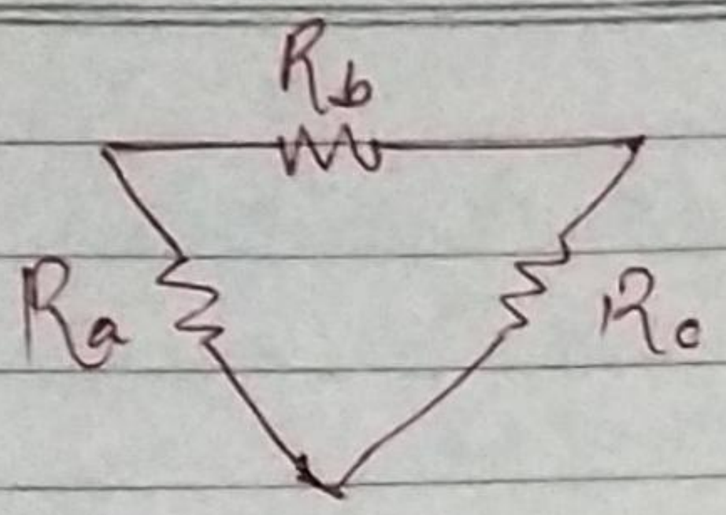
$$I_1 = \frac{I \cdot R_2}{R_1 + R_2} \qquad I_2 = \frac{I \cdot R_1}{(R_1 + R_2)}$$



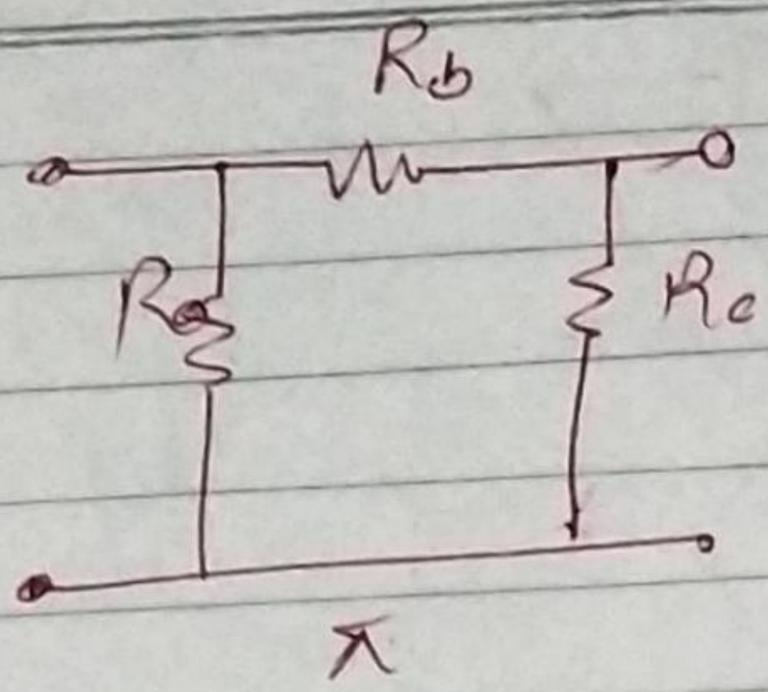
$$\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2}$$

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

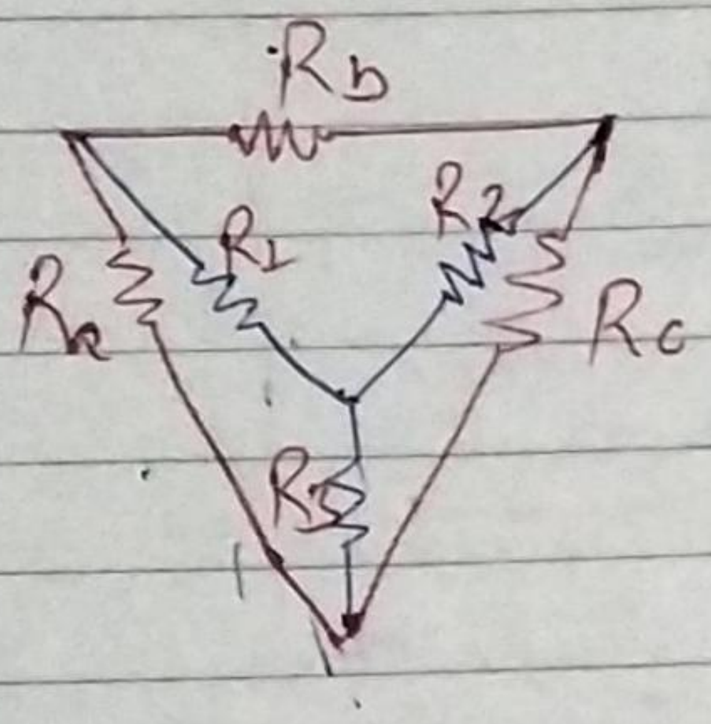
Scanned by TapScanner



DELTA



STAR



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 :-

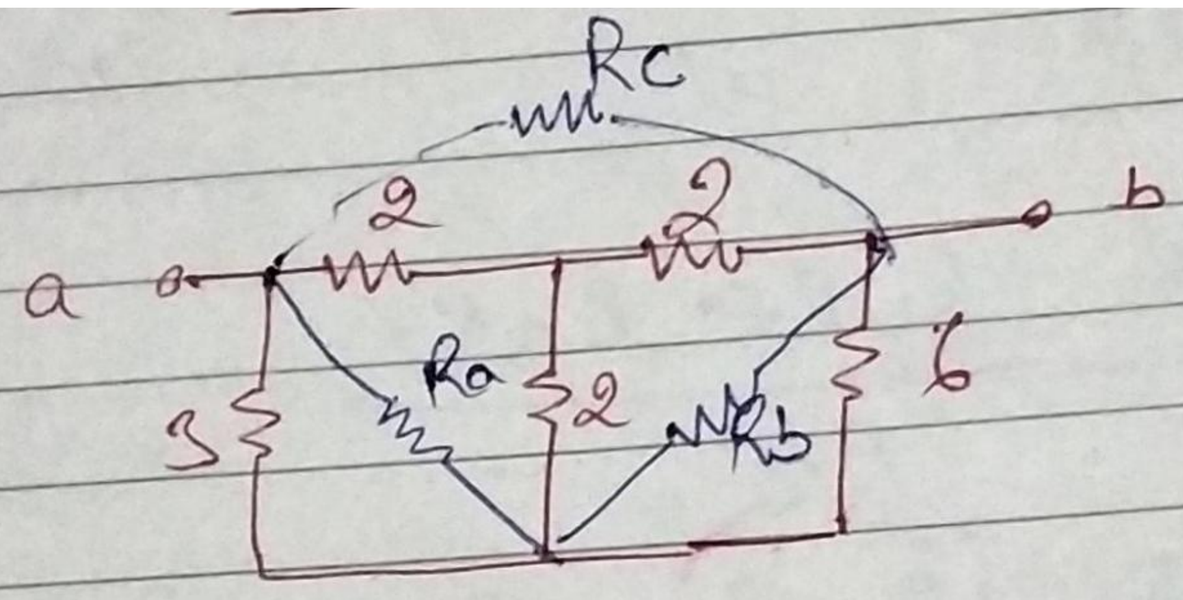
$$R_a = \frac{R_1 R_2 + R_2 R_3 + R_3 R_1}{R_2}$$

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

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

Scanned by TapScanner

Ques



Star to Delta

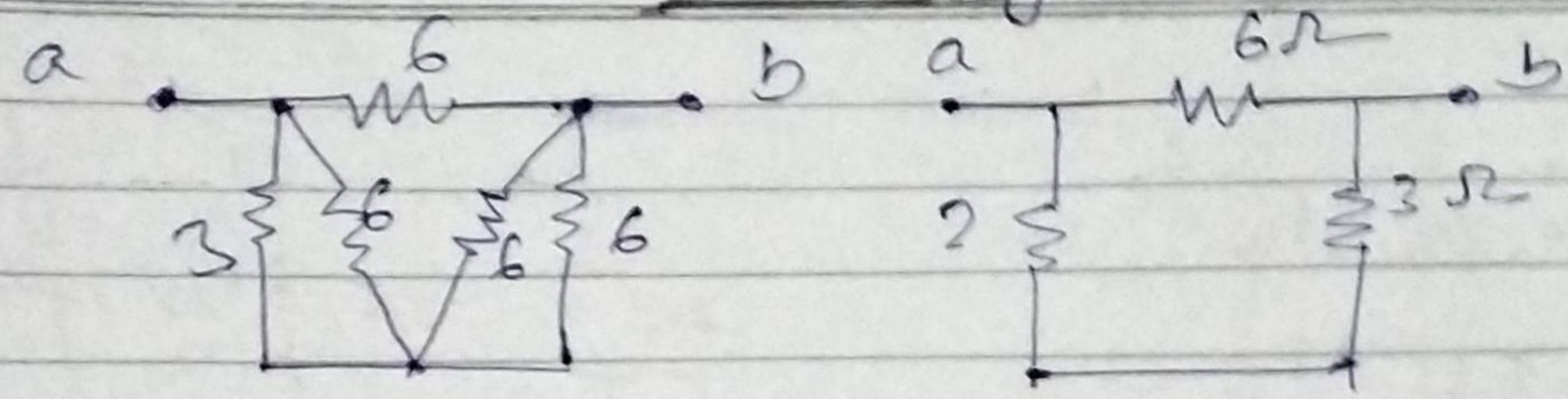
$$R_a = \frac{2\times2 + 2\times2 + 2\times2}{2} = 6\,\Omega$$

$$R_b = \frac{2\times2 + 2\times2 + 2\times2}{2} = 6\,\Omega$$

and, $R_c = 6\,\Omega$

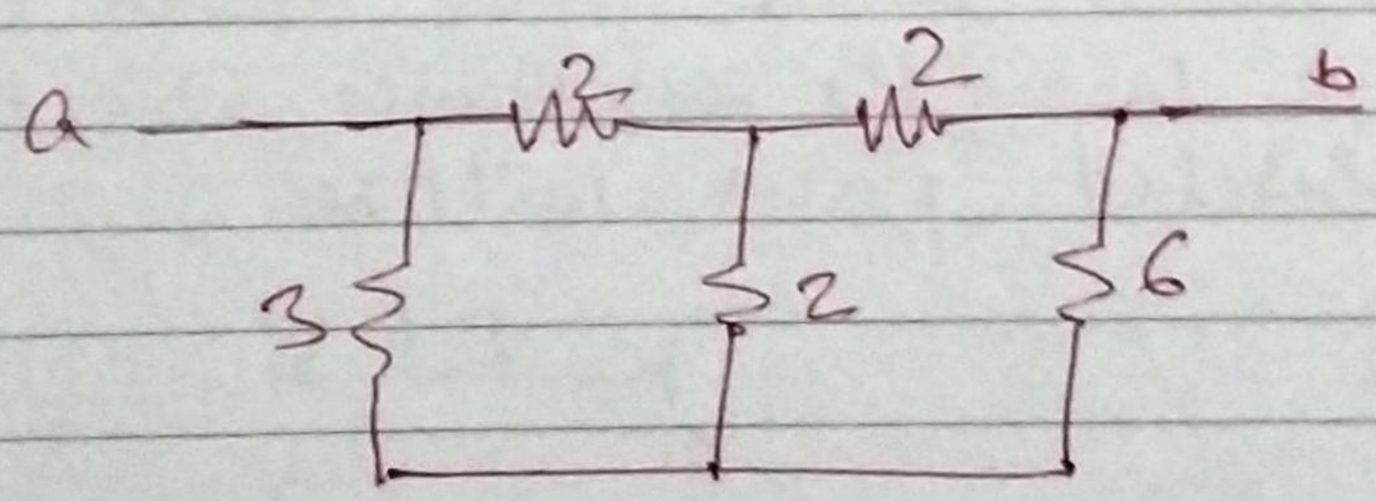
Scanned by TapScanner

NOTE:- ① When Resistors of equal value transform from star to Delta the resistance value increases by 3 times (and same of Inductance) ~~& capacitance~~ ② When capacitors of equal value transformed from Y to Delta the capacitance value decreases by 3 times.



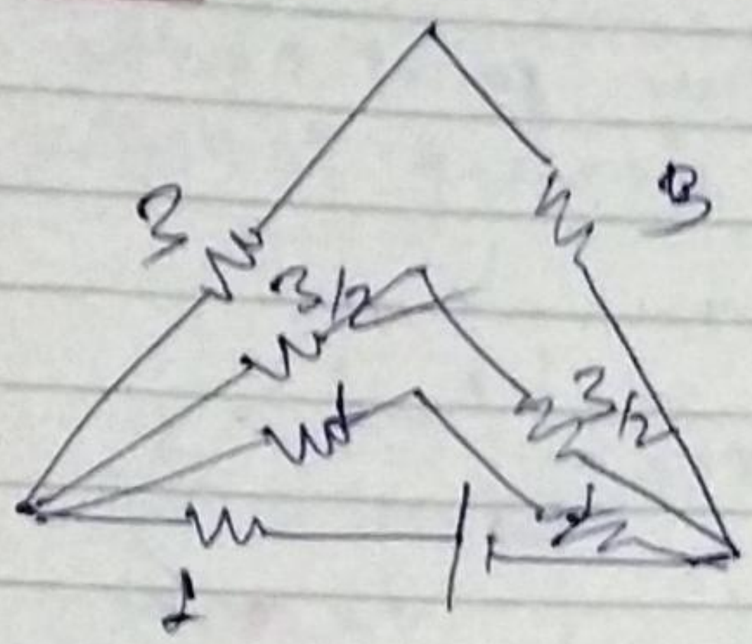
$R_{ab} = 6 \,||\, (2+3) \Rightarrow 6 \,||\, 5 = \frac{6 \times 5}{6+5} = \frac{30}{11}\,\Omega$

Delta to Star :-

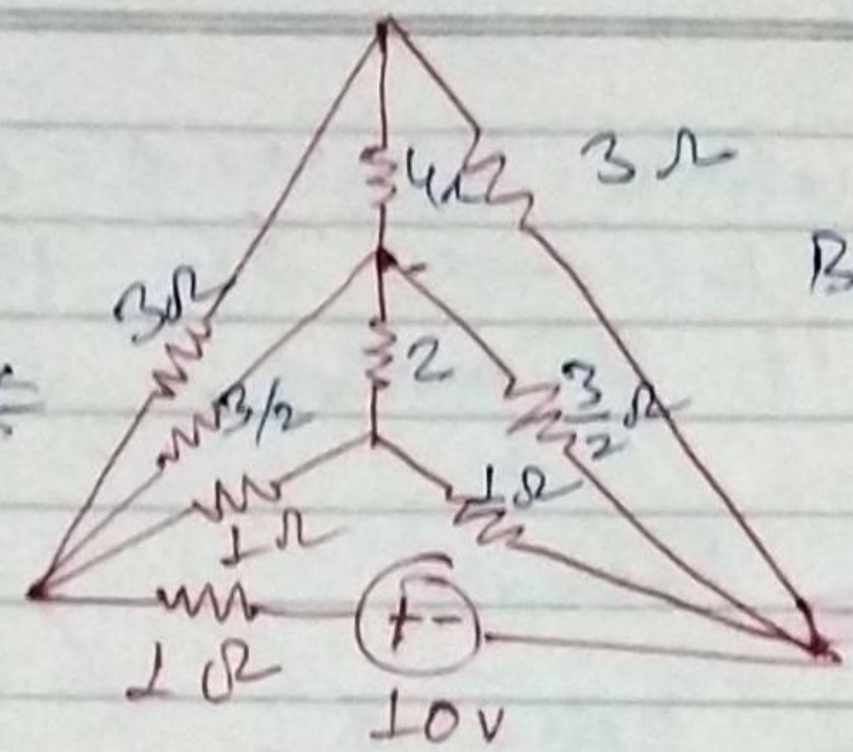


Scanned by TapScanner

Ques :-

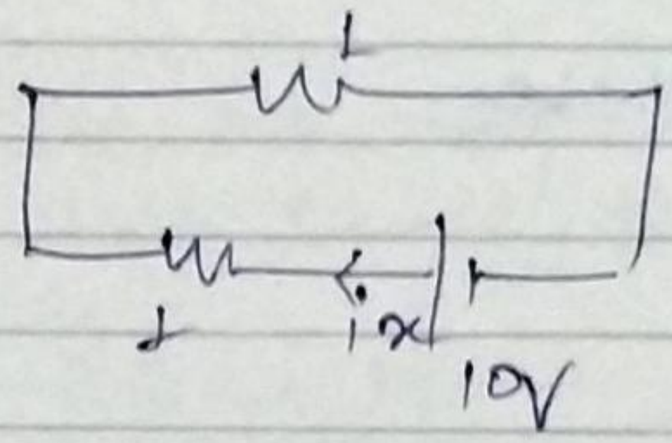


⇐



Balance bridge

$6 \,||\, 3 \,||\, 2 \quad = 2 \,||\, 2 \quad = 1\,\Omega$



$\boxed{ix = 5A}$

Type of Elements :-

1. Active And Passive Elements:- Active Elements— when an elements ~~are~~ is capable of delivering energy for infinite time or capable of providing power gain then the element is called as active element. for eg:- Current source, voltage source, transistor, opamp etc

Passive Elements:- when an element is not capable of providing energy independently for an infinite time or not capable of providing power gain then the element is called passive element.

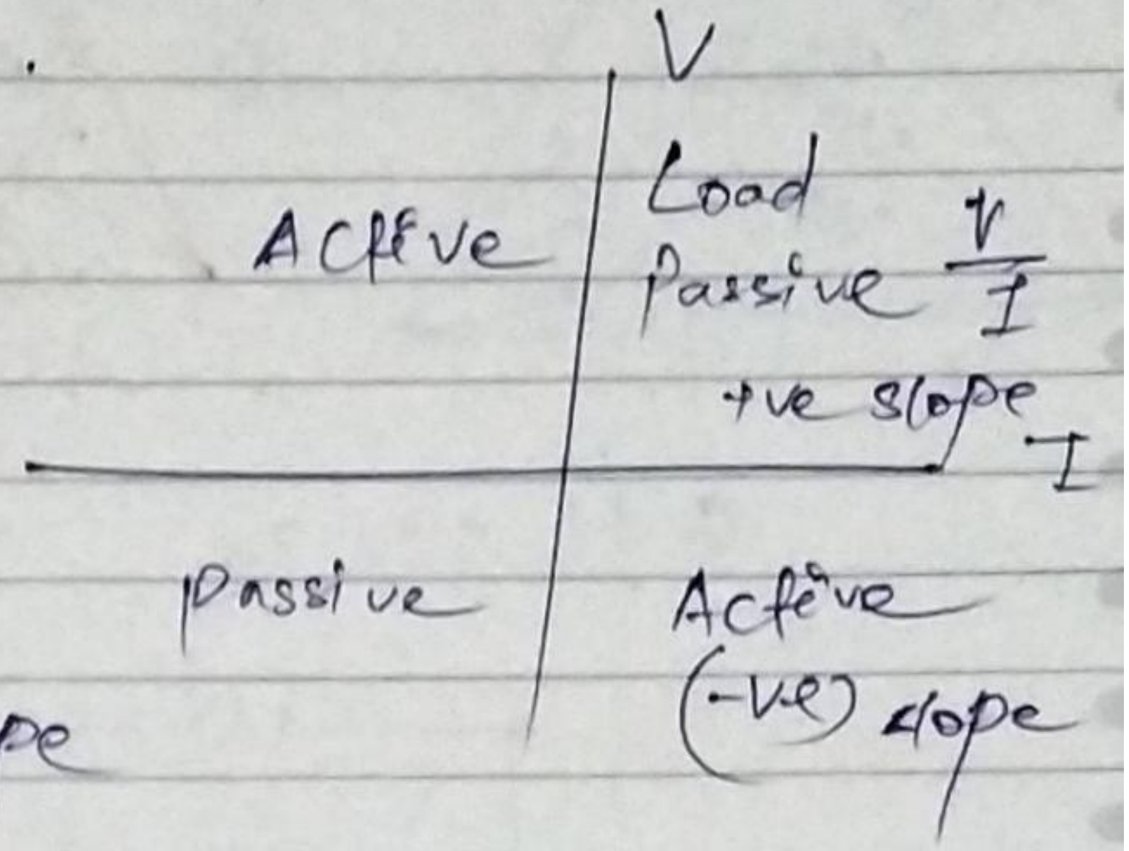
Eg:- Resistor, Inductor, Capacitor, transformer.

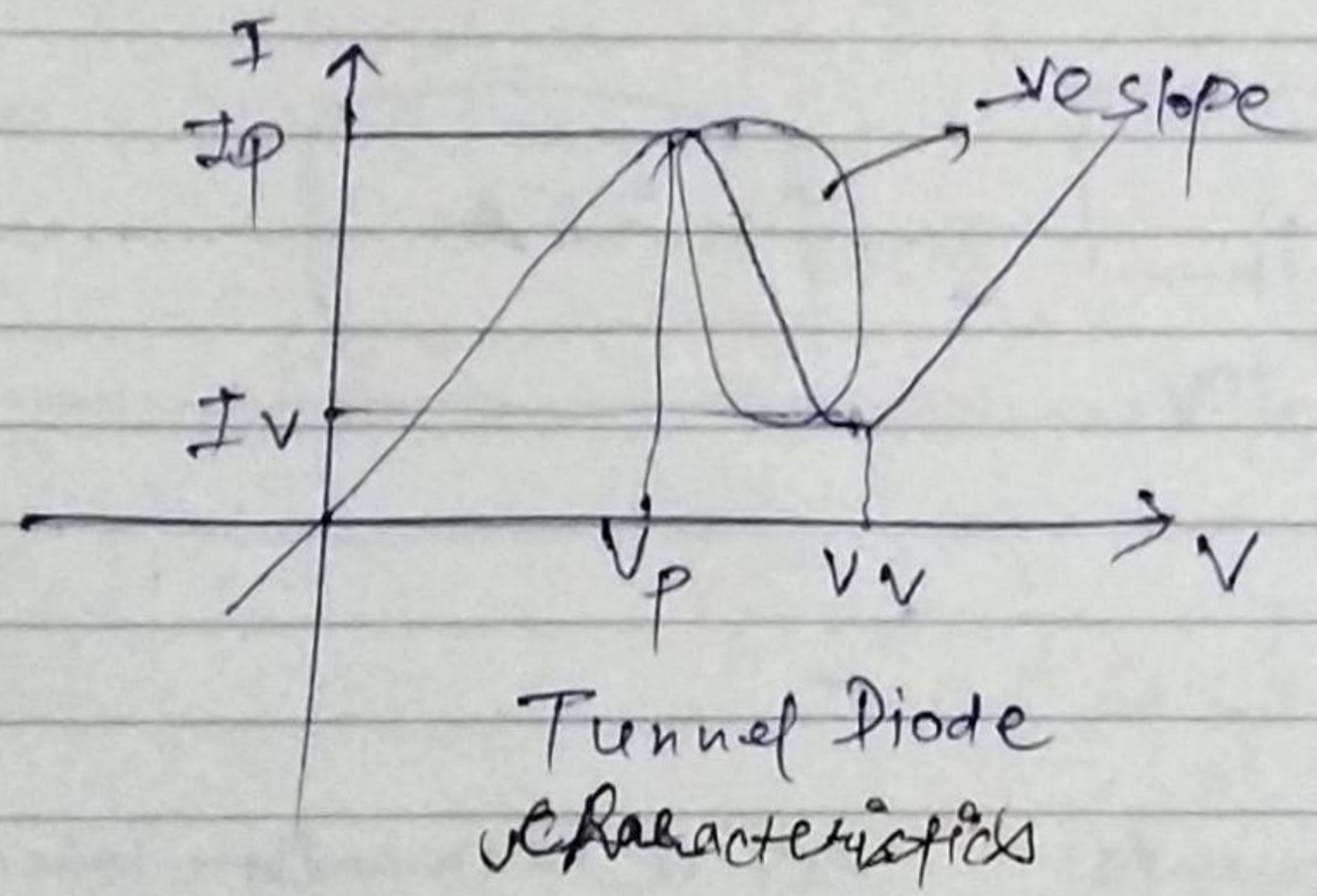
Scanned by TapScanner

* If ratio of voltage to current at any point on the char. curve is (-)ve then the element is active otherwise it is passive.

$P = VI$ Passive

$P = -VI$ Delivered





Tunnel Diode
Characteristics

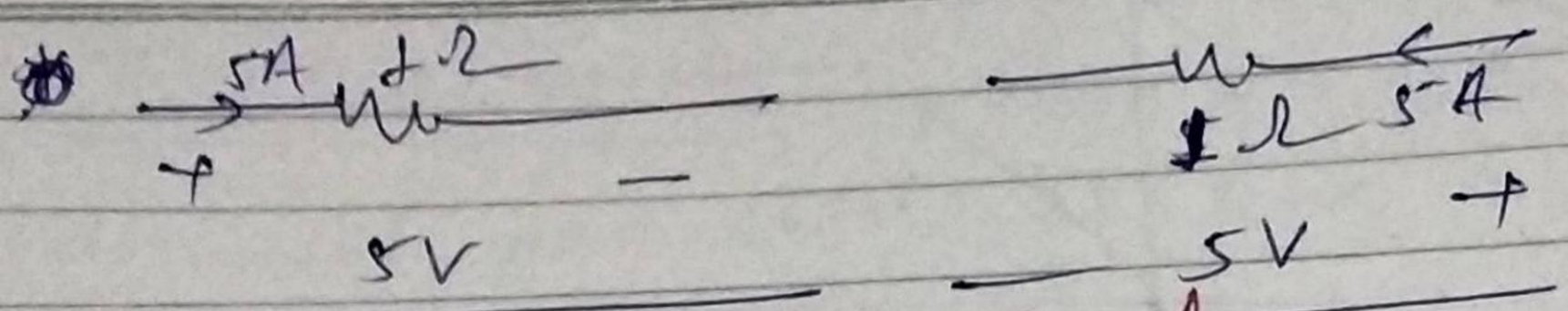
Bidirectional And unidirectional Element :-

* Bidirectional - when element properties and char. are independent of the direction of the current then the element is called as Bidirectional element.

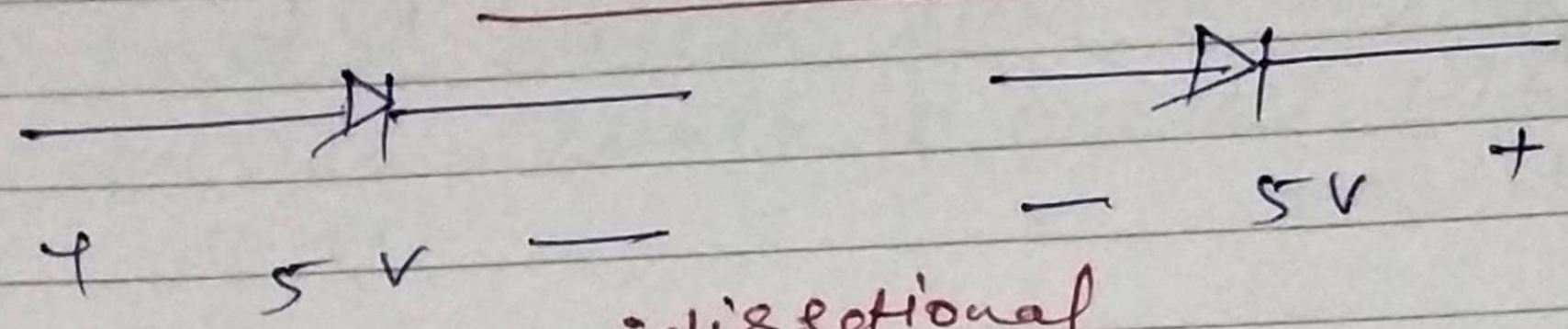
~~Unidir~~ * when element properties and char. depends upon the direction of the current then the element is called as unidirectional element.

* If the characteristic curve is similar in opposite quadrante then the element is bidirectional otherwise it is unidirectional.

Scanned by TapScanner



Bidirectional



unidirectional

Lumped Elements :- are considered as the separate elements which are very small in size.

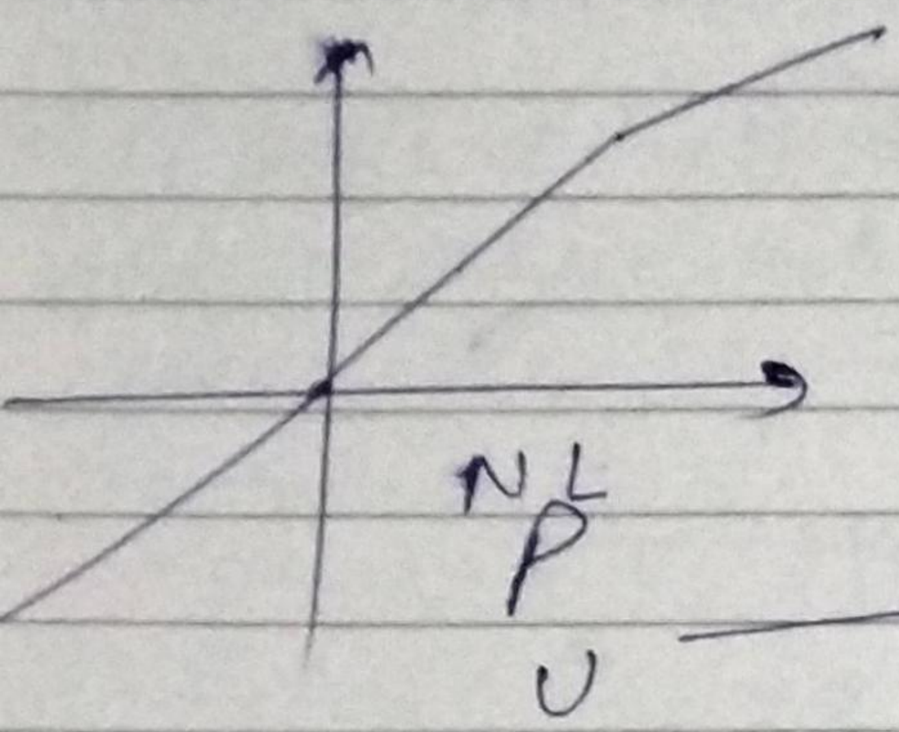
Distributed Elements — are electrically non separable.

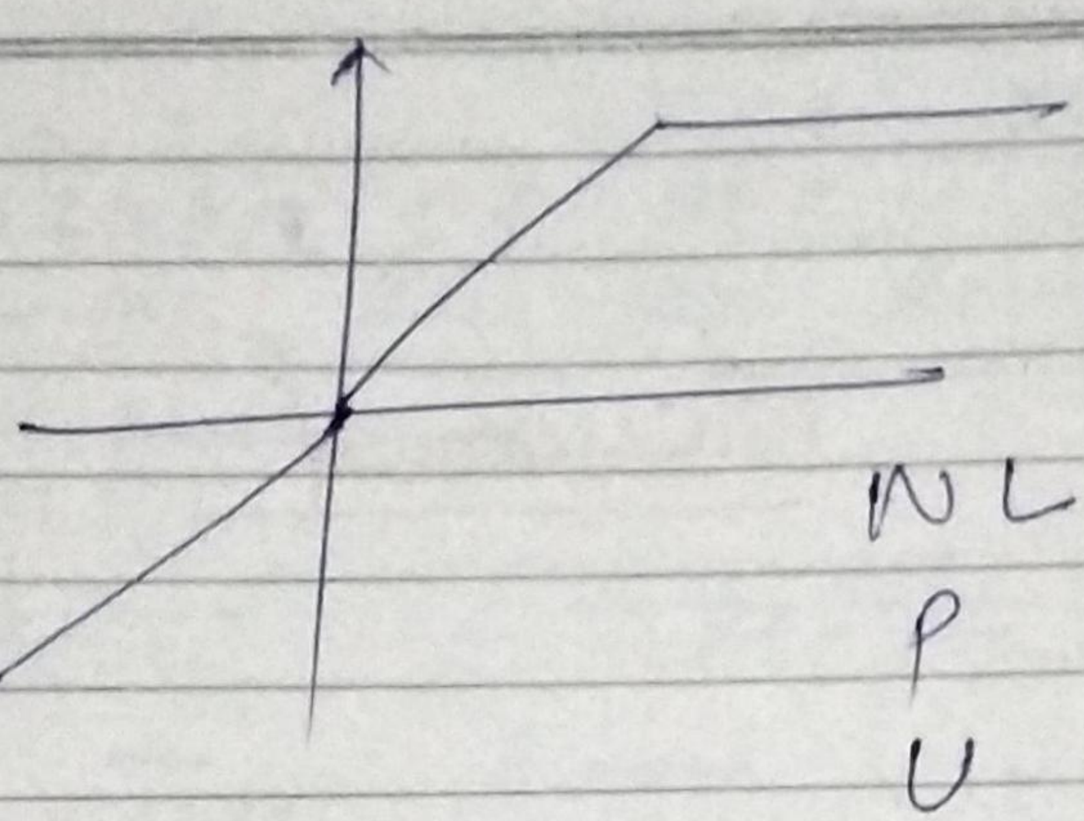
Linear And Non Linear Element :-

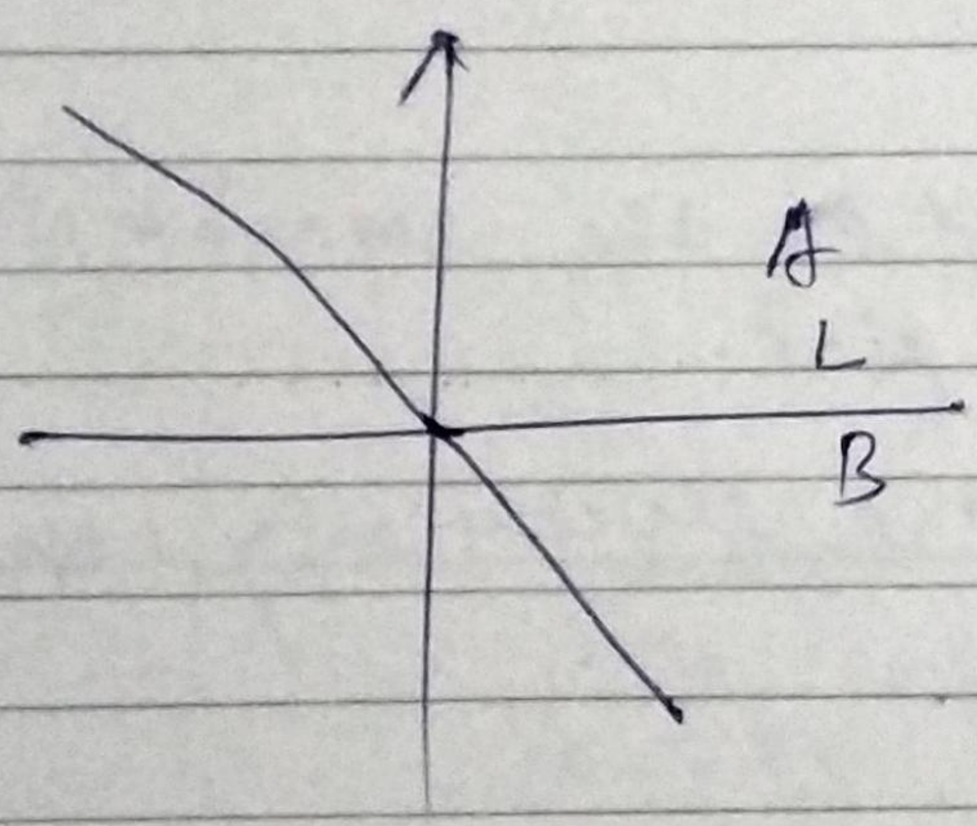
* Linearity is the property of an element is deriving a linear relationship b/w excitation and response.

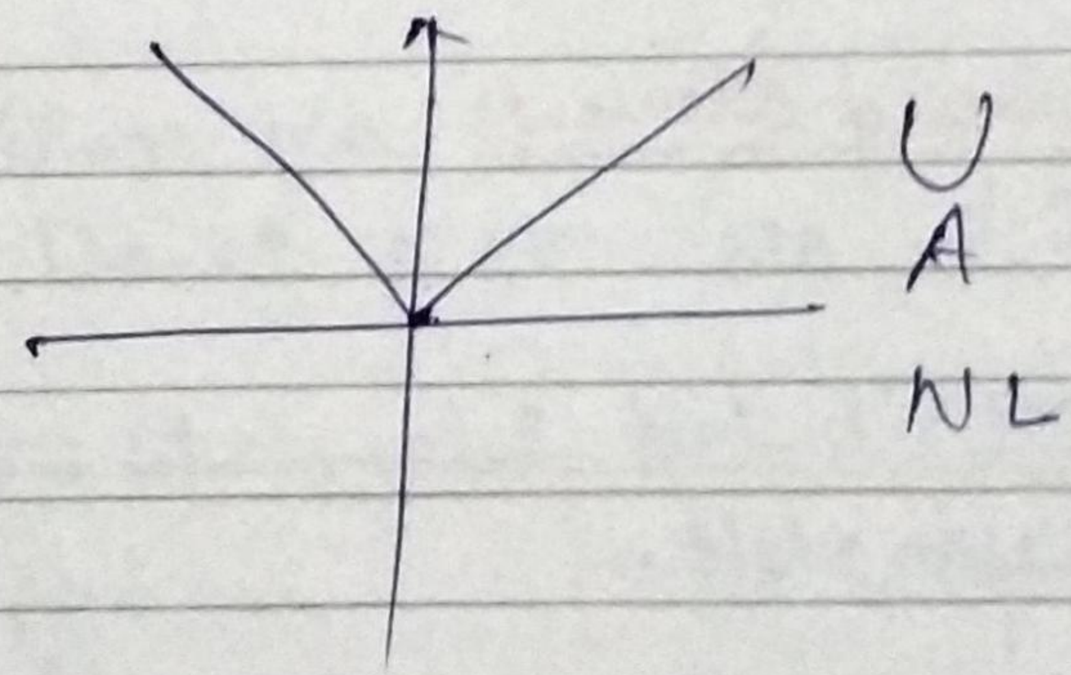
* Every Linear element must exibit bidirectional property.

Scanned by TapScanner





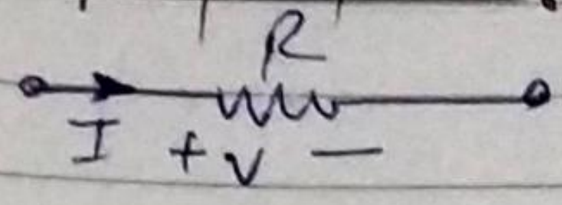




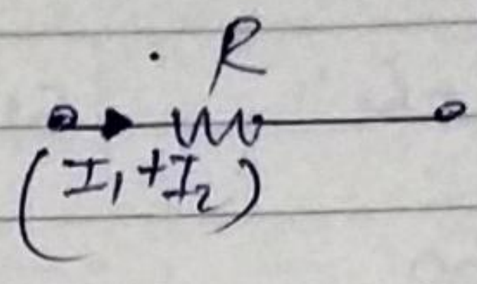
Scanned by TapScanner

Theorems :-

Superposition Theorem :-



$V = IR$

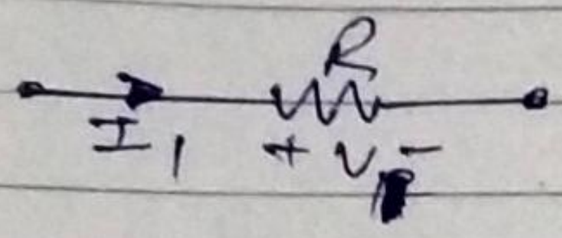


It follows law of additivity

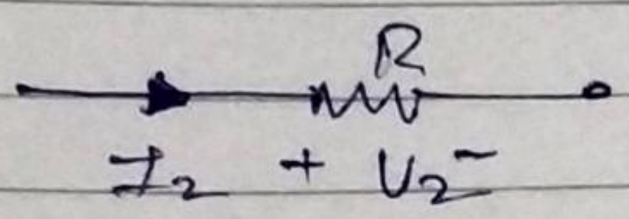
$V' = (I_1+I_2)R$

$= I_1R + I_2R$

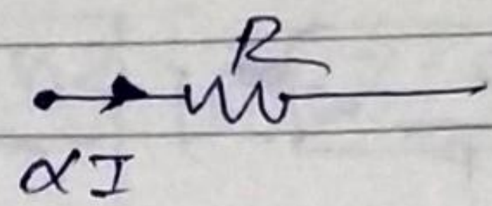
$= V_1 + V_2$



$V_1 = I_1R$



$V_2 = I_2R$

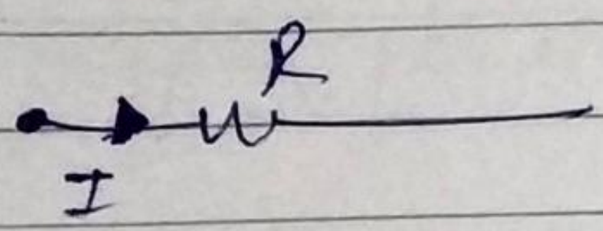


$V'' = (\alpha I)R$

$= \alpha(IR)$

$= \alpha V$

it follows law of homogeinity so it is linear.



$P = I^2R$

Non Linear due to NL (square) operator.

→ In a Linear Bilateral N/W containing more than one independent voltage and current source, the response in any element is the sum of the responses obtained with one source acting at a time and other sources be deactivated.

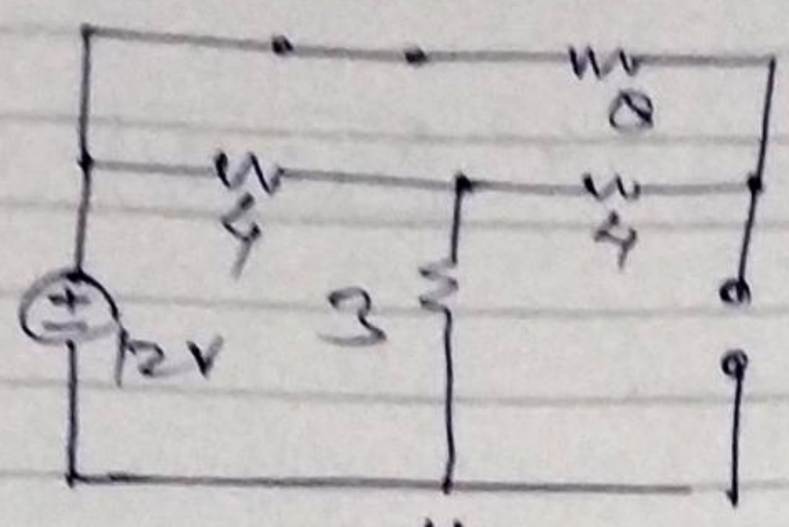
→ Deactivation means all independent sources are replaced by their internal resistances i.e voltage source is replaced by S.C. and current source by O.C.

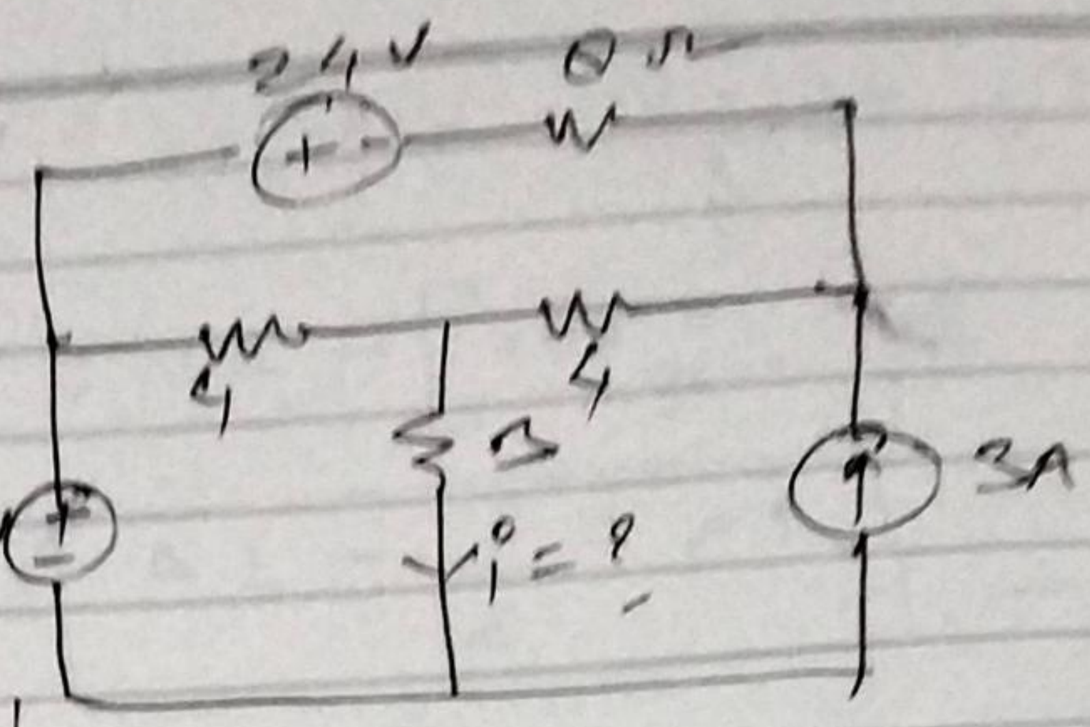
(Dependent sources remain as it is.)

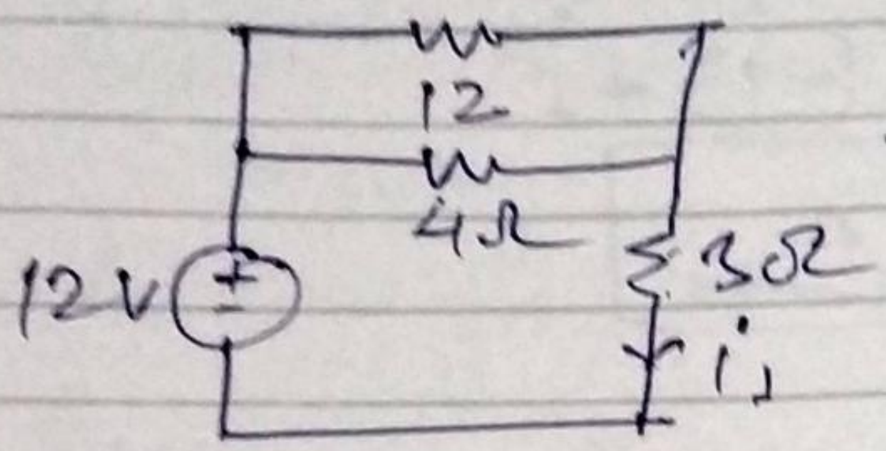
Ques:- Find the current flow in 3 Ω resistor by the use of superposition theorem.

Scanned by TapScanner

Case 1 :- 12 V



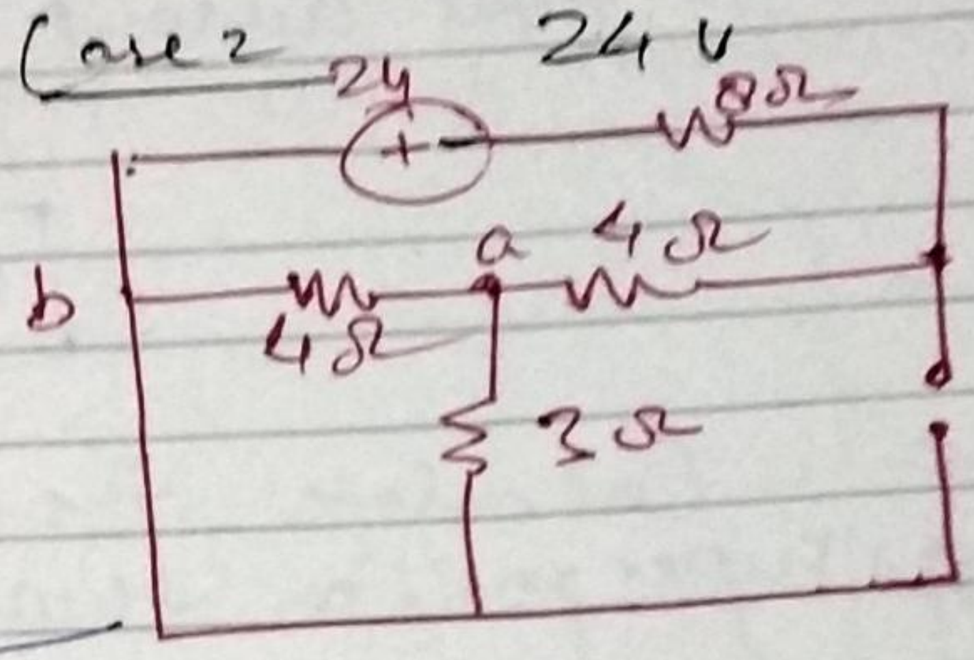


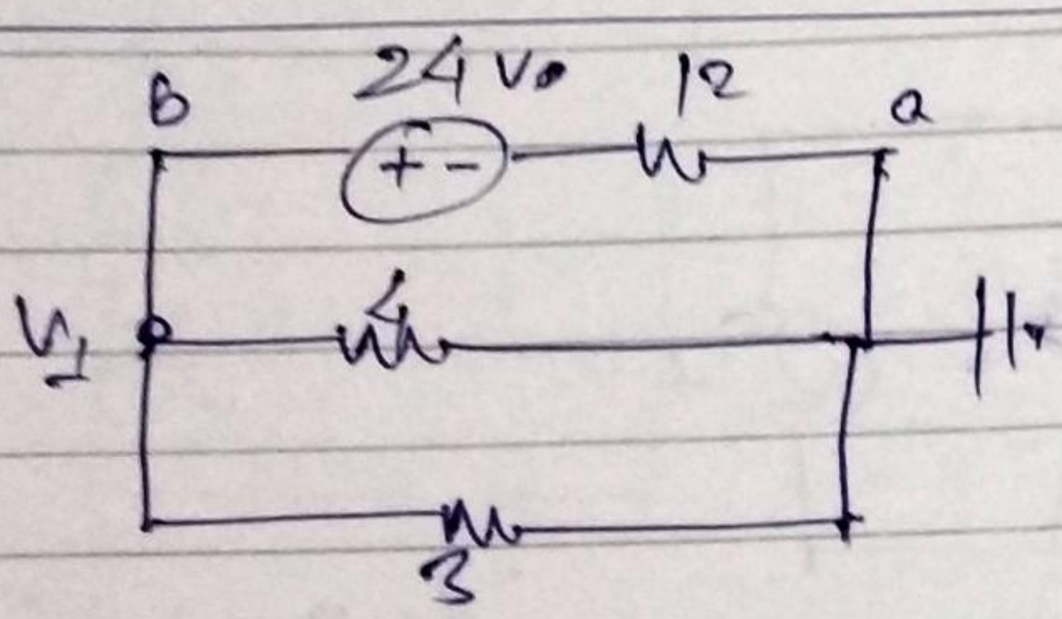


$i_1 = \frac{12}{6}$

$\boxed{i_1 = 2A}$

Case 2





Apply Nodal

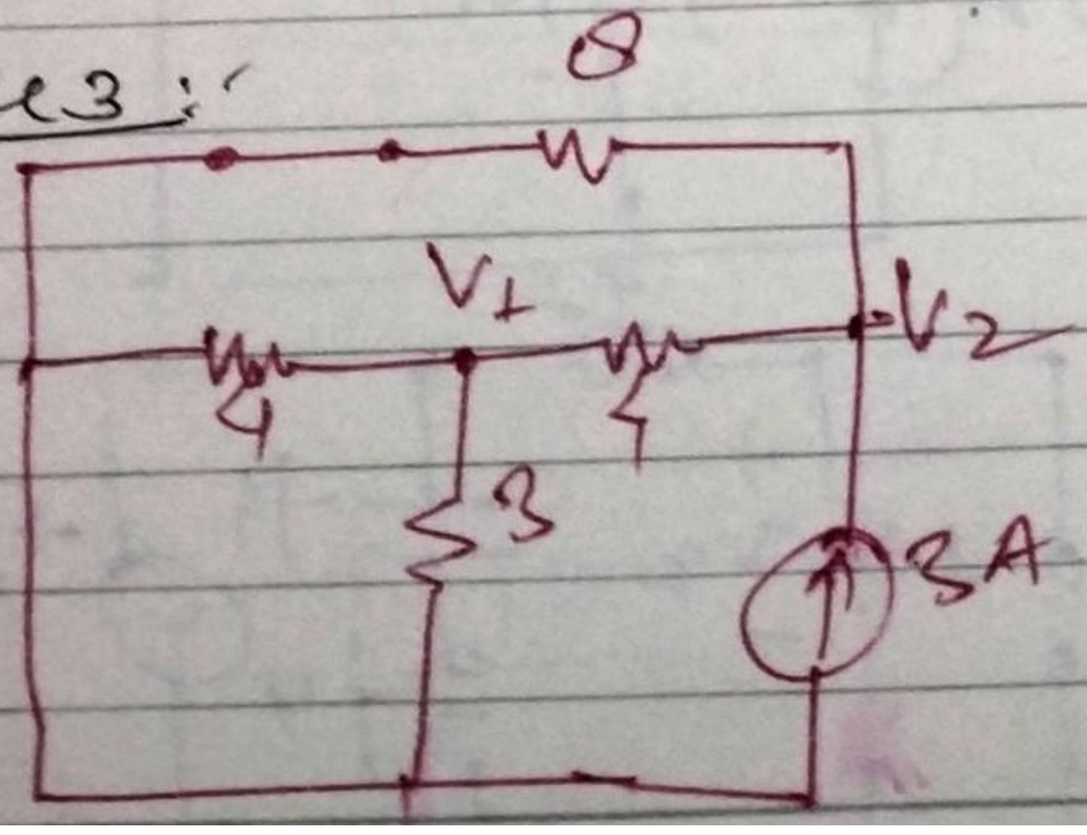
$$\frac{V_1 - 24}{12} + \frac{V_1}{4} + \frac{V_1}{3} = 0$$

$$V_1 - 24 + 3V_1 + 4V_1 = 0$$

$$\boxed{V_1 = 3V}$$

$$i_2 = \frac{0 - V_1}{3} = \frac{0-3}{3} \quad \boxed{i_2 = -1 \text{ A}}$$

Case 3 :-



$$\frac{V_1}{4} + \frac{V_1}{3} + \frac{V_1 - V_2}{4} = 0$$

$$V_1\left(\frac{10}{12}\right) = \frac{V_2}{4}$$

$$V_2 = \frac{10}{3} V_1 \quad \text{—— (1)}$$

Scanned by TapScanner

$$\frac{V_2}{8} + \frac{V_2 - V_1}{4} = 3 \qquad V_2 + 2V_2 - 2V_1 = 24$$

$$3\left[\frac{10}{3} V_1\right] - 2V_1 = 24 \qquad 8V_1 = 24 \qquad \boxed{V_1 = 3V}$$

$$\boxed{i_3 = \frac{3}{3} = 1A}$$

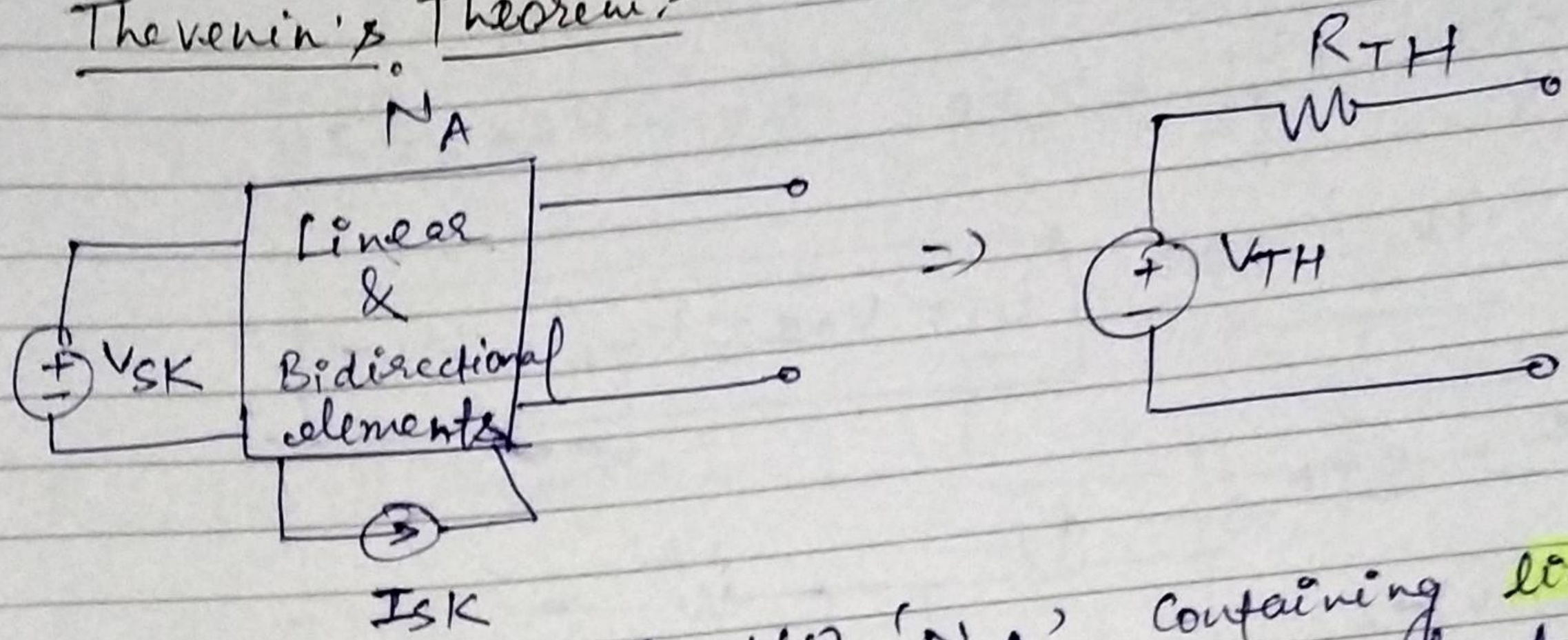
So total current $i = i_1 + i_2 + i_3$

$$= 2 + (-1) + 1$$

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

Scanned by TapScanner

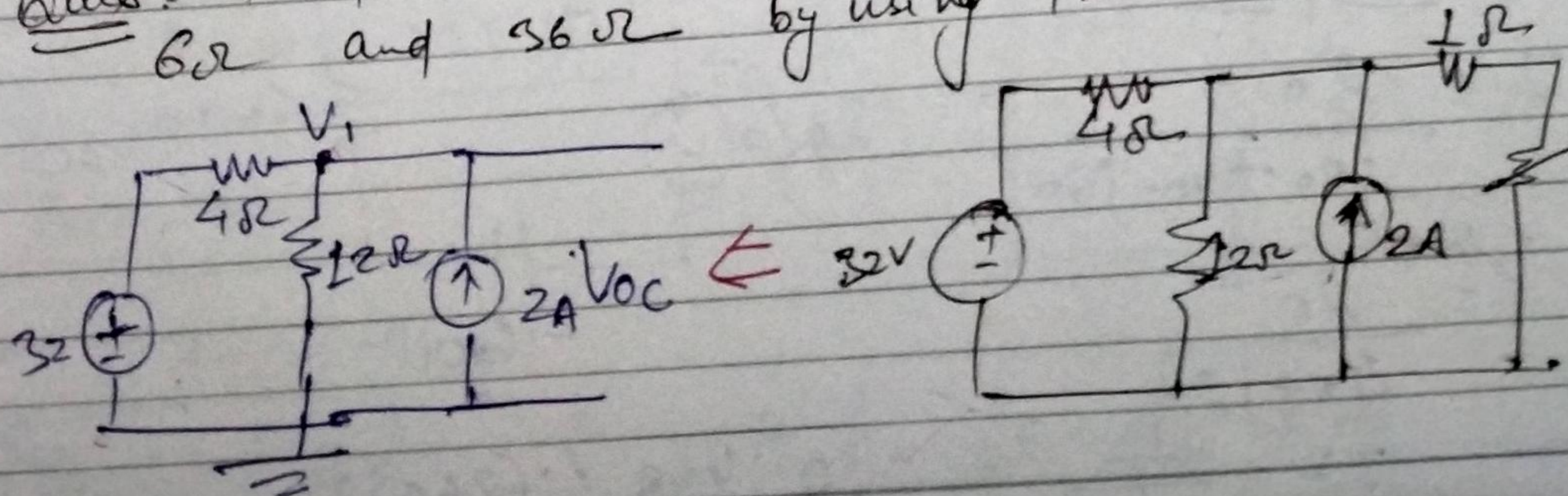
Thevenin's Theorem:-



→ A Two terminal N/W 'N_A' containing linear and bidirectional element and independent source is equivalent to a single N/W containing an equivalent voltage source 'V_{TH}' in series with the resistance 'R_{TH}'.

→ The source voltage is the open ckt voltage across the terminals of the N/W (N_A) and resistance 'R_{TH}' is the O/P resistance of 'N_A' measured at its terminals after deactivating or independent sources in 'N_A'.

Ques: Find the current through (R_L) when 'R_L' is 6Ω and 36Ω by using Thevenin's Theorem



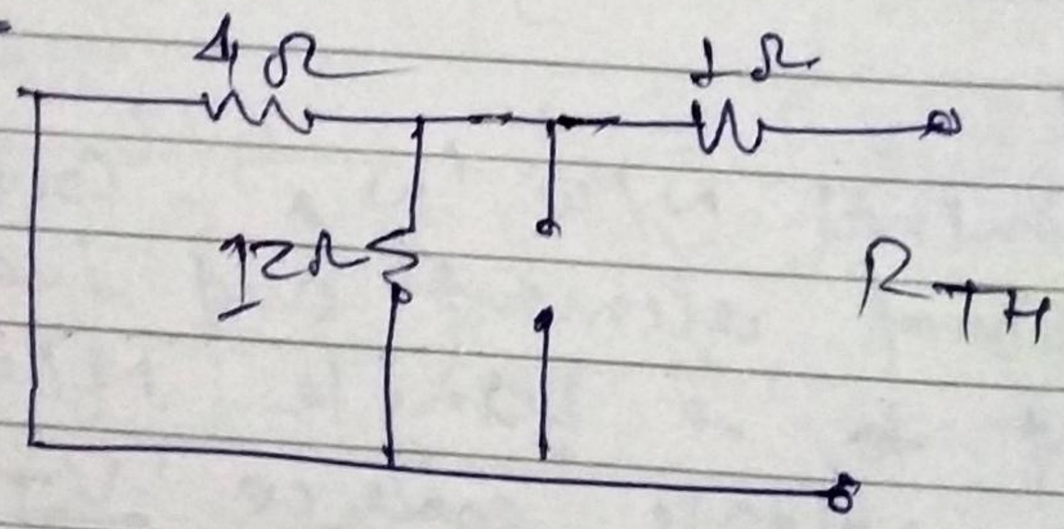
Scanned by TapScanner

Case 1 V_{TH}

$$\frac{V_1 - 32}{4} + \frac{V_1}{12} - 2 = 0 \qquad 3V_1 - 96 + V_1 = 24$$

$$4V_1 = 120 \qquad \boxed{V_1 = V_{oc} = V_{TH} = 30\,V}$$

Case 2 R_{TH}

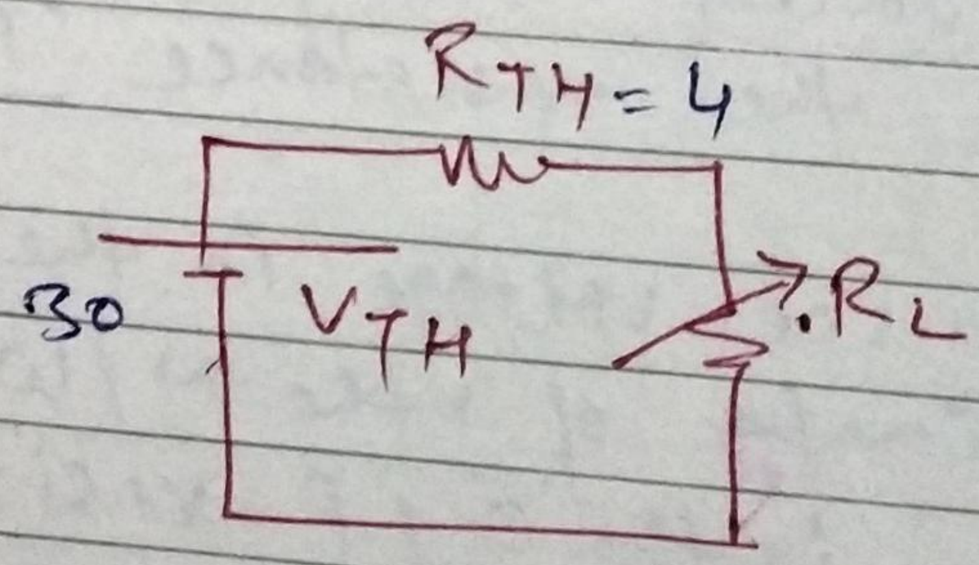


$R_{TH} = (12 \| 4) + 1$

$$\boxed{R_{TH} = 4\,\Omega}$$

(a) $R_L = 6\,\Omega$

$$I = \frac{30}{4+6} = 3A$$



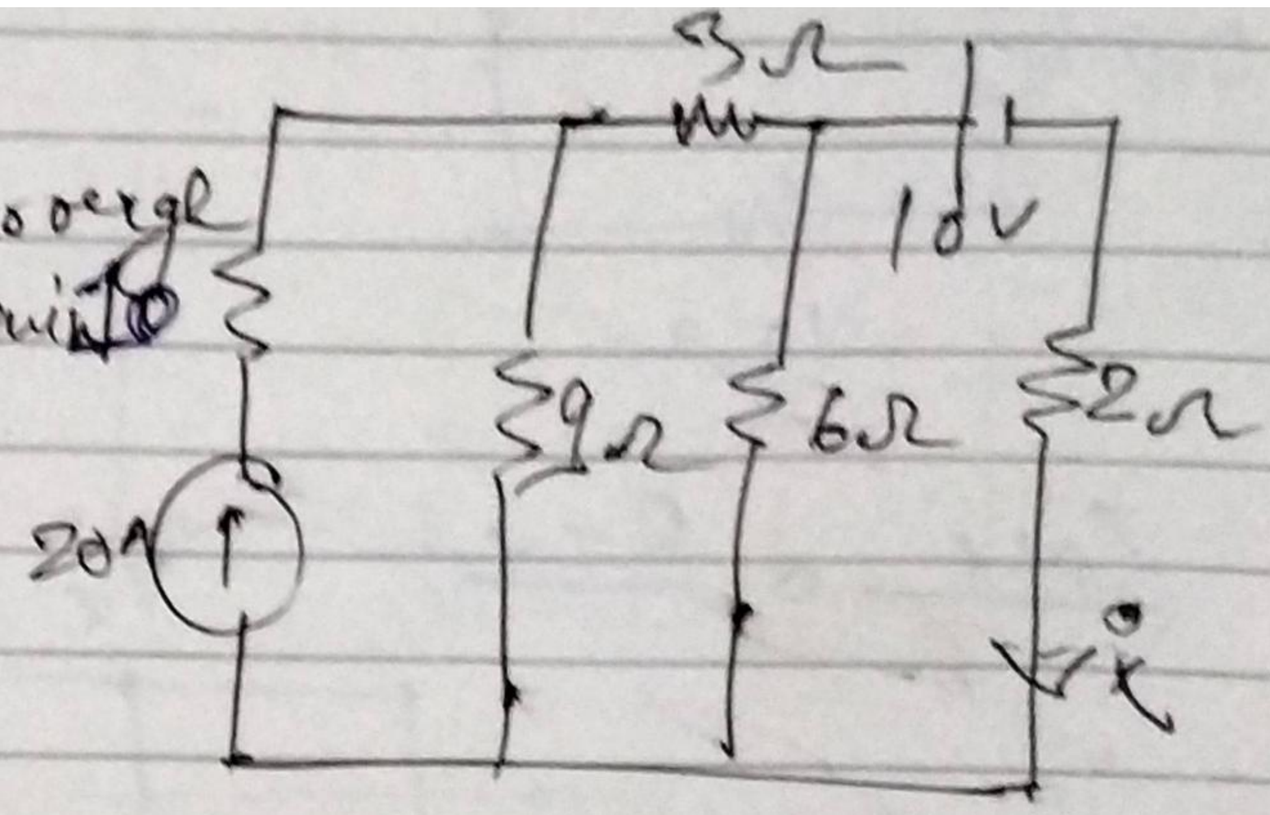
(b) $R_L = 36\,\Omega$

$$I = \frac{30}{40} = 0.75\,A$$

Scanned by TapScanner

Ques :-

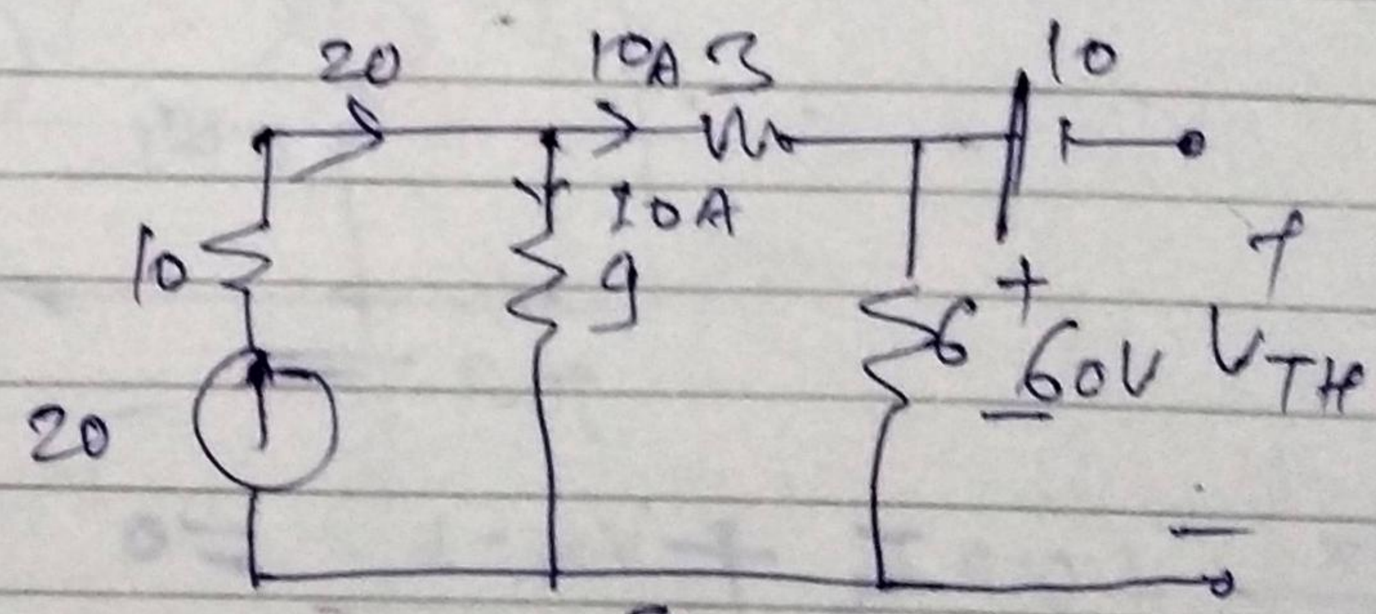
Find current flowing through 2Ω resistor by using thevenin's theorem.



Case :- V_{TH}

$-V_{TH} - 10 + 60 = 0$

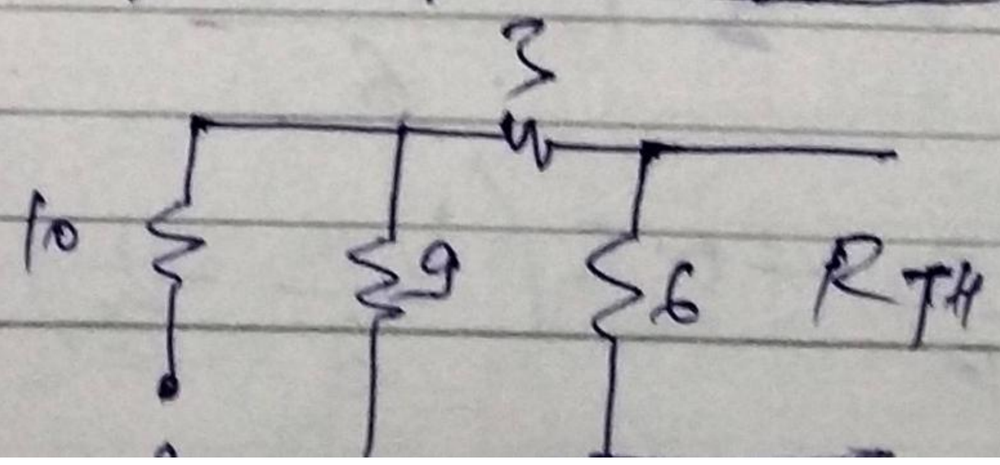
$$\boxed{V_{TH} = 50 \text{ volts}}$$



Case R_{TH} :-

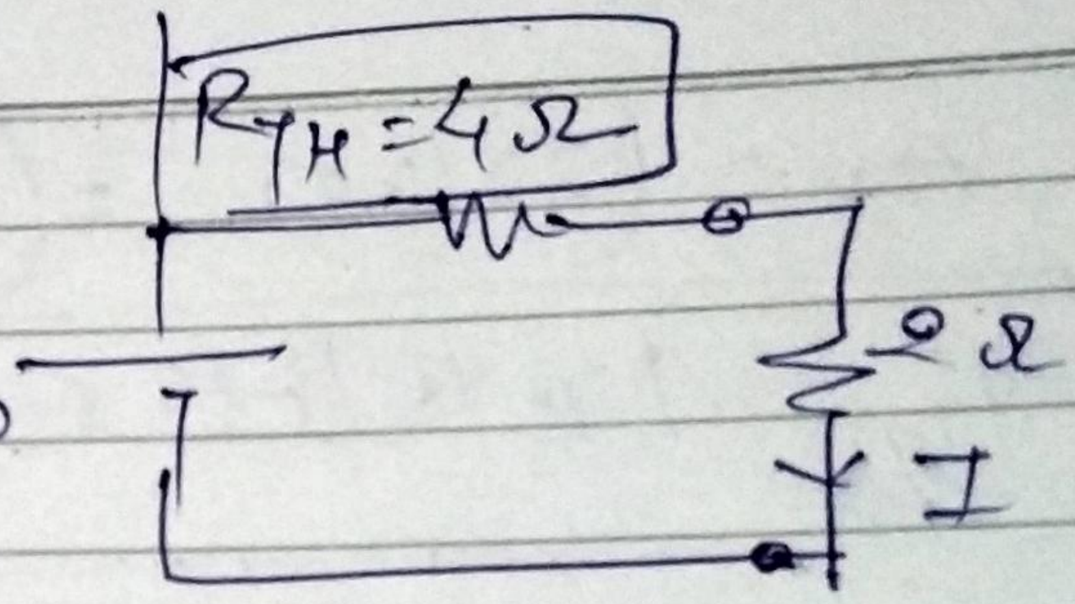
$(9+3) \parallel 6$

$$\boxed{R_{TH} = 4\Omega}$$



Scanned by TapScanner

$$\boxed{I = \frac{50}{6} = 8.33A}$$



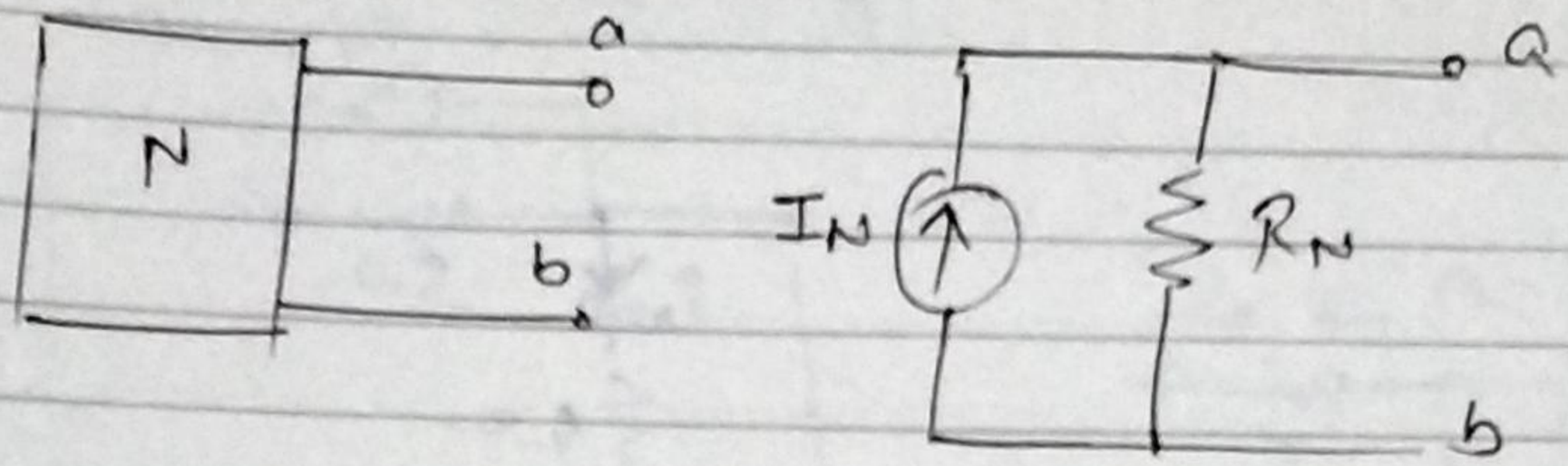
Scanned by TapScanner

NORTON'S THEOREM :-

→ A a two terminal N/W 'NA' containing linear, Bidirectional element and independent sources is equivalent to a simpler ~~simpler~~ N/W containing an independent current source, 'I_N' in parallel with a Resistance 'R_N'.

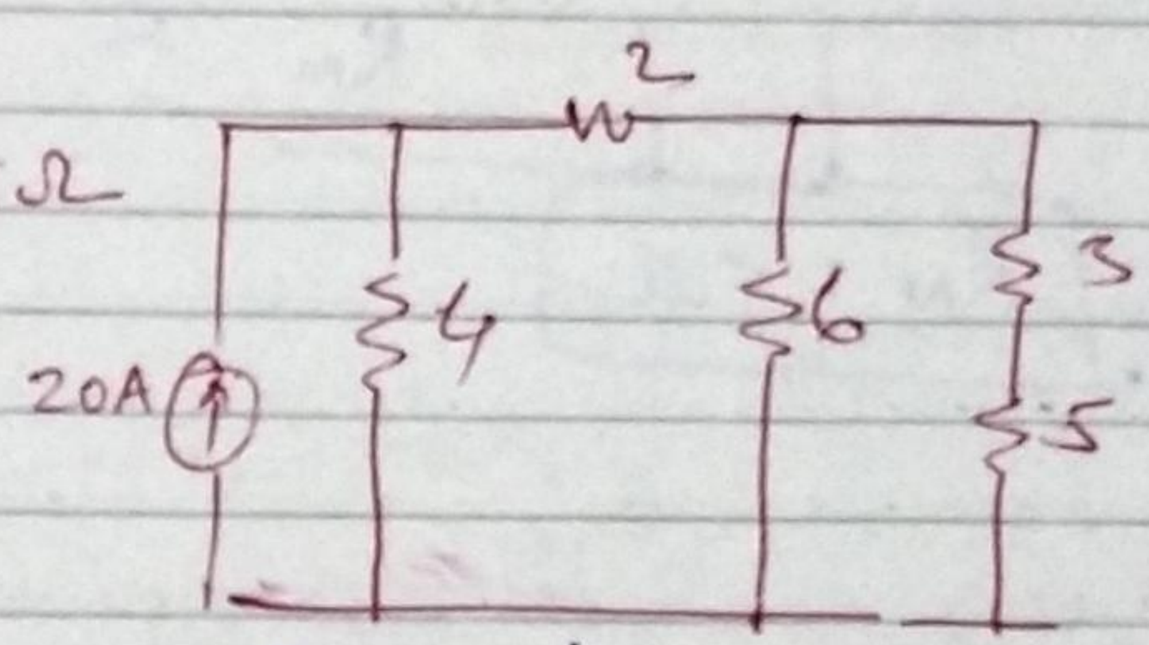
Scanned by TapScanner

→ Source current is a D.C. current across 'NA' and 'RN' is the resistance looking into the terminals after deactivating all independent sources in the N/W 'NA'.



Ques :-

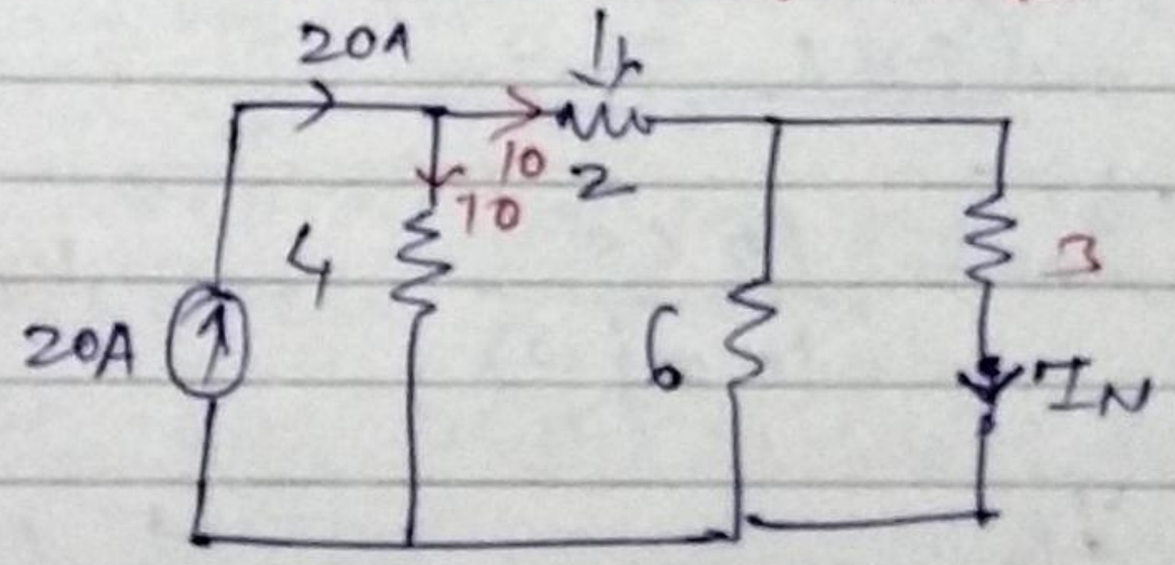
Find the current in 5Ω by using Norton's theorem.



Case 1:- IN

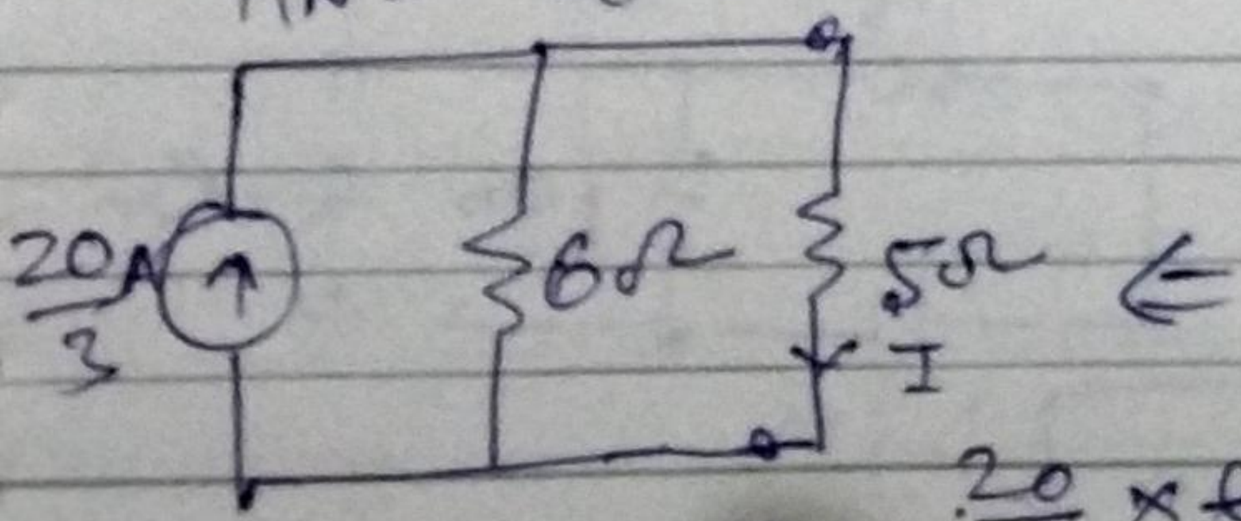
$I_N = \frac{10 \times 2}{3}$

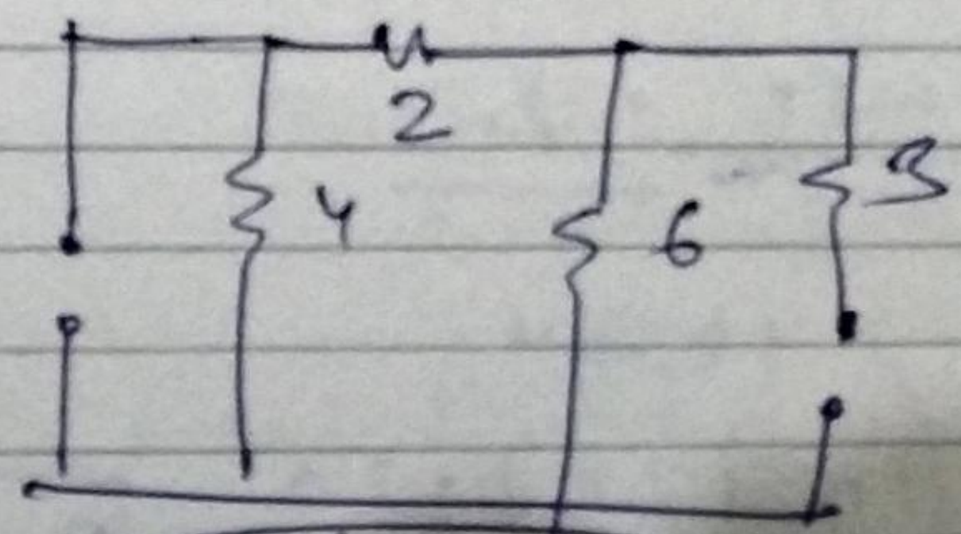
$I_N = \frac{20}{3} A$



Case 2:- RN

$R_N = 6\Omega$



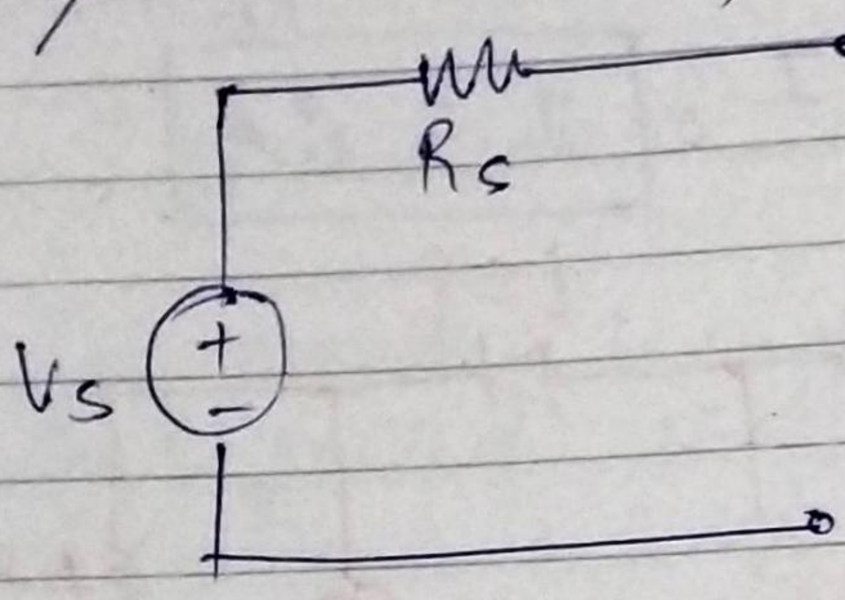


$I = \frac{\frac{20}{3} \times 6}{11}$

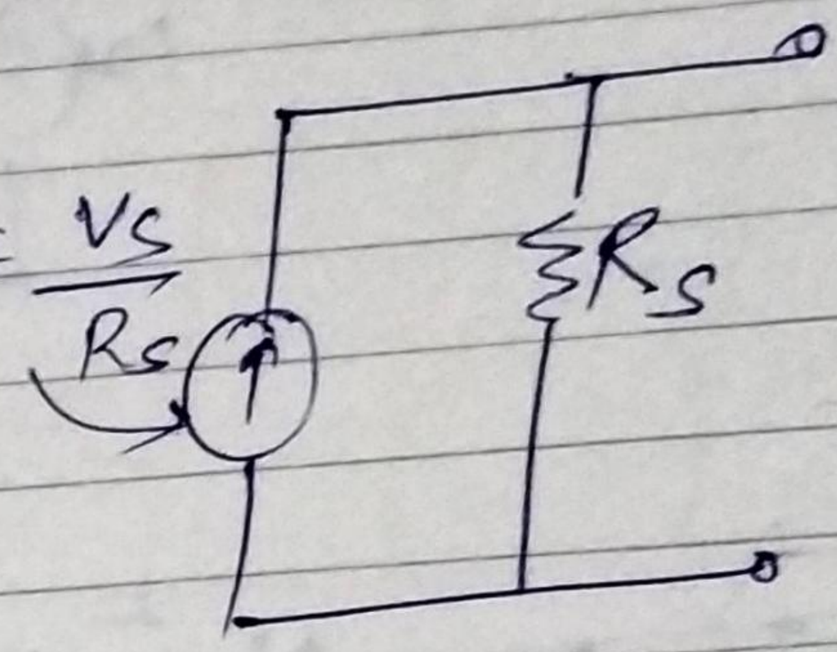
$I = \frac{40}{11} A$

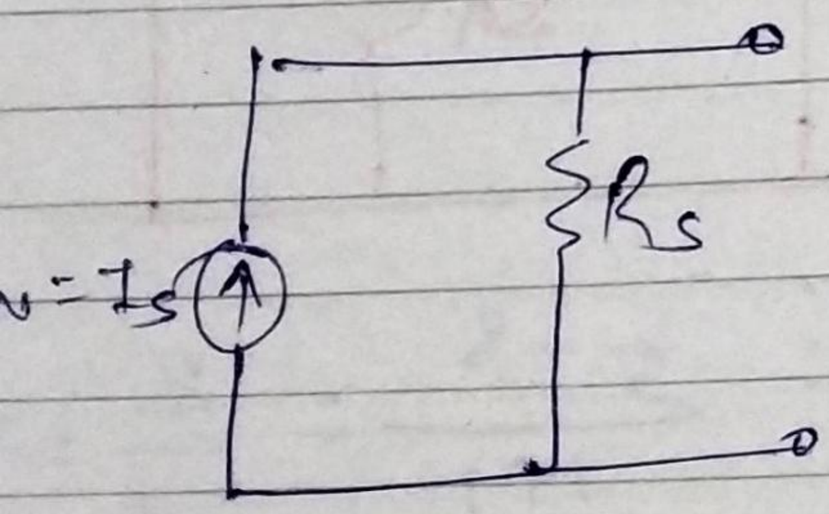
Scanned by TapScanner

Source Transformation :-

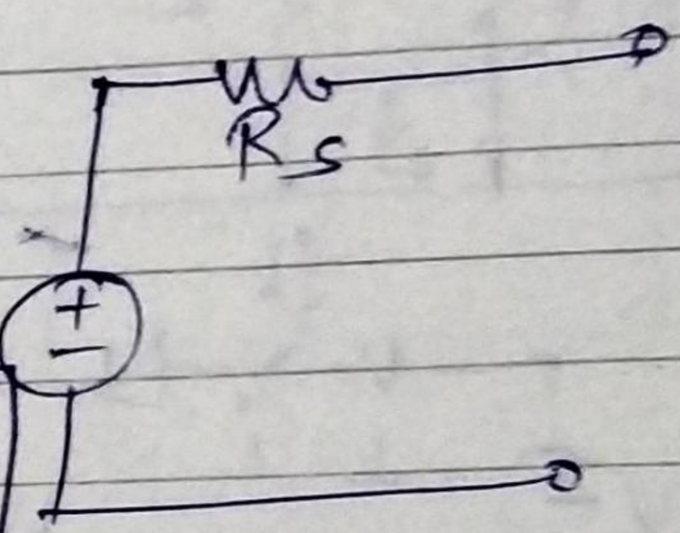


$= \quad I_N = \frac{V_S}{R_S}$





$= \quad V_{TH} = I_S R_S$

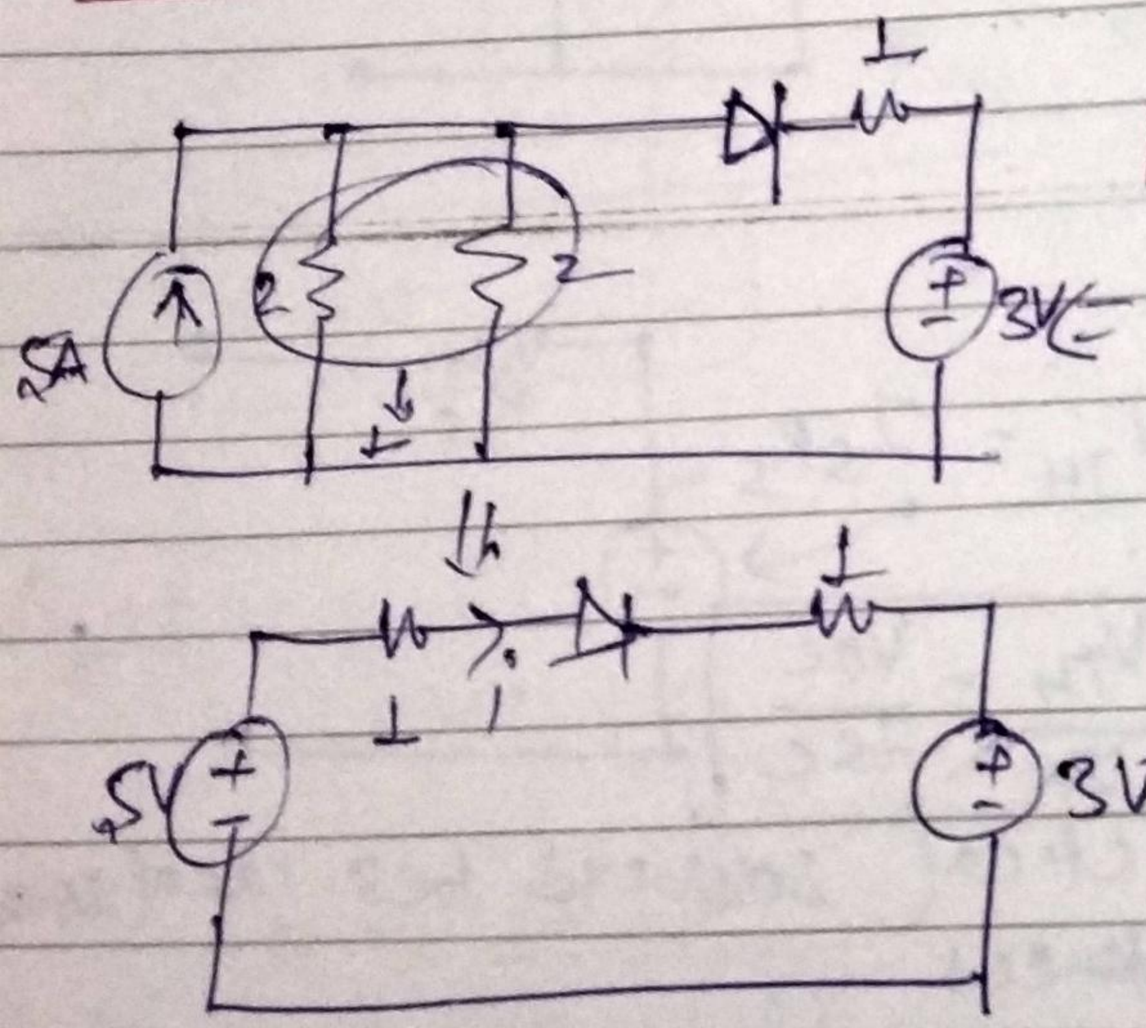


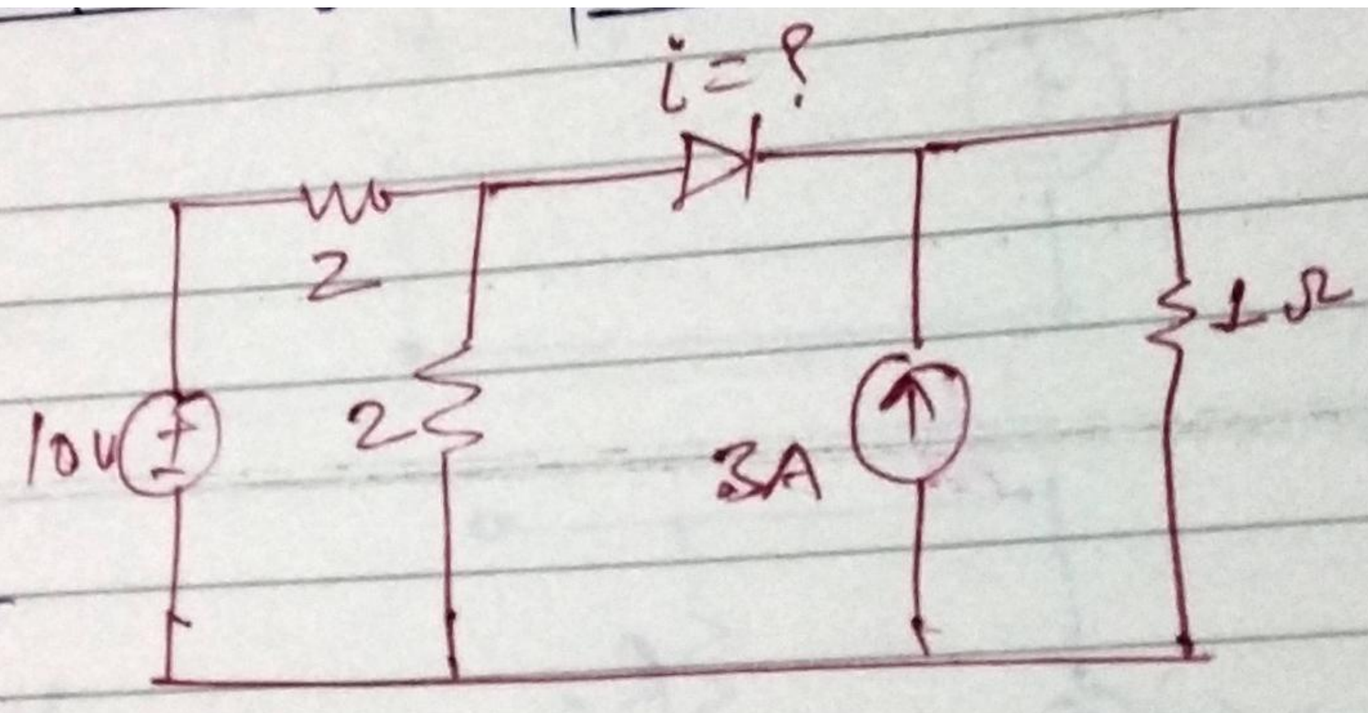
$$R_{TH} = \frac{V_{TH}}{I_N} = \frac{V_{OC}}{I_{SC}}$$

* applicable only for practical sources bcz ideal sources have zero internal resistances.

Scanned by TapScanner

Quiz :-



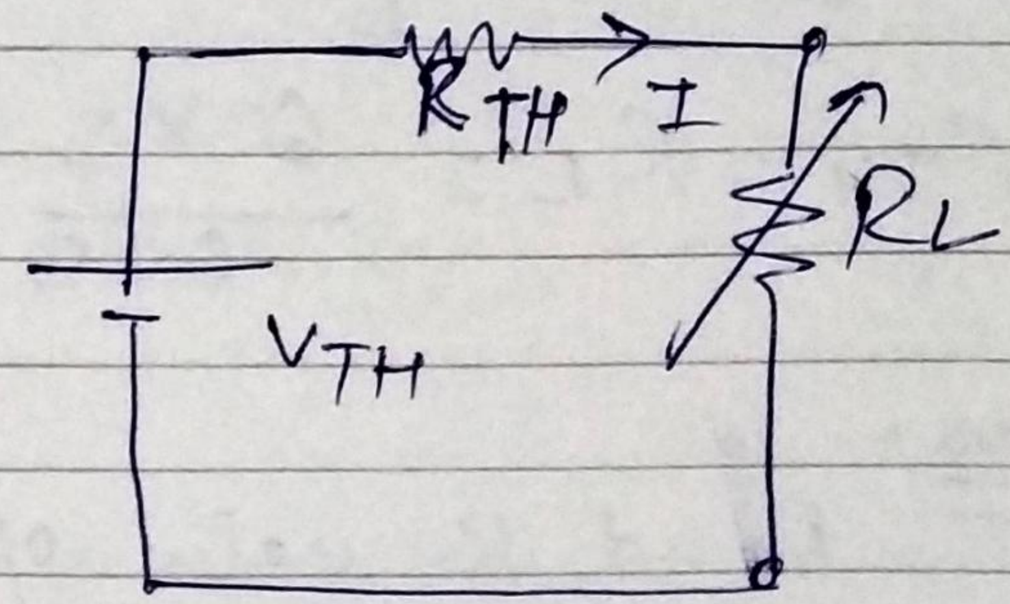


$$i = \frac{5-3}{1+1} = \frac{2}{2} = 1A$$

Scanned by TapScanner

Maximum power Transfer Theorem:-

$$I = \frac{V_{TH}}{(R_{TH}+R_L)}$$



$$P = I^2 R_L$$

$$P = \left(\frac{V_{TH}}{R_{TH}+R_L}\right)^2 \cdot R_L$$

$$\frac{dP}{dR_L} = V_{TH}^2 \left[\frac{(R_{TH}+R_L)^2 - R_L \cdot 2(R_{TH}+R_L)}{(R_{TH}+R_L)^4}\right] = 0$$

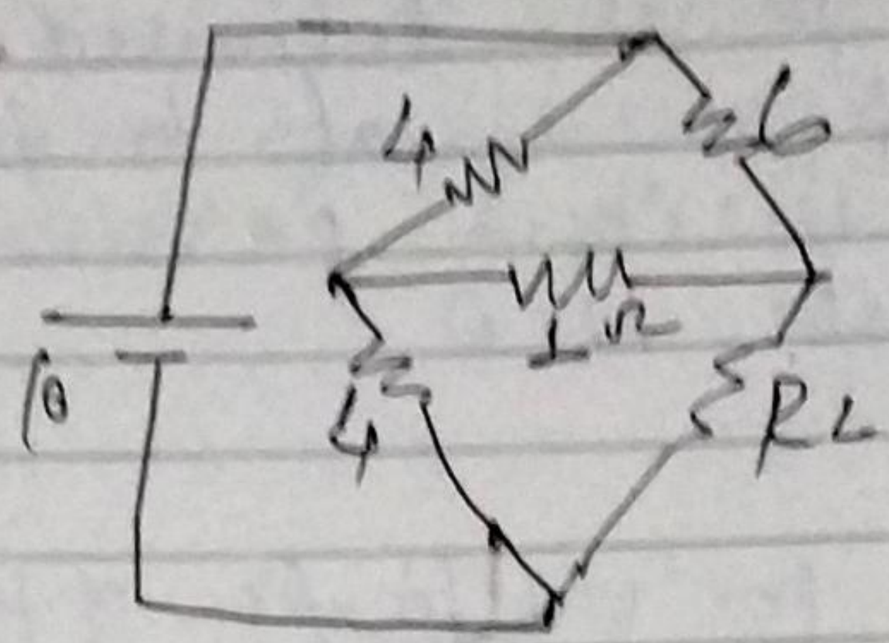
$$R_{TH}+R_L-2R_L=0 \qquad \boxed{R_{TH}=R_L}$$

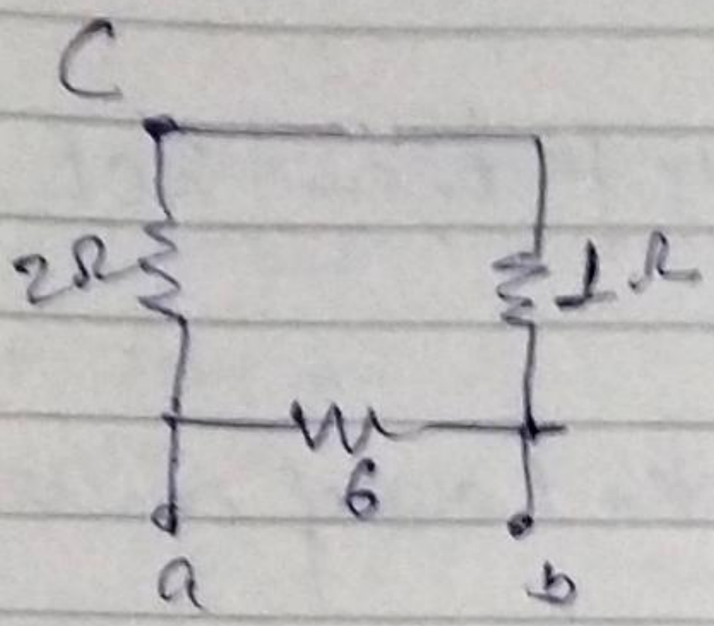
$$P_{max} = \frac{V_{TH}^2}{(R_{TH}+R_{TH})^2} R_{TH}$$

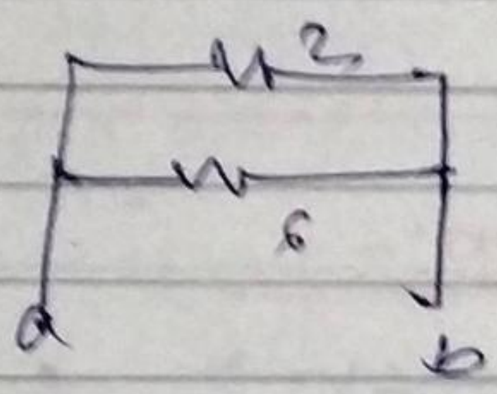
$$\boxed{P_{max} = \frac{V_{TH}^2}{4R_{TH}}}$$

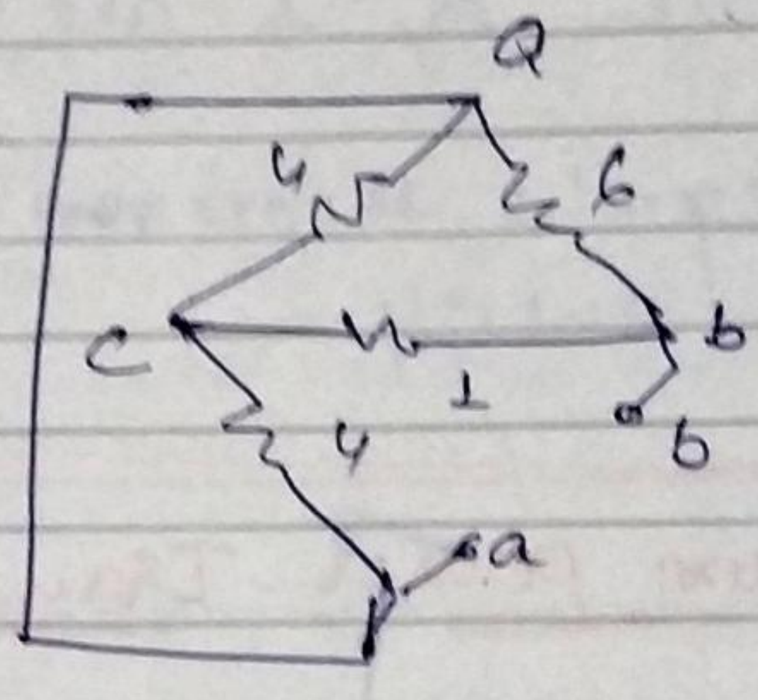
Scanned by TapScanner

Ques: for what value of R_L max power is transferred to it.





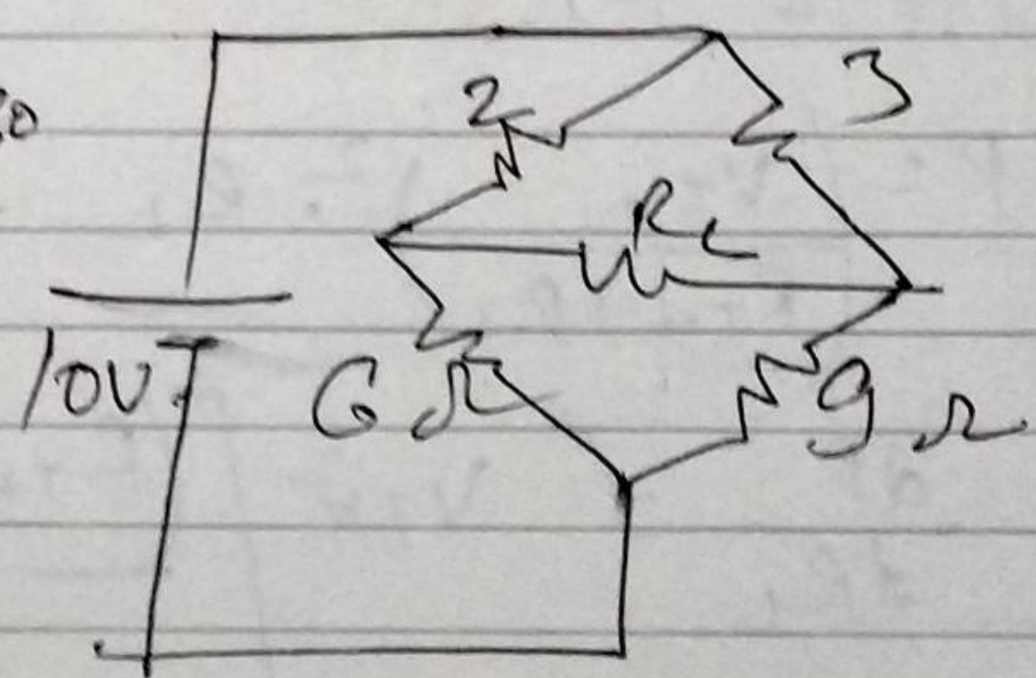




$$R_{TH} = R_L = \frac{6 \times 3}{6+3} = 2\Omega$$

Ques:-

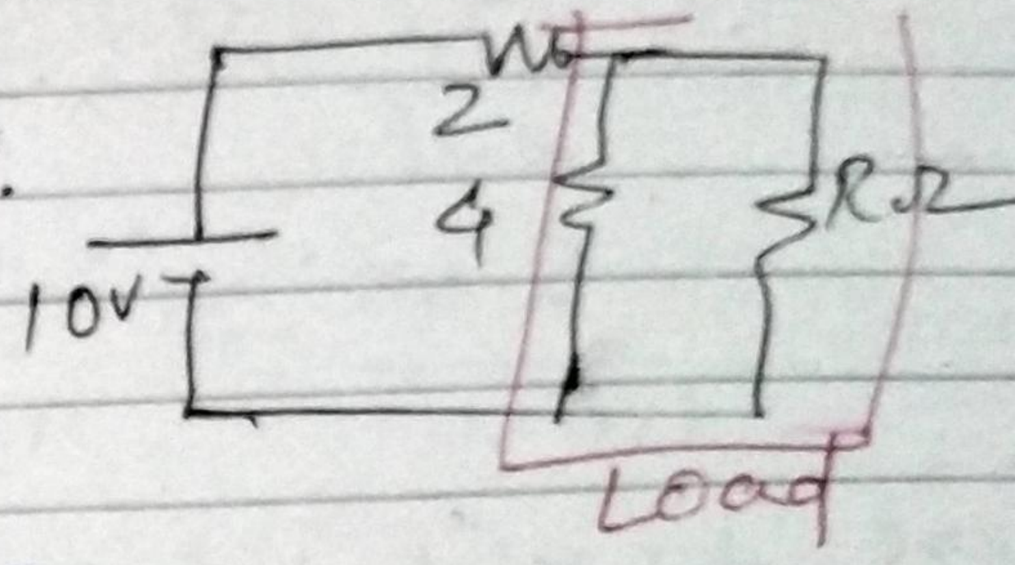
Find the value of R_L so that the max power can be transferred and max power.



As the bridge is balanced
∴ No current is flowing through R_L and hence power dissipation will be zero.

Scanned by TapScanner

Find the value of R so that max power can be transfered.



$R_L = R_{TH}$

$(4 \parallel R) = 2$

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

$\boxed{R = 4\,\Omega}$

Scanned by TapScanner