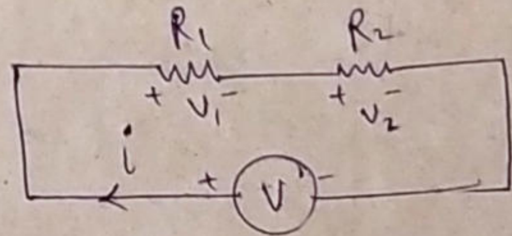
Voltage division rule :

→ applied for series combinⁿ as in series volt. divider.



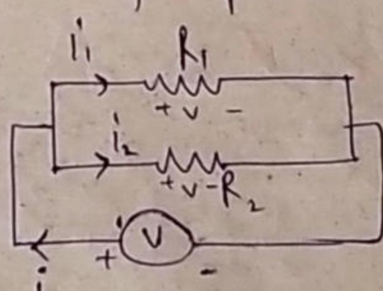
$i = \dfrac{V}{R_1+R_2}$ $\quad\therefore\quad$ $v_1 = iR_1 = \dfrac{VR_1}{R_1+R_2}$

$V_2 = iR_2 = \dfrac{VR_2}{R_1+R_2}$

i.e., $V_{resistor} = \left[\dfrac{\text{total voltage} \times \text{that resistor}}{\text{Equivalent resistance in series or sum of resist}}\right]$

Current division rule:

→ applied for parallel combⁿ as in parallel, current divider.



$i = i_1 + i_2$

$\cancel{i = \dfrac{V}{R_{eq}} = \dfrac{V(R_1+R_2)}{R_1R_2}}$

$i_1 = \dfrac{V}{R_1}$, $i_2 = \dfrac{V}{R_2}$

$\cancel{V = iR_1}$
$\cancel{V = iR_2}$
$\cancel{iR_1 = i_2R_2}$
$\cancel{\dfrac{V(R_1+R_2)}{R_1R_2} =}$

$i_1 = \dfrac{1}{R_1}\left[iR_{eq}\right] = \cancel{\dfrac{1}{R_1}\left[\dfrac{V(R_1+R_2)}{R_1R_2} \times (i_1+i_2)\right]}$

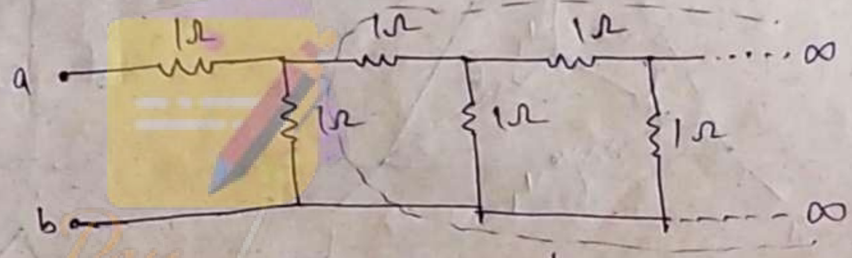
$i_1 = \dfrac{i}{\cancel{R_1}} \dfrac{\cancel{R_1}R_2}{(R_1+R_2)} \Rightarrow \boxed{i_1 = \dfrac{iR_2}{R_1+R_2}}$

$$i_2 = \frac{1}{R_2}\left(iR_{eq}\right) = \frac{1}{\cancel{R_2}}\left(i \times \frac{R_1\cancel{R_2}}{R_1+R_2}\right)$$

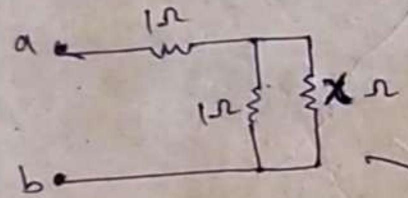
$$i_2 = \frac{iR_1}{(R_1+R_2)}$$

i.e. $i_{resistor} = \left[\dfrac{\text{total current} \times \text{opposit. resistance}}{\text{sum of resistances.}}\right]$

Q₂ find R_{eq} b/w a & b.



$R_{eq} = x\ \Omega$

⇒ 

→ $R_{eq} = \dfrac{1 \times x}{1+x} + 1$

$x = \dfrac{x}{1+x} + 1 \Rightarrow x - 1 = \dfrac{x}{1+x} \Rightarrow x^2 - 1 - x = 0$

$x^2 - x - 1 = 0 \Rightarrow x = \dfrac{1 \pm \sqrt{1+4}}{2} \Rightarrow x = \dfrac{1 \pm \sqrt{5}}{2}$

$x = \dfrac{1+\sqrt{5}}{2}\ \Omega$ //

Equivalent resistance using symmetry :

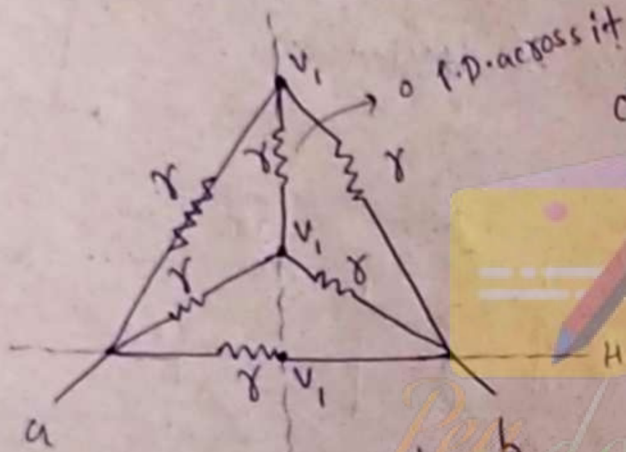
Vertical symmetry (Mirror)

- Points on V. plane have same potential
- Branches which are mirror img. about V.P. have same current.

Horizontal symmetry (folding)

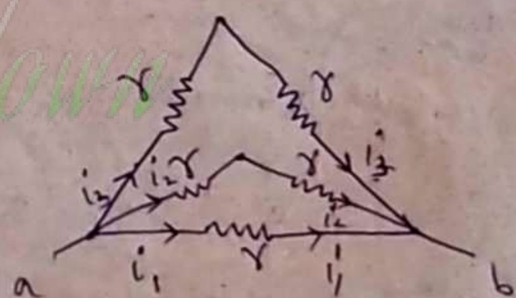
- all points which are mirror img. about Horz. plane have same pot.

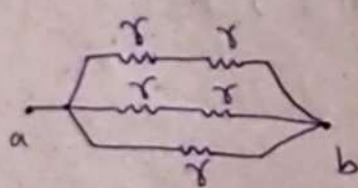
Q.



clearly H.P. about a-b doesn't posses symmetry but V.P. does.

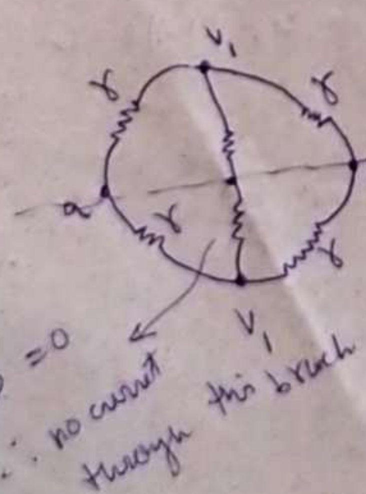
$\therefore$



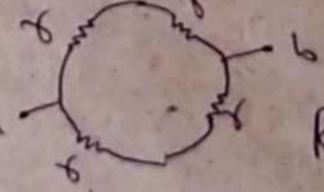


$R_{eq} = \frac{r}{2}$ //

Q.2



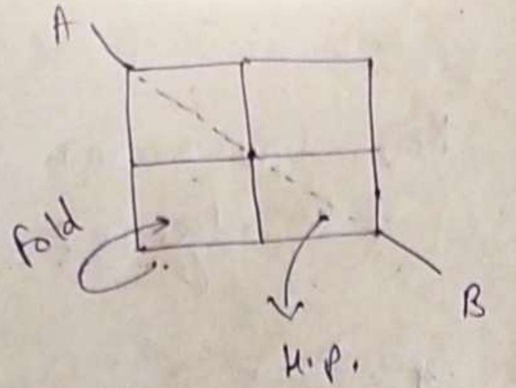
it posses both H.P.s & V.P.s.



$R_{eq} = r$

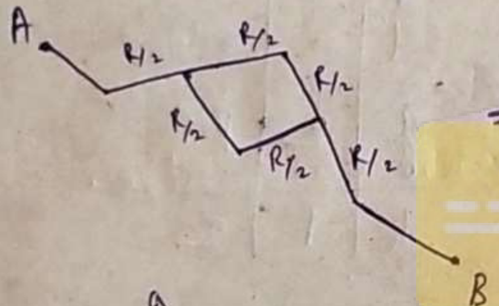
$\boxed{\text{So, basically, ko bhi symmetry ho pot. on that plane is same}}$

Q. 2



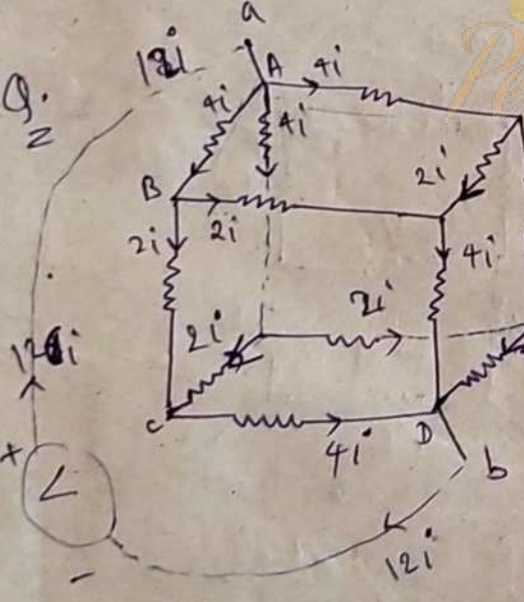
each small side have $R_{unit} = R$ then R_{eq} across A-B ?

→ let us use H.P.S as Folding symmetry i.e., fold about H.P & ~~replace~~ each $R \to \frac{R}{2}$



$\Rightarrow R_{eq} = \frac{3R}{2}$ //

Q. 2



each resist. value $= r$

find R_{eq} (a-b) ?

apply KVL along the ~~open~~ closed path aABCDba

~~$V_a - 4i - 2i - i = V_b$~~

$V - 4ir - 2ir - 4ir = 0$

$V = 10ir$

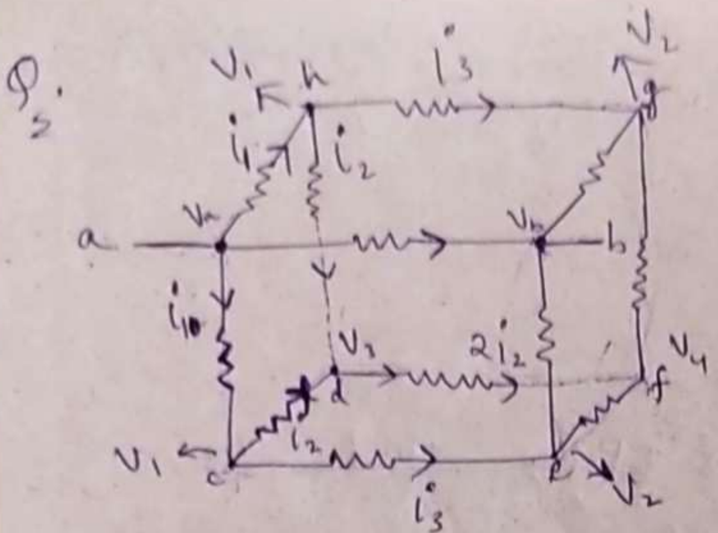
$V = 12i\,r_{eq}$

$12\cancel{i}\,r_{eq} = 10\cancel{i}\,r$

$r_{eq} = \frac{10}{12}r = \frac{5}{6}r$

$\Rightarrow \boxed{r_{eq} = \frac{5}{6}r}$

Q. 5



each resist. is $= r\,\Omega$

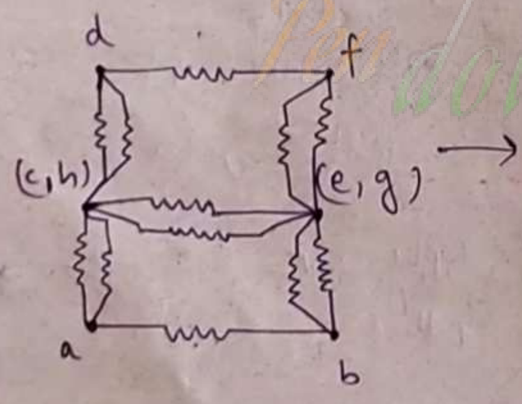
Req. b/w 2 corners of an edge is ?

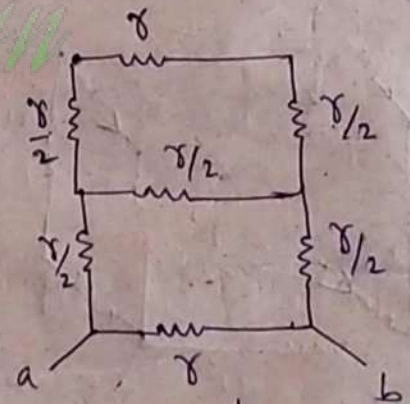
	to a	to b
c	1	2
e	2	1
f	3	2
d	2	3
g	2	1
h	1	2

$c \leftrightarrow h$ symmt. → equiv pot.

$e \leftrightarrow g$ symmt. → equiv. pot.

→ to avoid confusion let's redraw the circuit.





$$\therefore R_{eq} = \frac{\frac{7r}{5} \times r}{\frac{7r}{5} + \frac{r \times 5}{5}}$$

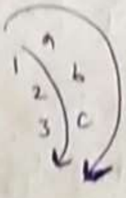
$$= \frac{7r}{12}$$

$$\frac{2r \times \frac{r}{2}}{2r + \frac{r}{2}}$$

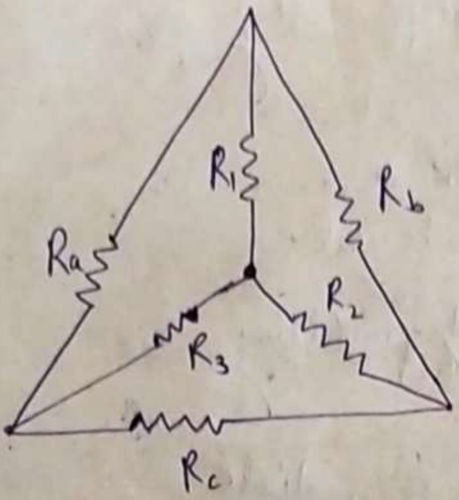
$$\frac{r^2 \times 2}{5r} \Rightarrow \frac{2r}{5}$$

$$\frac{2r}{5} + r \Rightarrow \frac{7r}{5}$$

* Star (Y) - delta (Δ) conversion



always



Δ to Y :

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

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

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

Y to Δ :

$$R_a = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_2}$$

$$R_b = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_3}$$

$$R_c = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_1}$$

Active & Passive elements :

- capable of delivering energy independently for an ∞ duration of time.

or

- capable to supply an avg. power $\neq 0$ to some ext. device, over an infinite time interval.

Hence, active elements are capable of providing power gain i.e. $\left(\frac{\text{output Power}}{\text{input Power}} \neq 0 \right)$

ex: volt. src, current src, transistor, op-Amp, diode etc.

→ Those which are not active are passive.

In short : Active → energy donors.

Passive → energy consumer.

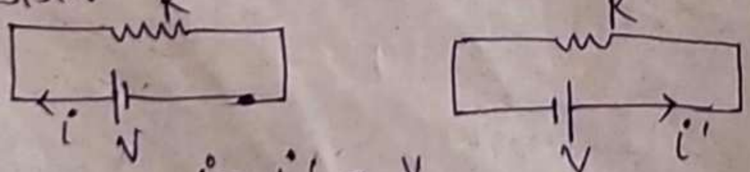
→ ex. inductor, resistor, capacitor, transformer etc.

Bidirectional & unidirectional elements :

→ Properties / characteristics are independent of the direc^n of current flow.

i.e. L→R flow ho ya R→L behaviour of element → same.

ex: Resistor

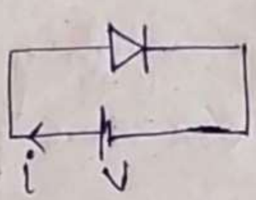


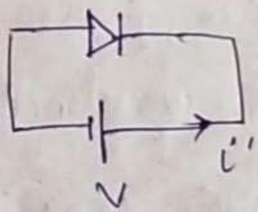
$$i = i' = \frac{V}{R}$$

means, in both cases resistance offered by resistor is same (independent of direc^n).

unidirectional → properties are direc^n dependant.

ex. diode



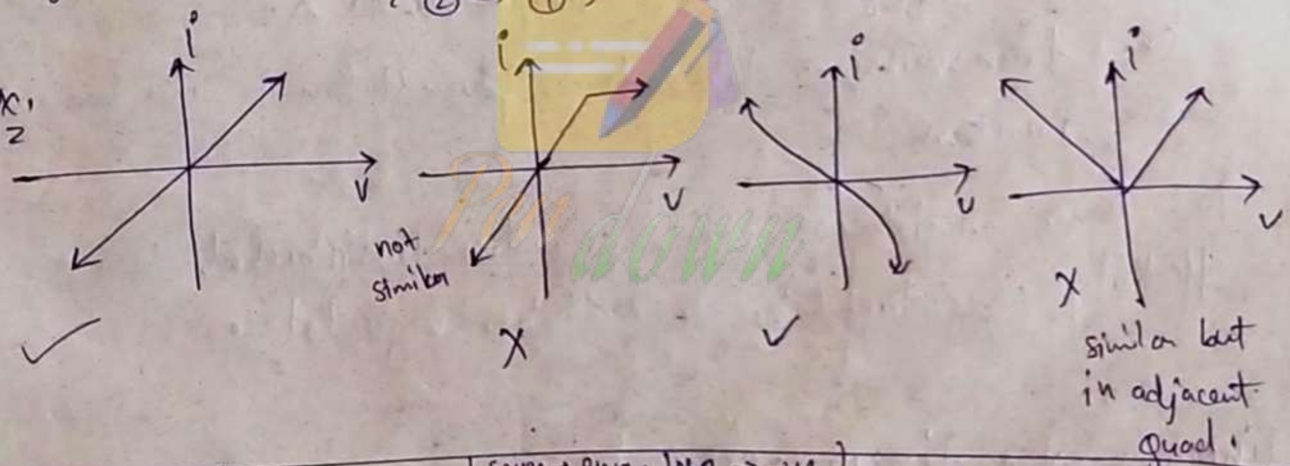


here $i > 0$ ie. $R \to 0$ $\qquad$ $i' = 0$ ie. $R \to \infty$

∴ Resistance (property) offered by diode in F.B direc^n is nearly zero but in R.B, resist. offe. is $\to \infty$.

Note: Bidirectional → characterstic curve is similar in opp. quadrants i.e. { ① ↔ ③, ② ↔ ④ }

ex.



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source → energy lose → −ve
sink → " accept → +ve

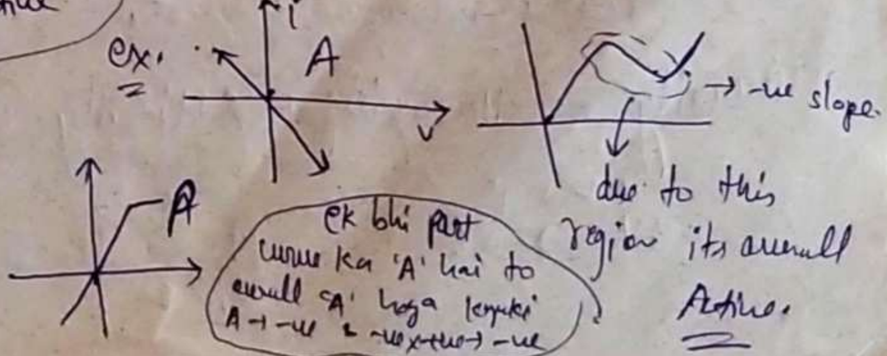
Note:

$i < 0, v > 0$ $P < 0$ source ⇒ Active	$i > 0$ $v > 0$ $P > 0$ sink → consumer → Passive
$i < 0$ $v < 0$ $P > 0$ sink → Passive	$i > 0$ $v < 0$ $P < 0$ source → Active

↓ Fails when resistance < 0 in ①st & ③rd quadrant

in short: whenever $\frac{V}{i} < 0$ i.e. $\boxed{\text{if slope} < 0 \longrightarrow \text{Active}}$

ex.



ek bhi part curve ka 'A' hai to overall 'A' hoga kyuki A → −ve & −ve × +ve → −ve

Lumped and distributed elements

↳ physical size of element is negligibly small when compared to wavelength of EM wave propagation.

ex: resistor, capacitor, inductor etc.

50 Hz
3×10^8 m/s

ex.

$$\lambda = \frac{v}{f} = \frac{3\times10^8}{50} = 6000 \text{ km}$$

50Hz

∴ we assume all characteristic properties are conc^n in that small portion.

distributed → physical size is comparable to λ.

ex. transmission line from power station to our home are ~1000 km

to isme resistance jaise properties distributed hai effectively on entire line & can't be neglected.

Linear & Non-linear elements:

↳ a linear relationship b/w excitation (i/p) & response (o/p).

ex: for a resistor, $V \propto i \Rightarrow V = iR$

∴ resistor is linear element.

for linearity both Homo & add. must be satisfied.

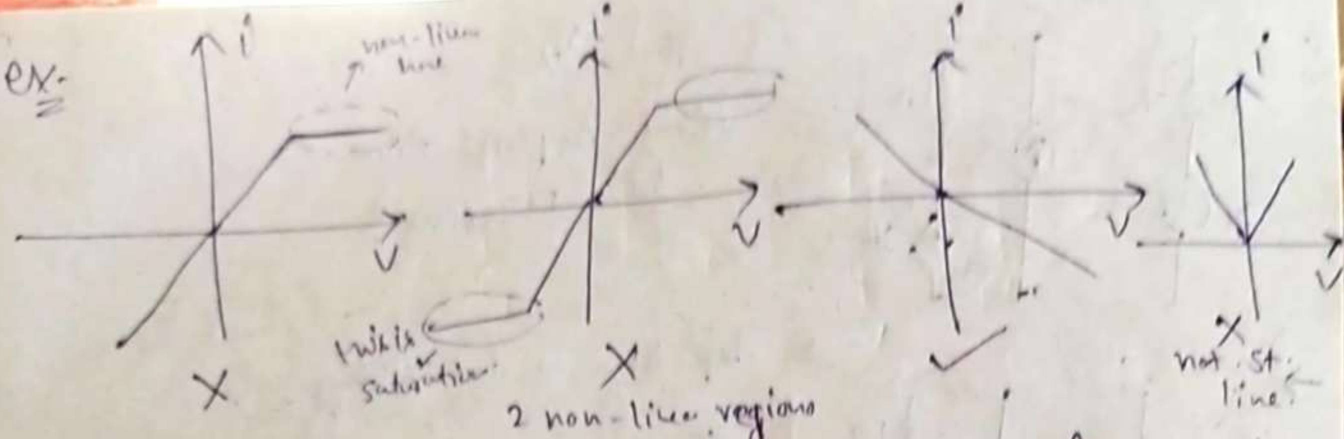
ohm's law → only for linear element ✓

• linearity = Homogeity + Additivity

ex: $V \to i$, $\alpha V \to \alpha i$

$V_1 \to i_1$, $V_2 \to i_2$ then $V_1 + V_2 \to i_1 + i_2$

ex:



Note: every linear element must exhibit bidirectional property

(∴ Graph must pass through origin + st. line & no saturation)

Circuit analysis theorems:

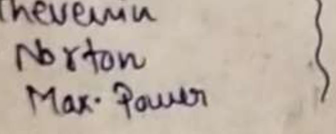
- superposition
- Thevenin
- Norton
- Max. Power

{ All these are valid for bilateral, linear and lumped elements in circuit }

① **Superposition:** volt./current across an element is alg. sum of vol./current in that element due to independent source acting alone at a time.

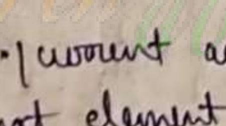
- apply when multiple sources are present.
- when considering 1 dep. src., replace all other depend. src by their R_{int}.

ex:



find 'V' using superposition,

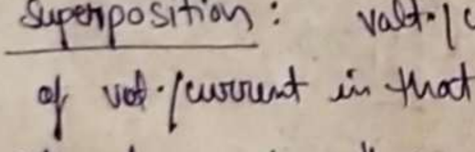
Taking (6V) in consideration →



→ $i_1 = \frac{6}{12} \Rightarrow 0.5A$

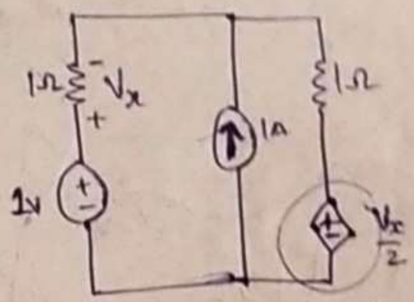
∴ $V_1 = 0.5 \times 4 \Rightarrow 2V$.

Taking (3A) in consid^n:



$V_2 = 3 \times \frac{8}{3}\Omega \Rightarrow 8V$

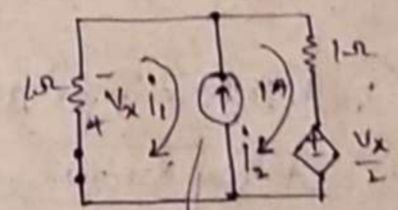
∴ $V = V_1 + V_2 \Rightarrow 10V$

Q. 

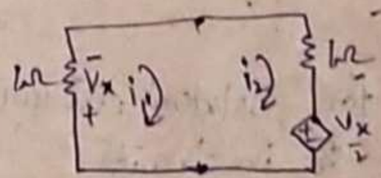
Find V_x = ?

using superposition theorem?

→ dep. src → do nothing.

→ 

→ current src b/w 2 meshes → supermesh.

∴ 

$$-i_1 - i_2 - \frac{V_x}{2} = 0$$

$$i_2 - i_1 = 1$$

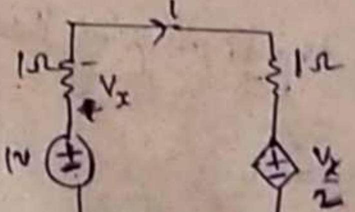
$$\& \; V_x = i_1$$

$$-i_1 - i_2 - \frac{i_1}{2} = 0$$

$$-\frac{3i_1}{2} - (1 + i_1) = 0 \Rightarrow -\frac{3i_1}{2} - \frac{2}{2} - \frac{2i_1}{2} = 0$$

$$-5i_1 = 2 \Rightarrow i_1 = -\frac{2}{5}$$

$$\therefore \underline{V_{x_1} = -0.4V}$$

then 

$$1 - V_x - i - \frac{V_x}{2} = 0$$

$$i = V_x$$

$$2 = 5V_x \Rightarrow V_{x_2} = 0.4V$$

∴ $$\boxed{V_x = V_{x_1} + V_{x_2} = 0V}$$