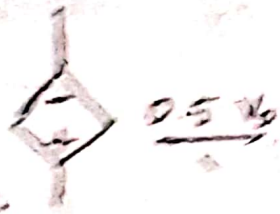
Source → teacher (supplier)

Sink → student (receiver)

Circuit Element

- Active Element
  - Voltage Source (±)
    - Independent
    - Dependent
  - Current Source (↑)
    - VC VS
    - VC CS
    - CC VS
    - CC CS
- Passive Element
  - Resistor
  - Inductor
  - Capacitor



VC VS

Voltage Controlled Voltage Source

CC VS

Current Controlled Voltage Source

CC CS

Current Controlled Current Source

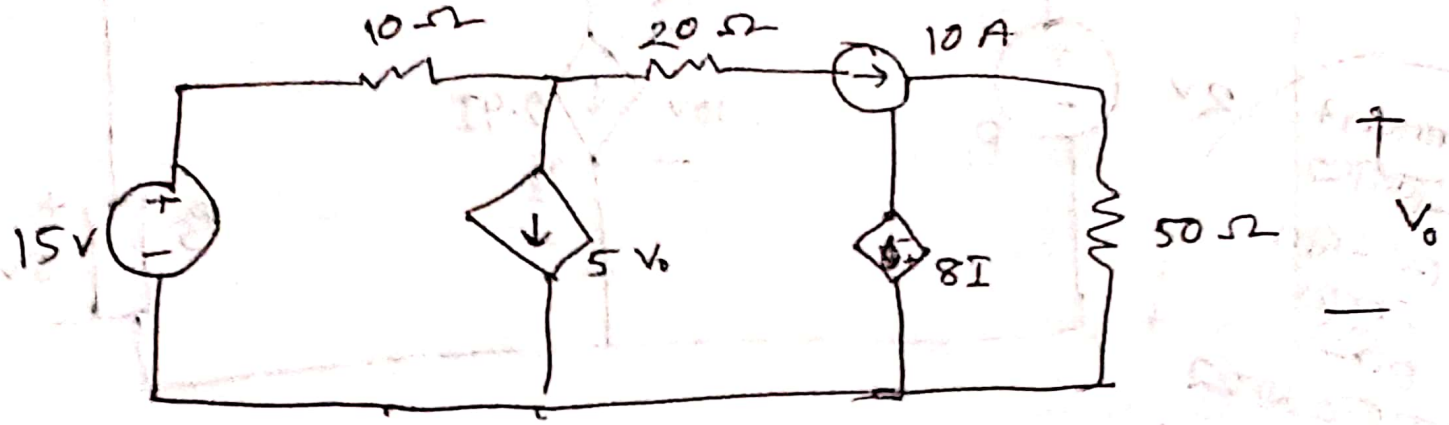
VC CS

Voltage Control Curre Sourc

Independent Voltage Source

Independent Current Source

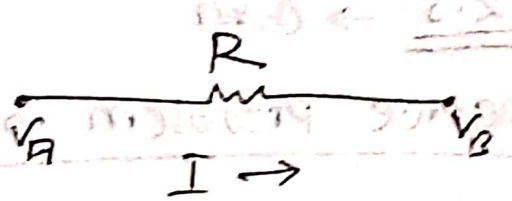
Current source বাস্তবে কোন existance নাই।



Chapter-2

Basic Laws

ওহমের সূত্র:



$V_A > V_B$

$I \propto V$

$I = GV$

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

$\therefore V = IR$

$$I = \frac{V_A - V_B}{R}$$

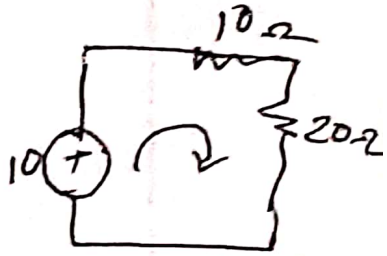
I যে কারেন্ট যাচ্ছে সেটা হচ্ছে যে কারেন্ট যাচ্ছে তার Difference divided by Resistance

Kirchoff's current law (KCL)

$i_1 + i_2 + i_3 = i_4$

KVL

Algebric sum of voltages inside a circuit will be equal zero

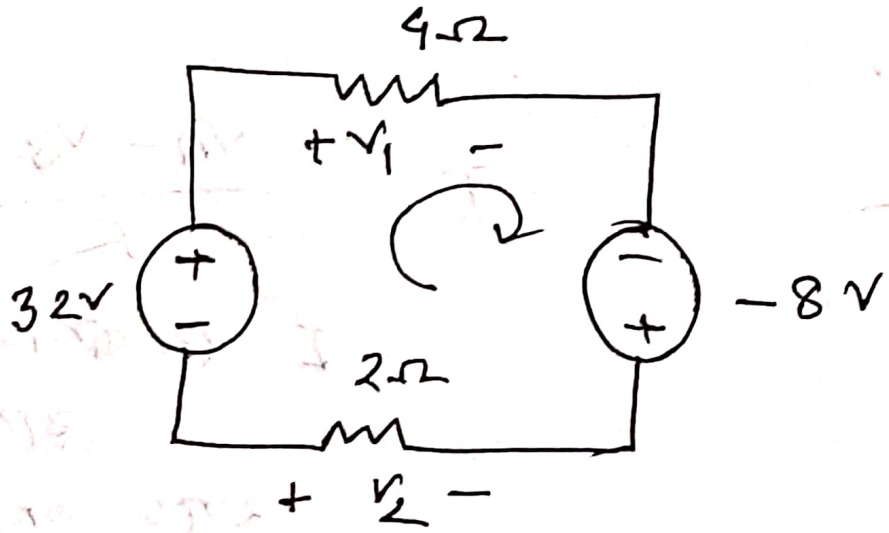


$-10 + 10i + 20i = 0$

Ex-2.5 → ch27

Practice Problem → 2.5

V_1 & V_2 = ?



Applying KVL

$$-32 + V_1 - (-8) - V_2 = 0$$

$$\Rightarrow -32 + 4i + 8 - (-2i) = 0$$

$$\Rightarrow -32 + 6i + 8 = 0$$

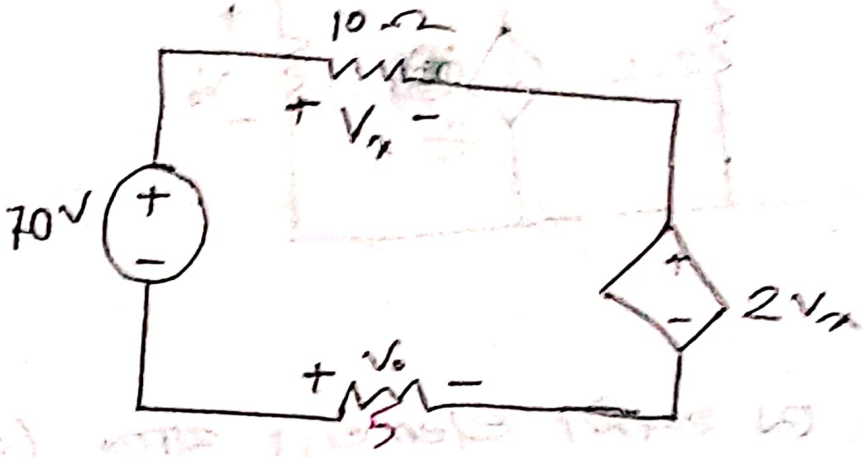
$$\Rightarrow i = 4A$$

$V_1 = +4i$
$= 4 \times 4 = 16$

$V_2 = -2i$
$= -8V$

20-11-2022

Practice Problem → 2.6



$-2V_x - V_x + 70 + V_o = 0$

$\Rightarrow -3V_x + 70 + V_o = 0$

$\Rightarrow -3(-10I) + 70 + 5I = 0$

$\Rightarrow 35I = -70$

$\therefore I = -2A$

$V_x = -10I$

$V_o = 5I$

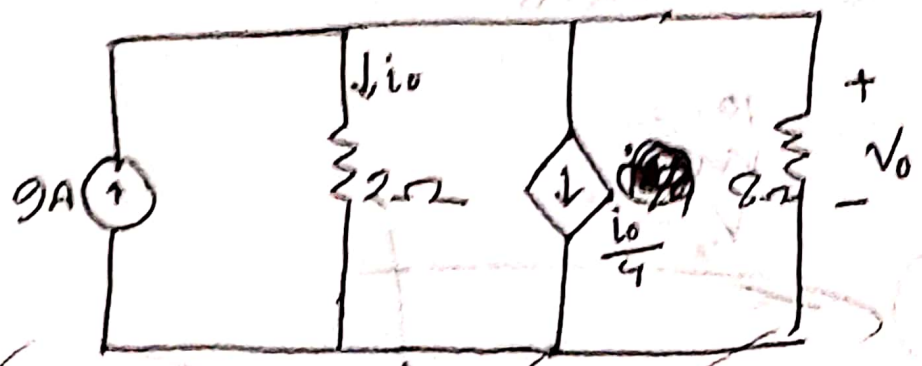
$\therefore V_x = -10 \times -2$

$= 20V$

$V_o = 5 \times (-2)$

$= -10V$

Ans



Branch → যে কয়টা element থাকে (4টা)

দুইয়ের অধিক Branch এর সাথে মিলিত হলে Node

Loop → Any closed path (6 টা)

Reference Node → যেটা Ground থাকে

এর থাকে Voltage = 0

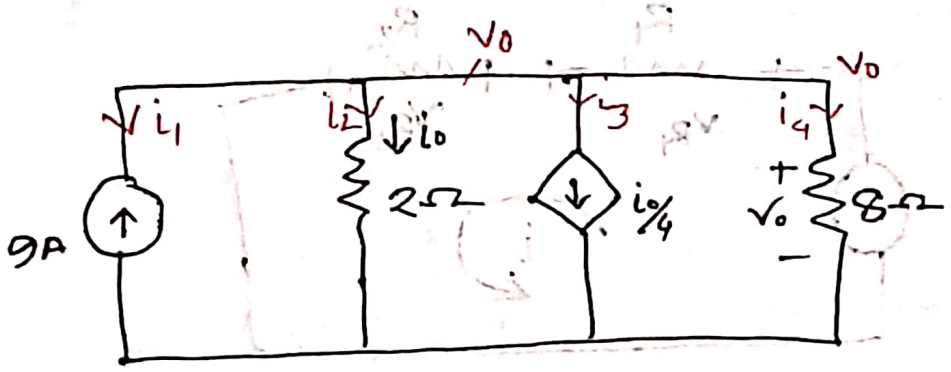
যেটা Ground এ থাকবে না

সেটা Non reference Node

$v = iR$

Parallel Branch ↳ Voltage similar
Series Branch ↳ Current similar

Find i_o & V_o



According to KCL —

$$i_1 + i_2 + i_3 + i_4 = 0$$

$$\Rightarrow -9 + i_o + i_o/4 + \frac{V_o - 0}{8} = 0$$

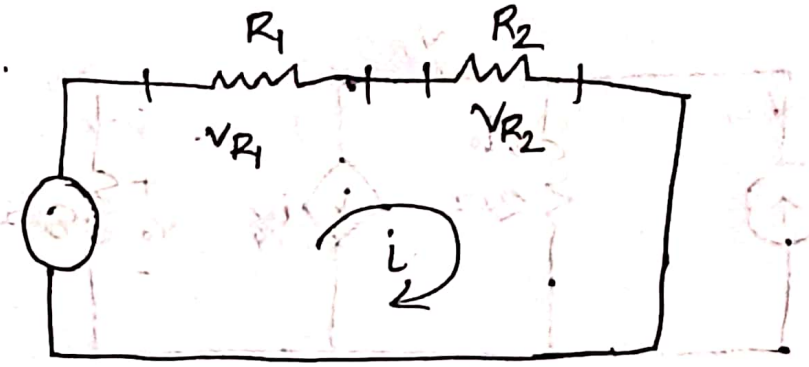
$$\Rightarrow -9 + 1.25\, i_o + V_o/8 = 0$$

$$\Rightarrow -9 + 1.25 \times V_o/2 + V_o/8 = 0$$

$$\Rightarrow V_o = 12\,V$$

$$\therefore i_o = 6\,A$$

Series Branches and Voltage Division



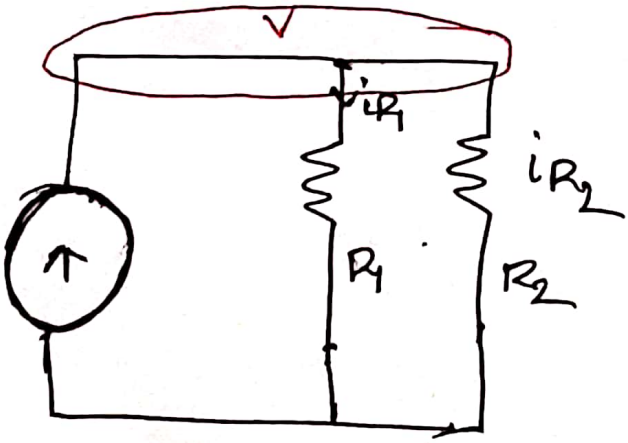
$$i = \frac{V_1}{R_1+R_2}$$

$$V_{R_1} = i \cdot R_1$$

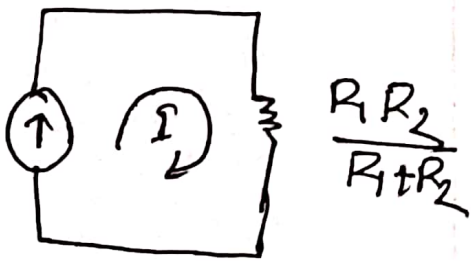
$$= \frac{V_1}{R_1+R_2} \times R_1$$

$$\therefore V_{R_1} = \left(\frac{R_1}{R_1+R_2}\right) V_1$$

$$V_{R_2} = \left(\frac{R_2}{R_1+R_2}\right) V_2$$



$\Rightarrow$



$$I = \frac{V}{\frac{R_1 R_2}{R_1+R_2}}$$

$$= \left(\frac{R_1+R_2}{R_1 R_2}\right) V$$

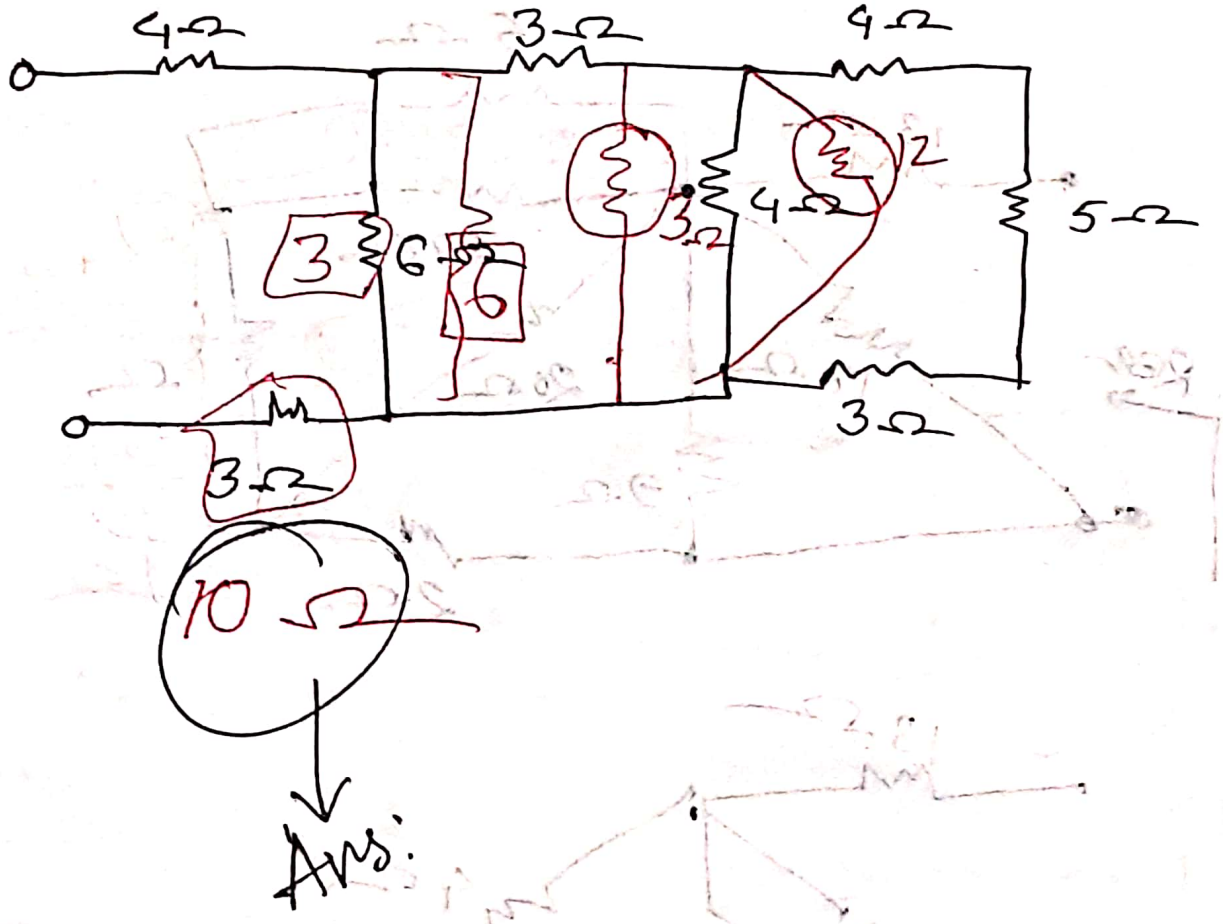
$$i_{R_1} = \frac{V}{R_1}$$

$$= \left(\frac{R_1 R_2}{R_1+R_2}\right) \times I \times \frac{1}{R_1}$$

$$= \left(\frac{R_2}{R_1+R_2}\right) I$$

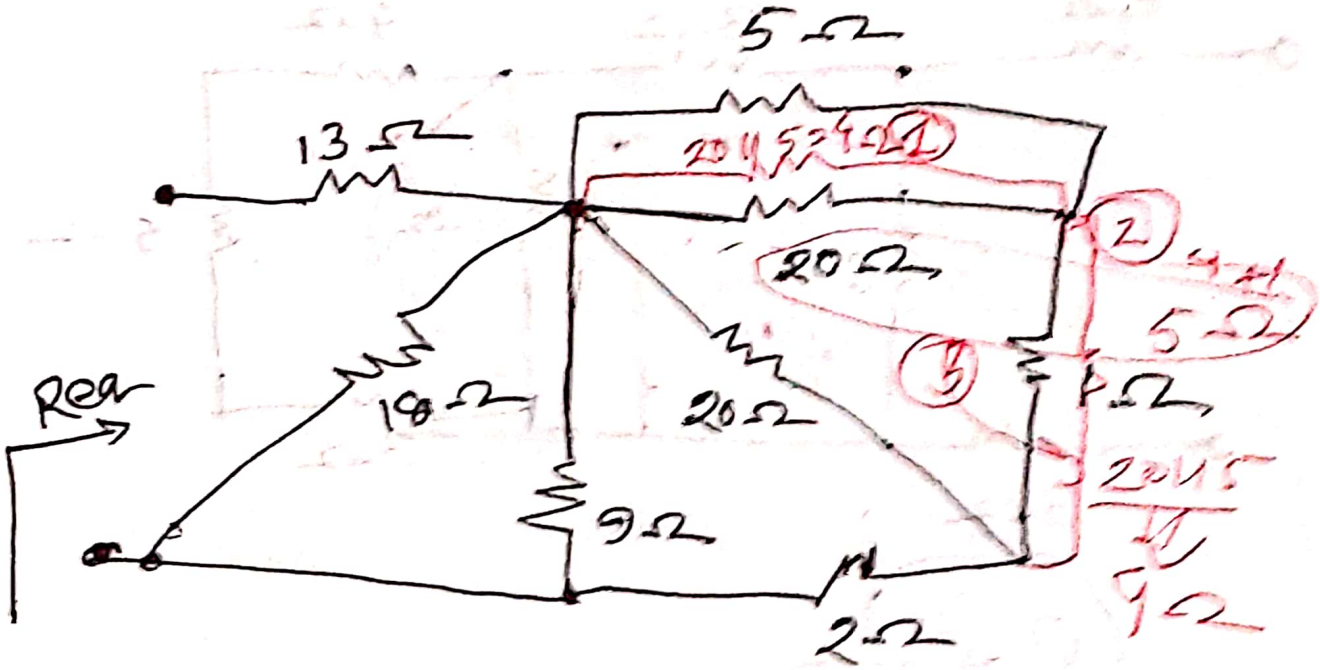
$$i_{R_2} = \left(\frac{R_1}{R_1+R_2}\right) I$$

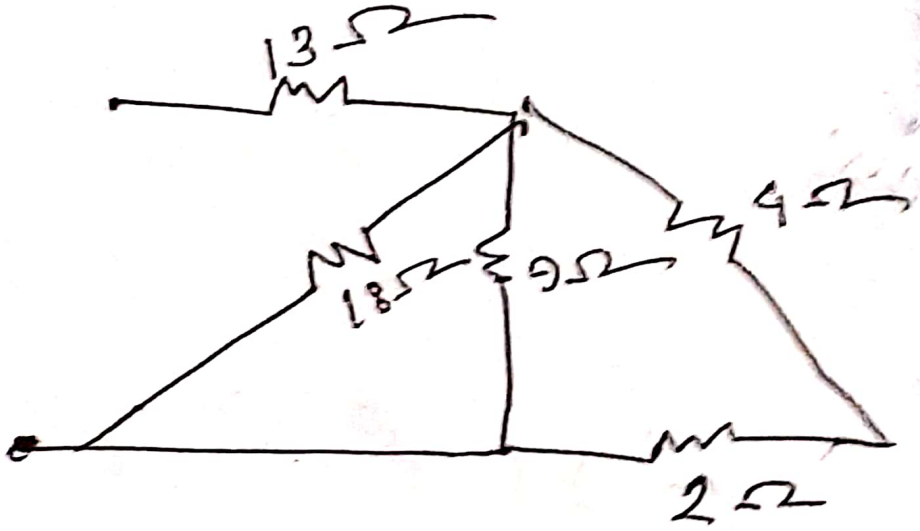
P.P → 2.9

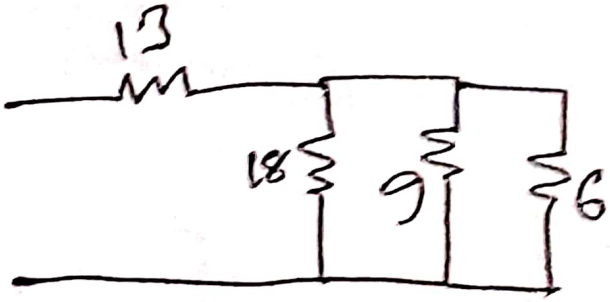


Ans:

P.P → 2.10

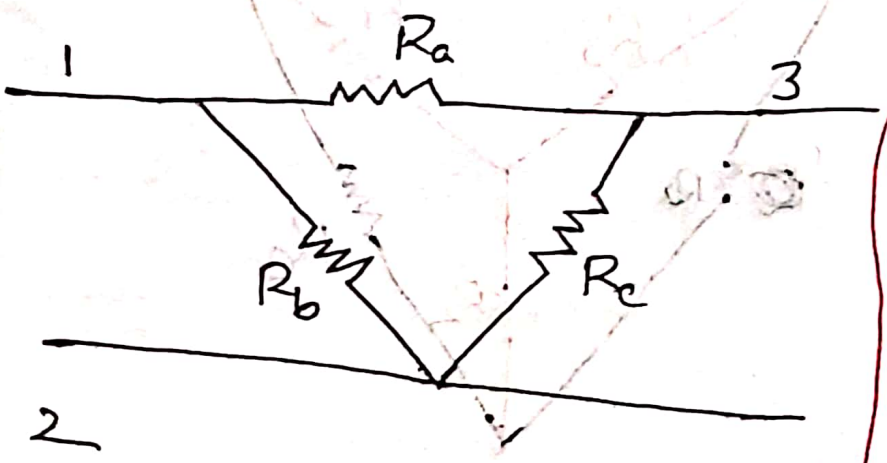


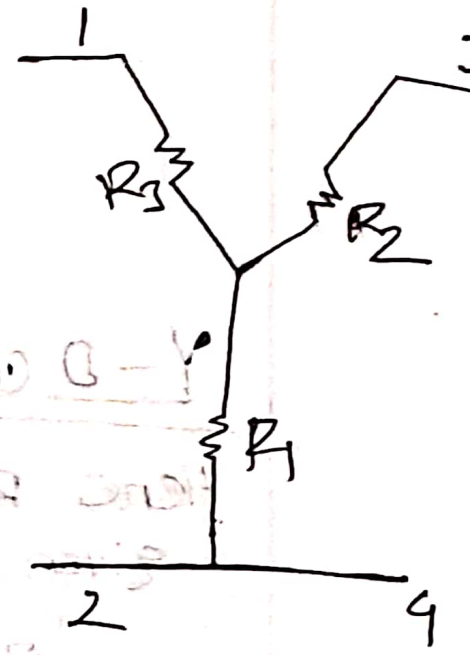




Short circuit → Resistance হীন তার।

Delta - Wye Transformation:





Delta

$$R_{12} = R_b \parallel (R_a + R_c)$$

$$= \frac{R_b (R_a + R_c)}{R_a + R_b + R_c}$$

~~R_{13} =~~

$$R_{13} = R_2 + R_3 = R_a \parallel (R_b + R_c) \quad \text{.....} (5)$$

$$R_{34} = R_2 + R_1 = R_c \parallel (R_a + R_b) \quad \text{..} (3)$$

Wye:

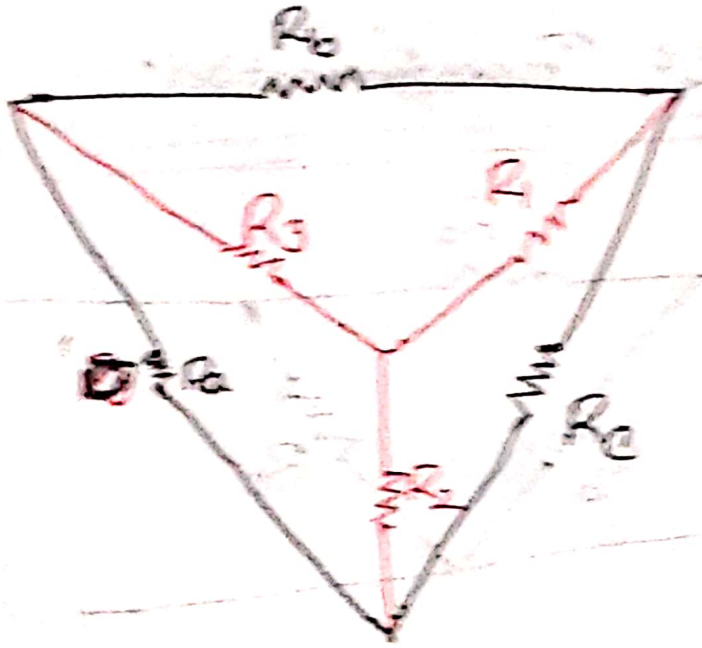
$$R_{12} = R_1 + R_3 \quad \text{---} (1)$$

(1) − (3)

$$R_1 + R_3 = \ldots$$

$$-R_1 - R_2 = \ldots$$

$$R_3 - R_2 = \ldots \quad \text{---} (4)$$



Y - D conversion

Here R_1, R_2, R_3 will given.

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

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

$$R_c = \frac{\ldots\ldots}{R_3}$$

D - Y conversion

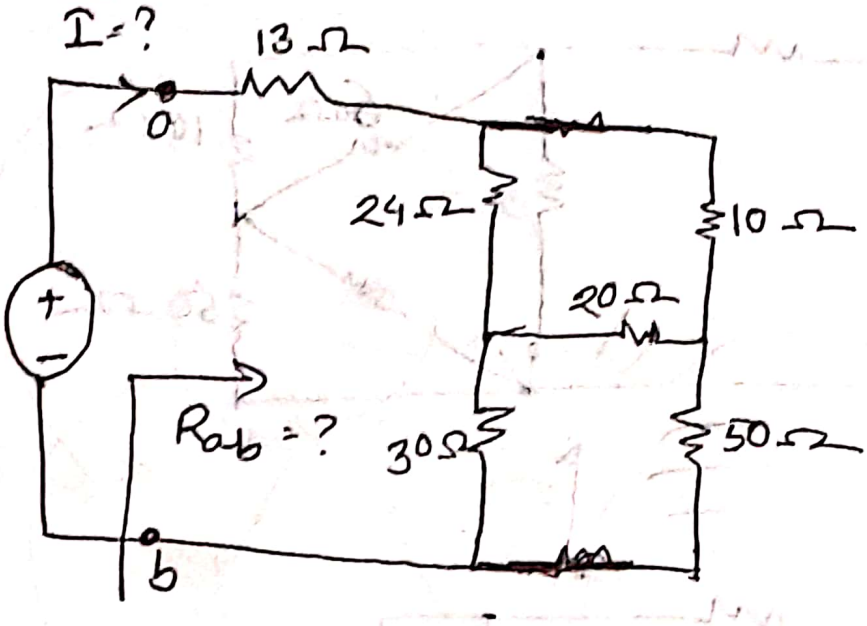
Here R_a, R_b, R_c will given

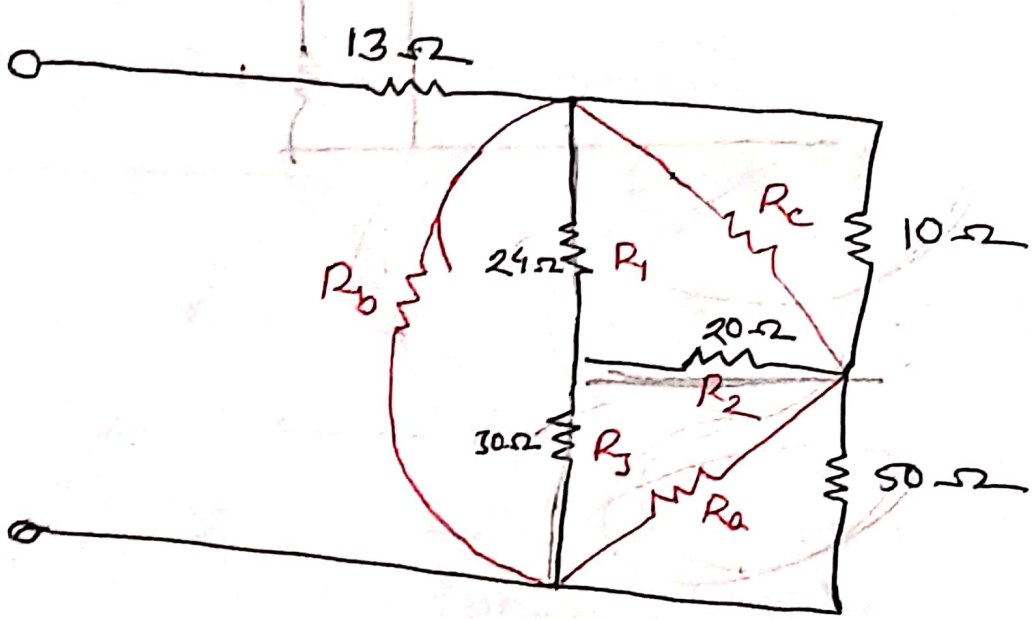
$$R_1 = \frac{R_bR_c}{R_a + R_b + R_c}$$

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

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

1.P → 2.D





∴ Y - D →

$$R_a = \frac{24\times20 + 20\times30 + 30\times24}{24}$$

$$= \frac{1800}{24}$$

$$= 75\,\Omega$$

$$R_b = \frac{1800}{20}$$

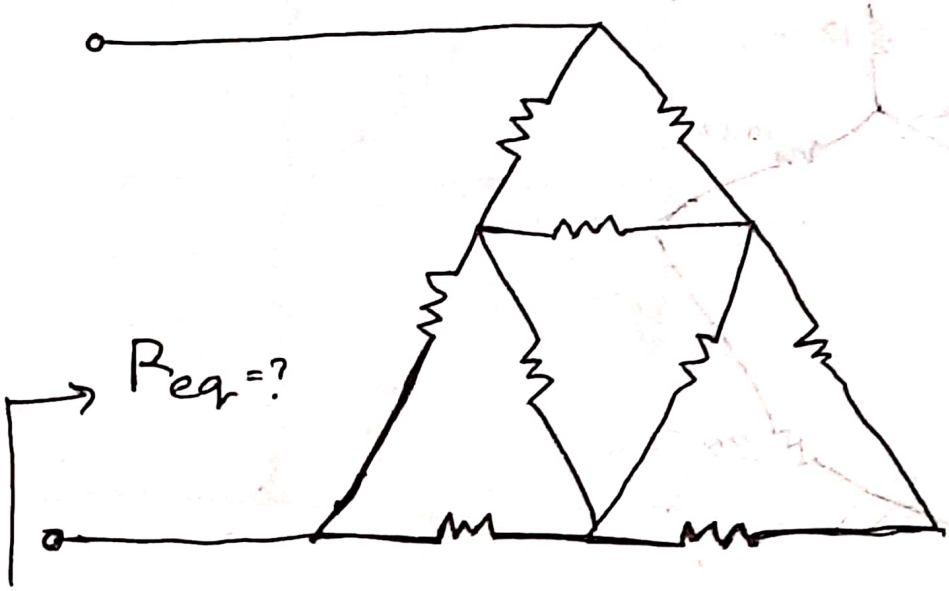
$$= 90\,\Omega$$

$$R_c = \frac{1800}{30}$$

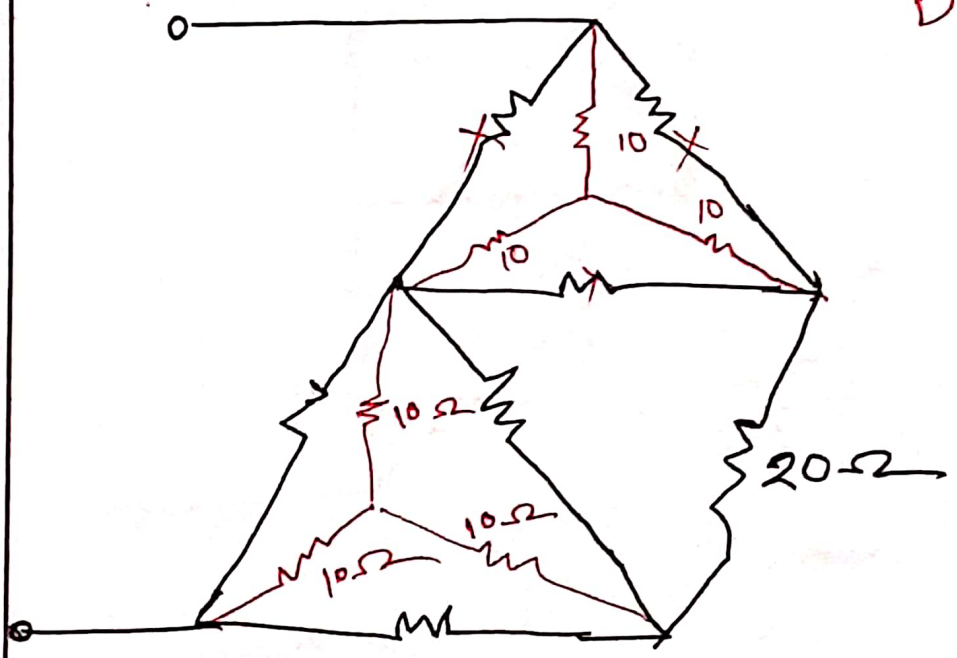
$$= 60\,\Omega$$

10Ω
50Ω
60Ω
20Ω
Paralelo
Paralelo
40Ω

Exercise -2.53



All resistance are 30 Ω



D - Y

$$R_1 = \frac{30 \times 30}{30 + 30 + 30}$$

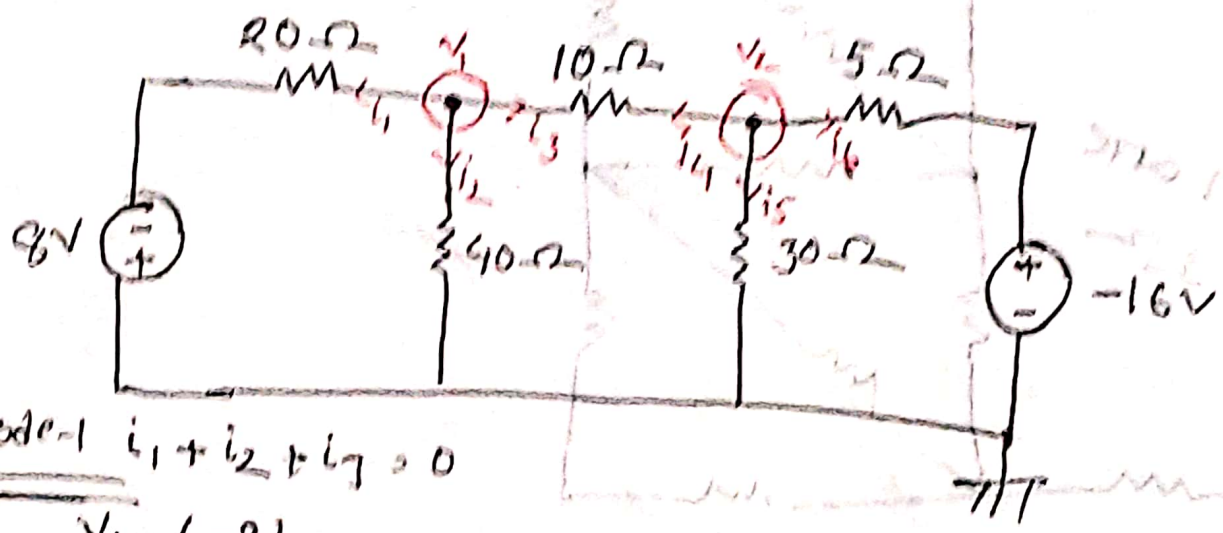
$$= \frac{900}{90}$$

$$= 10$$

10Ω
10Ω
10Ω
10Ω
10Ω
20Ω

1
2
3
1
1

Ah 1 arte
3 Sr



KCL in node-1 $i_1 + i_2 + i_3 = 0$

$$\frac{v_1 - (-8)}{20} + \frac{v_1 - 0}{40} + \frac{v_1 - v_2}{10} = 0$$

$$v_1 (\qquad) + v_2 (\qquad) = 0 \ldots\ldots (1)$$

KCL in node-2

$$i_4 + i_5 + i_6 = 0$$

$$\Rightarrow \frac{v_2 - v_1}{10} + \frac{v_2 - 0}{30} + \frac{v_2 - (-16)}{15} = 0$$

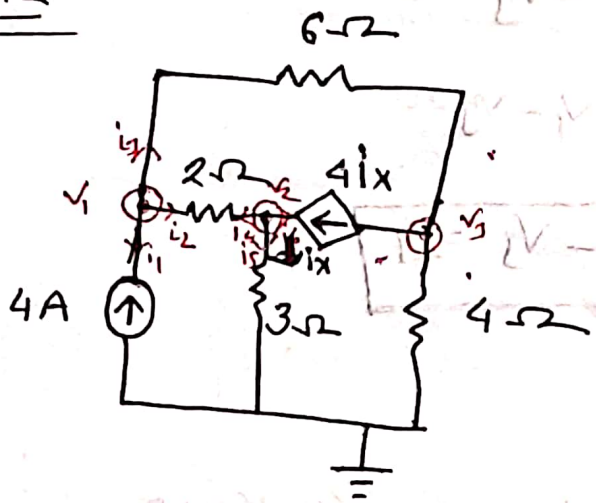
$\Rightarrow$

06-12

Chapter-3

Methods of Analysis

P. P → 3.2



Find the node voltages.

$V = IR$

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

KCL in node-1:

$$i_1 + i_2 + i_3 = 0$$

$$\Rightarrow -4 + \frac{v_1 - v_2}{2} + \frac{v_1 - v_3}{6} = 0$$

KCL in node-2:

$$i_4 + i_5 + i_6 = 0$$

$$\Rightarrow \frac{v_2 - v_1}{2} + \frac{v_2}{3} + (-4i_x) = 0 \quad [i_x =$$

$$\Rightarrow \frac{v_2 - v_1}{2} + \frac{v_2}{3} - 4 \cdot \frac{v_2}{3} = 0$$

KCL in node-3:

$$4i_x + \frac{v_3}{4} + \frac{v_3 - v_1}{6} = 0$$

$$\Rightarrow 4\frac{v_2}{3} + \frac{v_3}{4} + \frac{v_3 - v_1}{6} = 0$$

(I) $\Rightarrow$

$$-24 + 3(v_1 - v_2) + v_1 - v_3 = 0$$

$$\Rightarrow -24 + 3v_1 - 3v_2 + v_1 - v_3 = 0$$

$$\Rightarrow \boxed{4v_1 - 3v_2 - v_3 = 24}$$

(II)

$$\frac{1}{2}v_2 - \frac{1}{2}v_1 + \frac{1}{3}v_2 - \frac{4}{3}v_2 = 0$$

$$-\frac{1}{2}v_1 - \frac{1}{2}v_2 = 0$$

$$\Rightarrow v_1 = -v_2$$

(III) $\frac{4}{3}v_2 + \frac{1}{4}v_3 + \frac{1}{6}v_3 - \frac{1}{6}v_1 = 0$

$$\frac{5}{12}v_3 + \frac{4}{3}v_2 - \frac{1}{6}v_1 = 0$$

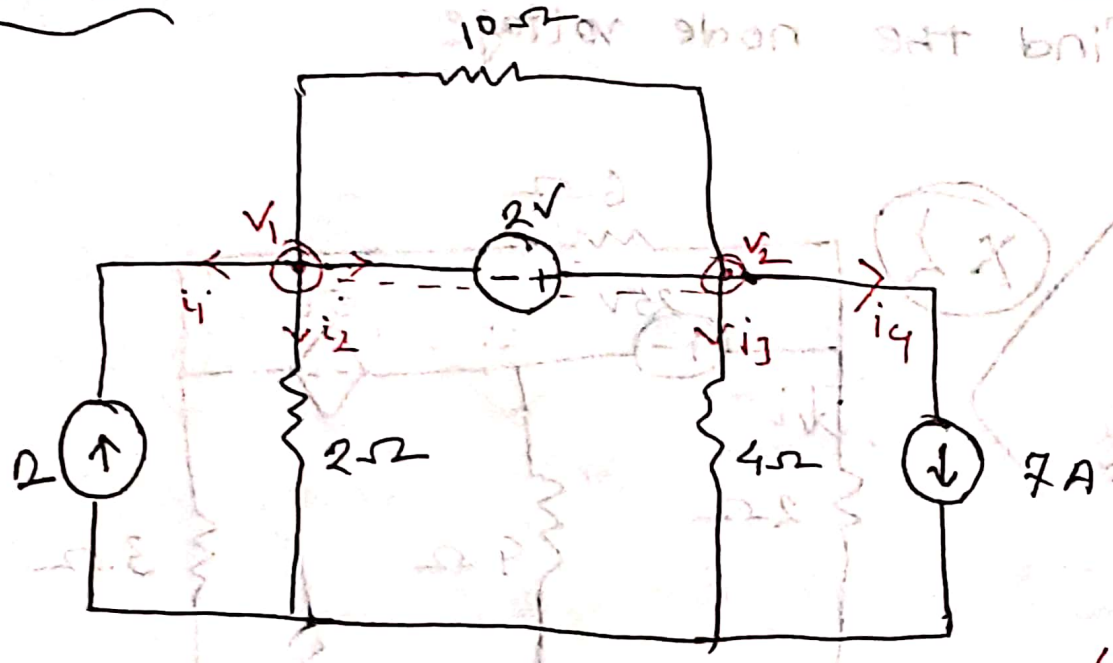
$$-2v_1 + 16v_2 + 5v_3 = 0$$

$$v_1 = \frac{20}{17} = 7.05$$

$$v_2 = -\frac{20}{17} = -7.05$$

$$v_3 = \frac{72}{15} = 25.41$$

Ex → 3.3



If there exists any voltage source (dependend/ Independent) in between two non-reference node we will call it as "Super Node".
SuperNode reacts as short circuit.

$v_2 - v_1 = 2$ [Positive side is bigger]

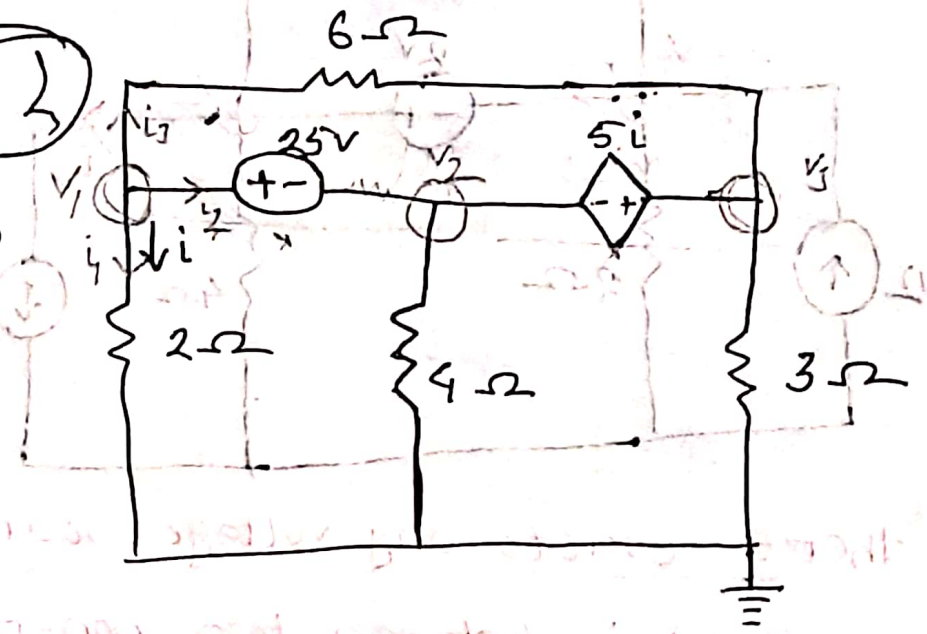
KCL -

$i_1 + i_2 + i_3 + i_4 = 0$

$\Rightarrow -2 + \frac{v_1 - 0}{2} + \frac{v_2 - 0}{4} + 7 = 0$ —— (2) [কারণ super node এটা না হিসাবে আসছে]

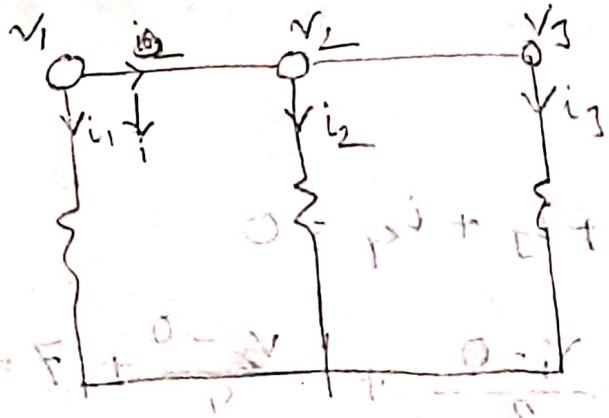
P.P → 3.4

Find the node voltage



$$V_1 - V_2 = 25 \quad \text{—— (i)}$$

$$V_3 - V_2 = 5i \quad \text{—— (ii)}$$



Applying KCL,

$$\frac{V_1 - 0}{2} + \frac{V_2 - 0}{4} + \frac{V_3 - 0}{3} = 0$$

$$\Rightarrow \frac{6V_1 + 3V_2 + 4V_3}{12} = 0$$

$\therefore 6V_1 + 3V_2 + 4V_3 = 0$ —— (III)

(II) $\Rightarrow$

$V_3 - V_2 = 5i$

$\Rightarrow V_3 - V_2 = 5 \times \frac{V_1}{2}$

$\Rightarrow 2V_3 - 2V_2 = 5V_1$

$\therefore 5V_1 + 2V_2 - 2V_3 = 0$ —— (IV)

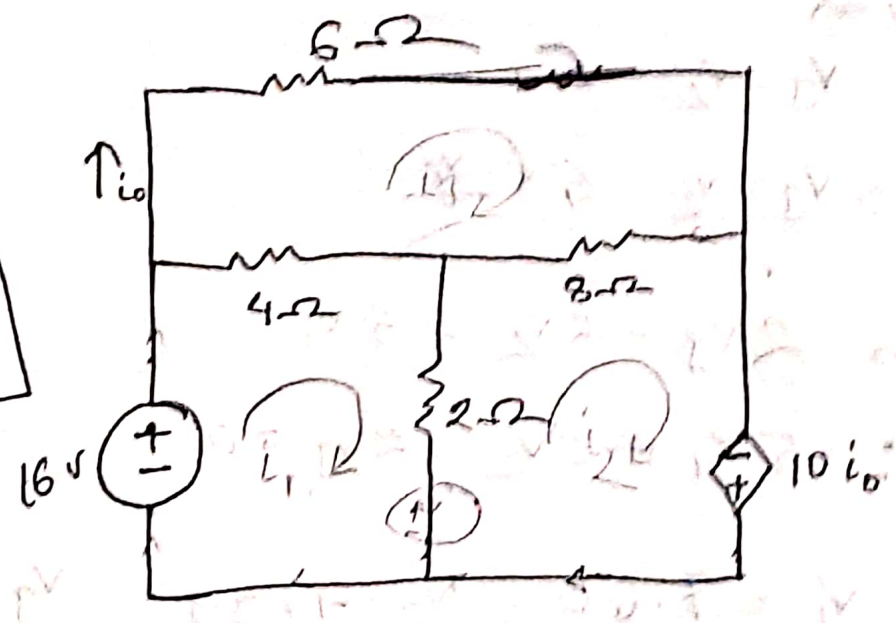
$\Rightarrow V_1 = 7.60, \quad V_2 = -17.39 \quad V_3 = 1.63$

Mesh: Mesh is a Loop that is containing no other Loop inside it.

Mesh ⇒ current source থাকলে ⇒ mesh current ⇒ EM ২টা।

P.P → 3.6

Find the mesh currents



KVL while using KVL

3 mesh is present

KVL in mesh-1

$$-16 + 4(i_1 - i_3) + 2(i_1 - i_2) = 0$$

⇒

KVL in mesh-2

$$\cancel{-16} - 10 i_o + 2(i_2 - i_1) + 8(i_2 - i_3) = 0$$

KVL in mesh-3

$$6 i_3 + 8(i_3 - i_2) + 4(i_3 - i_1) = 0$$

$-16 + 4i_1 - 4i_3 + 2i_1 - 2i_2 = 0$

$\Rightarrow \quad 6i_1 - 2i_2 - 4i_3 = 16 \quad \ldots \quad (i)$

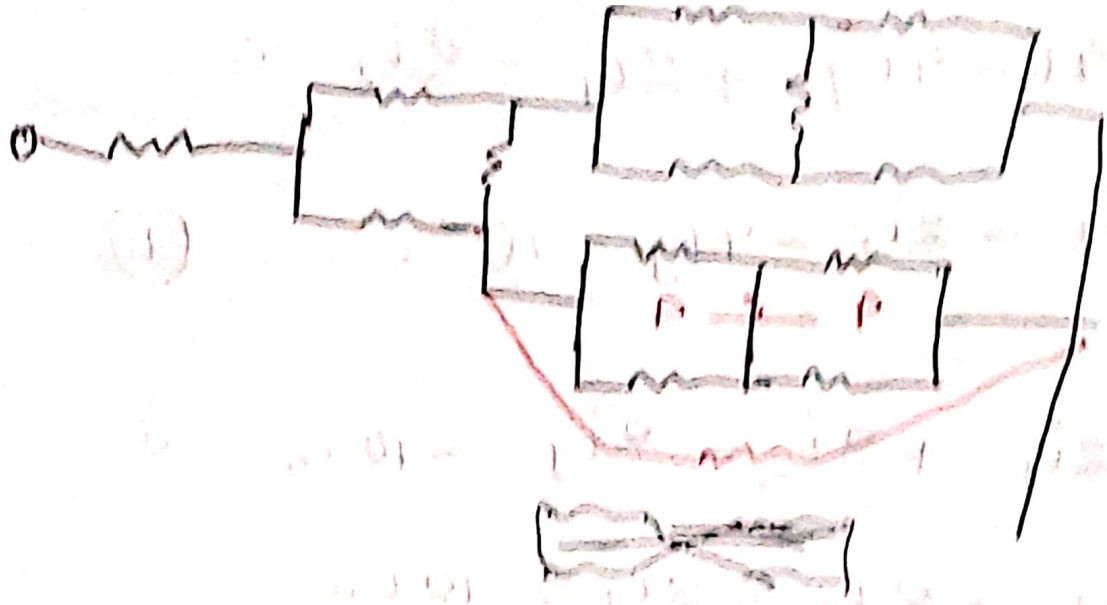
$2i_2 - 2i_1 + 8i_2 - 8i_3 - 10i_0 = 0$

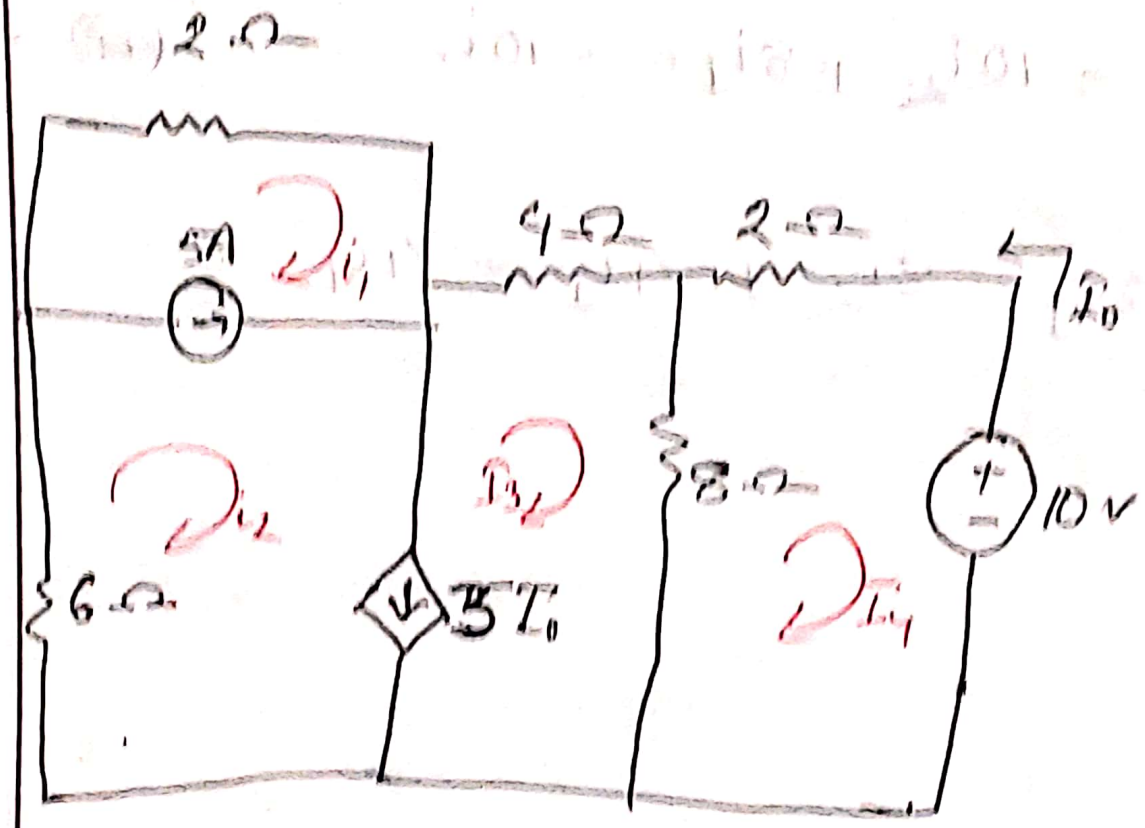
$\Rightarrow \quad 10i_2 - 2i_1 - 8i_3 = 10i_0$

$\Rightarrow \quad 2i_1 - 10i_2 + 8i_3 = -10i_0 \quad \ldots \quad (ii)$

$4i_3 + 8i_3 - 8i_2 + 4i_3 - 4i_1 = 0$

$\Rightarrow 6i$





<u>Super Meshs</u> If there exist any current source (Dependent/Independent) in between two mesh, we will call it as super mesh.

Mesh-1, KVL

$i_2 - i_1 = 5 \ldots$ ① [যে current এর Direction দিকে বেশি বড়]

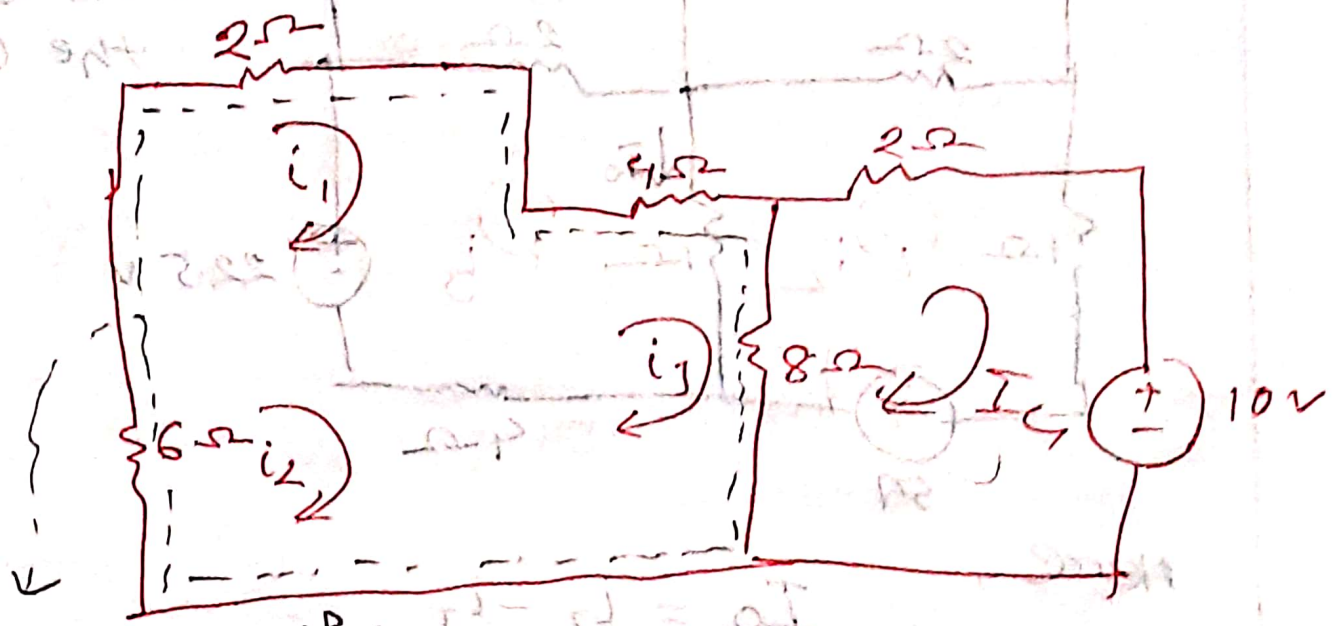
$\Rightarrow i_2 = 5 + i_1$

$i_1 + i_2 = 5$ [যদি i_2 clock wise, i_1 Anti clock wise হয়]

$i_2 - i_3 = 3I_0 = -3i_4$

$\Rightarrow i_2 - i_3 + 3i_4 = 0 \ldots$ ④

যে যে জায়গায় current source থাকে, সেই জায়গা বাদ হবে।



Super mesh।

$2i_1 + 4i_3 + 8(i_3 - i_4) + 6i_2 = 0 \ldots$

$\Rightarrow 2i_1 + 4i_3 + 8i_3 - 8i_4 + 6i_2 = 0$

$\Rightarrow$

Mesh-4

$$10 + 2(i_4 - i_3) + 2i_4 = 0 \quad \cdots\cdots \text{(IV)}$$

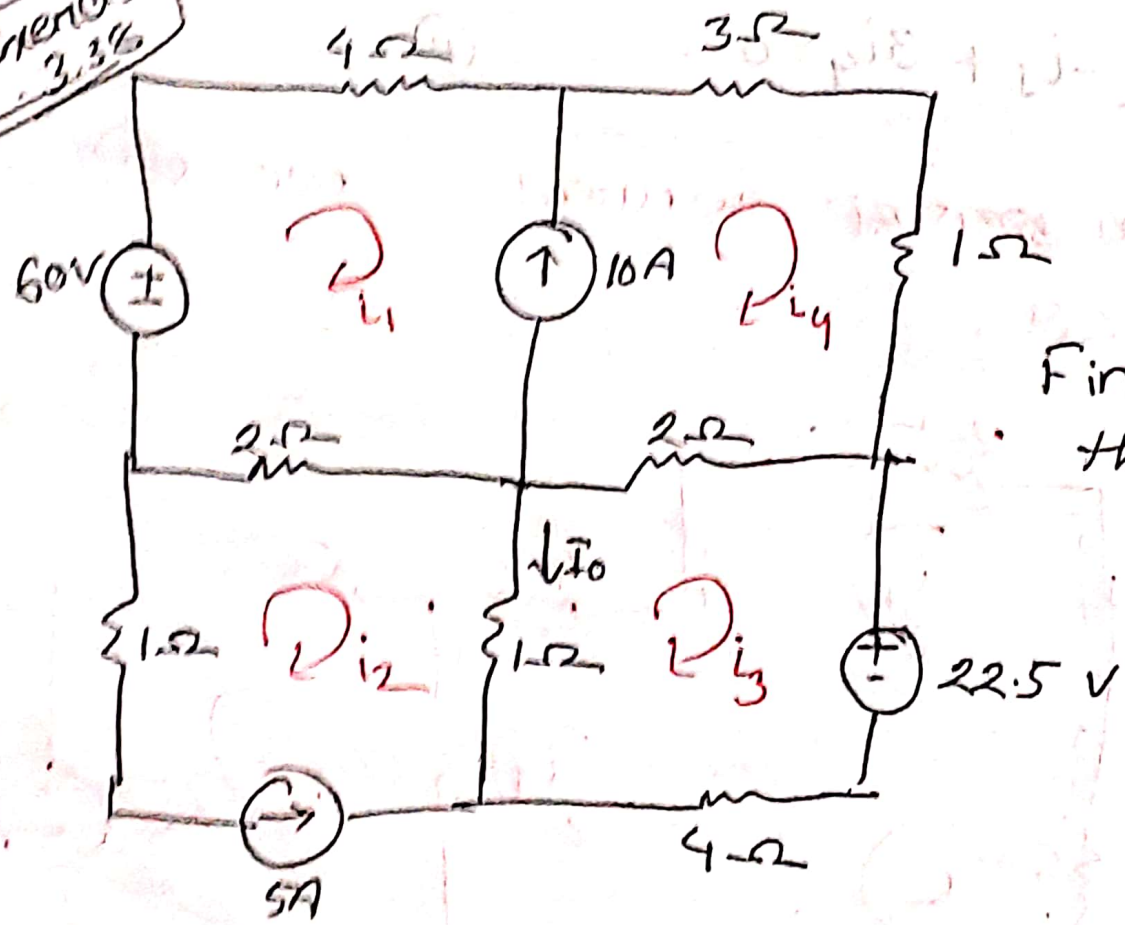
$$\Rightarrow 10 + 2i_4 - 2i_3 + 2i_4 = 0$$

$$\Rightarrow 10 i_4 - 2 i_3 = -10$$

$\therefore$ $i_1 = 2.5$ $\quad i_2 = 7.5$ $\quad i_3 = -7.5$ $\quad i_4 = -5$

(Ans) Right Ans: $i_1 = -7.5A$, $i_2 = -2.5A$, $i_3 = 3.93$, $i_4 = 2.14$

Exercise 3.36

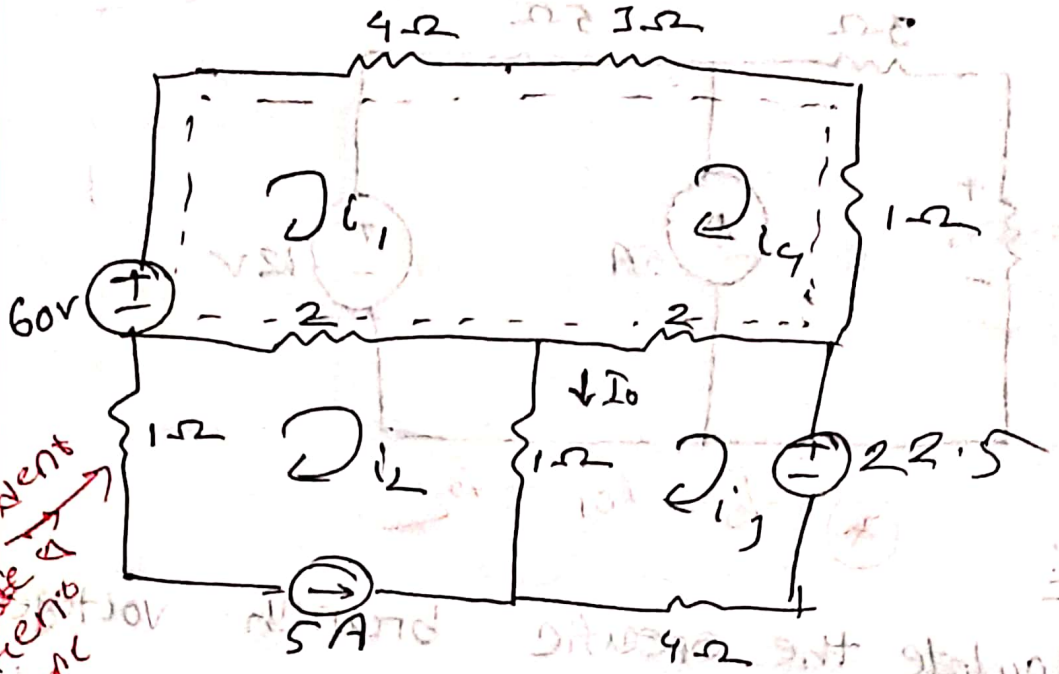


Find I_o in the circu

Here,

$$I_o = i_2 - i_3$$

$i_4 - i_1 = 10$ ..... (I)



Independent mesh current source

$4i_1 + 3i_4 + i_4 + 2(i_4 - i_3) + 2(i_1 - i_2) = 60$

$\Rightarrow 4i_1 + 6i_4 - 2i_3 + 2i_1 - 2i_2 = 60$

$\Rightarrow 6i_1 - 2i_2 - 2i_3 + 6i_4 = 60$

$\Rightarrow 3i_1 - i_2 - i_3 + 3i_4 = 30$ ..... (II)

Mesh - (III)

$2(i_3 - i_4) + 22.5 + 4i_3 - i_2 + i_3 = 0$

$\Rightarrow 22.5 + 7i_3 - i_4 = 0$

Mesh - (IV)

$i_2 = -5$

$i_1 = -1.06A$

$i_2 = -5A$

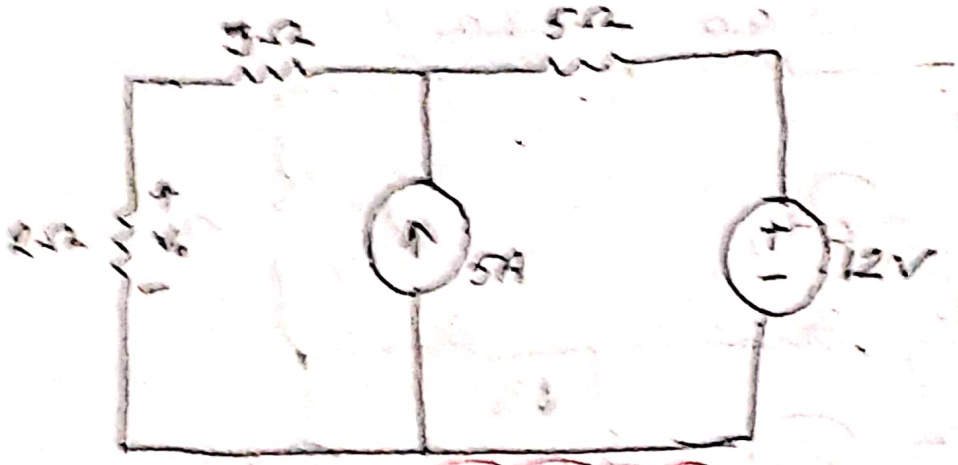
M.R.R.

Chap-9
Circuit Theorem

Superposition Theorem

4.3

Find V_o using ST



* $V_o = V_{o1} + V_{o2}$

STEPS:

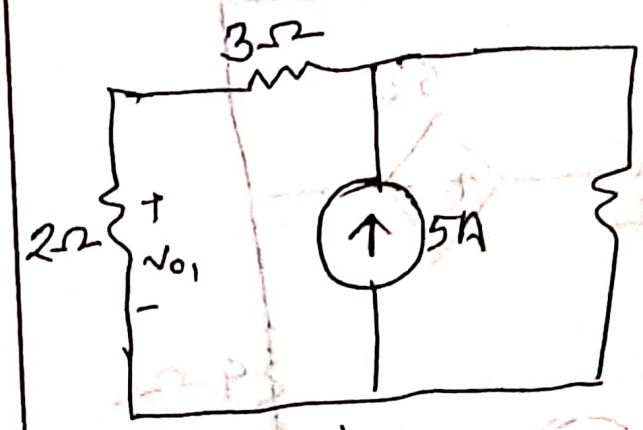
→ Calculate the specific branch voltage/current for all of the sources given

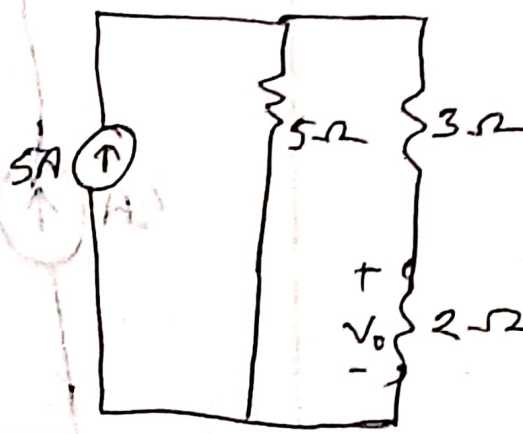
→ To make inactive
- → Current sources will be made open circuited
- → Voltage sources will be made short circuit.

→ Any dependent ~~sources~~ sources can never be made inactive.

Sol^n:

When 5A active:





$$I = \frac{5}{5+3+2} \times 5$$

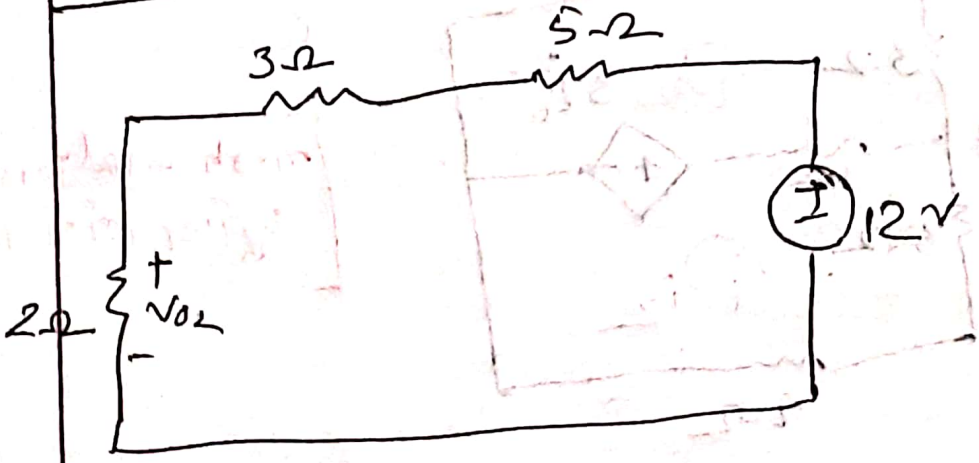
$$= \frac{25}{10}$$

$$= 2.5A$$

$$V_{o1} = 2.5 \times 2$$

$$= 5V$$

When 12V is active



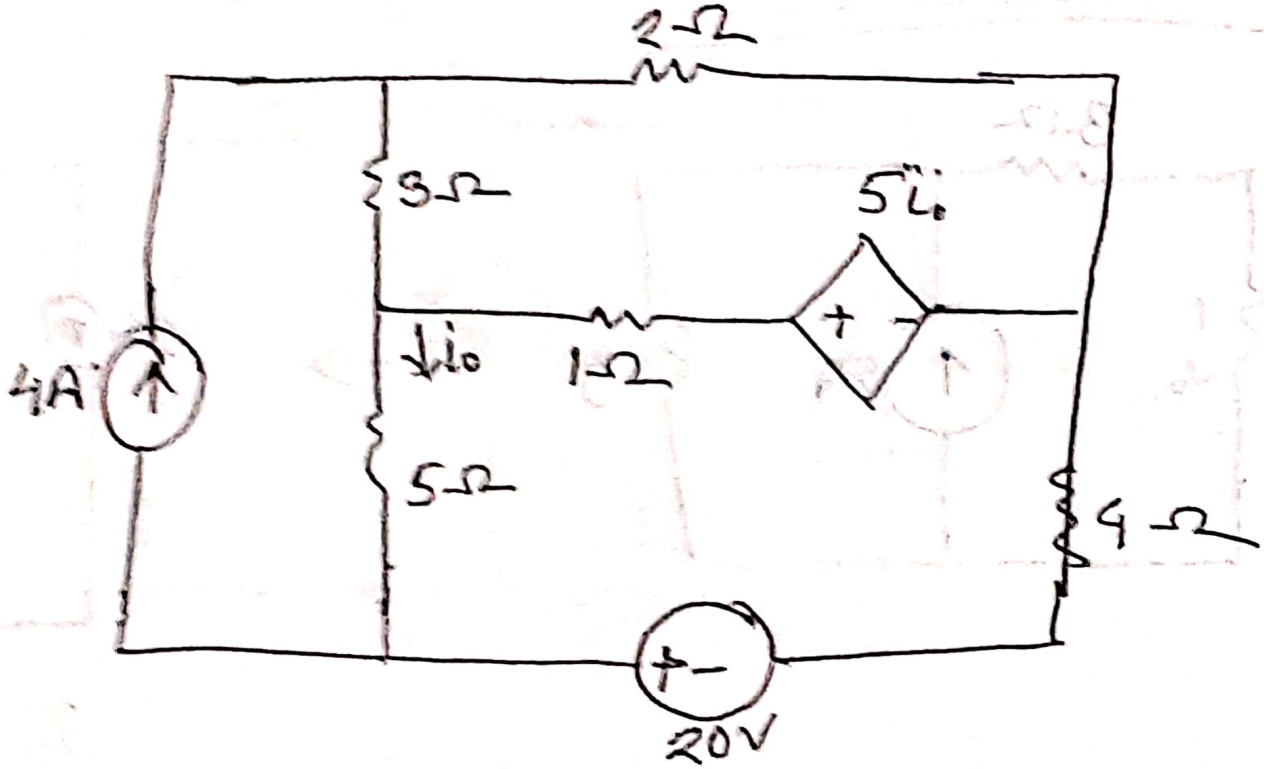
$$V_{o2} = \frac{2}{2+3+5} \times 12$$

$$= 2.4$$

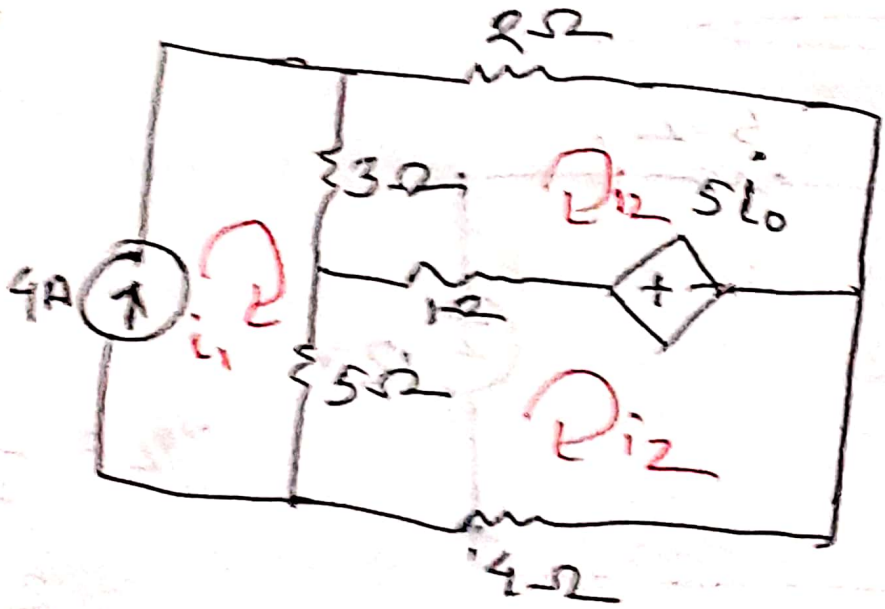
$$\therefore V_o = V_{o1} + V_{o2} = (5 + 2.4)V$$

$$= 7.4\ V$$

Ex - 4.4



When 4A Active



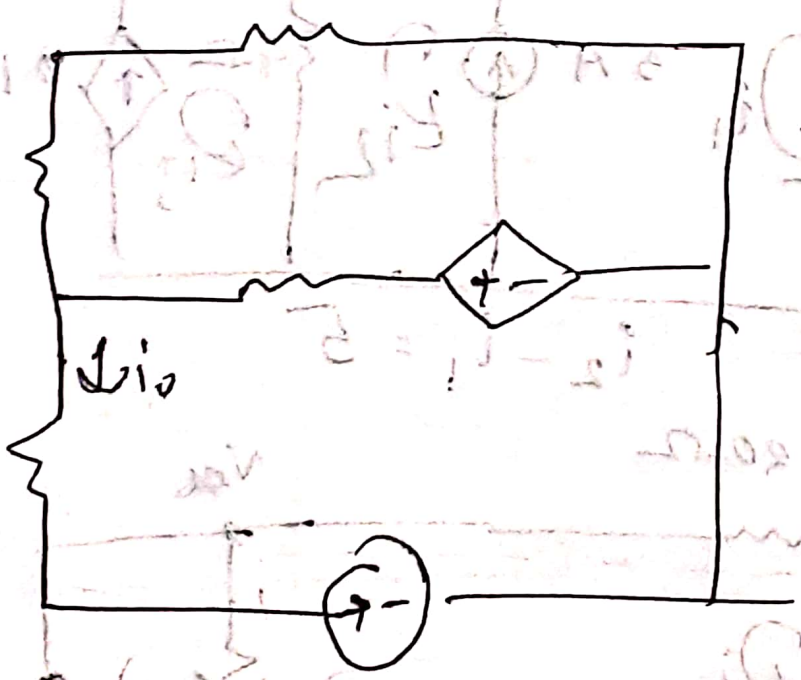
[mesh analysis
সুবিধা হবে]

Mesh 1

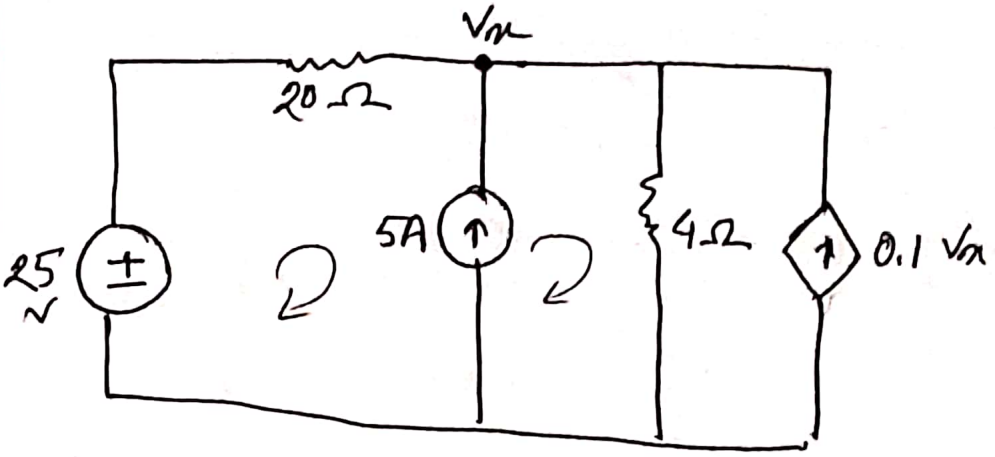
$i_1 = 4$

Mesh-2

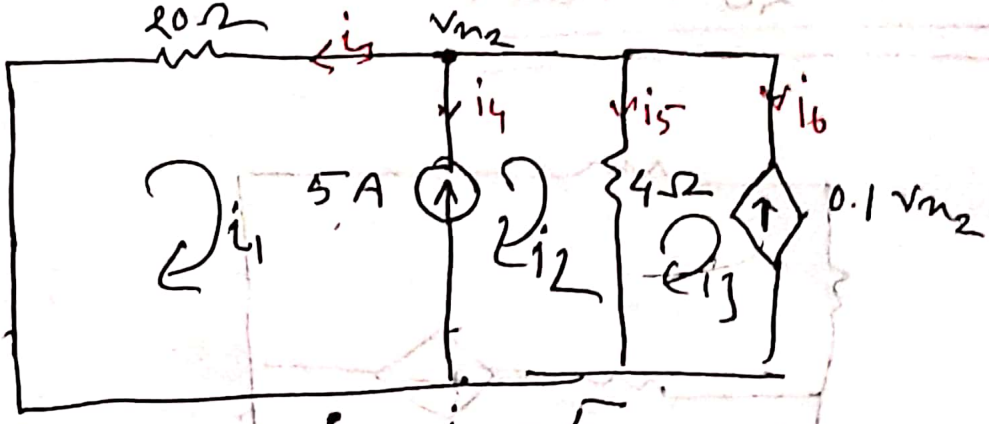
When 20 v Active



P.P 4.4



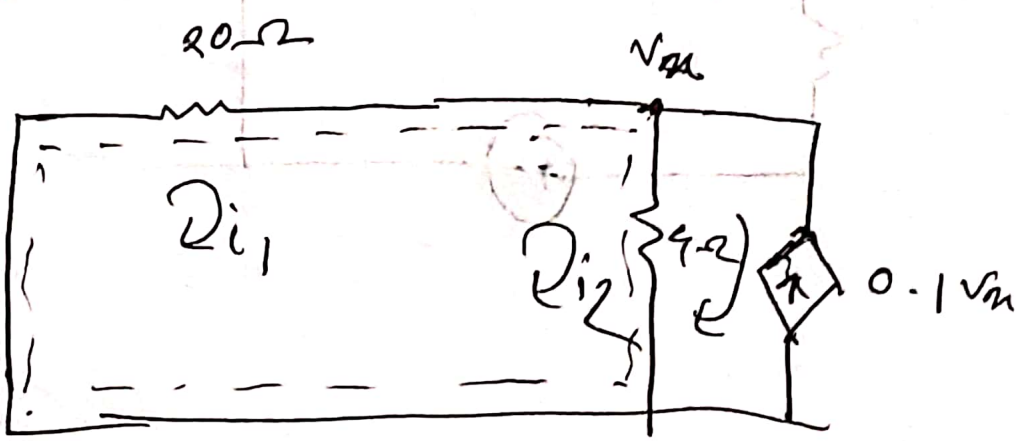
When 5A is Active



$i_2 - i_1 = 5$

Mesh ⇒ Node

Advantage



$$20 i_1 + 4(i_2 - i_3) = 0$$

$$\Rightarrow 20 i_1 + 4 i_2 - 4 i_3 = 0$$

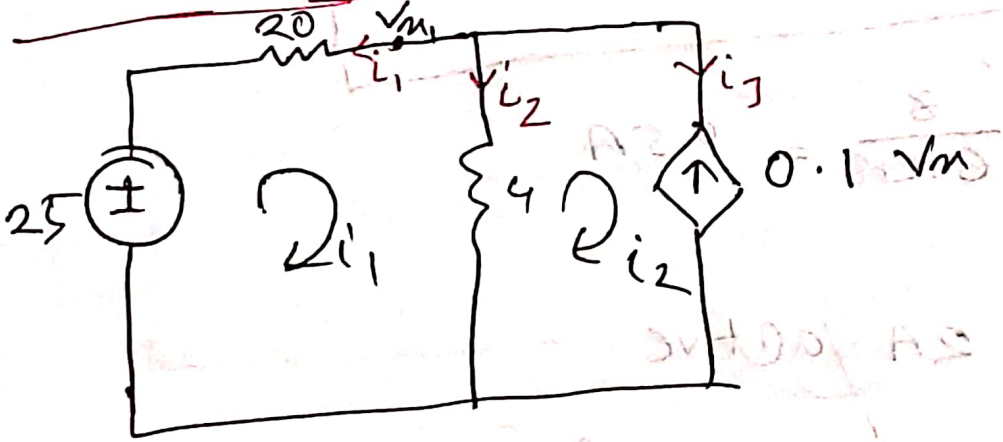
Mesh-1

~~$4(i_3 - i_2) =$~~

$$i_3 + i_4 + i_5 + i_6 = 0$$

$$\frac{v_{x_2} - 0}{20} + (-5) + \frac{v_{x_2} - 0}{4} + (-0.1\, v_{x_2}) = 0$$

When 25 v active

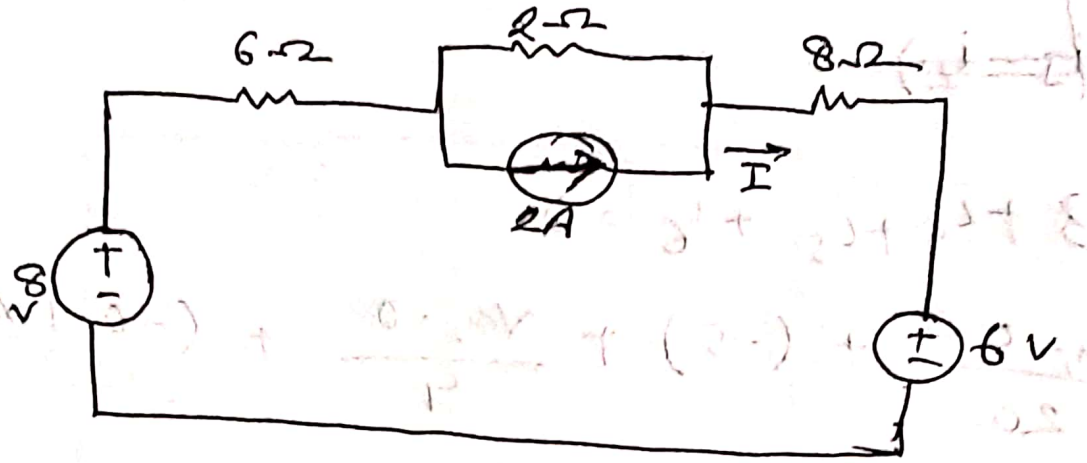


$$i_1 + i_2 + i_3 = 0$$

$$\rightarrow \frac{v_{x_1} - 25}{20} + \frac{v_{x_1} - 0}{4} - 0.1\, v_{x_1} = 0$$

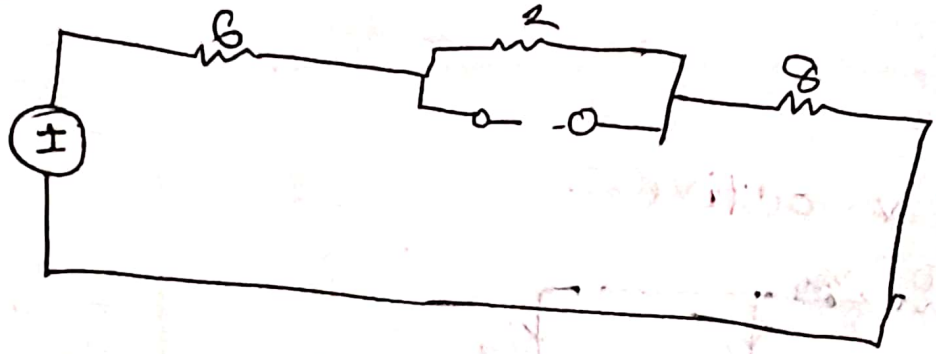
22/12-22

P.P - 4.5



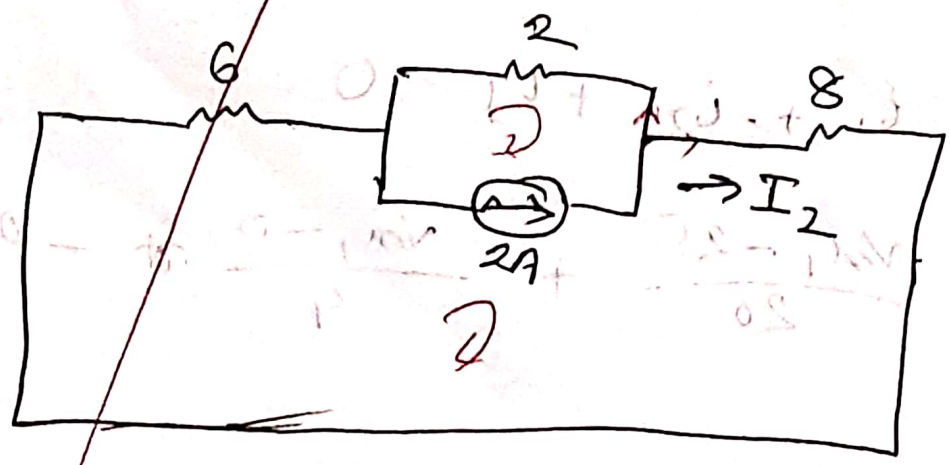
Soln:

① When 8V active



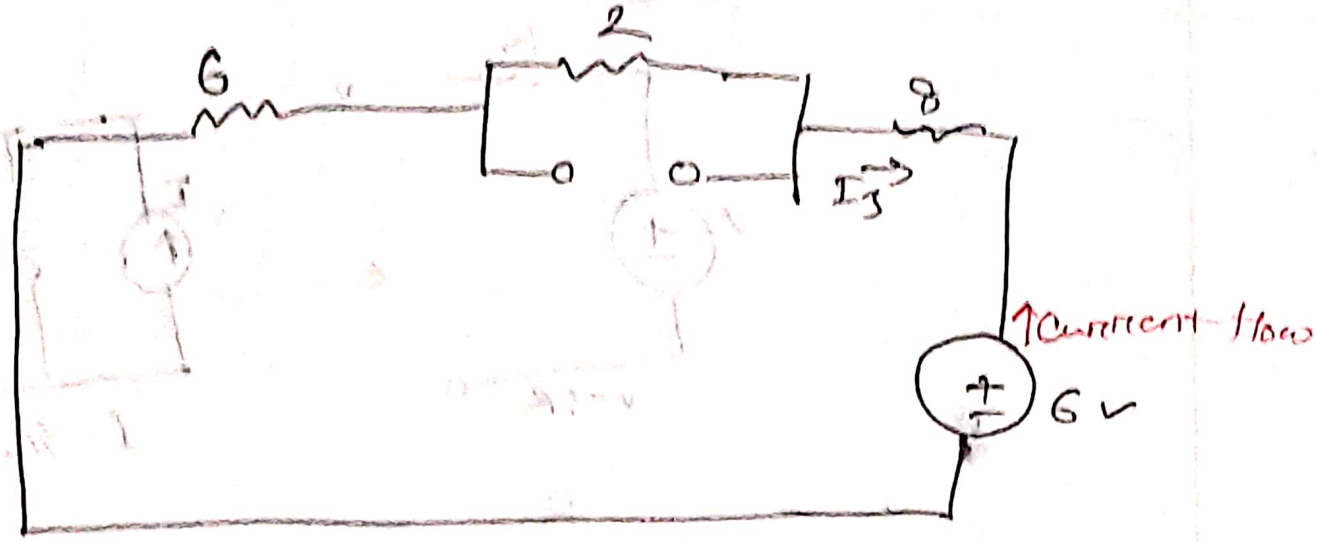
$$I_1 = \frac{8}{6+2+8} \Rightarrow 0.5A$$

② When 2A active



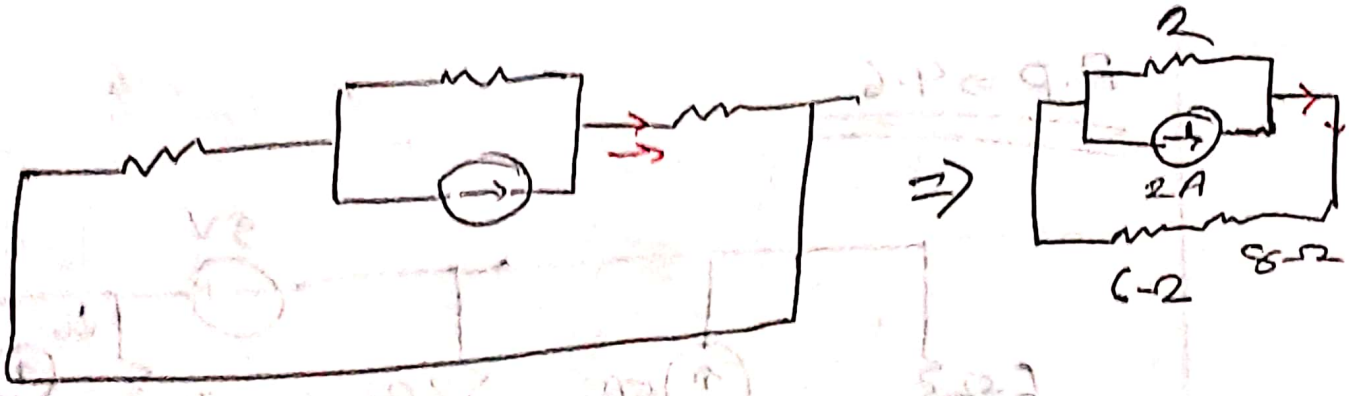
~~$I_2 = 2A$~~

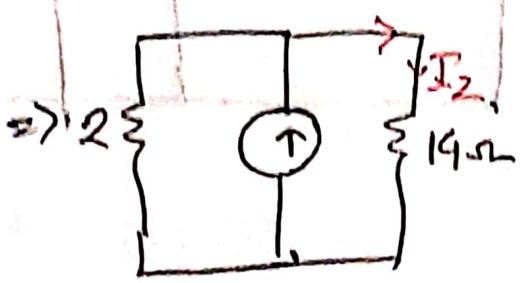
(iii) when 6V active



$$\therefore I_3 = \frac{6}{16} = \frac{3}{8} A \quad -0.375 A$$

(iv) when 2A active





$$\Rightarrow I_2 = \frac{2}{2+14} \times 2$$

$$= \frac{4}{16} A$$

$$= 0.25 A$$

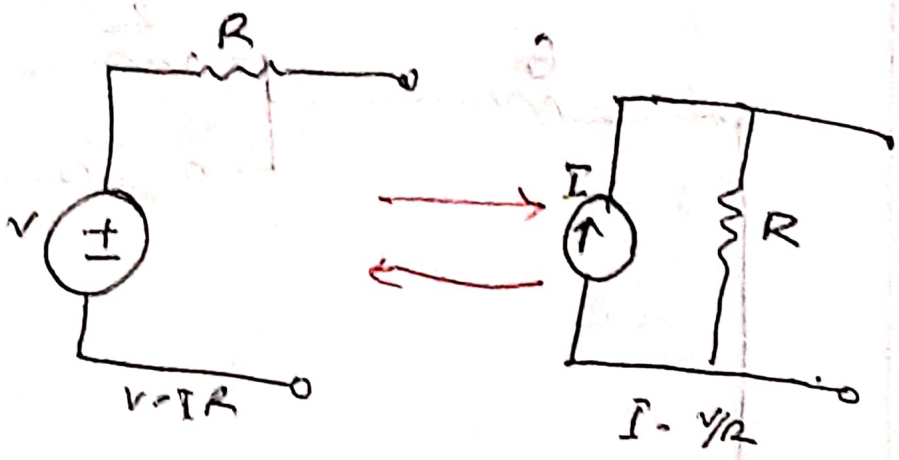
$$\therefore I = I_1 + I_2 + I_3 = .25 + .5 + (-0.375)$$

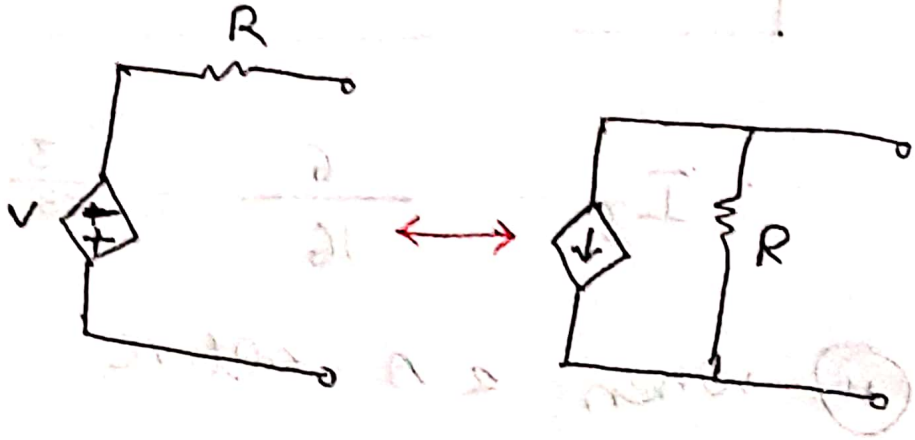
$$= 0.375 A$$

voltage source এর সাথে Resistance Always series এ থাকে, and current source এ parallel.

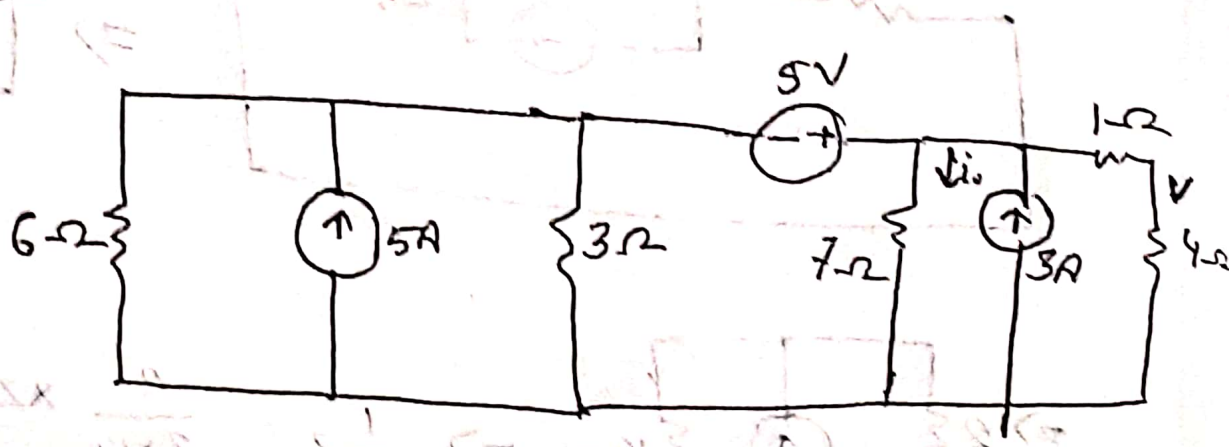
voltage কে current এ এবং current কে voltage এ ...

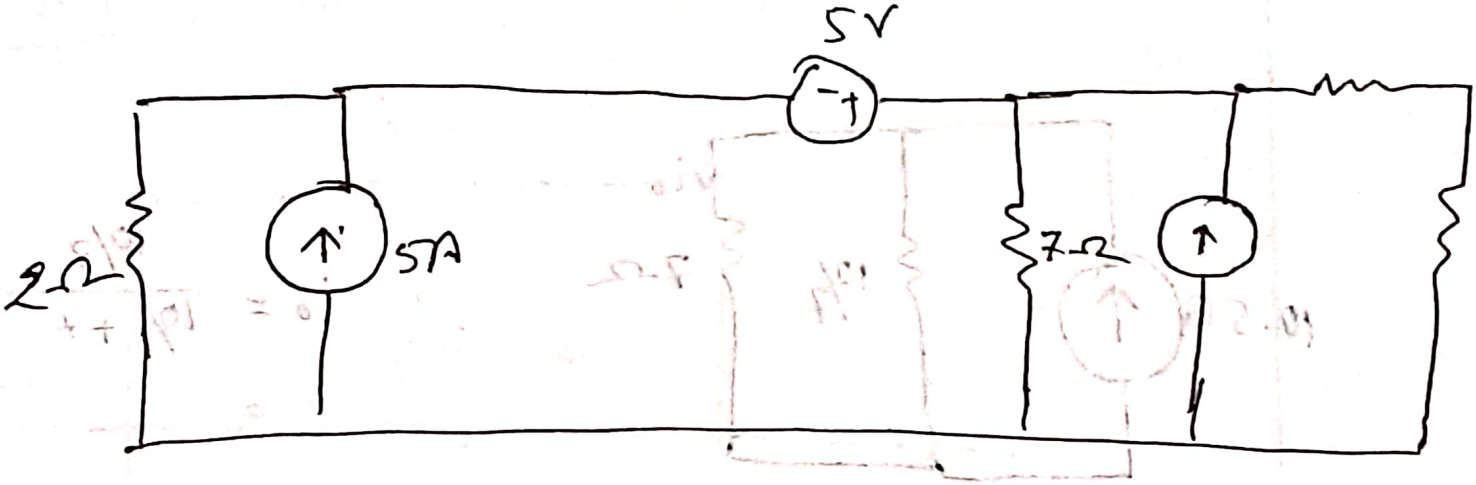
Source Transformation Theorem

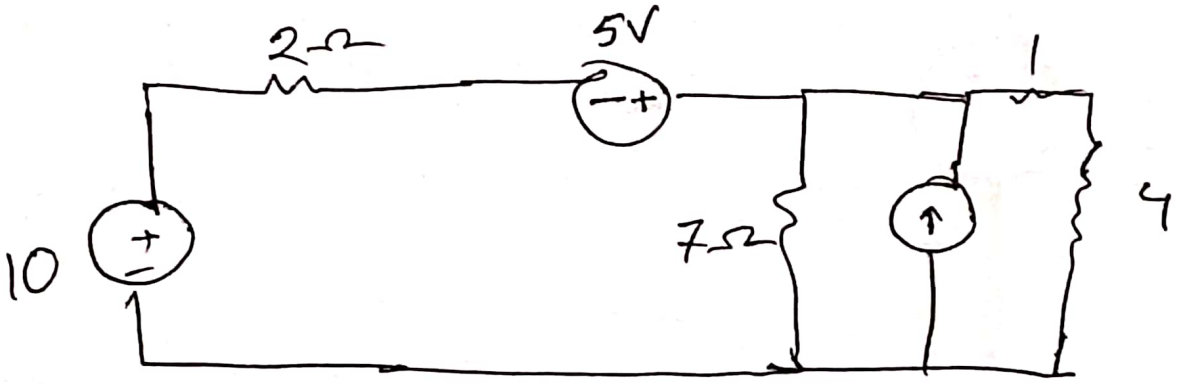




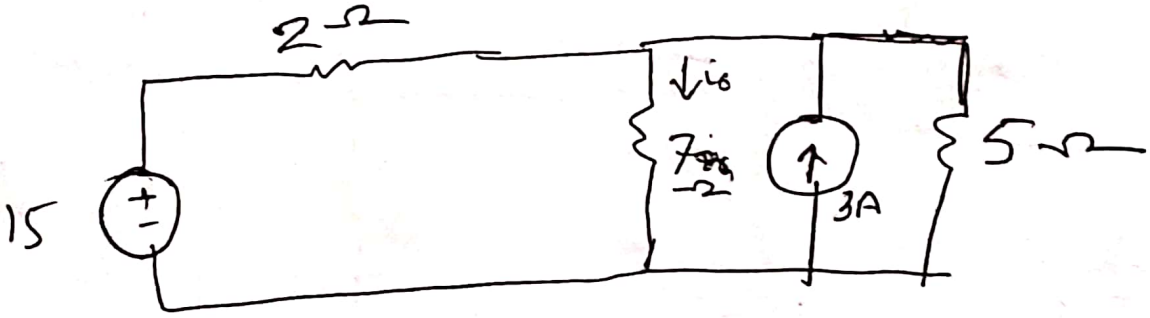
P.P ⇒ 4.6



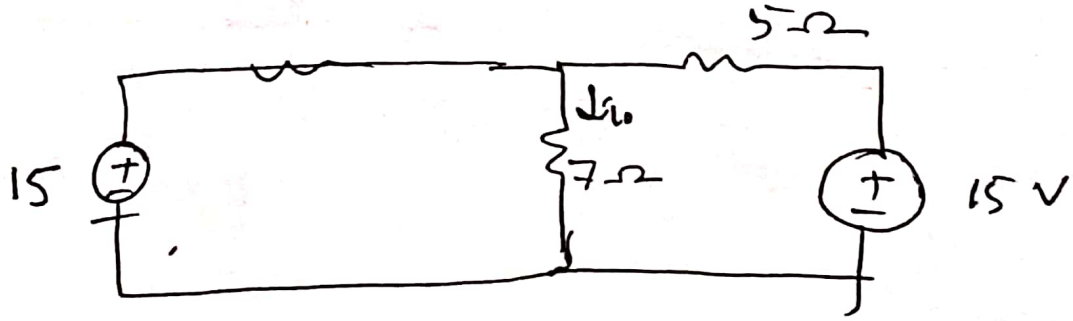


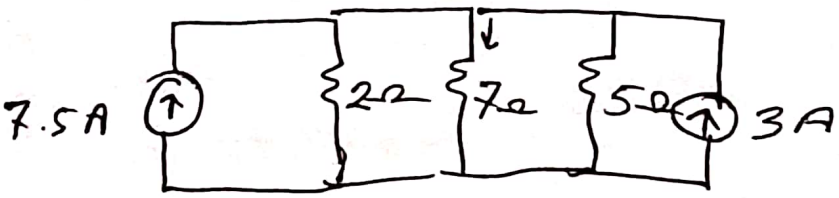


[series ⓐ দুইটা voltage source ⊕ ⊖ আলাদা থাকলে যোগ

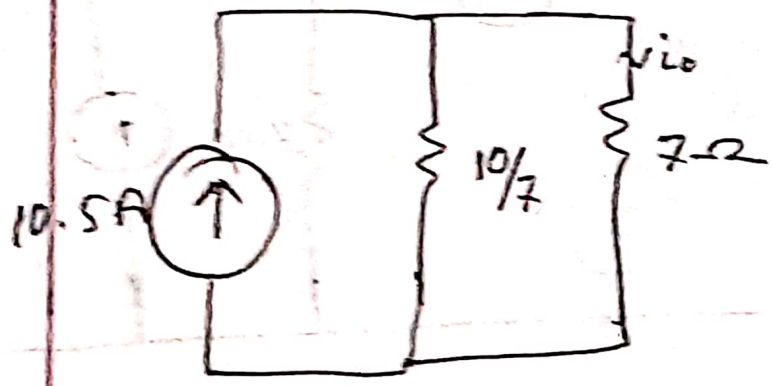


$v = IR$
$= 3 \times 5$
$= 15\,v$





[দুইটা current source same দিকে ⓐ থাকলে যোগ হয়]

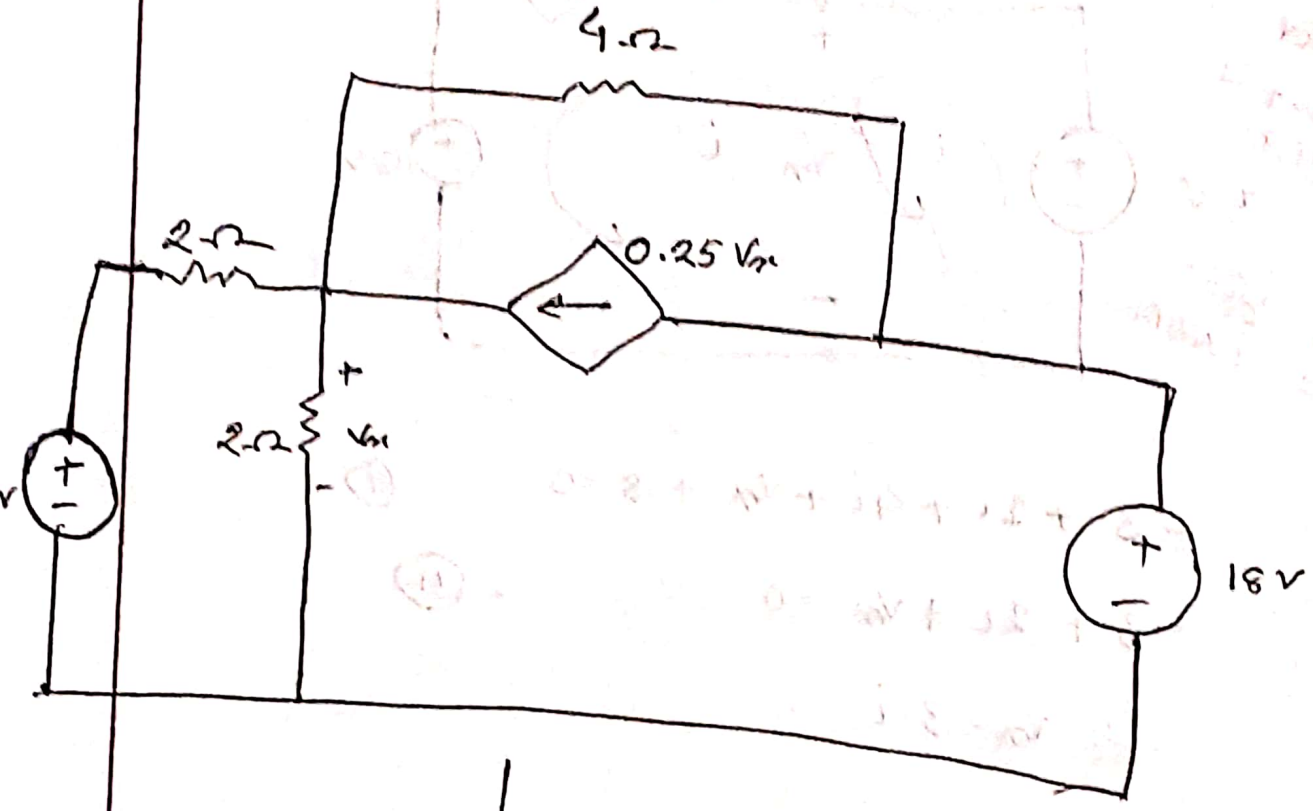


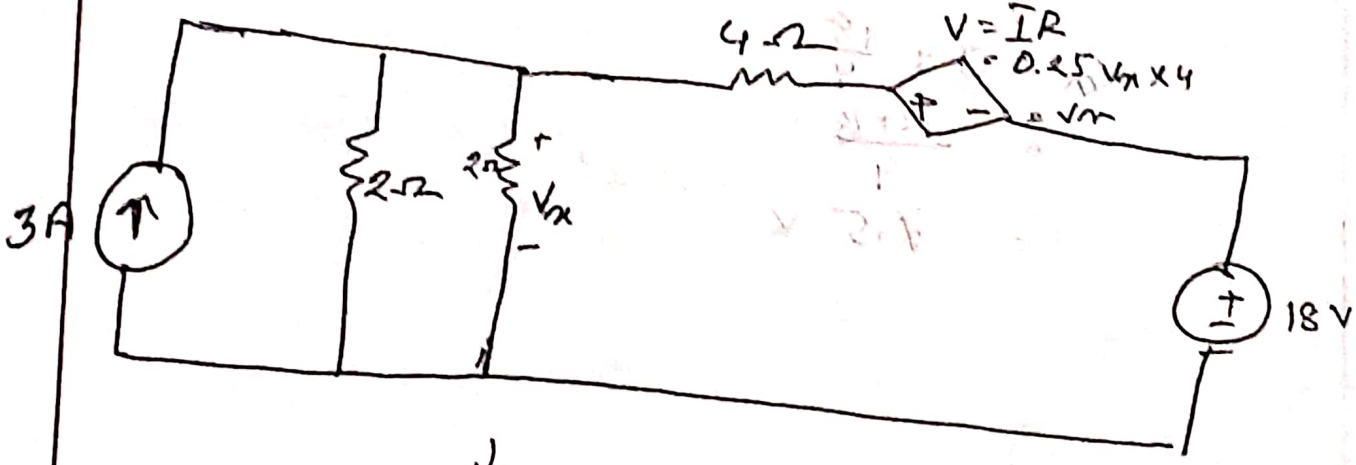
$$\therefore \; i_o = \frac{10/7}{10/7 + 7} \times 1$$

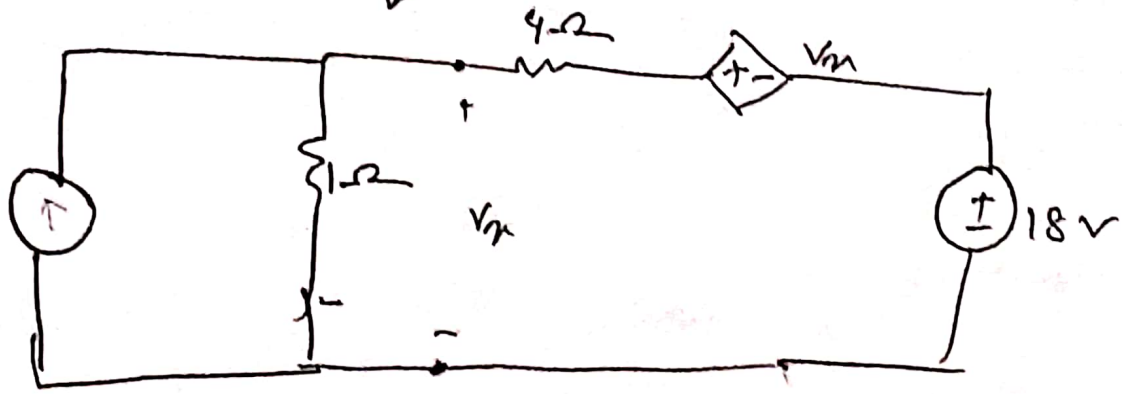
$$=$$

2ay

Ex-4.7 Find V_x using S.T.T

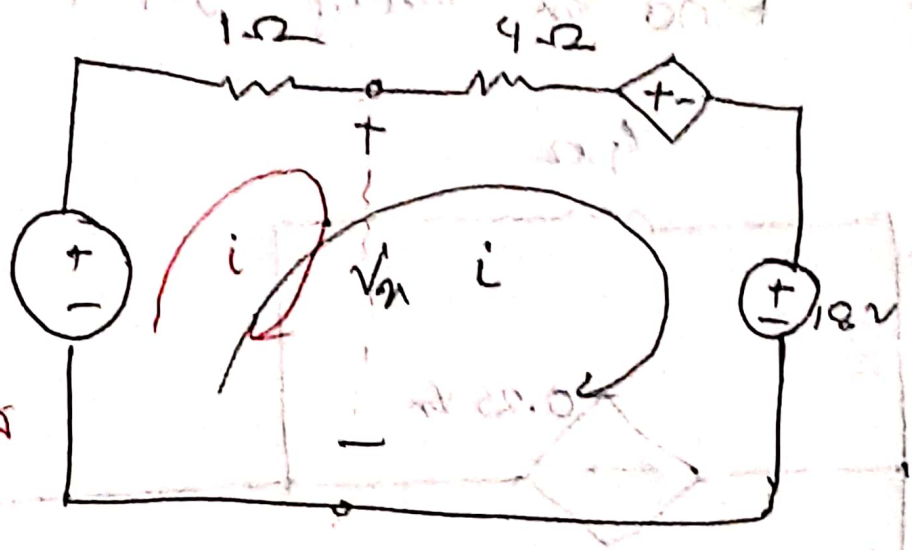






voltage থাকলে Resistance Compare করা যায়। Current থাকলে থাকলে

দুইটা i সমান কারণ circuit এ V_x দিয়ে কোন current যাবে না। সব কারণে পুরো circuit এ i সমান



$$-3 + 1i + 4i + V_x + 18 = 0 \quad \ldots\ldots (i)$$

$$-3 + 1i + V_x = 0 \quad \ldots\ldots (ii)$$

$$\therefore V_x = 3 - i$$

$$i = -18/4$$

$$V_x = 3 + \frac{18}{4}$$

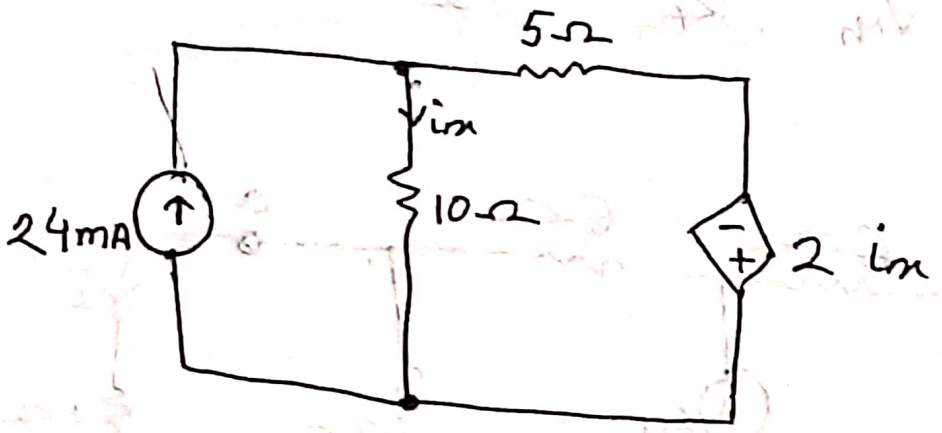
$$= \frac{12+18}{4}$$

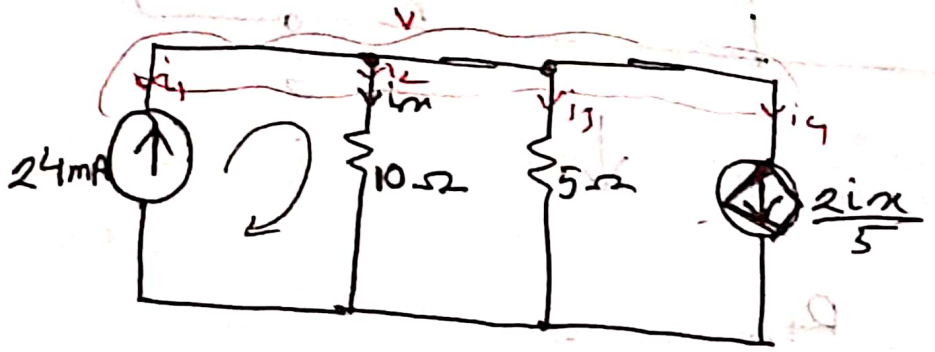
$$= 7.5 \text{ V}$$

$24 - \frac{2i_x}{5}$

$\frac{120 - 2i_x}{5}$

P.P-4.7 Find i_x using S.T.T





V. IR

$\frac{2i_x}{5}$

V. IR

$\frac{V}{R}$

$i_1 = 24$

$i_x = 24 -$

$i_1 + i_2 + i_3 + i_4 = 0$

$i_x = \frac{V}{10}$

$i_1 = -24$

$i_3 = V/5$

$i_2 = i_x$

$i_4 = \frac{2i_x}{5}$

$-24 + i_x + V/5 + \frac{2i_x}{5} = 0$

$\Rightarrow -24 + \frac{V}{10} + \frac{V}{5} + \frac{V}{25} = 0$

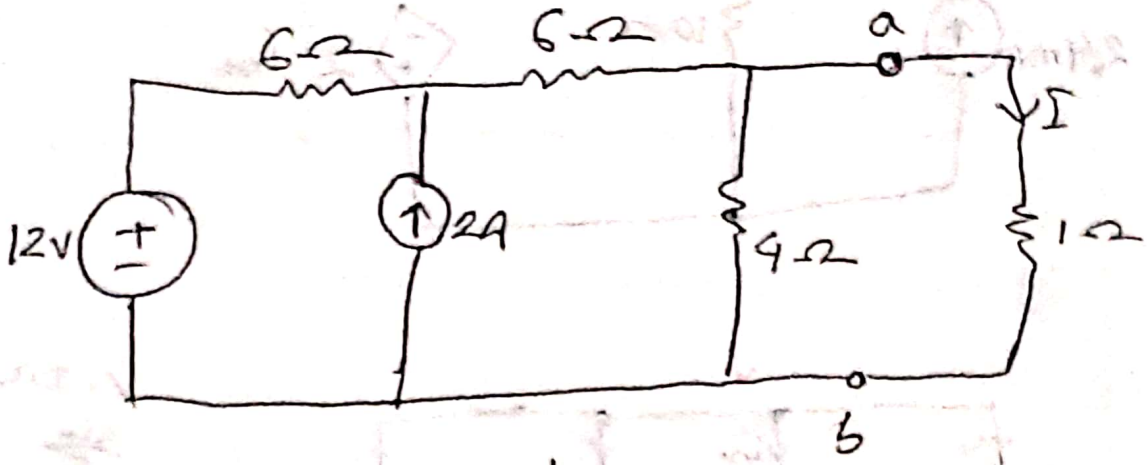
$\therefore V = 70.58$ mV

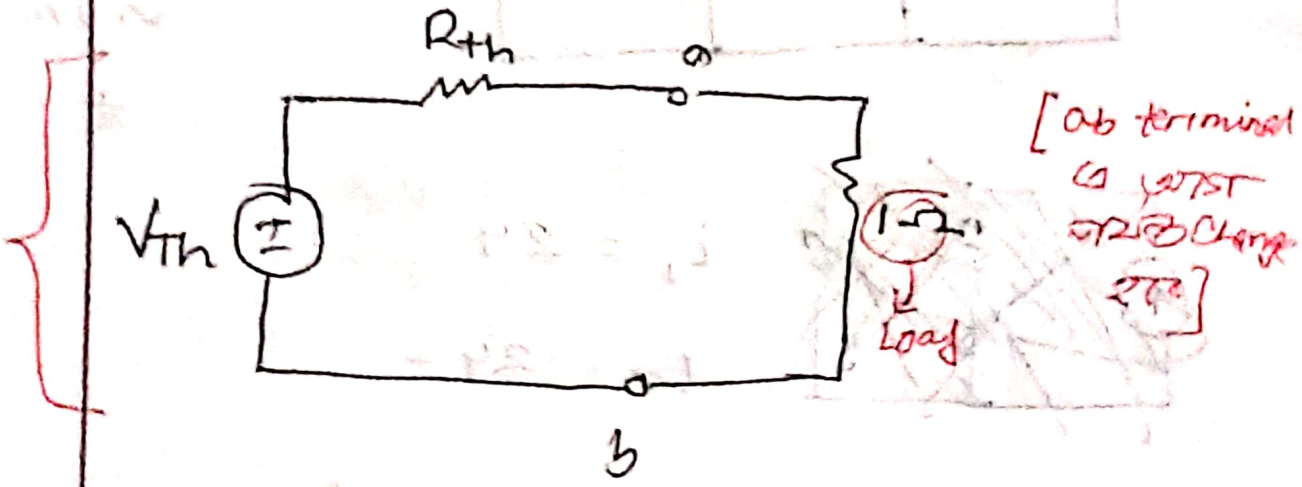
27/12/22

Thevenin Theorem

P.P - 4.8

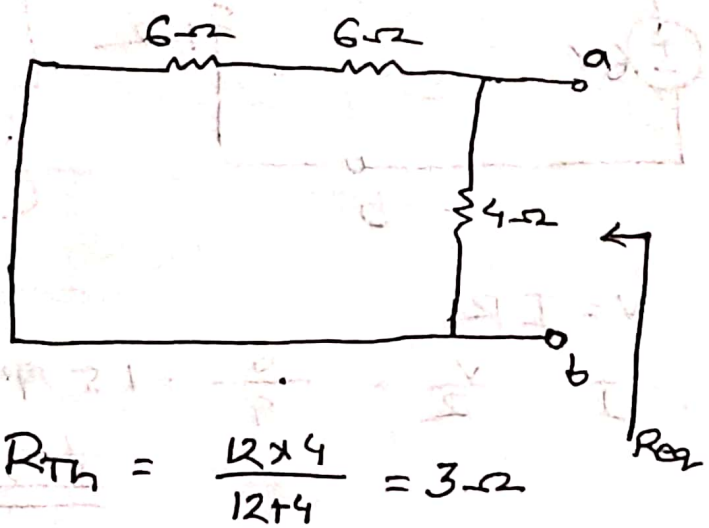
Find V_{th}, R_{th}, & I





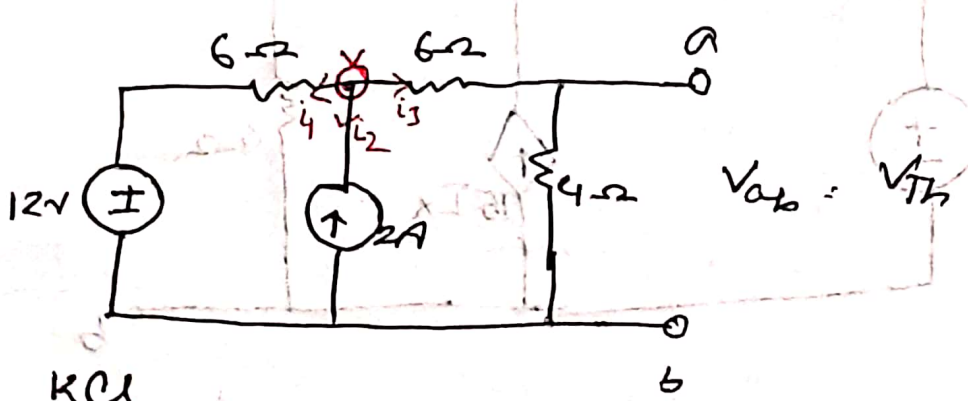
[ab terminal ও থেকে নামতে হবে]

Rth:



$$R_{th} = \frac{12 \times 4}{12+4} = 3\Omega$$

Vth: নির্ণয়ের জন্য circuit কে আগের অবস্থায় আনতে হবে।



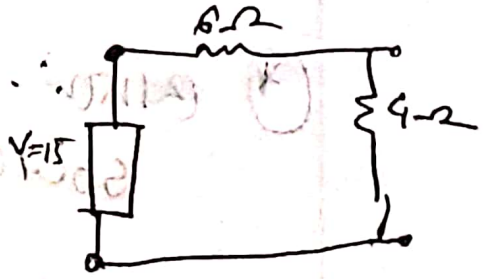
KCL

$i_1 + i_2 + i_3 = 0$

$$\rightarrow \frac{V-12}{6} - 2 + \frac{V-0}{10} = 0$$

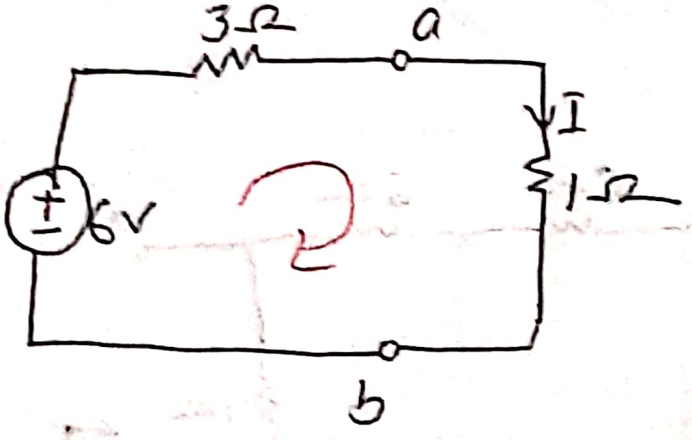
$$\Rightarrow \frac{5V - 60 - 60 + 3V}{30} = 0$$

$\therefore V = 15$



$$V_{th} = \frac{4}{10} \times 15$$

$= 6V$ (Ans)



Thevnin equivalent Circuit

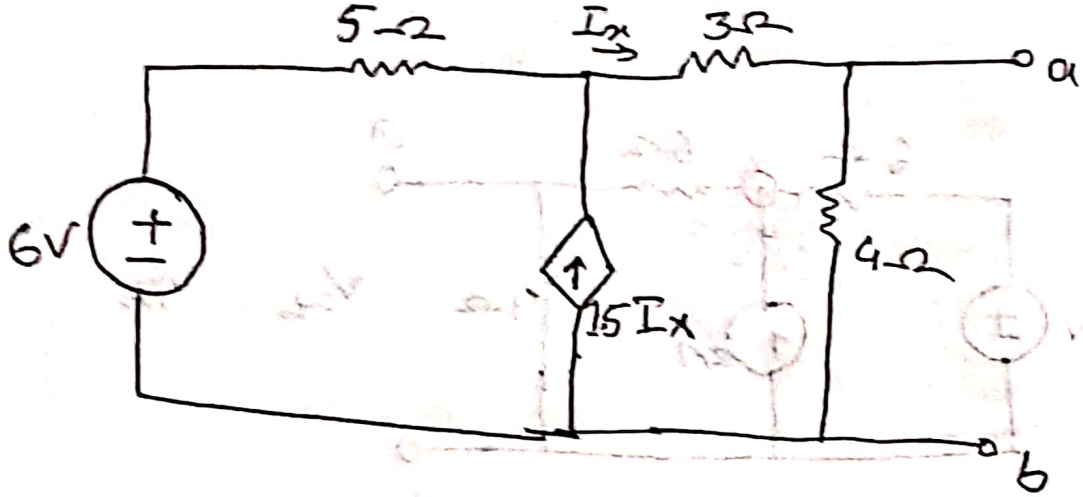
Voltage + series resistance

$V = IR$

$\therefore I = \frac{V}{R} = \frac{6}{4} = 1.5\ A$

Ans

P.P 4.9

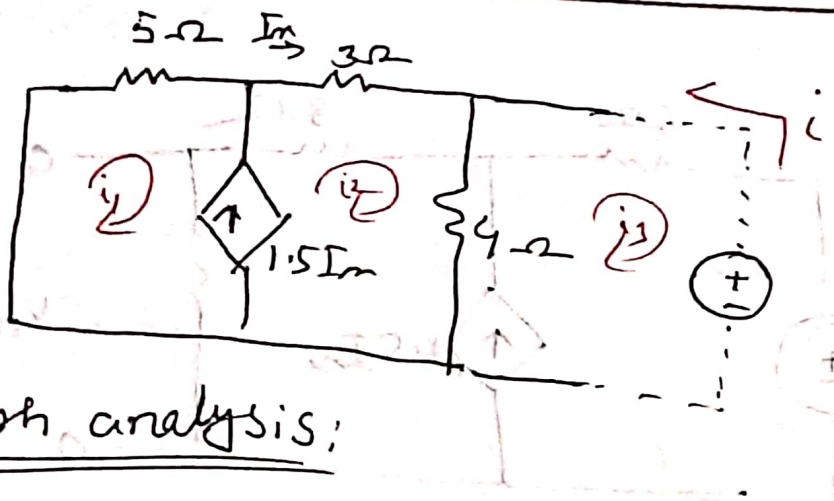


*Dependent source গুলো সবসময় Inactive ক

(*) যেটার terminal open সেখানে 1 voltage source connect করবো। [+ সবসময় উপরে

(*) তার থেকে কারেন্ট current হিসাব করবো [Reverse current,

Rth. Voltage Current Source inactive করা

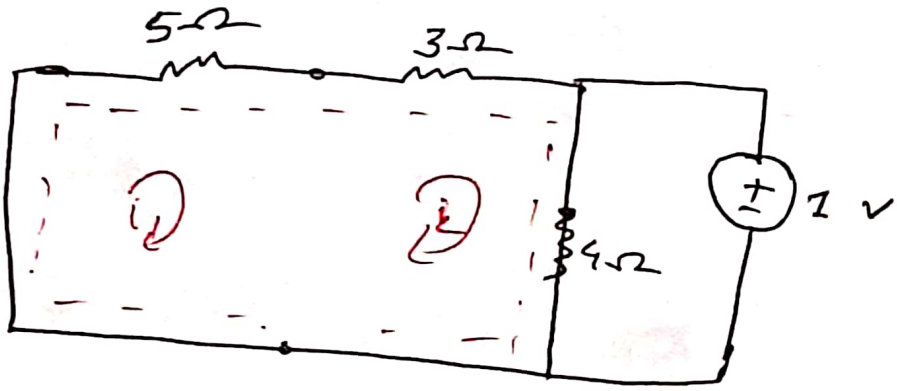


Mesh analysis:

$i_2 - i_1 = 1.5 I_x$ $\quad [I_x = i_2]$

$\Rightarrow i_2 - i_1 = 1.5 i_2$

$\Rightarrow i_1 + 0.5 i_2 = 0 \quad \ldots (1)$



Super mesh:

$5i_1 + 3i_2 + 4(i_2 - i_3) = 0$

$\Rightarrow 5i_1 + 3i_2 + 4i_2 - 4i_3 = 0$

$\Rightarrow 5i_1 + 7i_2 - 4i_3 = 0 \quad \ldots (II)$

3rd mesh:

$4(i_3 - i_2) + 1 = 0$

$\Rightarrow 4i_3 - 4i_2 = -1 \quad \ldots (III)$

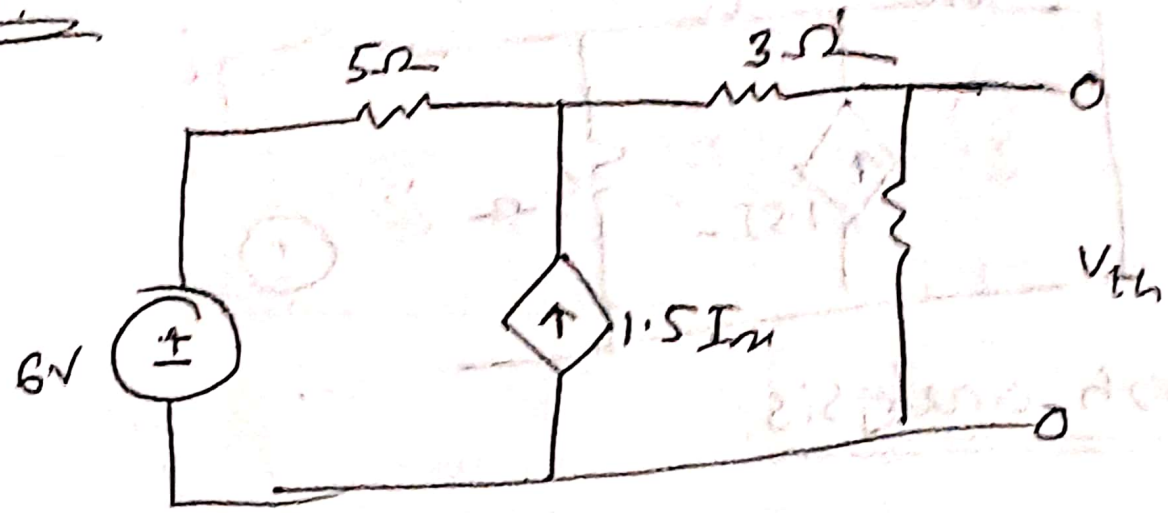
$i_1 = 1$

$i_2 = -2$

$i_3 = -2.25$

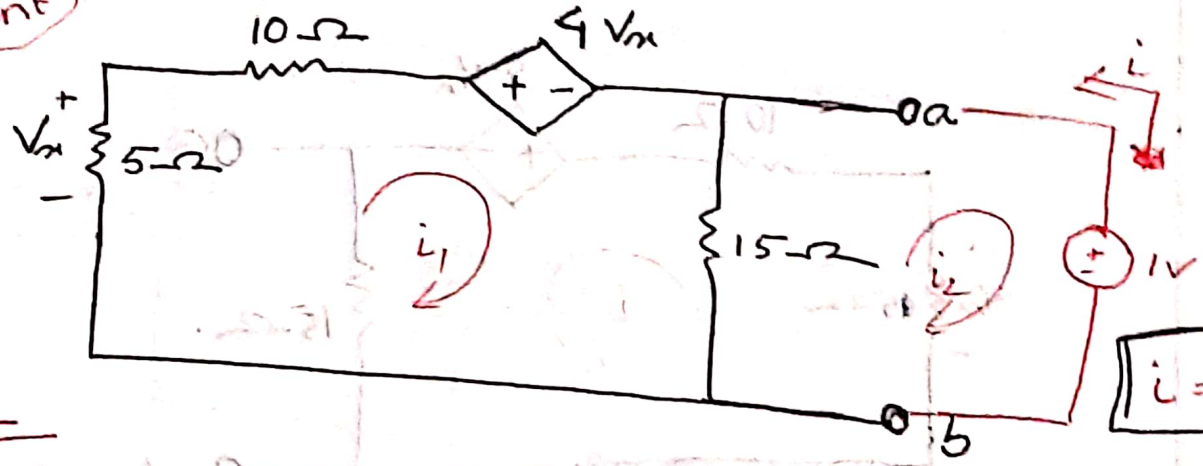
$i_2 - i_3$

V_{th}:



P.P → 4.10 :

Thevenin equivalent



$i = -i_2$

Rth:

$$5i_1 + 10i_1 + 4V_x + 15(i_1 - i_2) = 0$$

$V_x = -5i$

$$\Rightarrow 15i_1 - 20i_1 + 15i_1 - 15i_2 = 0$$

$$\Rightarrow 10i_1 - 15i_2 = 0 \quad \ldots\ldots \text{(i)}$$

$$15(i_2 - i_1) + 1 = 0$$

$$\Rightarrow -15i_1 + 15i_2 = -1 \quad \ldots\ldots \text{(ii)}$$

(i) + (ii) ⇒

$$-5i_1 = -1$$

$$\therefore i_1 = 1/5 = 0.2A$$

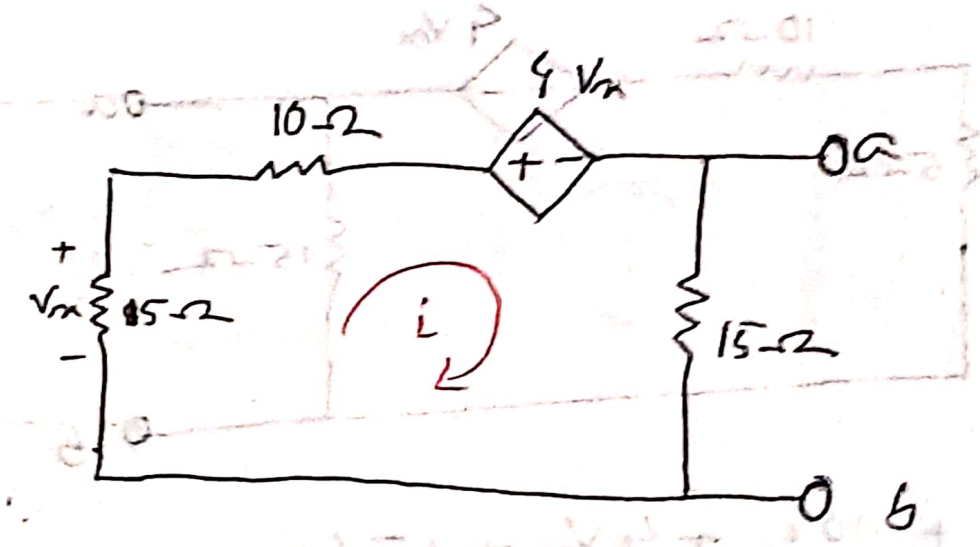
(ii) ⇒

$$i_2 = \frac{10i_1}{15} = \frac{10 \times 0.2}{15} = 0.133A$$

$$\therefore i = -i_2 = -0.133A$$

$$\therefore R_{th} = \frac{V}{i} = \frac{1}{-0.133} = -7.5\ \Omega$$

Vth:



$$5i + 10i + 4V_x + 15i = 0$$

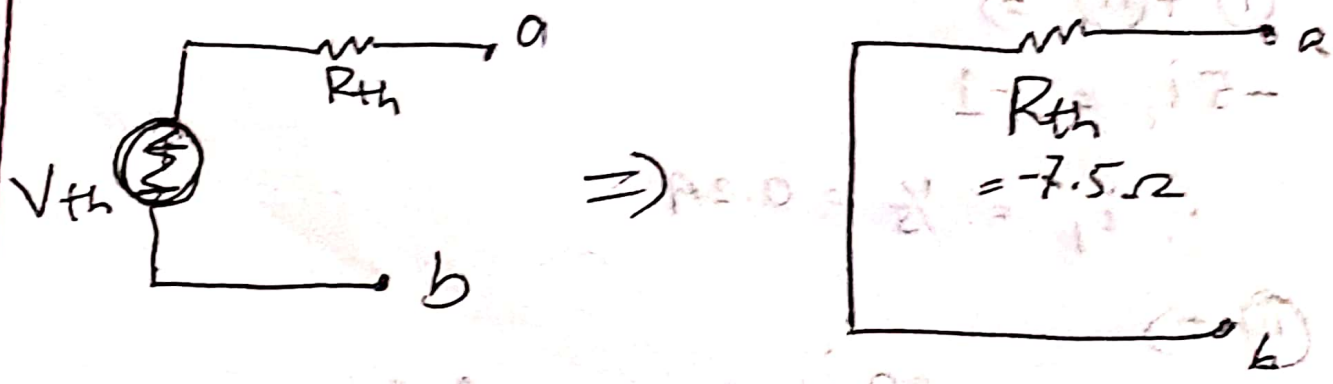
$$\Rightarrow 15i + 4(-5i) + 15i = 0$$

$$\Rightarrow 10i = 0$$

$$\therefore i = 0$$

$$\therefore V_{th} = 15 \times i$$

$$= 0$$

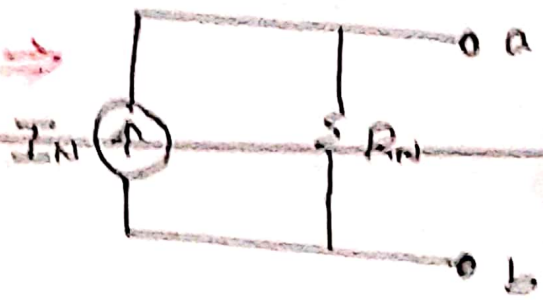


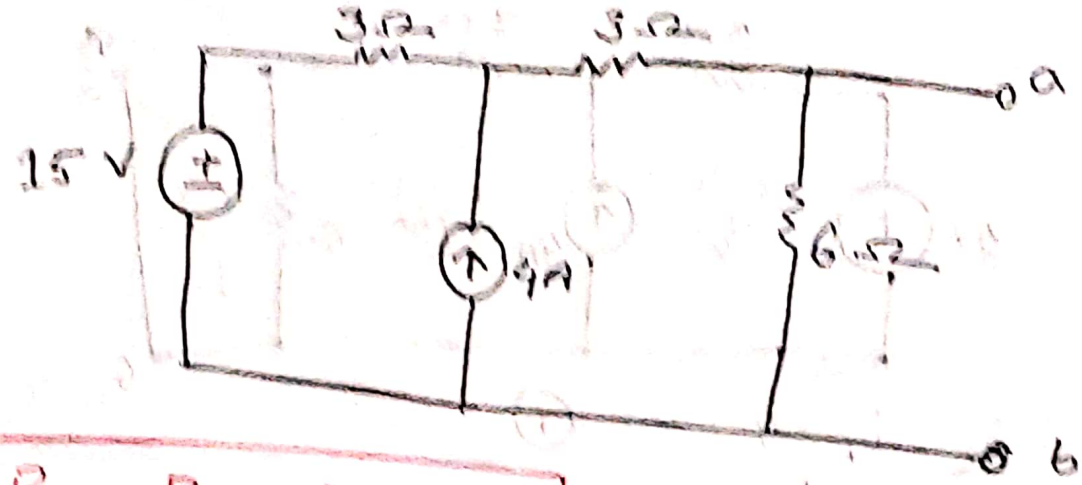
Resistance power supplier হিসেবে কাজ করে।

(*) Dependent source & Resistance

Norton Theorem ⇒

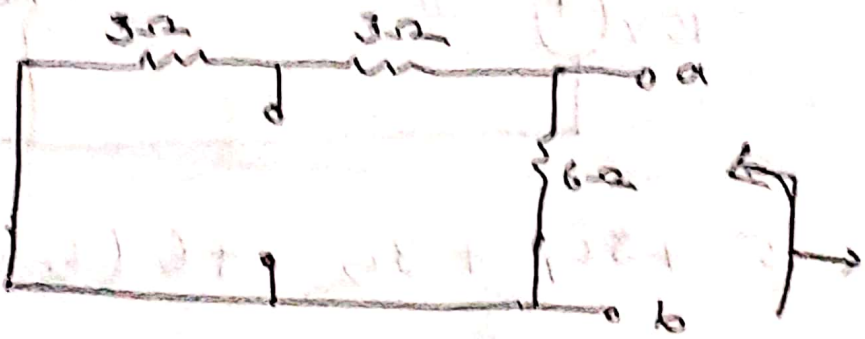
PP → 4.11





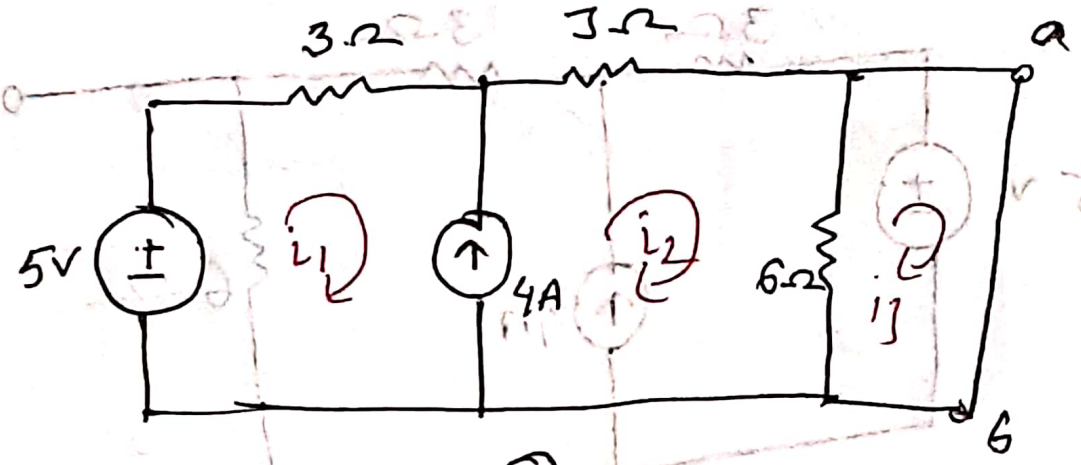
Note: $R_N = R_{in} = R_{ab} = R_{th}$

Inactivating independent sources we get -



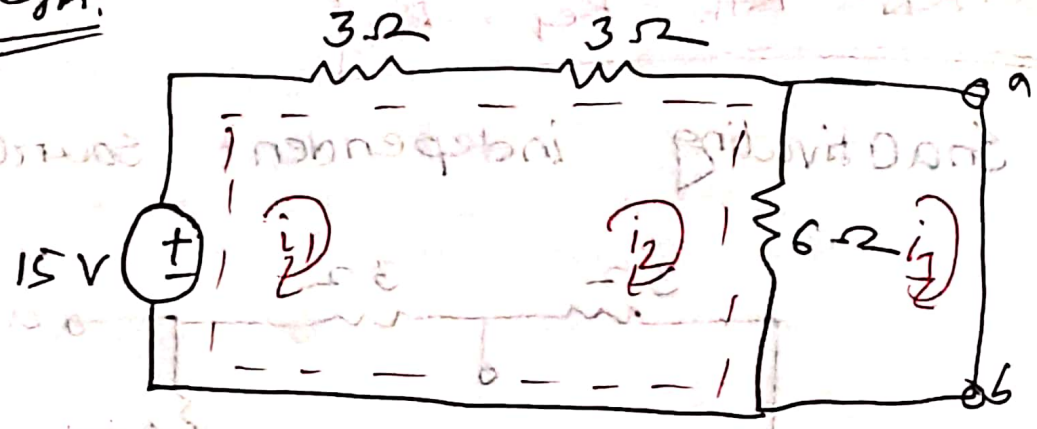
$R_N = (3+3) \parallel 6$
$= 3\Omega$

ab প্রান্ত short circuit করলে যে current যাবে সেটাই Norton Current.



$i_2 - i_1 = 4$ ---- (I)

Super Mesh:



$-15 + 3i_1 + 3i_2 + 6(i_2 - i_3) = 0$

$\Rightarrow 3i_1 + 9i_2 - 6i_3 = 15$ ---- (II)

Mesh 3

$6(i_3 - i_2) = 0$

$\Rightarrow -6i_2 + 6i_3 = 0$

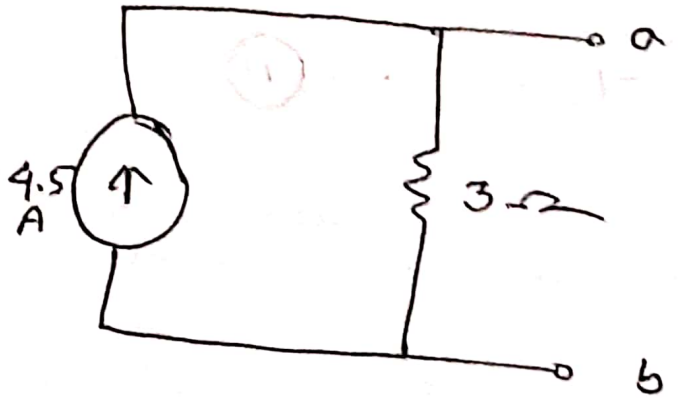
$\Rightarrow i_3 = i_2$ ---- (III)

$i_1 = 0.5$

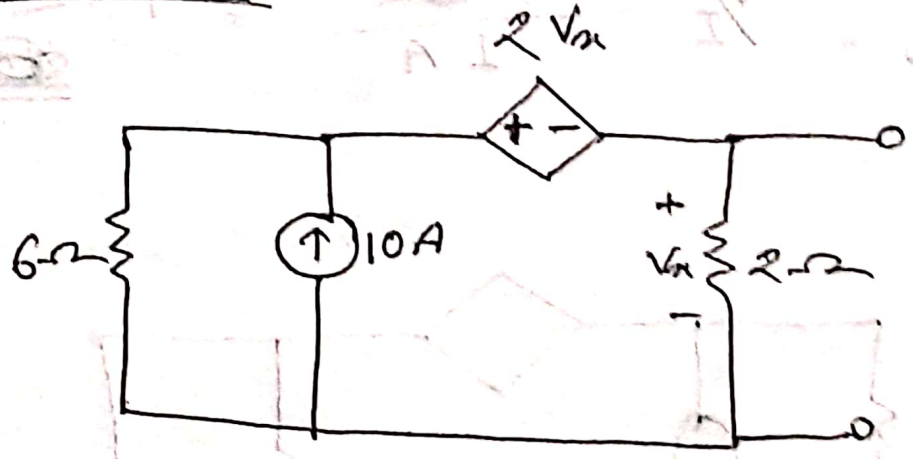
$i_2 = 4.5$

$i_3 = 4.5 = i_N$

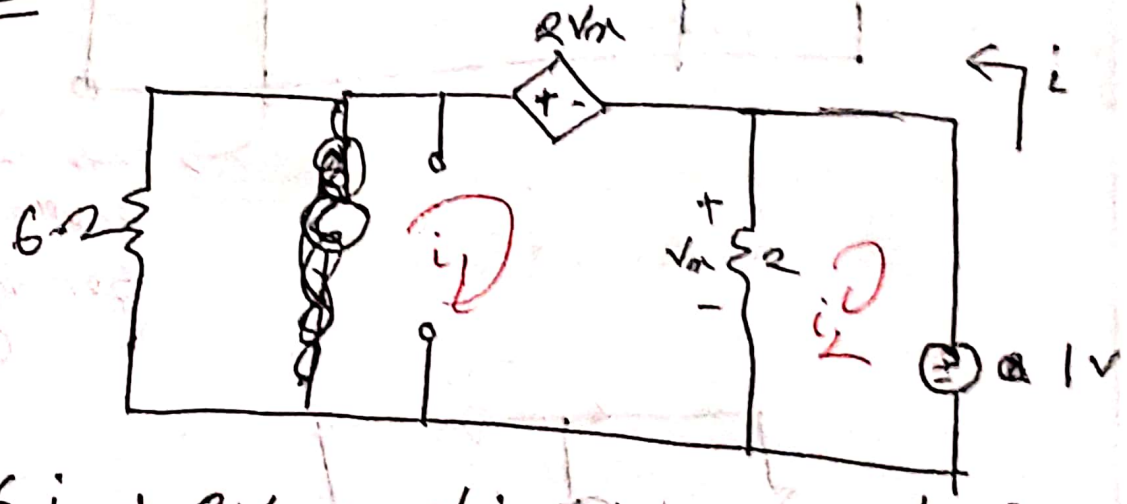
So, the Norton equivalent circuit will be –



P.P → 4.12 (Dependent Source থাকলে)



Solⁿ:



$6i_1 + 2V_x + 2(i_1 - i_2) = 0$

$\Rightarrow 6i_1 + 4(i_1 - i_2) + 2(i_1 - i_2) = 0$

$\Rightarrow 6i_1 + 6(i_1 - i_2) = 0$

$\therefore 12i_1 - 6i_2 = 0 \quad \ldots\ldots (1)$

$i = -i_2$

$V_x = 2(i_1 -$

$2(i_2 - i_1) + 1 = 0$

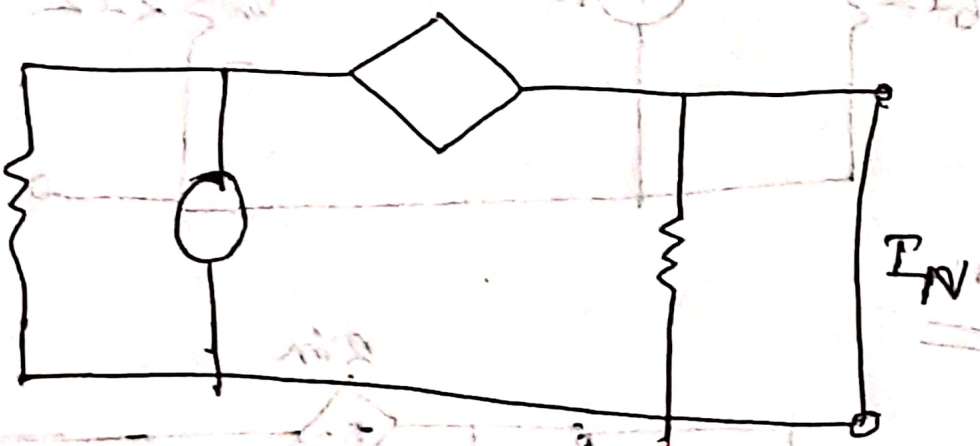
$\Rightarrow 2i_2 - 2i_1 = -1$ ..... (11)

$\therefore i_1 = -1/2$

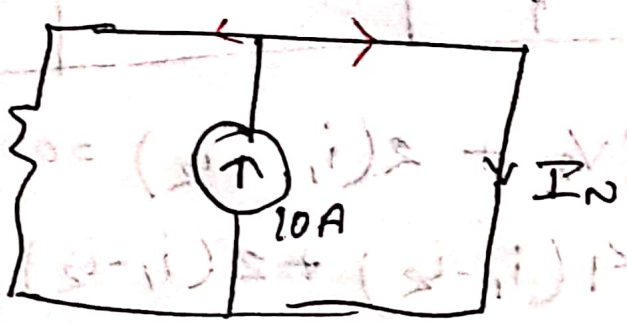
$i_2 = -1$

$\therefore i = -i_2 = 1$

$\therefore R_N = V/I = \frac{1\,\Omega}{1\,A} = 1\,\Omega$



this will be short circuit ab
So, V_x will b
0.

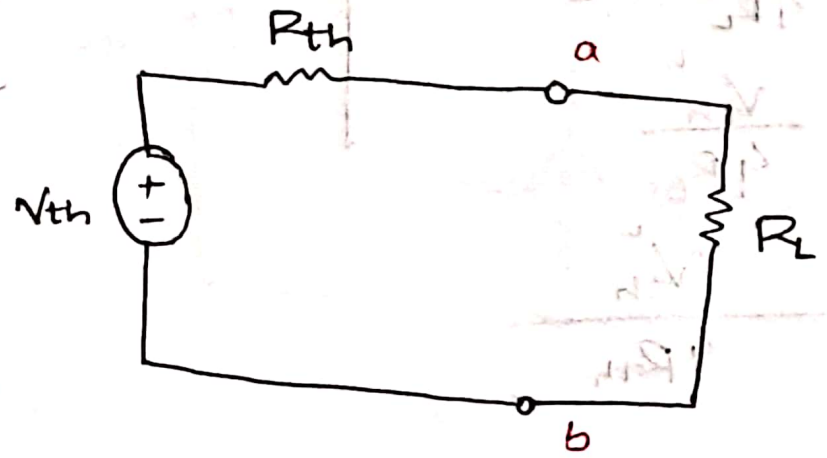


Because of short circuit
I_N will be 10

12/0.

Maximum Power Transfer Theorem

Load এ maximum power দেয়া এই theorem এর কাজ



যারা power consume করে তারা Load (ab)

$P = Vi$
$= i^2 R$

Power supplied to the load $P_L = i^2 R_L$

or

Power consumed by the load $= \left(\frac{V_{th}}{R_{th}+R_L}\right)^2 \cdot R_L$

Power will be maximum when $\frac{dP_L}{dR_L} =$

$$\frac{dP_L}{dR_L} = \left(\frac{V_{th}}{R_{th}+R_L}\right)^2 R_L$$

$$= V_{th}^2 \left[\frac{\quad}{\quad} \right]$$

$$= (R_{th}+R_L)^2 = 2R_L(R_L+R_{th})$$

$$\Rightarrow R_{th}+R_L = 2R_L$$

$$\boxed{R_{th} = R_L}$$

$$P_L = i_L^2 R_L$$

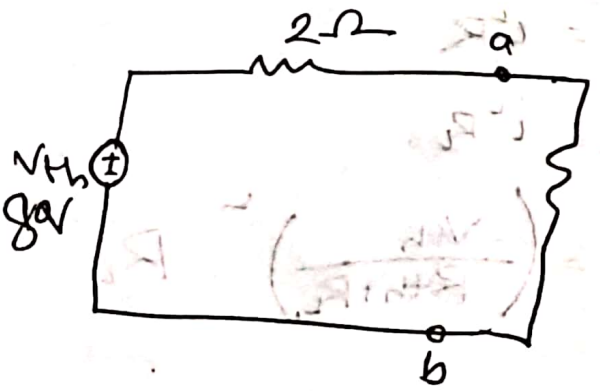
$$= \frac{V_{th}^2}{4R_L^2} \cdot R_L$$

$$= \frac{V_{th}^2}{4R_L}$$

$$i = \frac{V_{th}}{2R_L}$$

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

Case-1



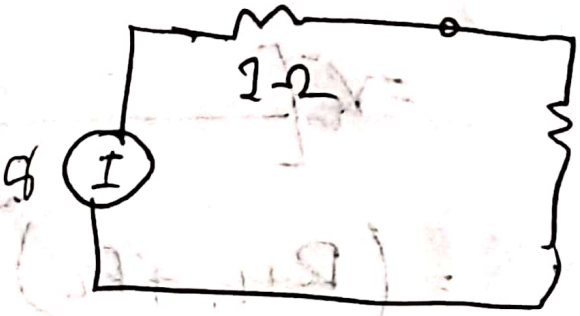
$R_L = 2\Omega$

$i = 8/4 = 2$

$$P_{max} = \frac{64}{8}$$

$$= 8\,W$$

Case-2



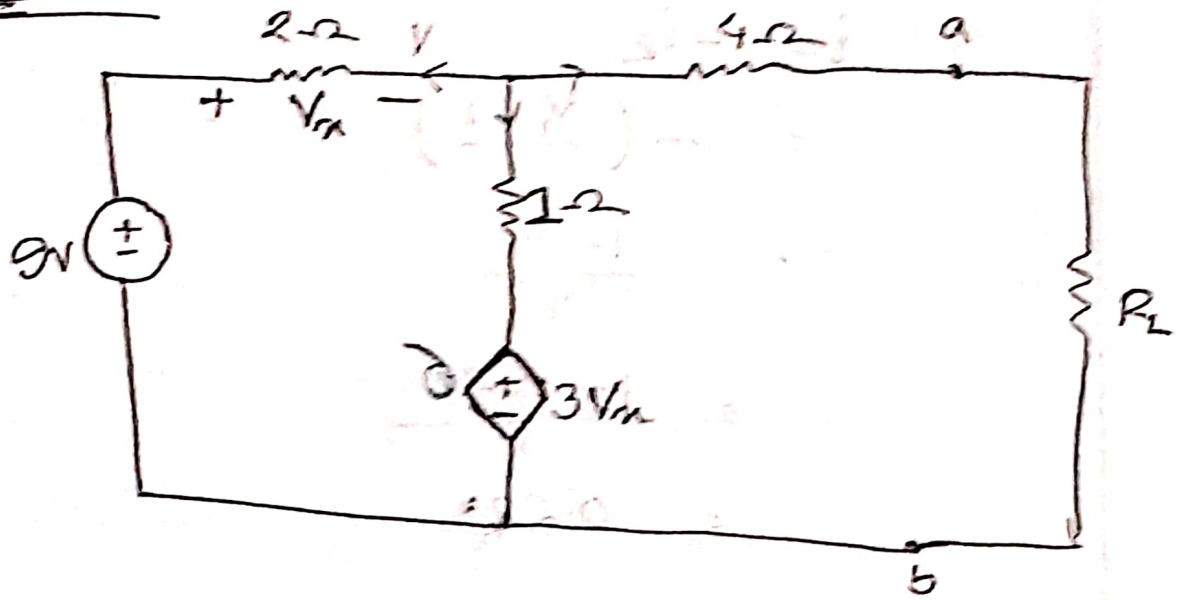
3Ω

$i = \frac{8}{4} = 2$

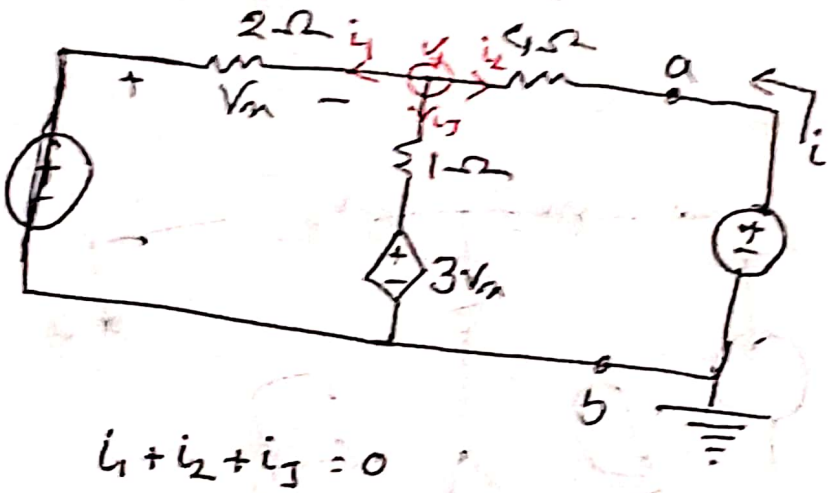
$$P_L = i^2 R_L$$

$$= 2^2 \times 3$$

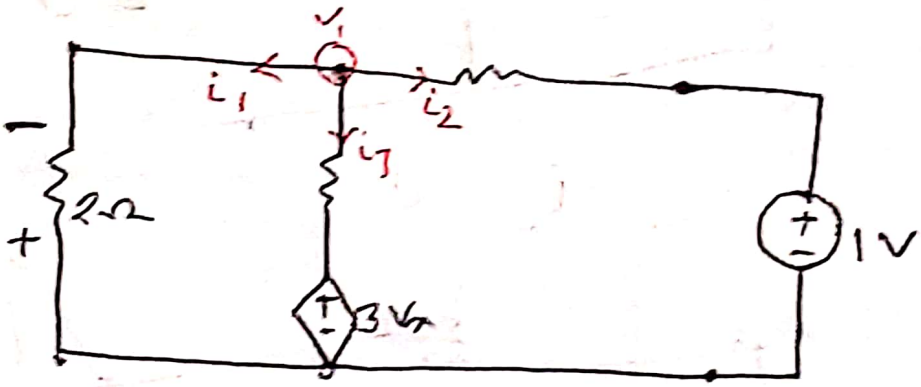
P.P 4.13



Soln:



$i_1 + i_2 + i_3 = 0$



$V_x = -V_1$

$$\frac{V_1}{2} + \frac{V_1 - 3V_x}{1} + \frac{V_1 - 1}{4} = 0$$

$$0.5V_1 + 4V_1 + .25V_1 = .25$$

$$\Rightarrow 4.75V_1 = .25 \quad \therefore V_1 = .0526$$

$$i = 1 - i_2$$

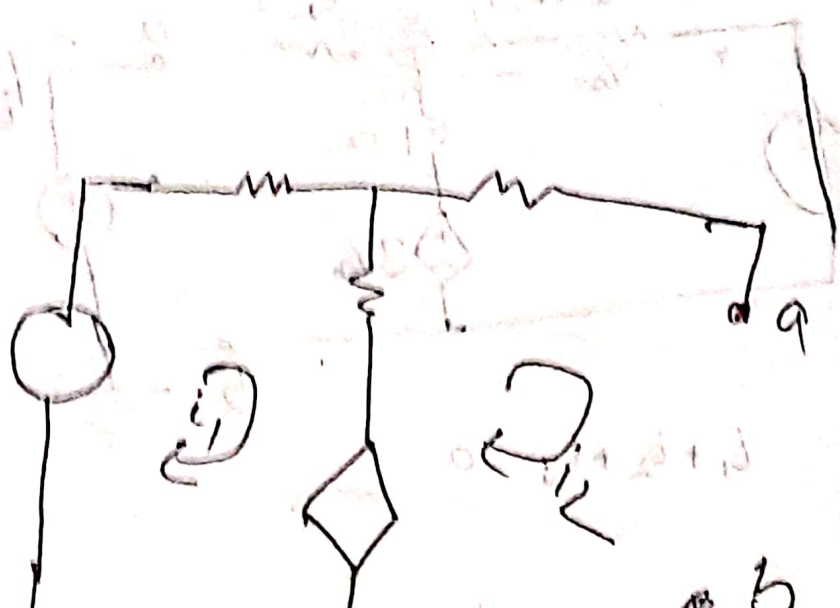
$$= -\left(\frac{V_1 - 1}{4}\right)$$

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

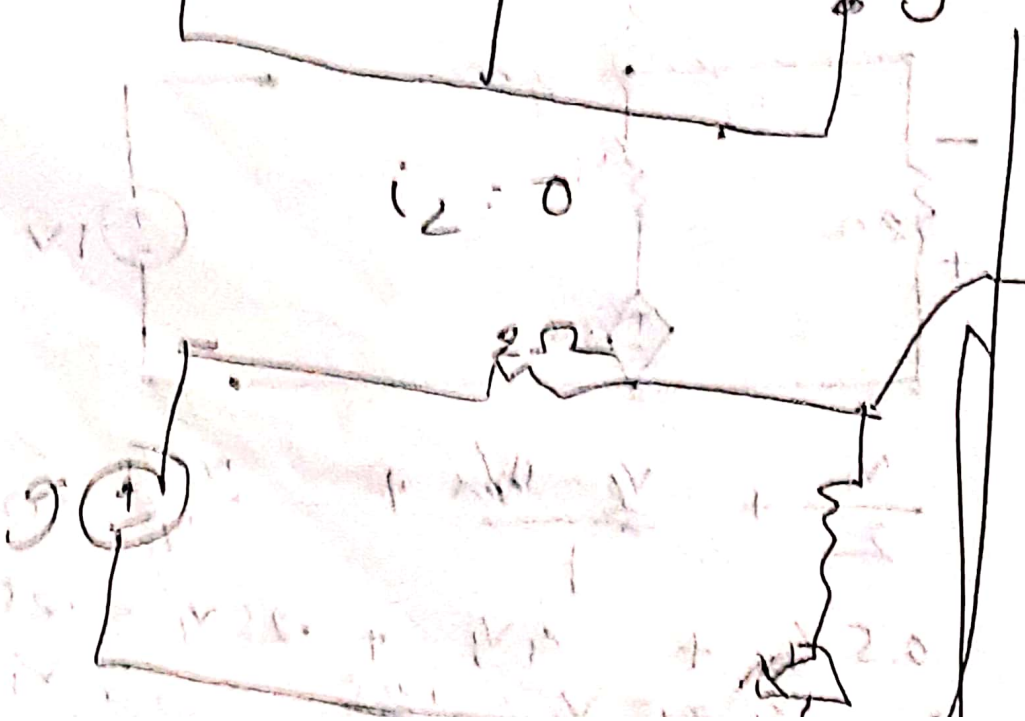
$$= \frac{1 - .526}{4}$$

$$= 0.23$$

$$\therefore R_{th} = \frac{V}{i} = \frac{1}{0.23} = 4.34\ \Omega$$



$i_2 = 0$



$9i = 9$

$\therefore i = 1$

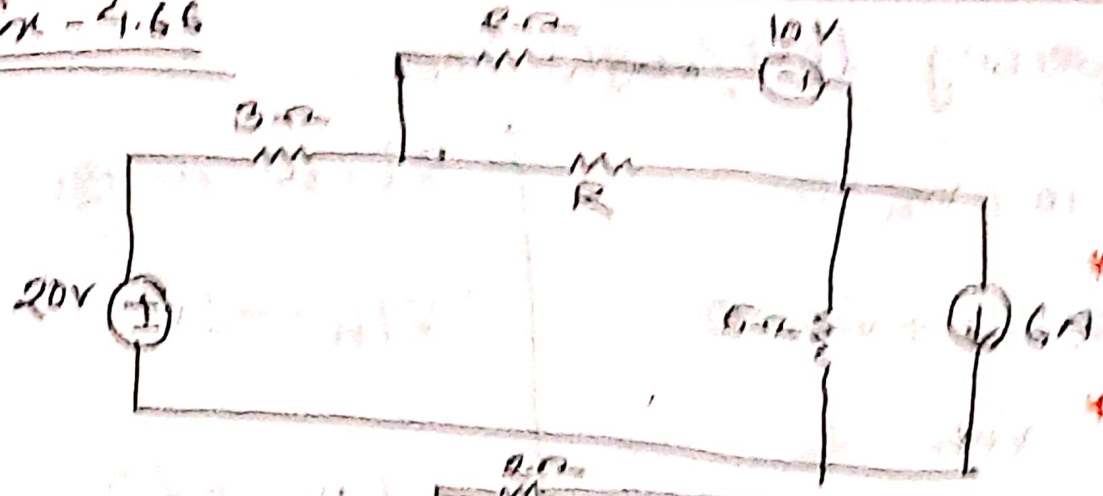
$-9 + 2i + 1i + 3i$

$-9 + V_1 + V_{th}$

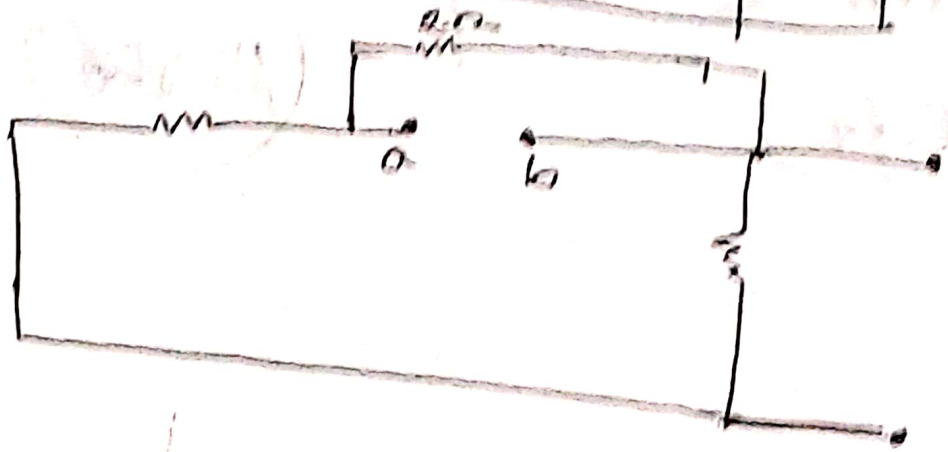
$-9 + 2 + V_{th}$

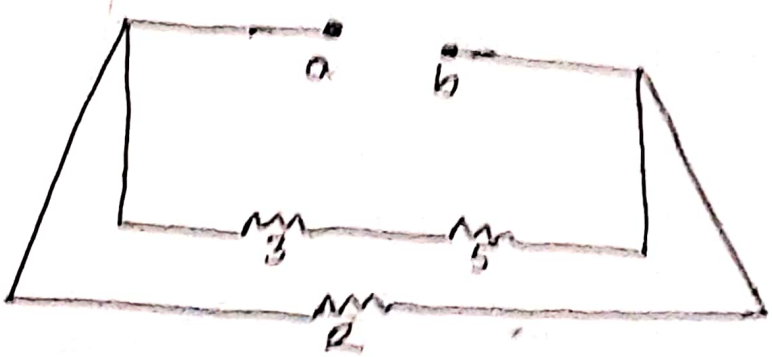
$\therefore V_{th} = 7$

Ex - 4.66



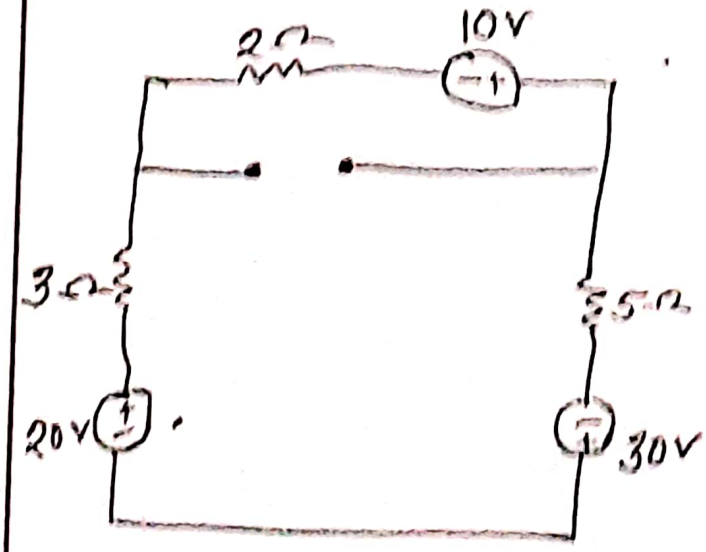
* When load resistance on in the middle
* make open circuit for
* Simplify



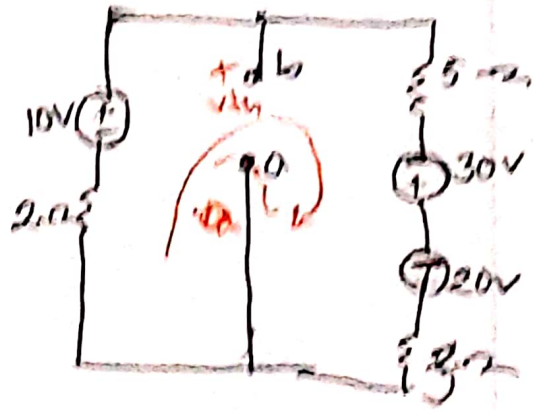


$R_{th} = \frac{3 \times 2}{3+2} = 1.6\,\Omega$

Again



→



Considering left / right loop

$-2i_1 - 10 + V_{th} = 0$

$+12 - 10 + V_{th} = 0$

$\therefore V_{th} = 2$

(Left)

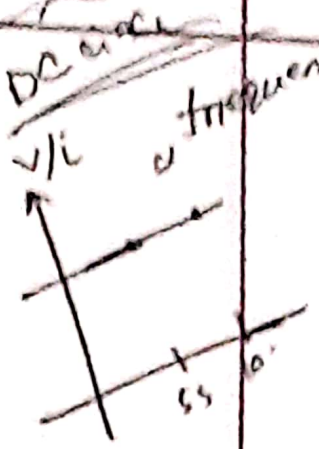
$-5i_1 - 40 - 20 + V_{th} = 0$

$V_{th} = -2V$

(Right)

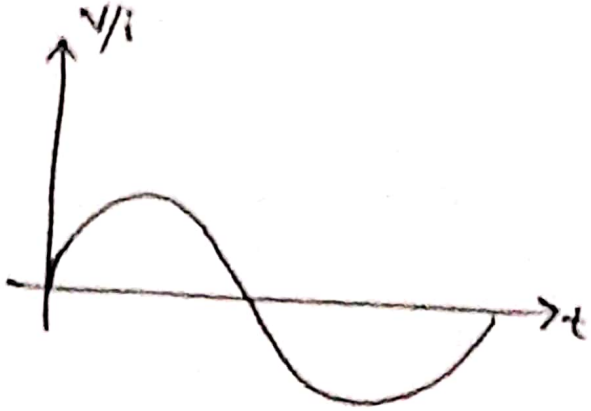
22/01/23

DC circuit



AC Circuits

~~Frequency domain~~



$A_m \sin(\omega t \pm \theta)$

A_m → max Amplitude

θ → Phase

$A_m \angle \pm\theta$

$\omega = 2\pi f$

time Domain Representation

$V = 200 \sin(50t - 75^\circ)$

V_m (max voltage)

$\omega = 50$

$f = \frac{50}{2\pi}$

$\theta = -75^\circ$

$A_m \sin(\omega t + \theta) = A_m \angle \pm\theta$

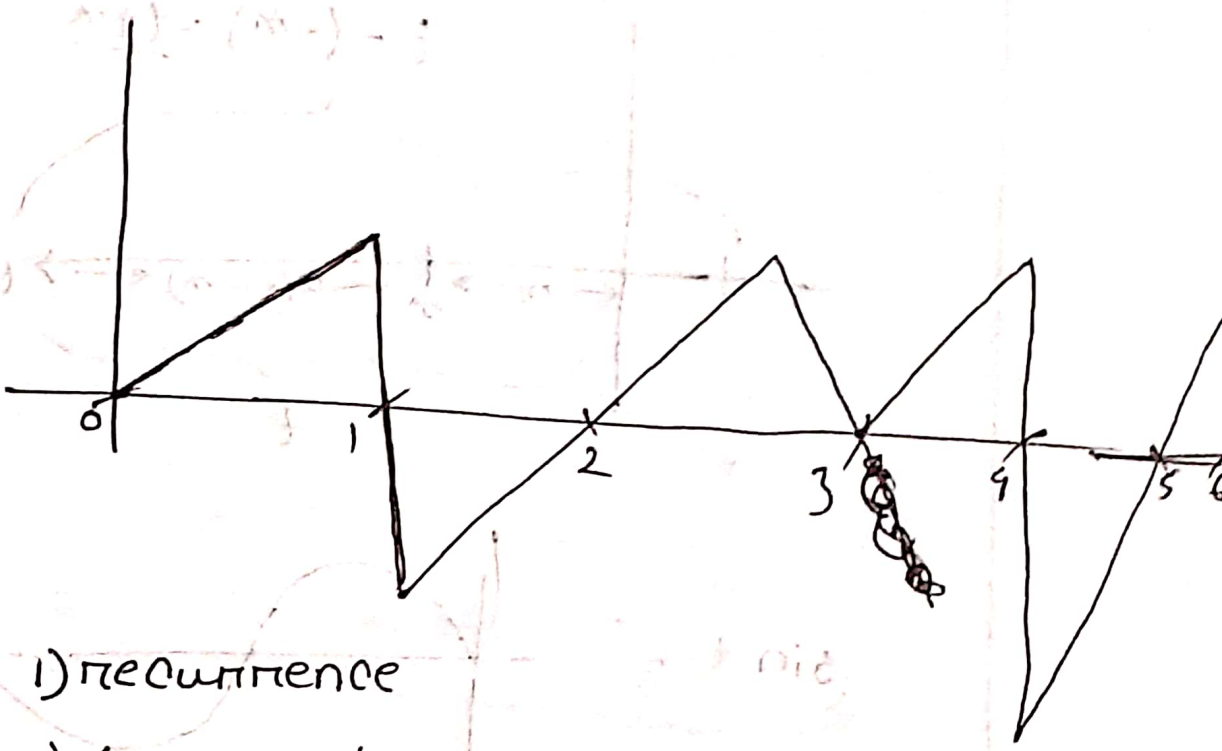
time Domain Representation

Phasor form or Frequency domain Representation

$V = 200 \sin(50t - 75^\circ)$

$\rightarrow 200 \angle -75^\circ$

Period



i) recurrence

ii) same pattern as started

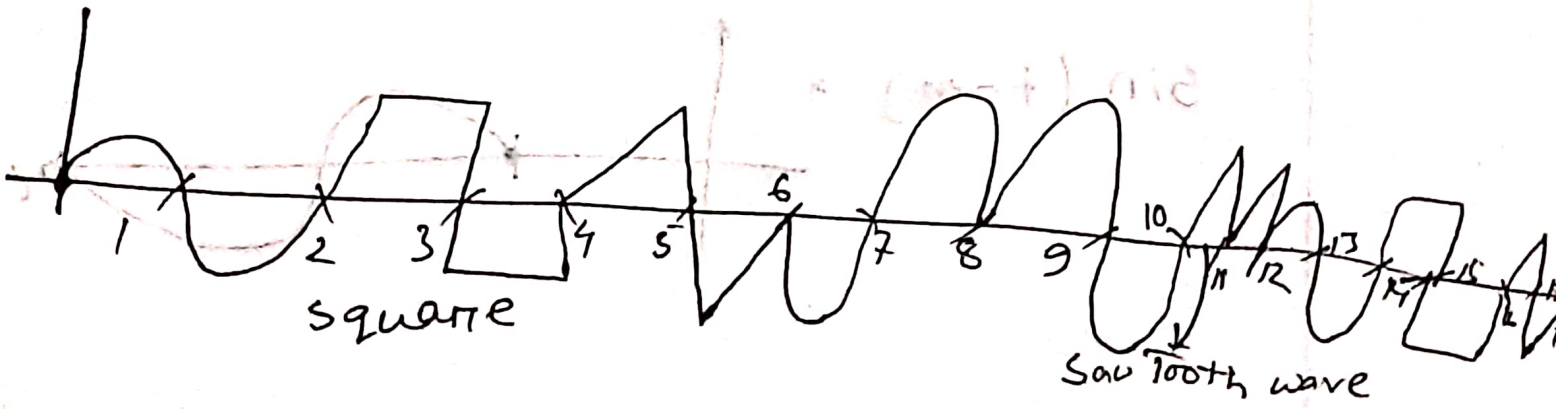
(Not same point)

↳ (0-1) same point हुआ

(0-3) same pattern

(3-6) " "

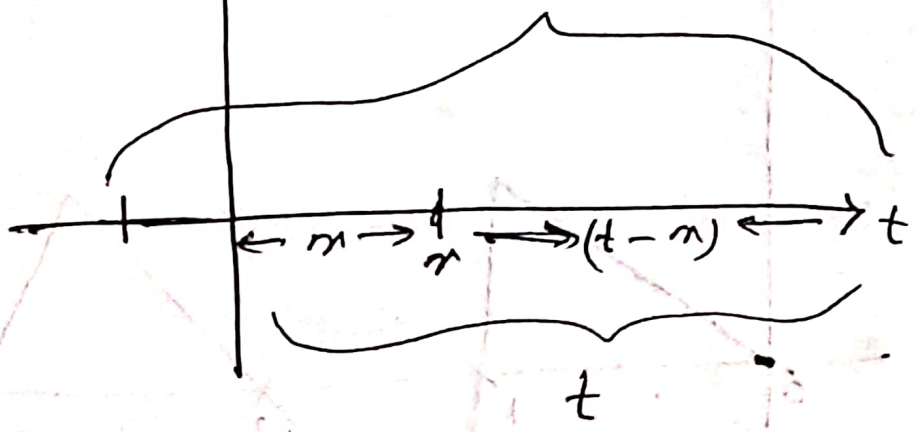
3 रहा period



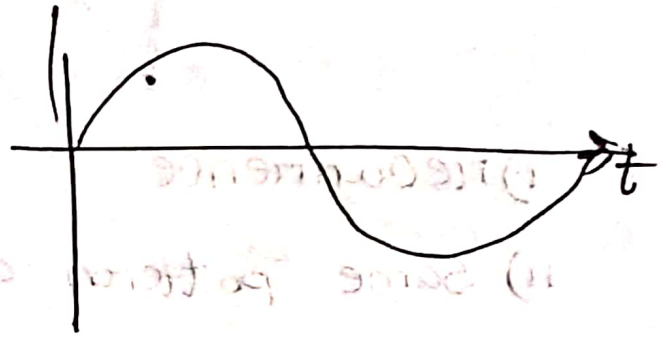
12 is period point

Phase Difference

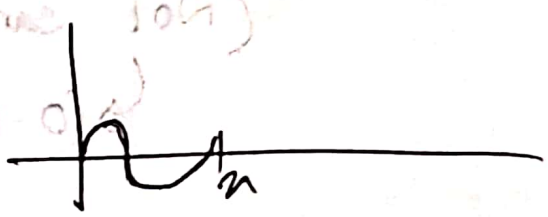
$t-(-x) = \underline{t+x}$



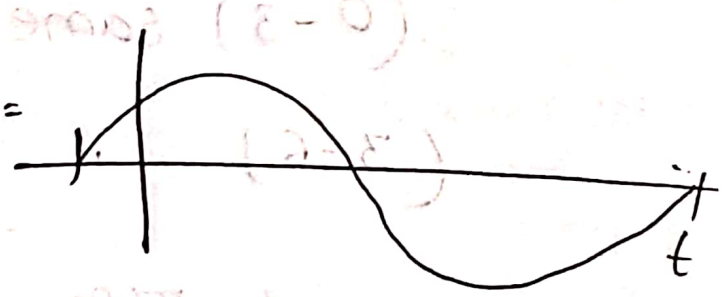
$\sin t =$



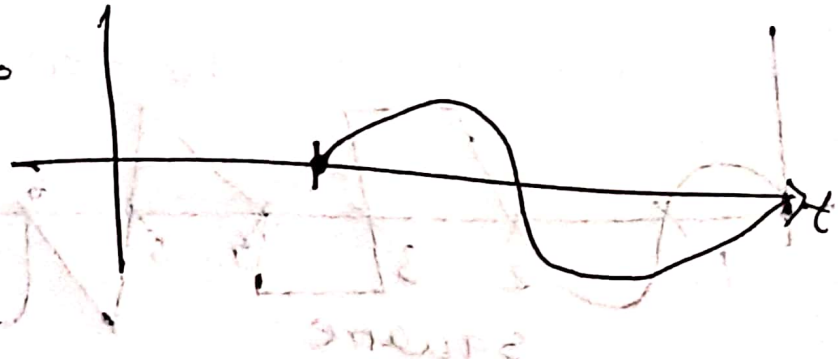
$\sin x =$



$\sin(t+x) =$



$\sin(t-x) =$



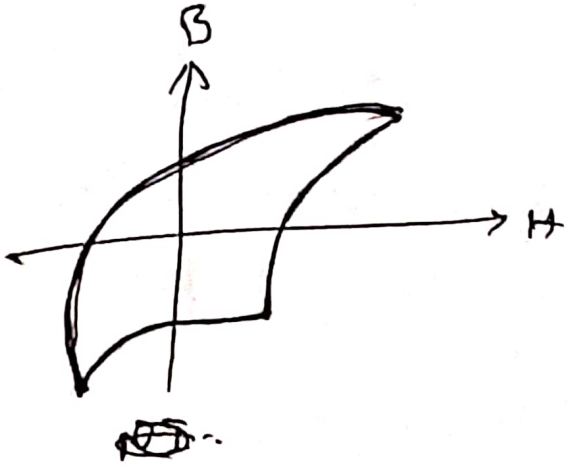
24-01-23

$R = R_e$

$I = \phi$

B-H curve

Hysteresis curve



[গ্রাফ থেকে meta
corresponding H
বের করবো]

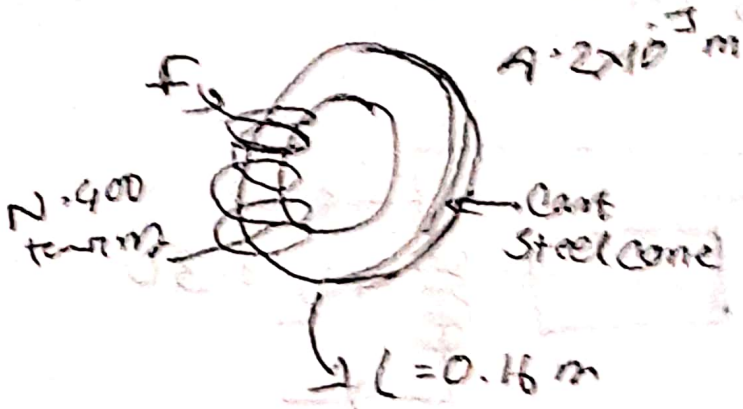
$\Delta I = Hl$ (কতটুকু Drop হচ্ছে)

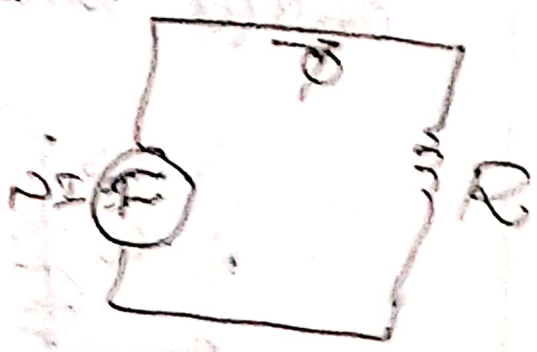
Magneto motive force ($\mathcal{F}$)

$B = \mu H$

$B = \phi / A$

Ex-11.3 (In Side)





$NI = Hl$

$\Rightarrow I = \frac{Hl}{N}$

H =

$l = 0.16\ m$

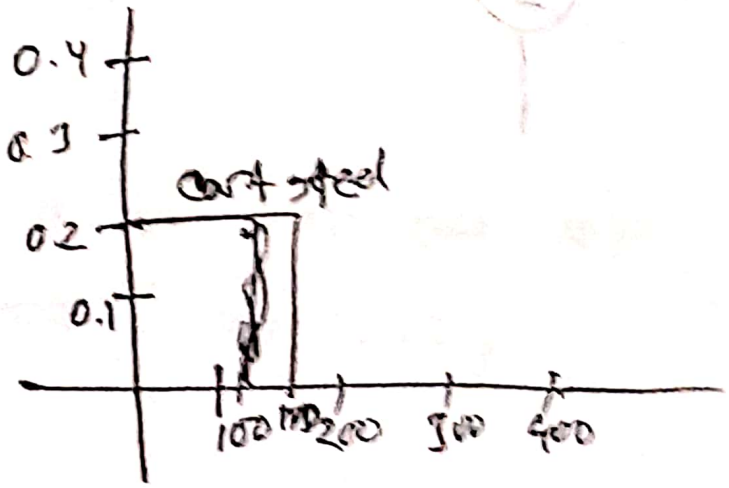
$N = 400$

$B = \phi/A$

$= \frac{4\times10^{-4}}{2\times10^{-3}}$

$= 2\times10^{-1}$

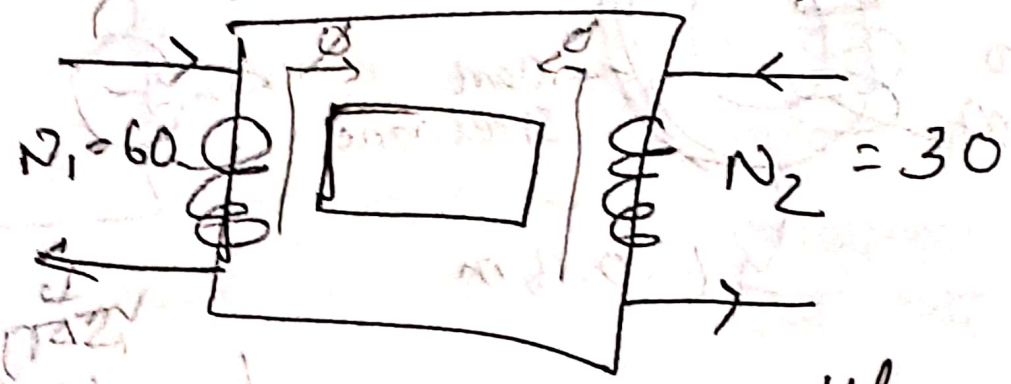
$= 0.2T$



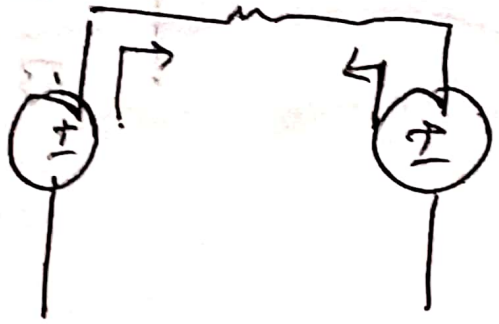
H নিলে হবে গ্রাফ থেকে।

↳ গ্রাফ দেওয়া থাকলে B থেকে H বের করতে হবে।

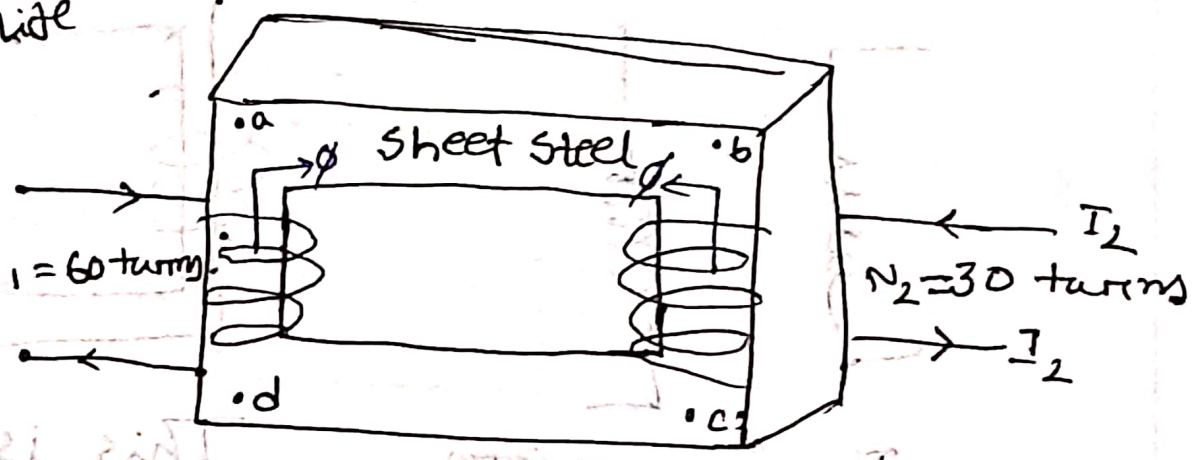
দুইটা NI থাকলে,
যেখানে turn বেশি সেটা বড় ধরবে



$$N_1 I_1 - N_2 I_2 = Hl$$



Example 11.5 From Slide



$$\underbrace{N_1 I_1 - N_2 I_2}_{\text{যেখানে turn বেশি সেটা বড় ধরবো}} = Hl$$

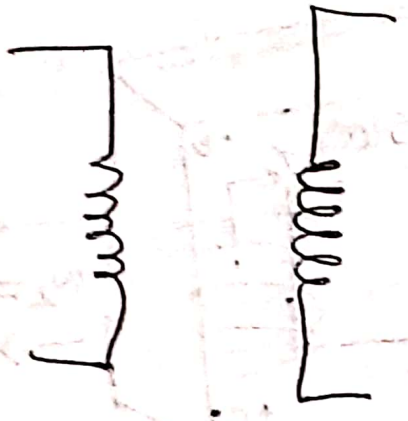
$$\Rightarrow I_2 = \frac{N_1 I_1 - Hl}{N_2}$$

$\phi = 1.5 \times 10^{-5}$

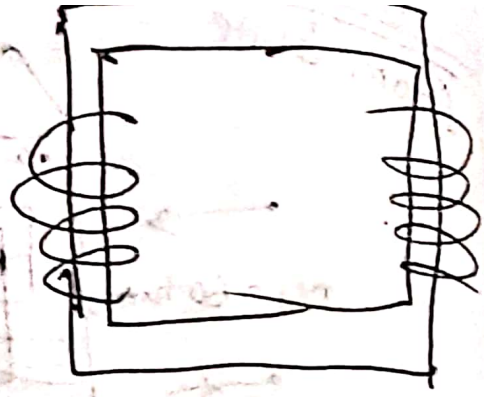
$A = .15 \times 10^{-3}$ m

$B = \phi / A = 0.1$ T

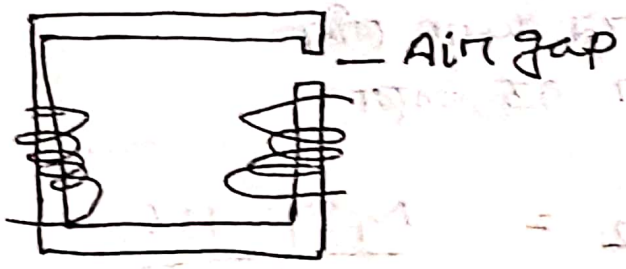
B এর মান বের করে, H এর মান বের করতে হবে (গ্রাফ থেকে).



This is air core



This is iron core

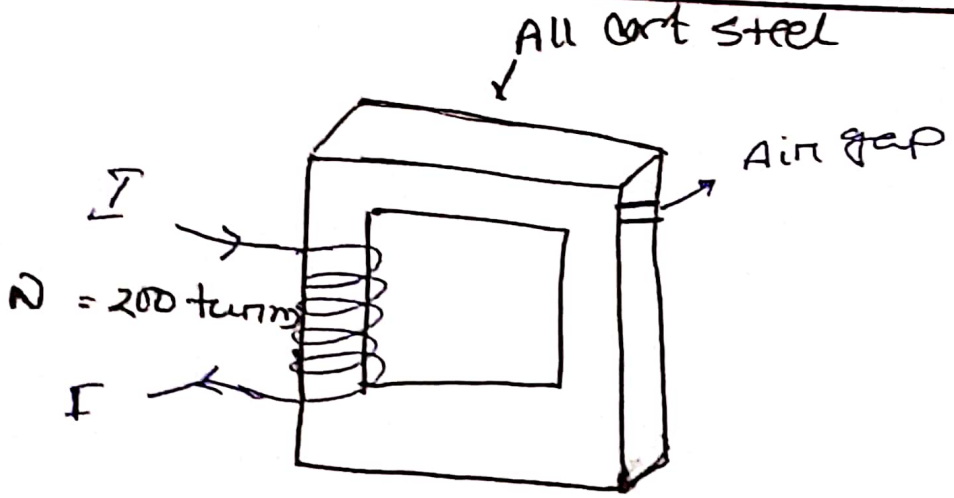


For Air gap

$$B_g = \frac{\phi_g}{A_g}$$

$$H_g = \frac{B_g}{\mu_0} = \frac{B_g}{4\pi \times 10^{-7}}$$

$$H_g = (7.96 \times 10^{5})\, B_g$$



$L_g = 2\times10^{-3}$ m

$NI = HL + (HL)_g$

$B = \phi/A$

$\phi = 0.75\times10^{-4}$

$A = 1.5\times10^{-4}$ m²

B-H গ্রাফ

$H = 280$

$H_g = (7.96\times10^{5})B_g$

Material

B_g 3 a

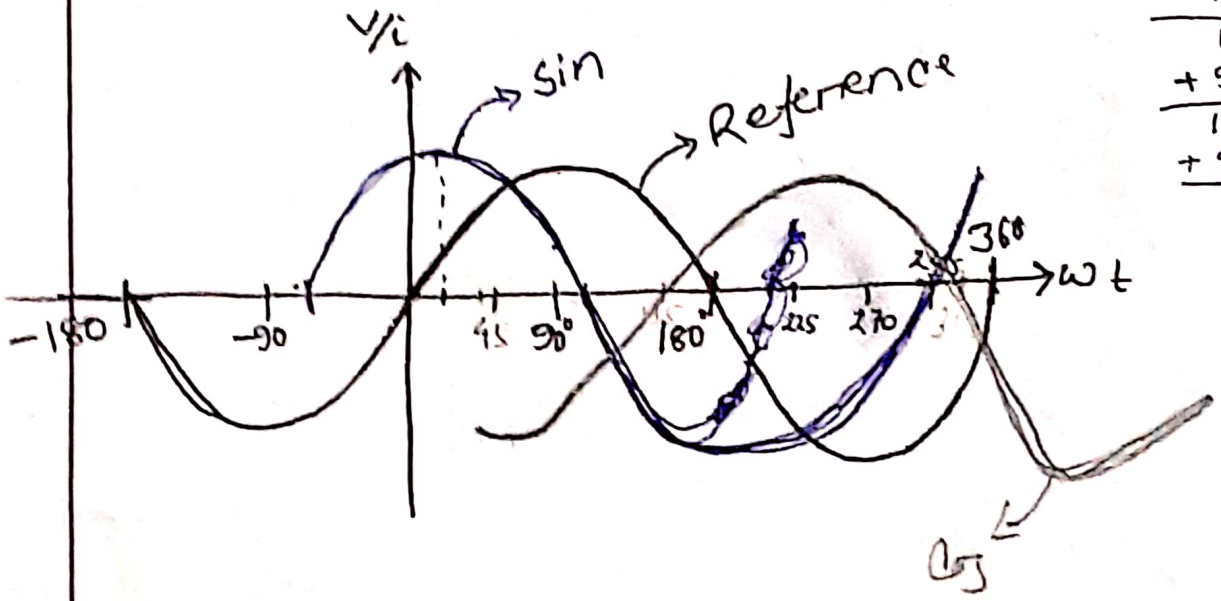
B_g sa

$v = 200 \sin(\omega t + 75^\circ)$

$i = -100 \cos(\omega t - 45^\circ)$

Sin

-75
$+90$
15
$+90$
105
$+90$
195



Cos

45
90
135
90
225
15
210

(*) Phase Difference

(*) which one leads whom?

Ans:

(i) Crossing zero line

(ii) Reaching positive peak

Decisions
যেকোন একটা হয়ে গেলে 2nd check নিতে হবে না।

$$\boxed{\begin{array}{c} v \text{ leads } i \\ \text{or} \\ i \text{ lags } v \end{array}}$$

Phase difference:

$$\theta_v - \theta_i$$

$$= 75 - (-45)$$

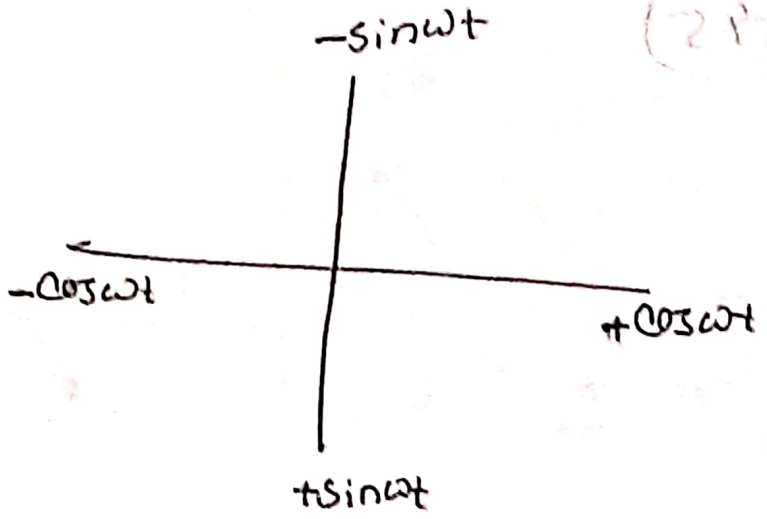
$$= 120^\circ$$

Phase difference
Mathematical Approach

$V = 200 \sin(\omega t + 75^\circ)$

$i = -100 \cos(\omega t - 45^\circ)$

দুইটা হলে একই shape এ আসবে সবটা হয় sin নয় cos।



For clock wise angle (-ve)

For Anti clock wise angle (+ve)

Process 1

$i = -100 \cos(\omega t - 45^\circ)$

$= 100 [-\cos(\omega t - 45^\circ)]$

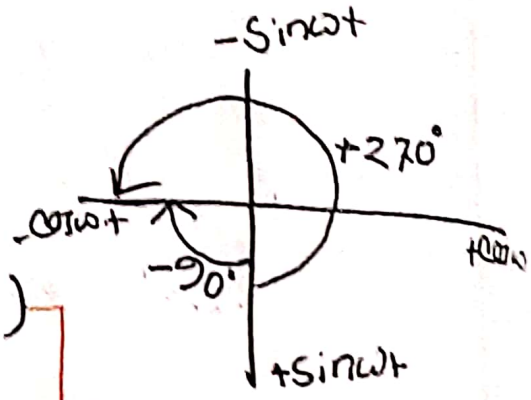
$= 100 \sin(\omega t - 45^\circ - 90^\circ)$

$\therefore i = 100 \sin(\omega t - 135^\circ)$

$\therefore \boxed{\theta = \theta_v - \theta_i}$

$= 75^\circ - (-135^\circ)$

$= 210^\circ$



Process

(i) যেটাকে বানাতে চাই সেটা লিখবো sin or cos

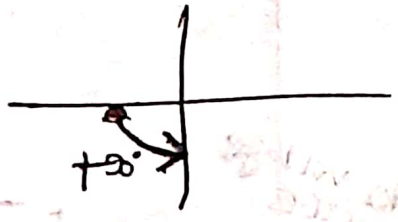
(ii) কোণ নেওয়ার ক্ষেত্রে যেটাতে যাবো সেটা থেকে যেটা ছিল সেটার দিকে clock or anti clock wise দেখাবো। যে হিসাবে

Process 2

$$v = 200 \sin(\omega t + 75^\circ)$$

$$= 200[\cos(\omega t + 75^\circ + 90^\circ)]$$

$$= -200 \cos(\omega t + 165^\circ)$$



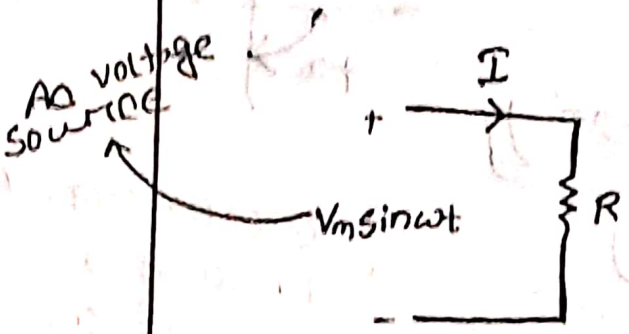
[যেকোন একটা process এ গেলেই হবে phase difference same হবে]

$$\boxed{\theta = \theta_v - \theta_i}$$

$$= 165 - (-45)$$

$$= 210^\circ$$

R, L, C Circuit



$$V_R = iR$$

$$i = V/R = \frac{V_m \sin\omega t}{R}$$

$$i = I_m \sin\omega t \quad \left[I_m = \frac{V_m}{R}\right.$$

Impedence, Z = AC circuit ও comprising বাধা।

Resistive Impedence, Z_R = শুধু Resistance থাকলে

$$\therefore \boxed{Z_R = \frac{V_m}{I_m} \angle(\theta_v - \theta_i)}$$

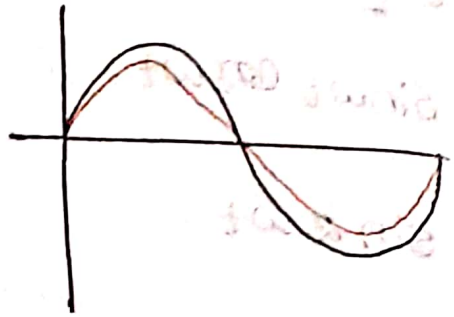
$\angle$ = Angle

$$= \frac{V_m}{V_m/R} \angle(0^\circ - 0^\circ)$$

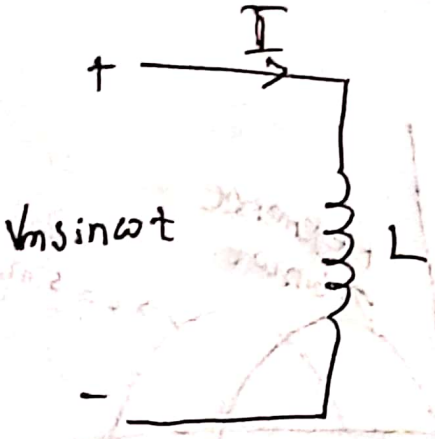
$\theta_v = 0$ কারণ $V_m \sin\omega t$

$$= R \angle 0^\circ$$

Phase difference শূন্য মানে তারা একই point থেকে যাত্রা শুরু করে।



They are in Phase
No leading or
Laggings.



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

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

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

$$\therefore i = \frac{1}{L}\int V_m \sin\omega t\,dt$$

$$= \frac{V_m}{\omega L}(-\cos\omega t)$$

$$= \frac{V_m}{\omega L}\left[\sin(\omega t - 90^\circ)\right]$$

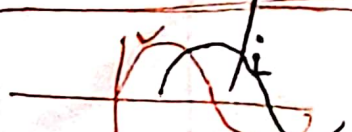
$$i = I_m \sin(\omega t - 90^\circ) \quad \Big/ \; I_m = \frac{V}{\omega}$$

Inductive impedence, $\therefore Z_L = \frac{V_m}{I_m}\angle(\theta_v - \theta_i)$

$$= \frac{V_m}{V_m/\omega L}\angle(0^\circ - (-90^\circ))$$

Inductive reactance, $X_L = \omega L \angle \pm 90^\circ$ —2

Inductor 90 ahead



[Inductor voltage current থেকে lead করে]

07/02/23

$P_L = Vi$

$= V_m \sin\omega t \, [-I_m \cos\omega t]$

$= -V_m I_m \sin\omega t \cos\omega t$

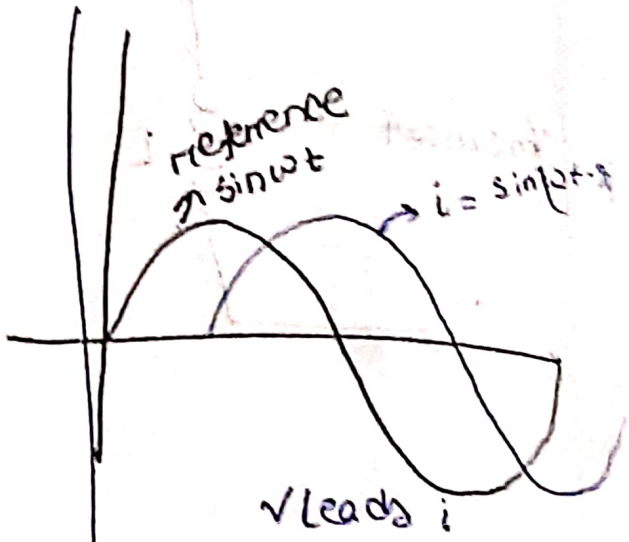
$= -\frac{V_m I_m}{2} \sin 2\omega t$

t = ২ভাগের wave এর

$W_L = Pt$

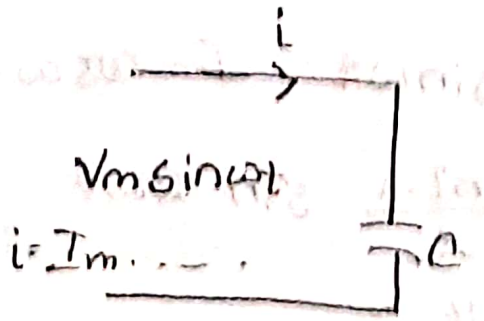
$= \int_{T/4}^{T/2} P_L dt$

$= \frac{1}{2} L I_m^2$



Q: explain v leads i in inductor circ

Capacitive Branch:

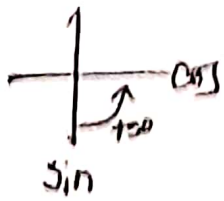


$$i = C \frac{dv}{dt}$$

$$= C \frac{d}{dt}(V_m \sin \omega t)$$

$$= C V_m \omega \cos \omega t$$

$$i = \frac{V_m}{1/\omega C} \cos \omega t$$



$$= \frac{V_m}{1/\omega C} \sin(\omega t + 90)$$

$$= I_m \sin(\omega t + 90)$$

Capacitive Impedence, $Z_C = \frac{V_m}{I_m} \angle(\theta_v - \theta_i)$

$$= \frac{V_m}{I_m} \angle(0^\circ - 90^\circ)$$

$$= \frac{V_m}{1/\omega C} \angle -90^\circ$$

Capacitive Reactance, $X_C = \frac{1}{\omega C}$

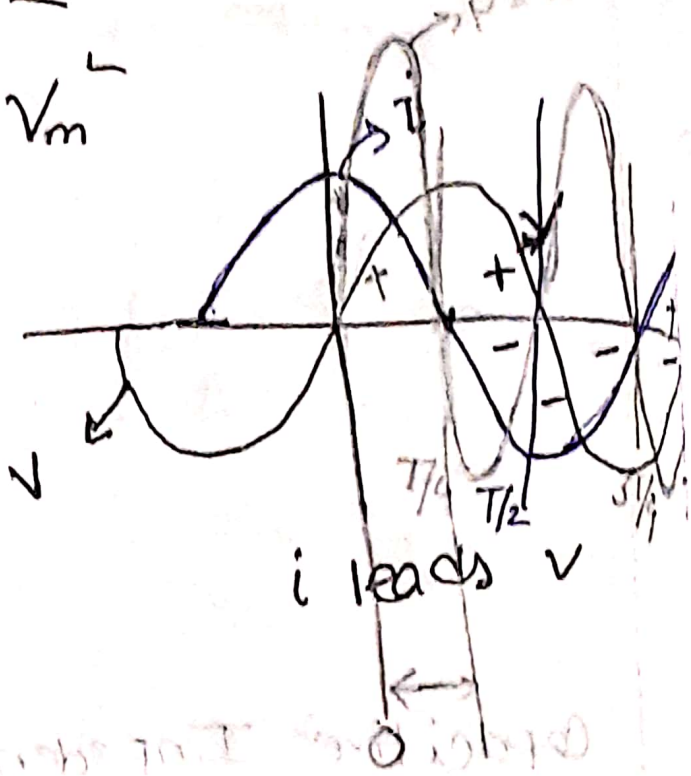
$$P_c = vi$$

$$= V_m \sin\omega t \cdot I_m \cos\omega t$$

$$= \frac{V_m I_m}{2} \sin 2\omega t$$

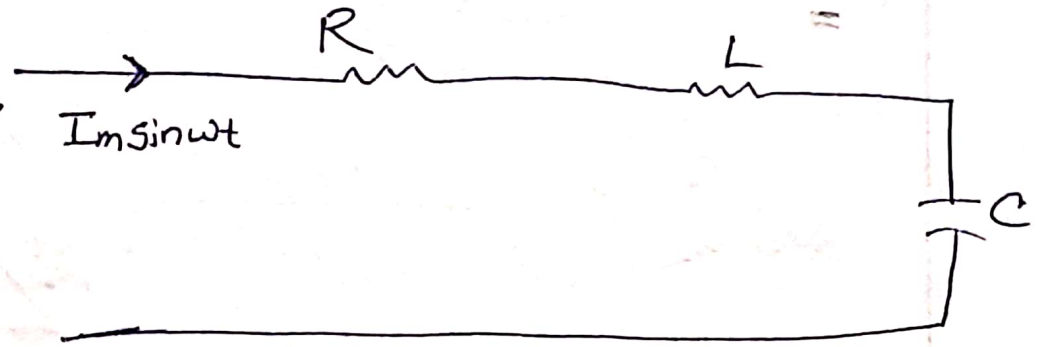
$$W_C = \int_0^{T/4} \frac{V_m I_m}{2} \sin 2\omega t \, dt$$

$$= \frac{1}{2} C V_m^2$$



RLC circuit

যেহেতু current similar এই input হিসেবে current নিচ্ছি। হিসাবের সুবিধার্থে



$$V = V_R + V_L + V_C$$

$$= (I_m \sin\omega t)\cdot R + L\frac{dI_m \sin\omega t}{dt} + \frac{1}{C}\int I_m \sin\omega t \, dt$$

Here,

$$i_C = C\frac{dV_C}{dt}$$

$$dV_C = \frac{i_C}{C}dt$$

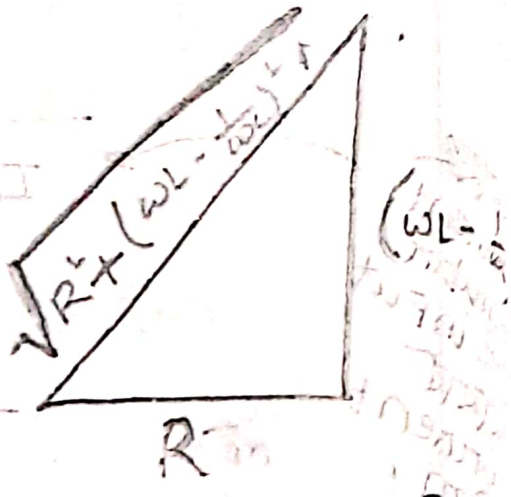
$$\int dV_C = \frac{i_C}{C}dt$$

$$V_C = \frac{1}{C}\int i_C \, dt$$

$$V = RI_m \sin\omega t + L I_m \omega \cos\omega t + \frac{1}{C}\left[\frac{-I_m \cos\omega t}{\omega}\right]$$

$$V = R I_m \sin\omega t + I_m \cos\omega t \left[\omega L - \frac{1}{\omega C}\right]$$

$=$



$$\cos\theta = \frac{R}{\sqrt{R^2+(\omega L-\frac{1}{\omega C})^2}}$$

$$\sin\theta = \frac{\omega L - 1/\omega C}{\sqrt{R^2+(\omega L-\frac{1}{\omega C})^2}}$$

$$\Rightarrow \frac{V}{\sqrt{R^2+(\omega L-1/\omega C)^2}\, I_m} = \frac{R I_m \sin\omega t}{\sqrt{R^2 \ldots}} + \frac{I_m}{\sqrt{R^2 \ldots}} \cos\omega t \left[\omega L - \frac{1}{\omega C}\right]$$

$$= I_m \sin\omega t \cos\theta + I_m \cos\omega t \cdot \sin\theta$$

$$= I_m \left[\sin(\omega t + \theta)\right]$$

$$\therefore V = \sqrt{R^2+(\omega L - 1/\omega C)^2} \cdot I_m \sin(\omega t + \theta)$$

$$Z_{RLC} = \frac{V_m}{I_m} \angle \theta_v - \theta_i$$

$$= \frac{\sqrt{R^2 + (\omega L - 1/\omega C)^2}\, I_m}{I_m} \angle \theta - 0$$

$$Z_{RLC} = \sqrt{R^2 + (\omega L - 1/\omega C)^2} \angle \theta$$

Here,

$$\theta = \tan^{-1} \frac{\omega L - 1/\omega C}{R}$$

02/04

$u = 200 \sin(\omega t - 45^\circ)$

Operating at 30 cycle per second

$R = 20\,\Omega$

$L = 10\,mH$

$C = 20\,\mu F$

i) Find Z_{RLC}

ii) Find Current, I

i) $Z_{RLC} = \sqrt{R^2 + (\omega L - 1/\omega C)^2} \angle \tan^{-1} \frac{\omega L - 1/\omega C}{R}$

$\omega = 2\pi f \qquad f = 1/T$

ii) Find current, $I = V/Z_{RLC}$

$= \frac{200 \angle -45}{20 \angle 30}$ → V ⊖ (

→ ① (যোগ পাওয়া গিয়ে

$= 10 \angle -45 - (-30)$

$= 10 \angle -15$

$10 \angle -30^\circ$

From last Class,

$$P = vi$$

$$= V_m \sin(\omega t + \theta) \cdot I_m \sin\omega t$$

$$= V_m I_m \left(\sin\omega t \cdot \cos\theta + \cos\omega t \cdot \sin\theta\right) \sin\omega t$$

$$= V_m I_m \left(\sin^2\omega t \cdot \cos\theta + \sin\omega t \cdot \cos\omega t \sin\theta\right)$$

$$= V_m I_m \left[\tfrac{1}{2}(1 - \cos 2\omega t)\cos\theta + \tfrac{1}{2}\sin 2\omega t \cdot \sin\theta\right]$$

$$= \underbrace{\underbrace{\frac{V_m I_m \cos\theta}{2}}_{\text{Real Power}} - \frac{V_m I_m}{2}\cos 2\omega t \cdot \cos\theta}_{\text{Real power}} + \underbrace{\frac{V_m I_m}{2}\sin 2\omega t \sin\theta}_{\text{Reactive Power}}$$

~~Instantaneous~~ Instanteneous

Avarage & RMS Value

avarage

$$\int_0^T V_m \sin\omega t$$

$$T$$

$$E_{avg}, V_{avg} = \frac{1}{T}\int_0^T v\,dt$$

$$= 0.636\ V_m$$

$$\int_0^T V_m \sin\omega t$$

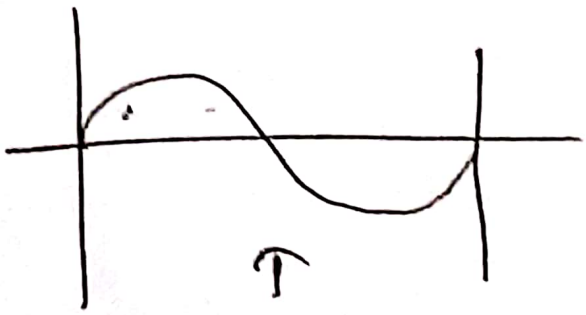
$$= V_m\left[\frac{-\cos\omega t}{\omega}\right]$$

$$= \frac{\cos\omega T}{\omega}$$

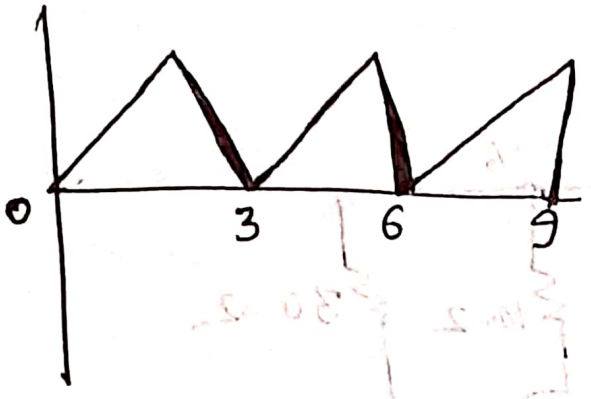
Root Mean Square

$$V_{rms} = \sqrt{\frac{\int_0^T v^2\,dt}{T}} = .707\ V_m$$

এই ক্ষেত্রে figure এর total voltage 0 এবং time period T/2 হলো, মানে অর্ধেক



$$E_{avg} = \frac{1}{T/2}\int_0^{T/2} V_m \sin$$



এখানে period 0-3
এখানে শূন্য হওয়ার সম্ভাবনা নাই।

$$\therefore V_{avg} = \frac{1}{3}\int_0^3 V\, dt$$

$$V_{rms} = \sqrt{\frac{1}{3}\int_0^3 (v)^2\, dt}$$

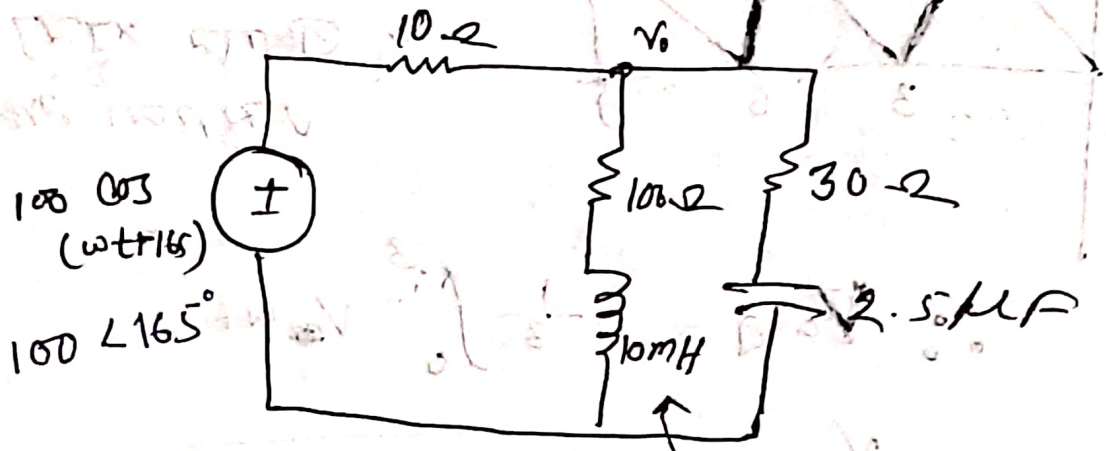
Always greater than 1

(F.F) Form Factor $= \dfrac{\text{RMS value}}{\text{Avg value}}$

Crest / peak Factor $= \dfrac{\text{Peak value}}{\text{RMS value}}$

$$= \frac{V_m}{0.636\, V_m}$$

This is time Domain



If cosine is given angel = θ

If sine is " " = ∠-90+θ

$\omega = 10$

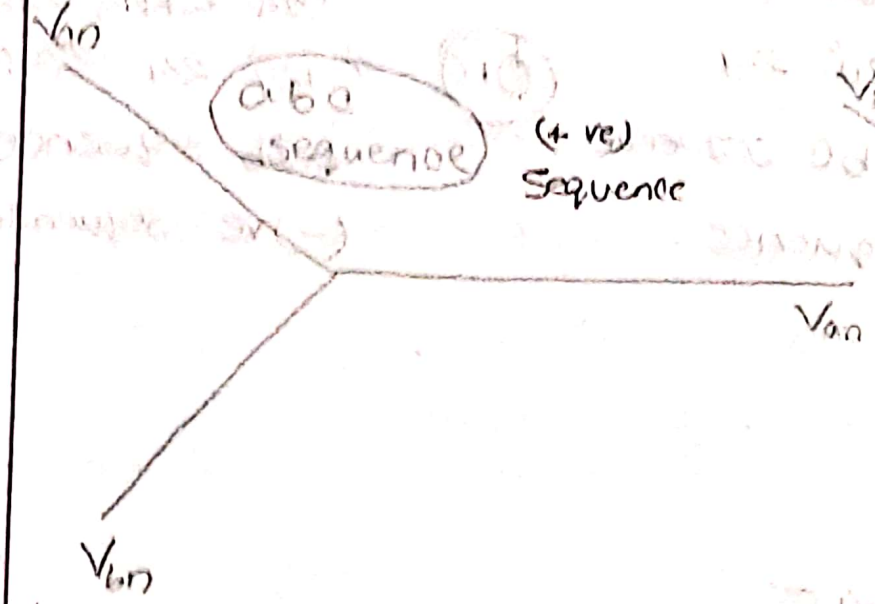
$j\omega L$ $\frac{1}{j\omega C}$

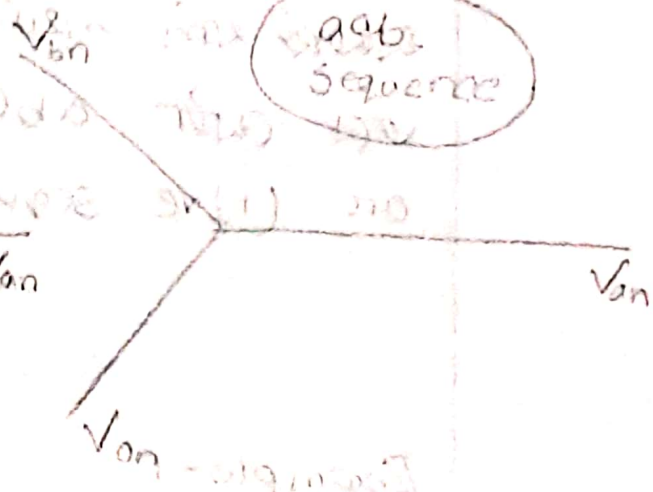
$\frac{1}{j\omega C}$

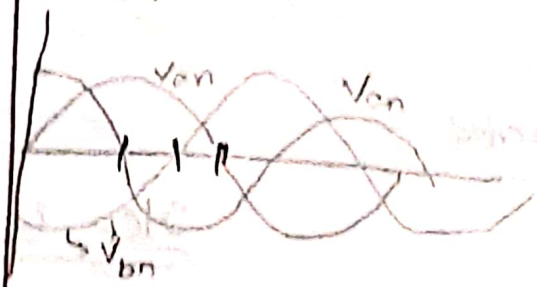
$= j \times 10 \times 10 \times 10^{-3}$

$= 0.1j$

Three Phase Circuit





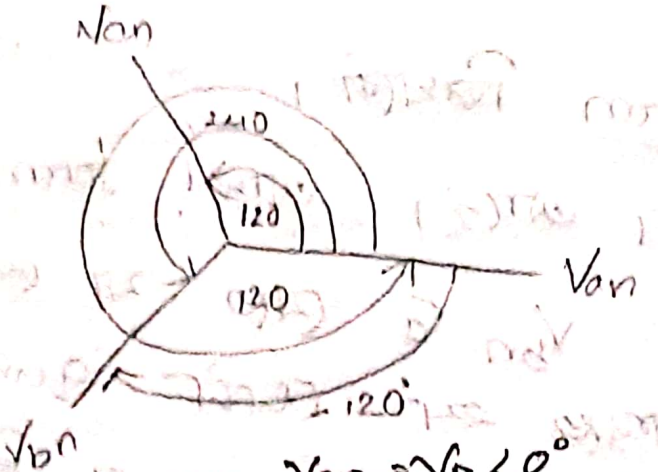


$V_{an} = V_p \sin\omega t = V_p\angle 0^\circ$

$V_{bn} = V_p \sin(\omega t - 120^\circ)$

$V_{cn} = V_p \sin(\omega t - 240^\circ)$

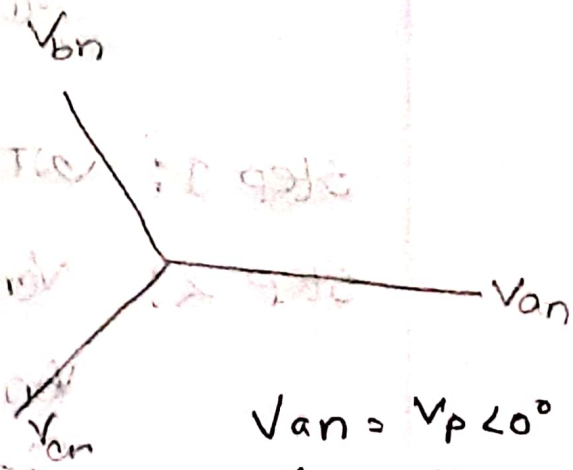
Harmonics যত কম Machine এর sound তত কম। Three phase এ এই Harmonics থাকে না। তাই Preferable.



$V_{an} = V_p\angle 0^\circ$

$V_{bn} = V_p\angle 0^\circ - 120^\circ$

$V_{cn} = V_p\angle -120^\circ$



$V_{an} = V_p\angle 0^\circ$

$V_{cn} = V_p\angle -120^\circ$

$V_{bn} = V_p\angle -240$

an এর সাথে bn এর সমর্পক যদি -120° হয় তবে সেটা abc sequence or (+)ve sequence.

or

an এর সাথে bn এর সমর্পক যদি -120° হয় তবে সেটা acb sequence or (−)ve sequence.

Example-1

$V_{bn} = 120^\circ \angle -45^\circ$

$V_{an} = ?$

$V_{bn} = ?$

For abc sequence

Soln:

Step-1

$V_{an} = V_p \angle 0^\circ$

$V_{bn} = V_p \angle -120^\circ$

$V_{cn} = V_p \angle -240$

Step-2

$V_{an} = 120 \angle -45+0$

$V_{bn} = 120 \angle -45+120$

$V_{cn} = 120 \angle -45^\circ$

Step 1: আদর্শ form লিখবো।

Step 2: V_{cn} দেওয়া আছে। আদর্শ form এ V_{cn} থেকে V_{bn} এ যেতে যা যোগ বা বিয়োগ করতে হয় সেটা question এর V_{an} এর সাথে যোগ বা বিয়োগ দিতে হবে।

Example-2

Given,

$V_{an} = 220 \cos(\omega t - 40^\circ)$

$V_{bn} = 220 \cos(\omega t - 280^\circ)$

$V_{cn} = 220 \cos(\omega t - 160^\circ)$

Find the sequence

Difference between the angles

Here, V_{an} and V_{cn} is -120°

So it is acb sequence.

Line Voltage, V_L

Line Current, I_L

Phase Voltage, V_ϕ

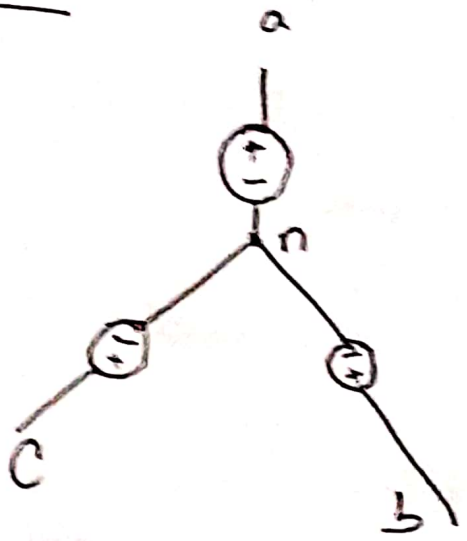
Phase Current, I_ϕ

for,

Supply { Y – Y, Y – Δ, Δ – Y, Δ – Δ } Connection Network

Load

Y – Y



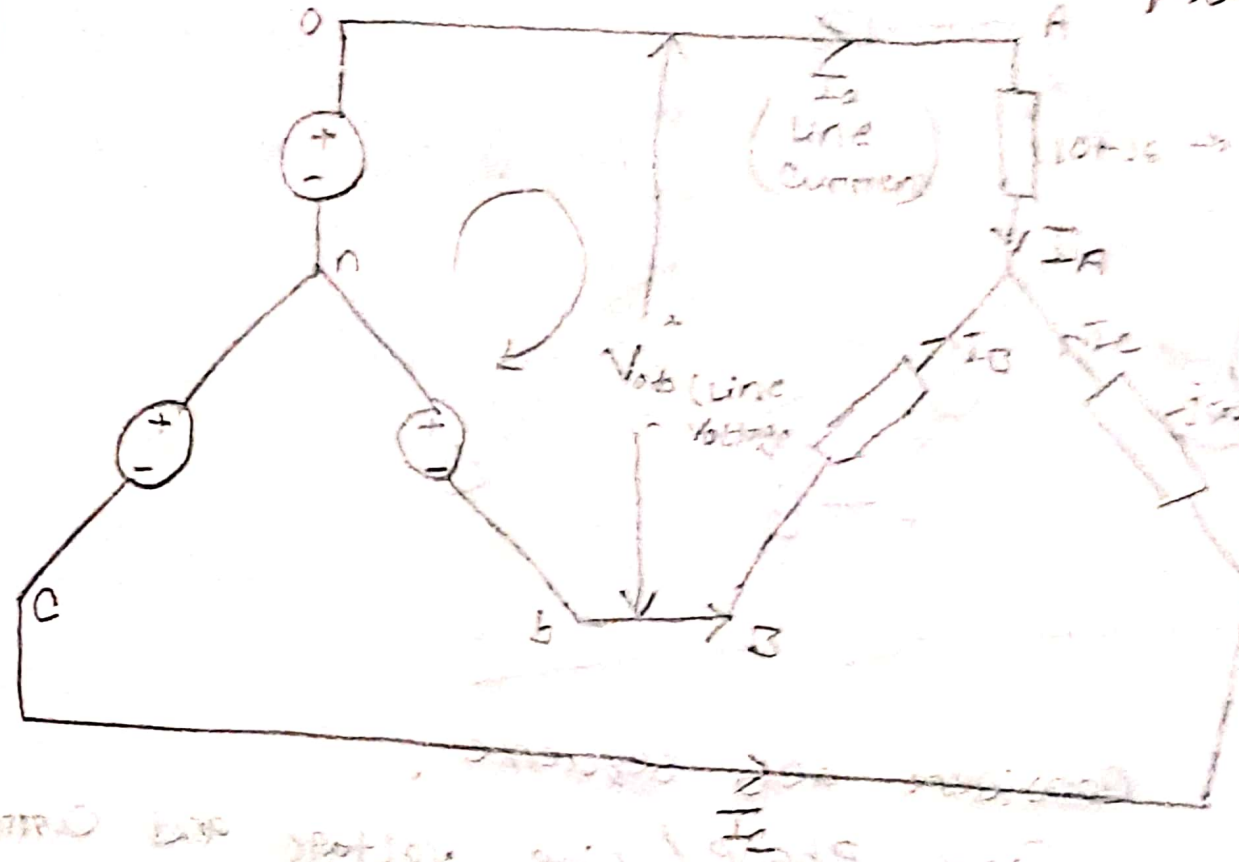
Y-ব এর (–) প্রান্ত সব এক সাথে Connect থাকে যার Point n

Supply থেকে যেটা Load এ যাবে সেটা Line. এর ভেতর যে অংশে যাবে সেটা Line Current

Phase : প্রতিটা element যে আলাদা আলাদা Phase. Z_{L1}, Z_{L2}, Z_{L3}, V_{bn}, V_{an}, etc

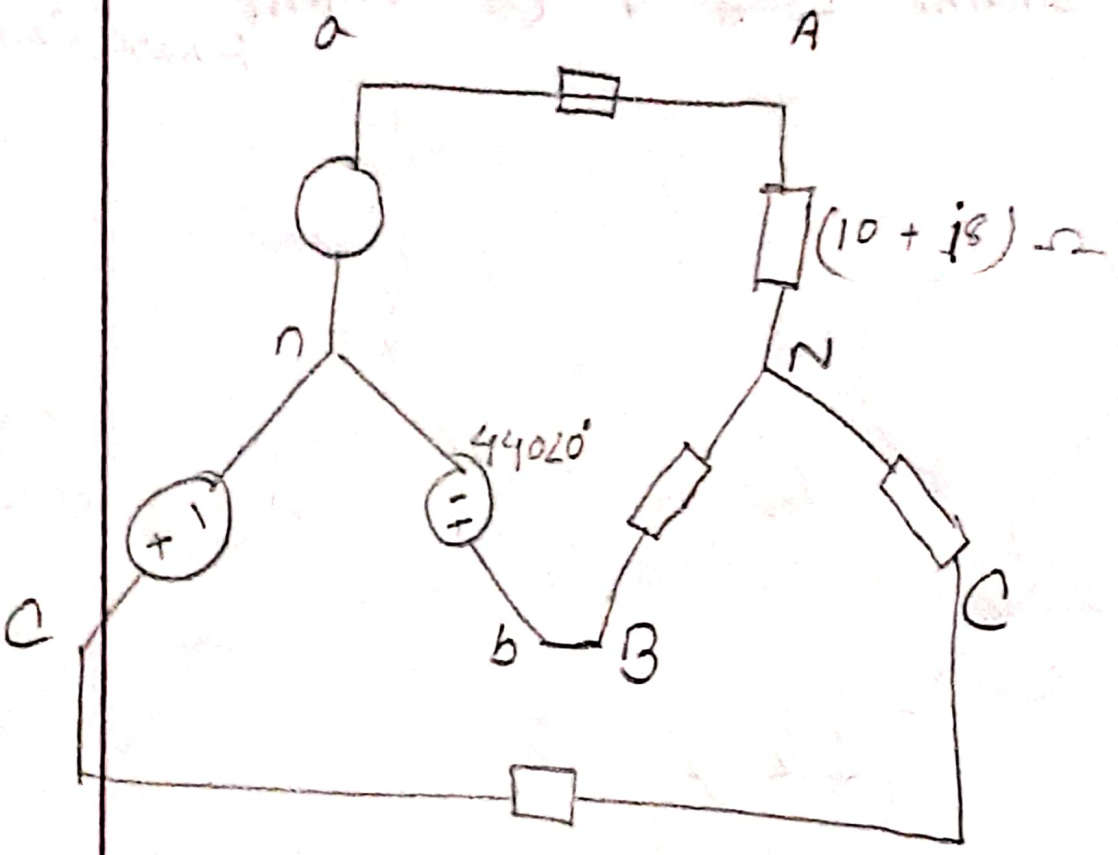
⇒ Voltage source এর supply end এর যে Phase সেটা Phase voltage.

⇒ আলাদা আলাদা Load এ যে current যাই সেটা Phase current



$$+V_{ab} + V_{bn} - V_{an} = 0$$

$$\therefore V_{ab} = V_{an} - V_{bn}$$



Consider acb sequence.

Find Phase/ Line voltage and current.

Here,

$V_{bn} =$

V_{an}.

$V_{cn} =$

$V_{bn} = 440\angle 0$

$V_{an} = 440\angle +240°$

$V_{cn} = 440\angle +120°$

$V_{ab} = V_{an} - V_{bn}$

$V_{bc} = V_{bn} + V_{cn}$

$V_{ca} = V_{cn} - V_{an}$