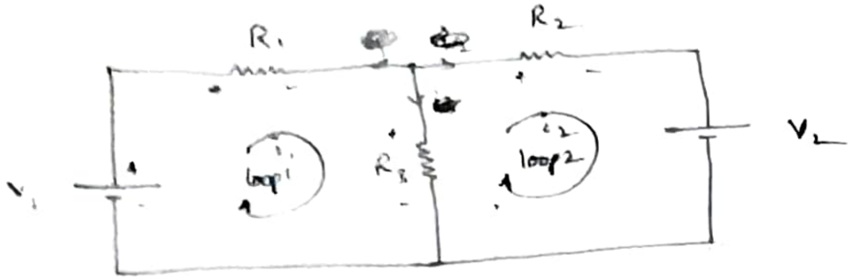
Mesh Analysis

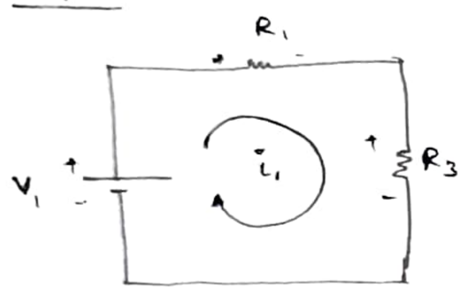


→ Assume CW or ACW dir^n in loops

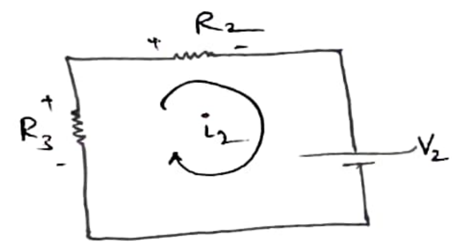
→ form equations in i_1, i_2, etc. by KVL in individual loops

→ Solve & find i_1, i_2, etc..

Loop ①



loop ②



$$-i_1R_1 - (i_1 - i_2)R_3 + V_1 = 0$$

$$V_1 = i_1R_1 + (i_1 - i_2)R_3$$

$$V_1 = i_1R_1 + i_1R_3 - i_2R_3$$

$$V_1 = i_1(R_1 + R_3) - i_2R_3 \quad \text{——} ①$$

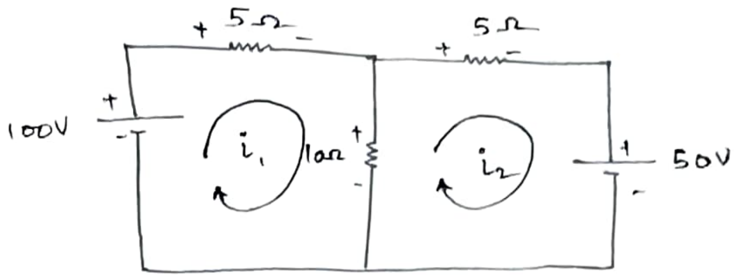
$$+(i_2 - i_1)R_3 - i_2R_2 - V_2 = 0$$

$$V_2 = i_2R_3 - i_2R_2 - i_1R_3$$

$$V_2 = i_2(R_3 - R_2) - i_1R_3 \quad \text{——} ②$$

Solve both & find answers (required one's).

Problem



Ans

Loop ①

$100 - 5i_1 - 10(i_1 - i_2) = 0$

$100 - 5i_1 - 10i_1 + 10i_2 = 0$

$-15i_1 + 10i_2 = -100$

$15i_1 - 10i_2 = 100$

$3i_1 - 2i_2 = 20$

Loop ②

$-5i_2 - 50 - 10(i_2 - i_1) = 0$

$-5i_2 - 50 - 10i_2 + 10i_1 = 0$

$-15i_2 + 10i_1 = 50$

$-3i_2 + 2i_1 = 10$

$6i_1 - 4i_2 = 40$

$6i_1 - 9i_2 = 30$

$5i_2 = 10$

$\boxed{i_2 = 2A}$

$3i_1 - 4 = 20$

$3i_1 = 24$

$\boxed{i_1 = 8A}$

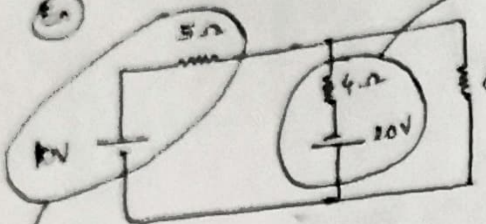
$\boxed{i_3 = i_1 - i_2 = 6A}$

⊛ Source Transformations

1) Voltage source to current source

Ex

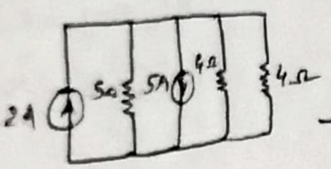
$i = \frac{20}{4} = 5A$



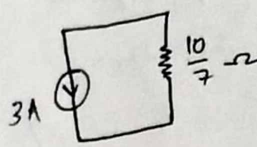
$I = \frac{V}{R} = \frac{10}{5} = 2A$

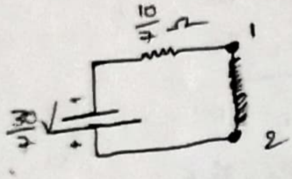
↓

if Voltage & resistor in series replace with current & resistance in parallel.



→



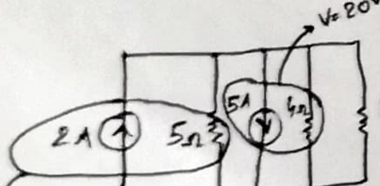


2) Current source to voltage source

If current & resistor are in parallel then replace it with voltage & resistor in series

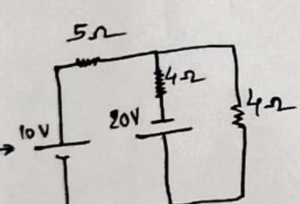
Ex

V = 20V



V = 10

→



⊛ Super-position Theorem

→ It is just like love pinki gets from her n no. of boyfriends.

Total love = $L_1 + L_2 + L_3 + \dots$

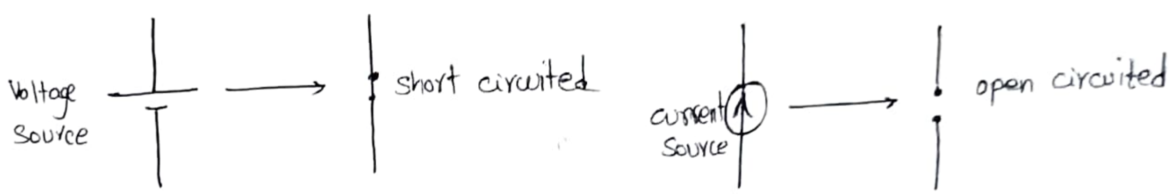
→ And also love of Boyfriend 1 does not depend on love of other boyfriends.

→ Each love to pinki is independent from all other loves pinki gets.

Definition

→ The voltage/current across an element in a linear circuit is algebraic sum of voltages/current across that element due to each independent source acting alone.

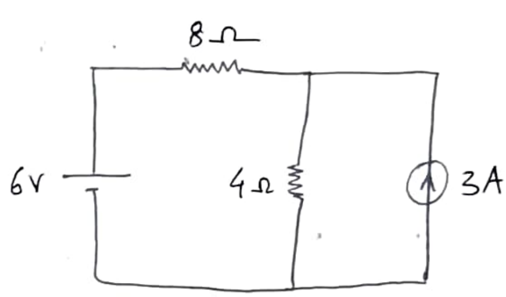
→ Each independent source is either open circuited/short circuited



→ Do not turn off dependent sources

→ Theorem is not valid for non-linear circuits.

Example Problem



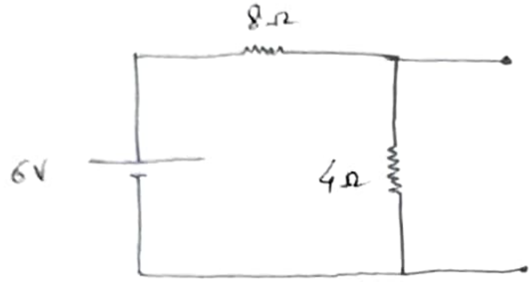
Find voltage across 4Ω resistor

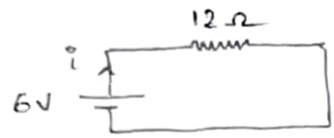
Ans

$$V_{4\Omega} = (V_{4\Omega})_{PD} + (V_{4\Omega})_{I}$$

Case ①

For $(V_{4\Omega})_{PD}$ ⟶ remove current source → Open circuit





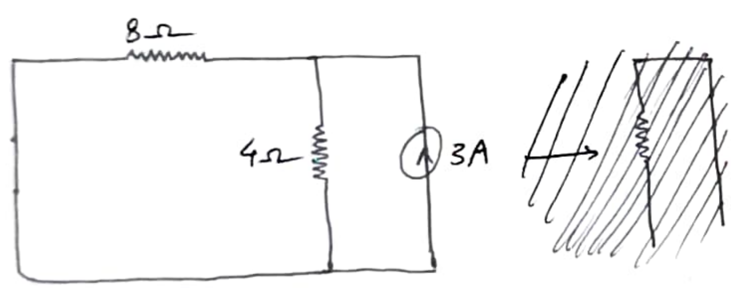
$i = \frac{V}{R} = \frac{6}{12} = 0.5A$

$(V_{4\Omega})_{PD} = i_{4\Omega} \times 4 = 0.5 \times 4 = 2V$

$\boxed{(V_{4\Omega})_{PD} = 2V}$

Case ②

For $(V_{4\Omega})_I$ ⟶ remove voltage source → Short Circuit



Applying Current division rule

$i_{4\Omega} = 3 \times \frac{8}{8+4} = \cancel{3} \times \frac{\cancel{8}^{2}}{\cancel{12}_{4}} = 2A$ $\boxed{(V_{4\Omega})_I = 8V}$

Answer

$V_{4\Omega} = 2 + 8 = 10 \rightarrow \boxed{V_{4\Omega} = 10V}$ $i_{4\Omega} = 2A \rightarrow (V_{4\Omega})_I = i_{4\Omega} \times 4 = 2 \times 4 = 8$

⊛ Norton's Theorem

→ A linear & bidirectional 2 terminal network can be replaced by an equivalent circuit consisting of current source I_N in parallel with resistor R_N.

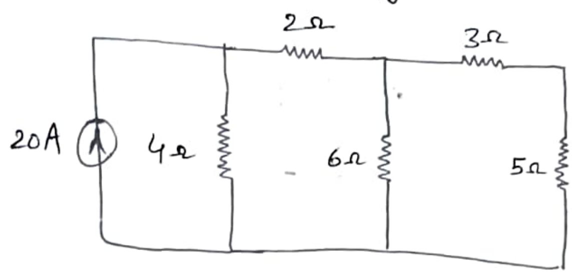
→ To find I_N → short circuit current through terminals

→ To find R_N → Input resistance at terminals when independent sources are turned off

→ Finally replace circuit with Eq. circuit with load resistance in parallel.

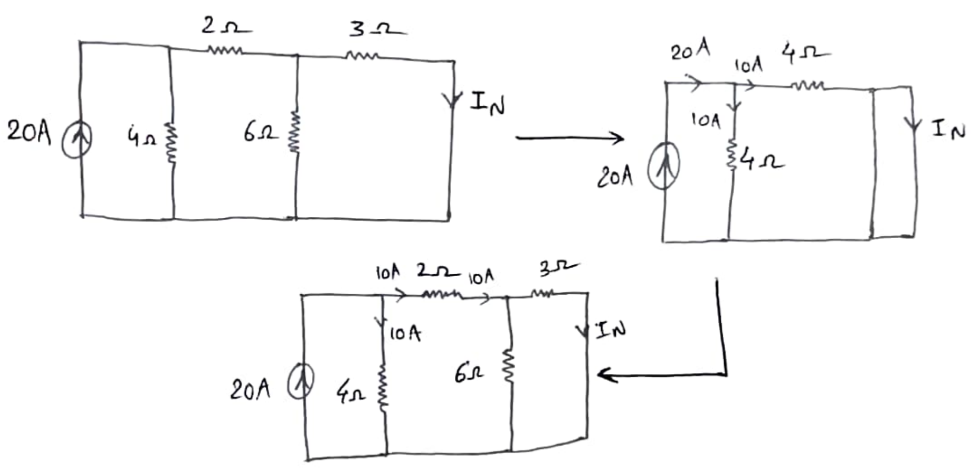
Example Problem

Find current flowing through 5Ω Resistance.



Ans

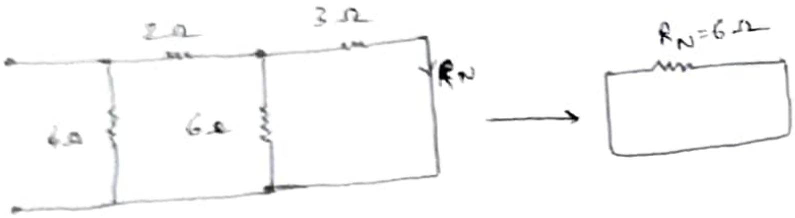
To find I_N



$$I_N = 10 \times \frac{6}{6+3} = 10 \times \frac{\cancel{6}^{2}}{\cancel{9}_{3}} = \frac{20}{3} \text{ A}$$

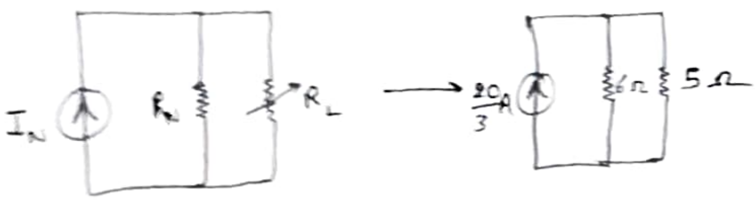
$$\boxed{I_N = \frac{20}{3} \text{ A}}$$

To find R_N



$\boxed{R_N = 6\,\Omega}$

Now replace given circuit with eq circuit then attach load resistance in parallel



$$i_{5\Omega} = \frac{20}{\cancel{3}} \times \frac{\cancel{6}\,2}{6+5} = \frac{40}{11}\,A$$

$$\boxed{i_{5\Omega} = \frac{40}{11}\,A}$$

→ Hence by Norton's Theorem.

* Thevenin Theorem

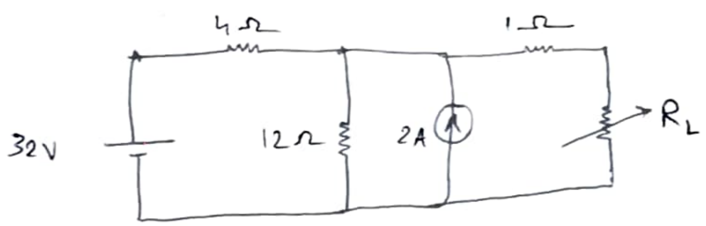
→ A linear bidirectional 2 terminal n/w can be replaced by an equivalent circuit consisting V_{th} & R_{th} with a load resistance in series.

→ To find V_{th} → open circuit voltage at terminals

→ To find R_{th} → Input resistance at terminals when all independent sources are off.

→ Finally replace with eq. circuit with R_L in series

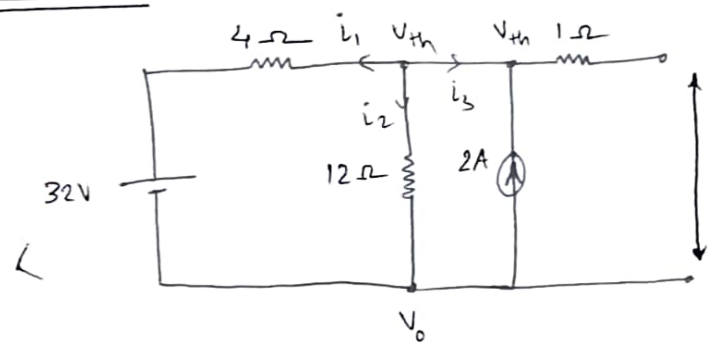
Example Problem



Find current flowing through load resistance when it is (i) 6Ω
(ii) 16Ω

Ans

To find V_{th}



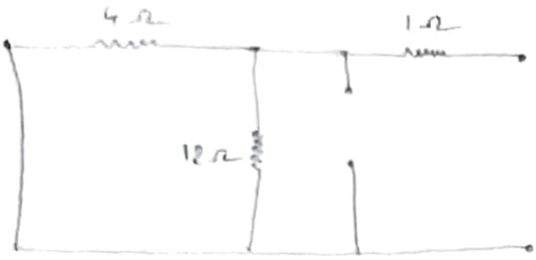
V_{th} should be here but due to open circuit it is placed as shown.

Applying KCL

$$\frac{V_{th}-32}{4} + \frac{V_{th}-0}{12} + (-2) = 0$$

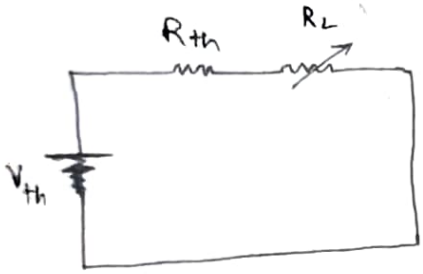
$$3V_{th} - 96 + V_{th} - 24 = 0 \Rightarrow 4V_{th} = 120 \Rightarrow \boxed{V_{th} = 30V}$$

To find R_{th}

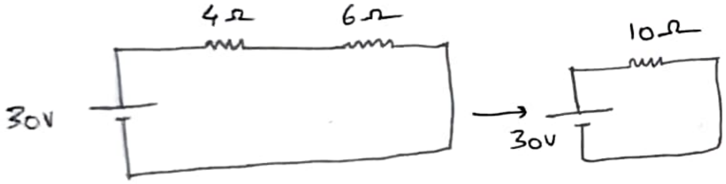


$$\boxed{R_{th} = 4\Omega}$$

Now replace given circuit with eq circuit consisting of V_{th}, R_{th} and load resistance in series.

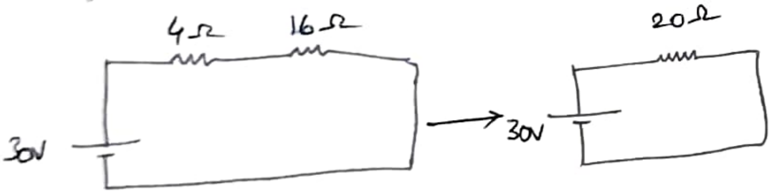


(i) $R_L = 6\Omega$



$i = 3A$

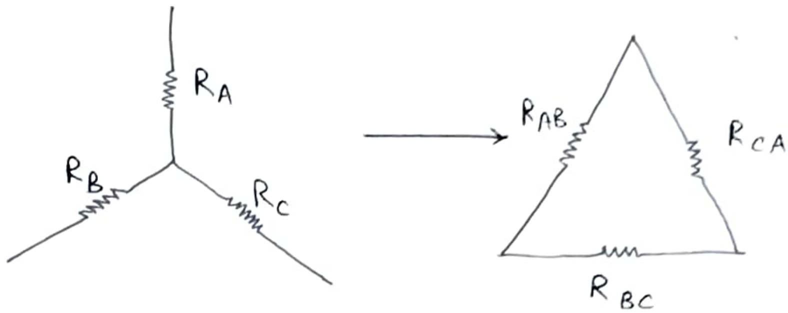
(ii) $R_L = 16\Omega$



$i = 1.5A$

(*) Star to Delta Connection
(λ) (Δ)

(Ex)

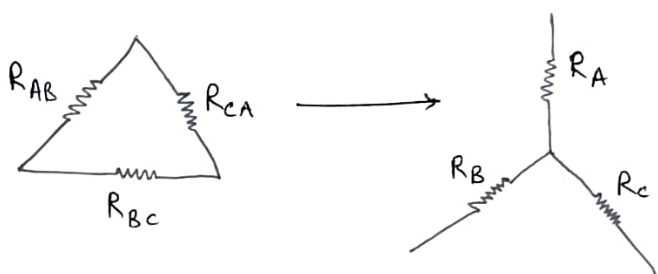


$$R_{AB} = \frac{R_A R_B + R_B R_C + R_C R_A}{R_C}$$

$$R_{BC} = \frac{R_A R_B + R_B R_C + R_C R_A}{R_A}$$

$$R_{CA} = \frac{R_{AB} + R_{BC} + R_{CA}}{R_B}$$

(*) Delta to Star Connection
(Ex) (Δ) (λ)



$$R_A = \frac{R_{AB} \times R_{CA}}{R_{AB} + R_{BC} + R_{CA}}$$

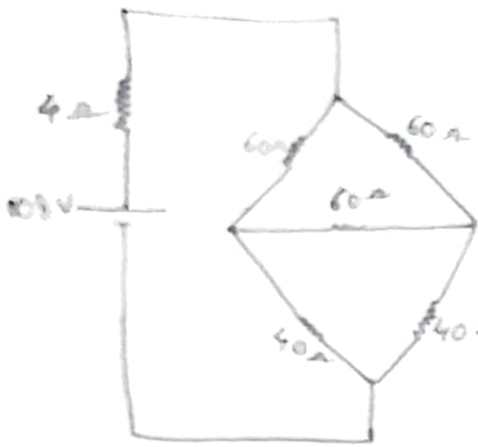
$$R_B = \frac{R_{AB} \times R_{BC}}{R_{AB} + R_{BC} + R_{CA}}$$

$$R_C = \frac{R_{BC} \times R_{CA}}{R_{AB} + R_{BC} + R_{CA}}$$

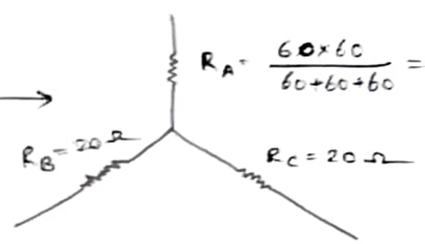
Problem

Method ①

Find current through circuit

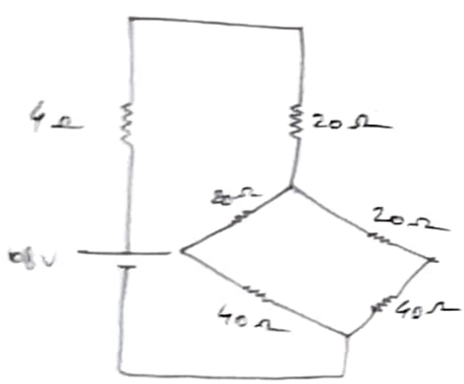


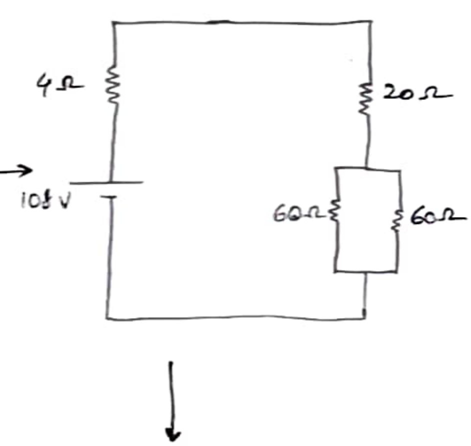
let us convert Δ of 60Ω into λ



$$R_A = \frac{60 \times 60}{60+60+60} = \frac{\overset{20}{\cancel{3600}}}{\cancel{180}} = 20\Omega$$

So finally

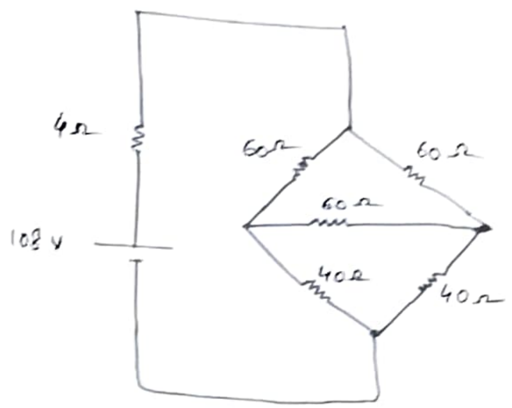




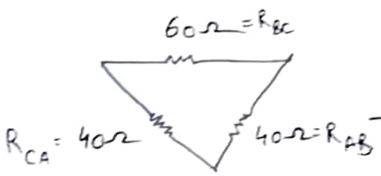
$$i = \frac{V}{R} = \frac{108}{54} = 2A$$

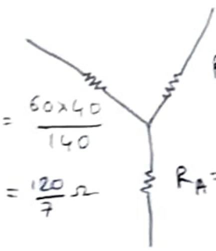
$$\boxed{i = 2A}$$

Method ②



Let us convert Δ to λ





$R_B = \frac{40\times\cancel{60}^{3}}{\cancel{140}_{7}} = \frac{120}{7}\,\Omega$

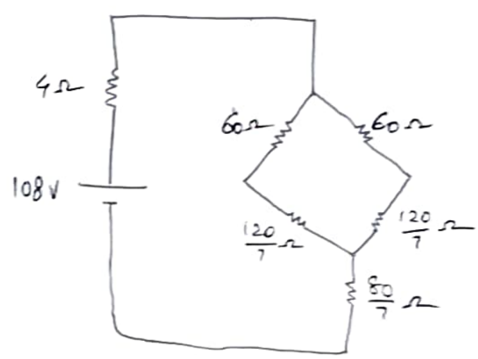
$R_C = \frac{60\times 40}{140}$

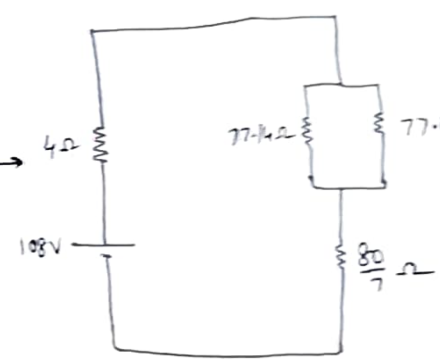
$R_C = \frac{120}{7}\,\Omega$

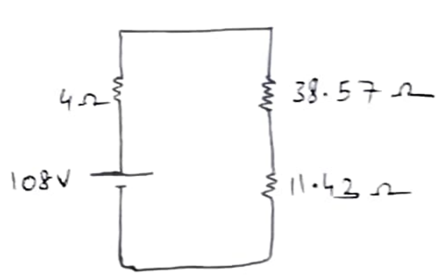
$R_A = \frac{R_{AB}\times R_{CA}}{R_{AB}+R_{BC}+R_{CA}} = \frac{40\times 40}{60+40+40} = \frac{\cancel{1600}^{80}}{\cancel{140}_{7}}$

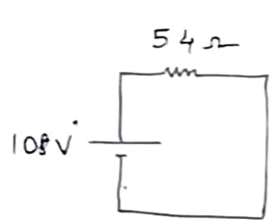
$= \frac{80}{7}\,\Omega$

So Finally





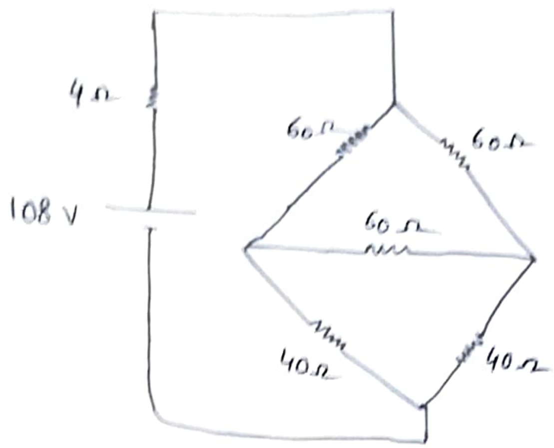




$i = \frac{108}{54} = 2\,A$

$\boxed{i = 2A}$

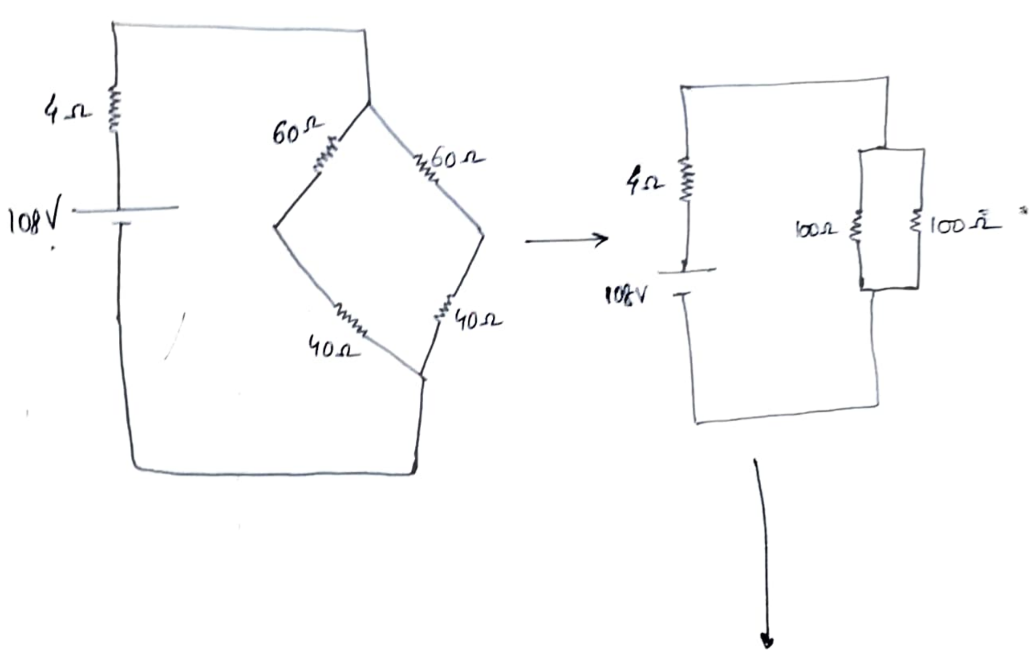
Method ③ (Not in syllabus)

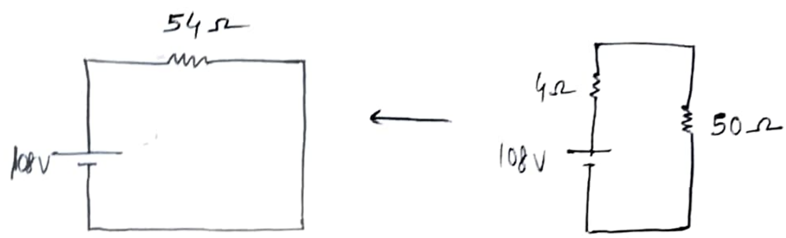


Applying Wheatstone Bridge

$$\frac{P}{Q} = \frac{R}{S}$$

middle one, 60Ω gets removed





$$i = \frac{V}{R} = \frac{108}{54}$$

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