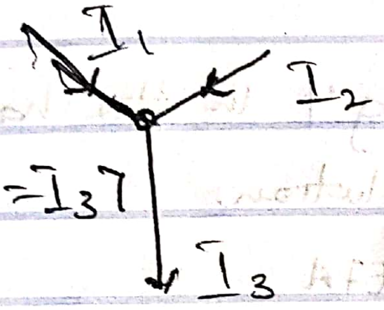
CIRCUIT

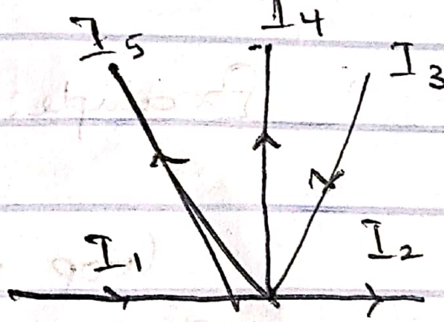
⇒ Limitations of ohm's law

⇒ Kirchoff's Laws < 1824 - 87 >

(i) First law



$< I_1 + I_2 = I_3 >$



$\Sigma I_{entering} = \Sigma I_{leaving}$

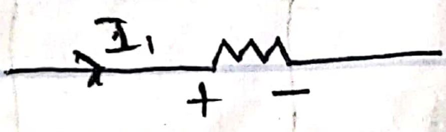
$I_1 + I_3 = I_2 + I_4 + I_5$

(ii) Second law < Mesh or Voltage law >

Potential voltage Rise $\Sigma E = \Sigma IR$ = Potential voltage drops.

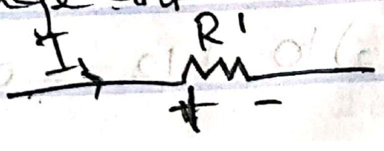
$\Sigma E - \Sigma IR = 0$

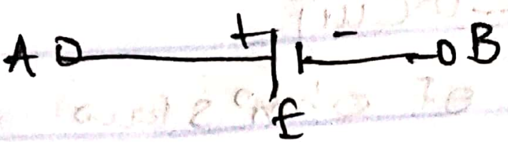
THE END OF A RESISTOR THROUGH WHICH CURRENT ENTERS, IS THEN POSITIVE, WITH RESPECT TO THE OTHER END



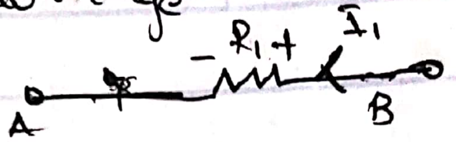
Rules Applied when tracing single circuit

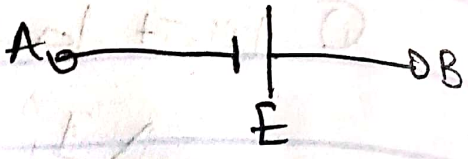
1) Voltage drop





Voltage Rise





Example: Fig 4 in the handout.

Solution.

Loop ABEFA

$-I_1 R_1 - I_3 R_3 + E_1 = 0$

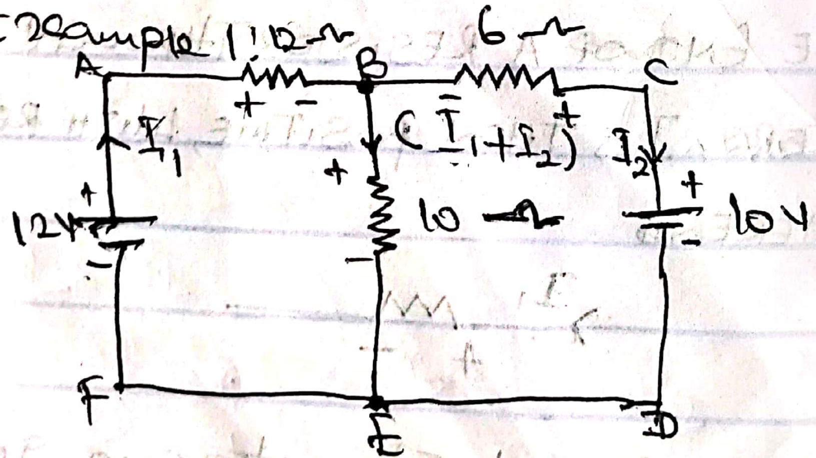
$E_1 = I_1 R_1 + I_3 R_3$ ---- (1)

Loop BCDEB

$I_2 R_2 - E_2 + I_3 R_3 = 0$

$E_2 = I_2 R_2 + I_3 R_3 = E_2$

Example 1



ABEFA loop

$-I_1 12 - (I_1 + I_2) 10 + 12 = 0$

$-I_1 12 - I_1 10 + I_2 10 + 12 = 0$

$-22I_1 + 10I_2 + 12 = 0$ --- (1) $\div$

$\cancel{-22}$ $11I_1 + 5I_2 - 6\cancel{1} = 0$ --- (6).

BCDEFD loop:

$6I_2 - 10\cancel{v} + 10(I_1 + I_2) = 0$

$6I_2 - 10\cancel{v} + 10I_1 + 10I_2 = 0$

$16I_2 - 10\cancel{v} + 10I_1 = 0$

$10I_1 + 16I_2 - 10 = 0$

$5I_1 + 8I_2 - 5 = 0$ --- (ii).

$11I_1 + 5I_2 - 6 = 0$ --- (1) $\times 5$

$5I_1 + 8I_2 - 5 = 0$ --- (2) $\times 11$

$\cancel{55}I_1 + 25I_2 - 30 = 0$

$\cancel{55}I_1 + 88I_2 - 55 = 0$

$-63I_2 + 25 = 0$

$\frac{-63I_2}{-63} = \frac{-25}{-63}$

$I_2 = 0.3974A$

Substituting I_2 into equation 1.

$11I_1 + 5(0.3974) - 6 = 0$

$11I_1 - 4.013 = 0$

$11I_1 = 4.013$

$$I_1 = \frac{4.013}{11} = 0.3648 \simeq 0.365\,A$$

Hence, Current through 12Ω resistor, $I_1 = 0.365A$

Current through 6Ω Resistor, $I_2 = 0.397A$

Current through 10Ω resistor, $I_1 + I_2 = 0.762A$

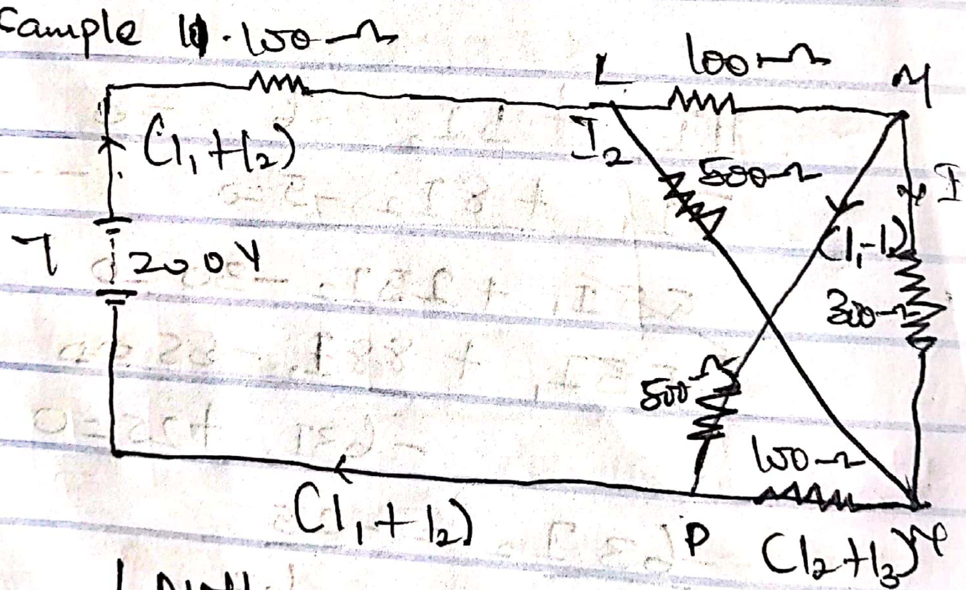
The voltage drop across;

12Ω resistor $= 0.365 \times 12 = 4.38V$

6Ω resistor $= 0.397 \times 6 = 2.38V$

10Ω resistor $= 0.762 \times 10 = 7.62V$

Example 10.



LMNL

$$-100I_1 - 300I_3 + 500I_2 = 0$$

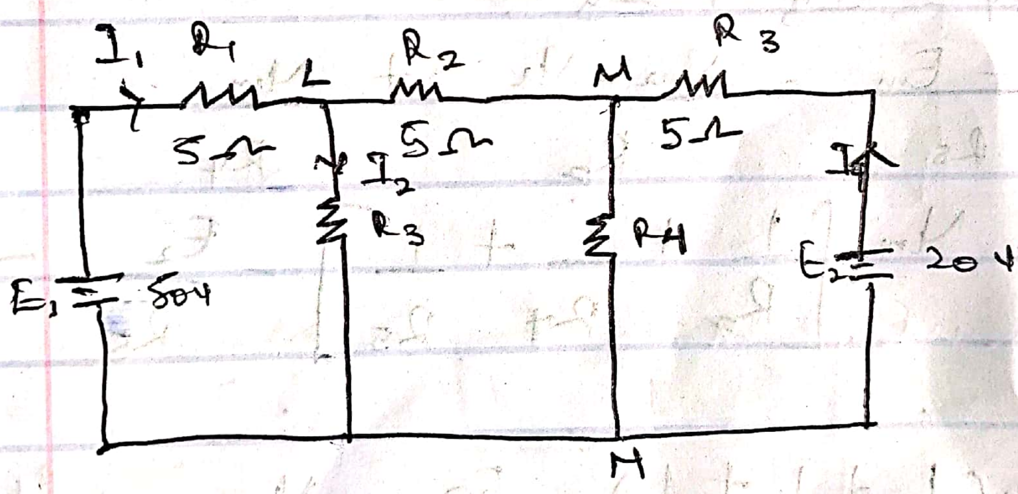
$$I_1 - 3I_3 + 5I_2 = 0$$

$$-I_1 + 5I_2 - 3I_3 = 0 \quad \text{--- (1)}$$

Loop MNPM & $-300I_3 - 100(I_2 + I_3) + 500(I_1 - I_3) = 0$

$$I_1 - 0.2I_2 - 1.8I_3 = 0$$

3/05/2023 Ndt Modal analysis.



No of equations $= n-1 = 3-1 = 2$

$I_1 = I_2 + I_3$

$I_1 = \frac{E_1 - V_L}{R_1}$

$I_2 = \frac{V_L}{R_3}$, $I_3 = \frac{V_L - V_M}{R_2}$

$$-\frac{E_1}{R_1}-\frac{V_L}{R_1}$$

$$\frac{E_1-V_L}{R_1}=\frac{V_L}{R_3}+\frac{V_L-V_m}{R_2}$$

$$\frac{E_1}{R_1}-\frac{V_L}{R_1}=\frac{V_L}{R_3}+\frac{V_L}{R_2}-\frac{V_m}{R_2}$$

$$\frac{V_L}{R_1}+\frac{V_L}{R_2}+\frac{V_L}{R_3}-\frac{E_1}{R_1}-\frac{V_m}{R_2}$$

$$\left[V_L\left(\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}\right)-\frac{E_1}{R_1}-\frac{V_m}{R_2}\right] \quad (1)$$

$$I_4=I_3+I_5$$

$$\frac{E_1-E_m}{R_5}=\frac{V_m-V_L}{R_2}+\frac{V_m}{R_4}$$

$$V_m\left[\frac{1}{R_2}+\frac{1}{R_4}+\frac{1}{R_5}\right]-\frac{E_2}{R_5}-\frac{V_L}{R_2}=0$$

$$V_L\left(\frac{1}{5}+\frac{1}{5}+\frac{1}{10}\right)-\frac{50}{3}-\frac{V_m}{5}=0 \quad \text{--- (1)}$$

$$V_m\left(\frac{1}{5}+\frac{1}{10}+\frac{1}{5}\right)-\frac{20}{3}-\frac{V_L}{5}=0 \quad \text{--- (2)}$$

Equation 1 $= 2.5V_L - V_m - 50 = 0$

Equation 2 $= 2.5V_m - V_L - 20 = 0$

$V_L = 27.60$

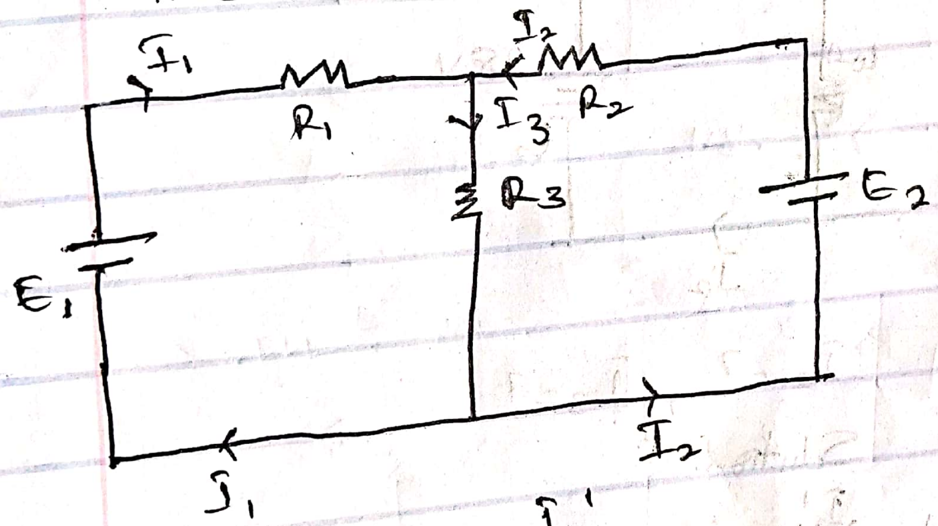
$V_m = 19.054$

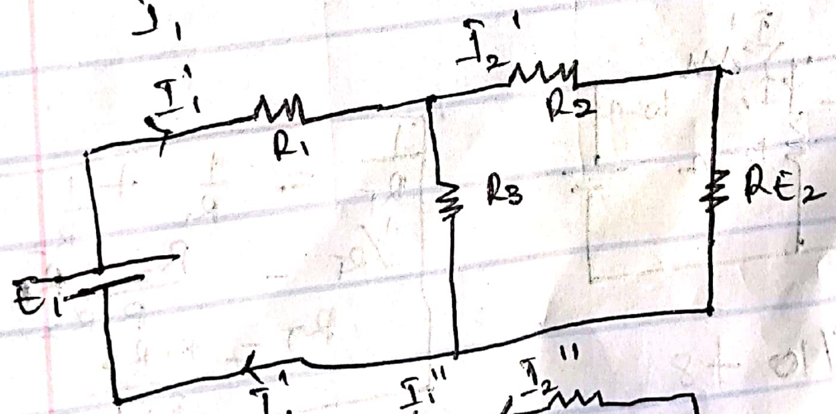
$I_2 = \frac{V_L}{10} = \frac{27.6}{10} = 2.76$ A

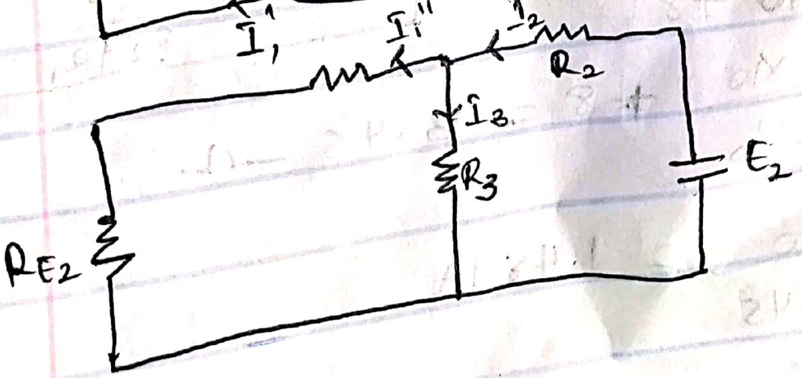
$I_5 = \frac{V_m}{10} = \frac{19.05}{10} = 1.905$ A

=> Superposition Theorem

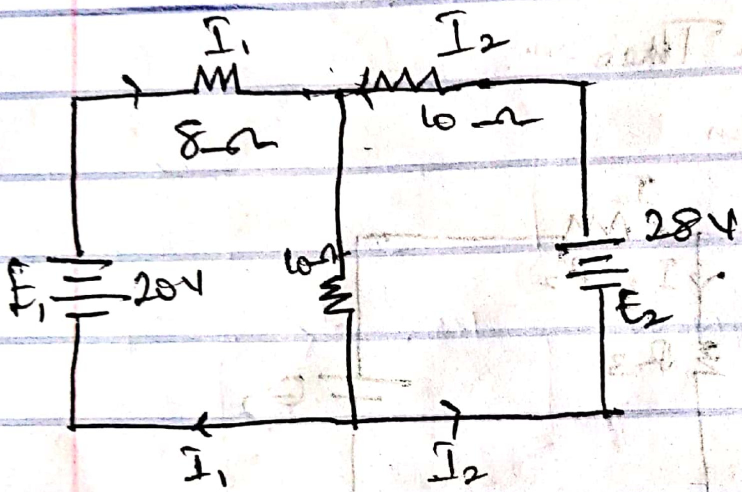
This theorem





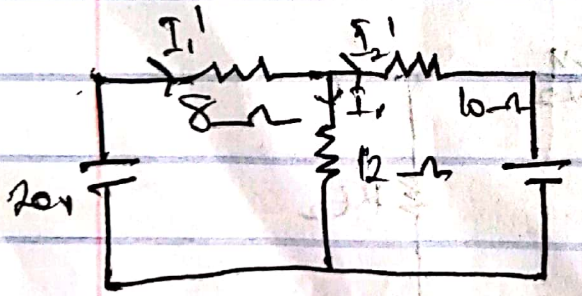


$$I_3 = I_3' + I_3''$$
$$I_1 = I_1' - I_1''$$
$$I_2 = I_2' + I_2''$$
$$I_2 = I_2'' - I_2'$$



$I_1 = ?$, $I_2 = ?$, $I_3 = ?$

Solution



$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$$
$$1/R_T = \frac{R_2 + R_1}{R_1 R_2}$$ → NOTE
$$R_T = \frac{R_1 R_2}{R_2 + R_1}$$

// means Parallel

$$R_T = 12 // 10 + 8$$
$$R_T = \frac{12 \times 10}{12 + 10} + 8 = 13.45\ \Omega$$

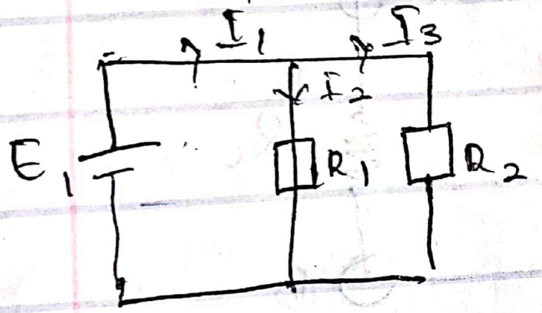
$$I_1' = \frac{20}{13.45} = 1.487A$$

$I_2' = 1.487 \times \frac{12}{10+12}$

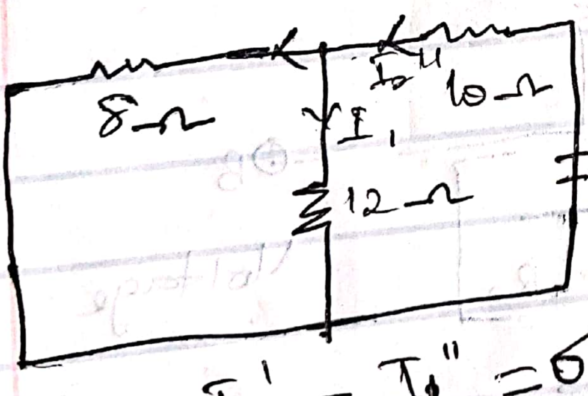
$= 0.81A$

$I_1' = 1.487 \times \frac{10}{10+12} = 0.675A$

CURRENT DIVIDER.



$I_2 = I_1 \frac{\times R_2}{R_1+R_2}$; $I_3 = I_1 \frac{\times R_1}{R_1+R_2}$



$R_T = 10 + 12/8 = 14.8\Omega$

$I_2'' = 28/14.8 = 1.892A$

$.284$ $I_1'' = 1.892 \times 12/12+8 = 1.135A$

$I_3'' = 1.892 \times (8/12+8) = 0.257A$

$1.487 - 1.135$

$= 0.352\ \Omega$ (L to M)

$I_1 = I_1' - I_1'' =$

$1.892 - 0.81 = 1.082A$ (M to N)

$I_2 = I_2'' - I_2' =$

$0.675 + 0.757 = 1.432A$ (M to Q)

$I_3 = I' + I''$

6/6/2023 Thevenin's

$$I = \frac{E_{th}}{R_{th} + R_L}$$

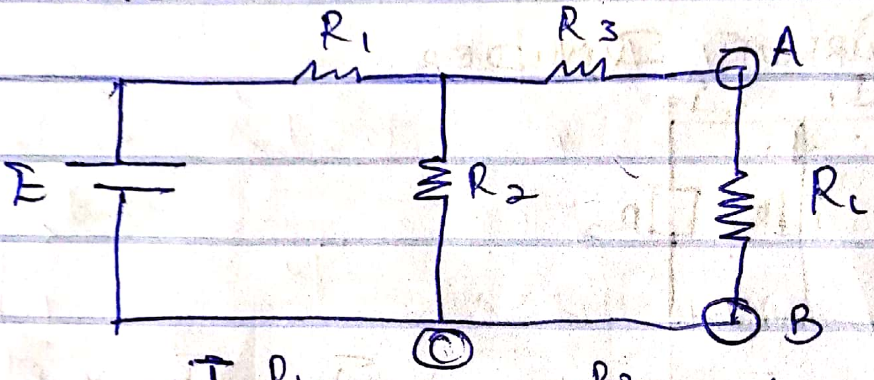
$E_{th} = V_{oc}$

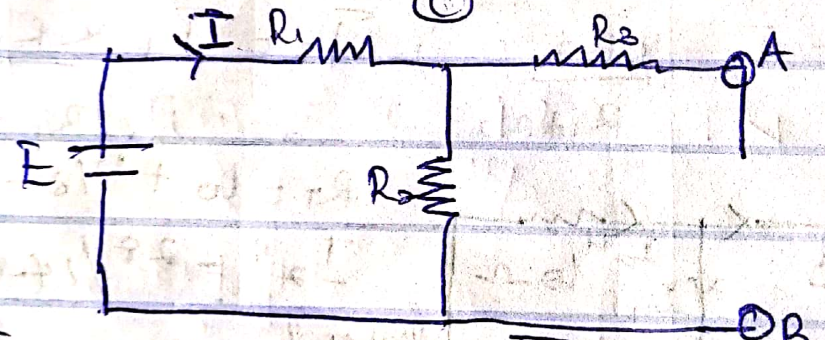
$$I = \frac{E}{R_1 + R_2}$$

$E_{th} = I \times R_2$

$$E_{th} = \frac{E}{R_1 + R_2} + R_2$$

R_{th} = Equivalent Resistance of the N/th





$$\boxed{E_{th} = E \times \frac{R_2}{R_1 + R_2}}$$

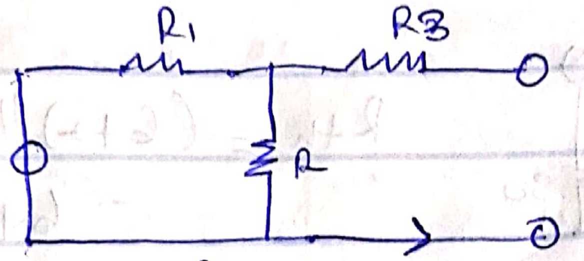
Voltage

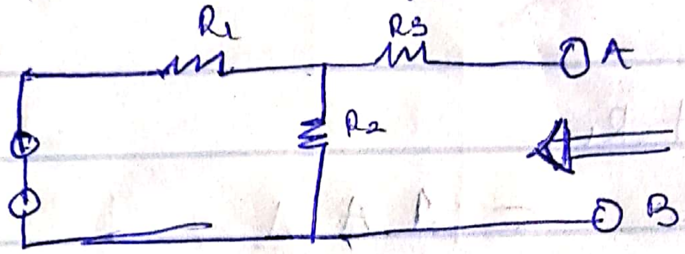
$$I = \frac{V}{R} = \frac{E}{R_1 + R_2}$$

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

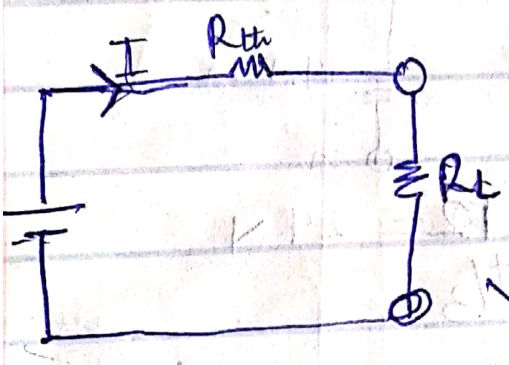
$E_{th} = I \times R_2 =$

$$E_{th} = \frac{E}{R_1 + R_2} \times R_2$$





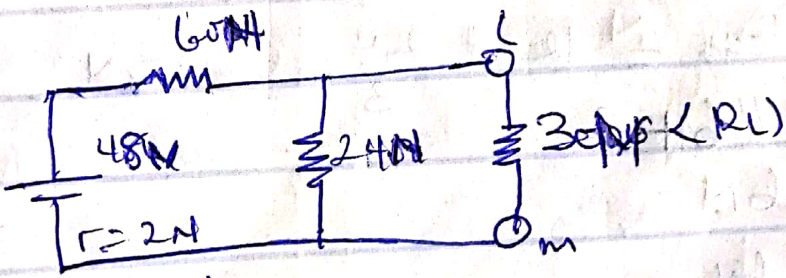
$$R_{th} = R_1 \,//\, R_2 + R_3 = \frac{R_1 R_2}{R_1 + R_2} + R_3$$

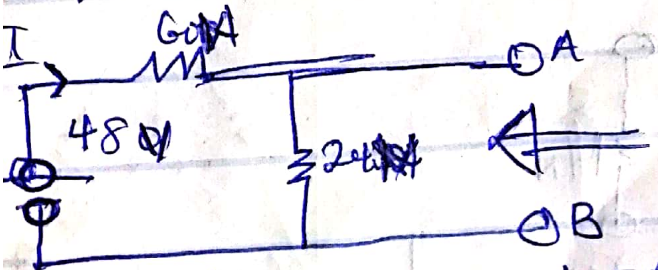


$$I = \frac{E_{th}}{R_1 + R_2}$$

$$V_{RL} = I \times R_L$$

$$= \frac{E_{th}}{R_{th} \times R_L} \times R_L$$

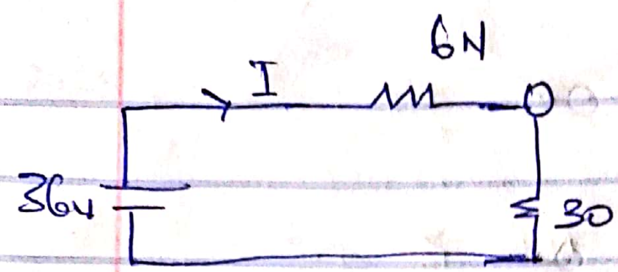




$$E_{th} = I' \times 24$$

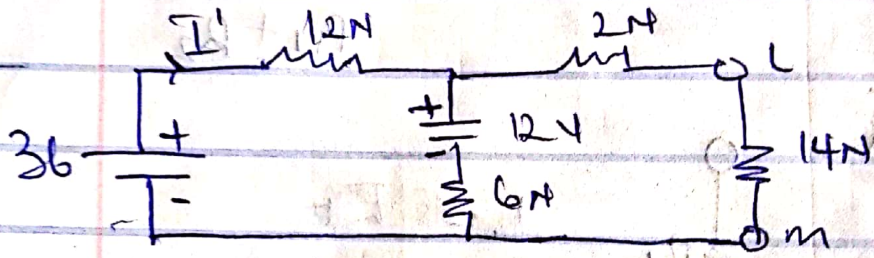
$$= 1.5 \times 24 = 36V$$

$$I' = \frac{48}{16+24+2} = 1.5A$$



$R_{th} = (6+2) \| 24$
$= 6\Omega$

$$I = \frac{E_{th}}{R_{th} + R_L}$$
$$= \frac{36}{6+30} = 1\ A$$



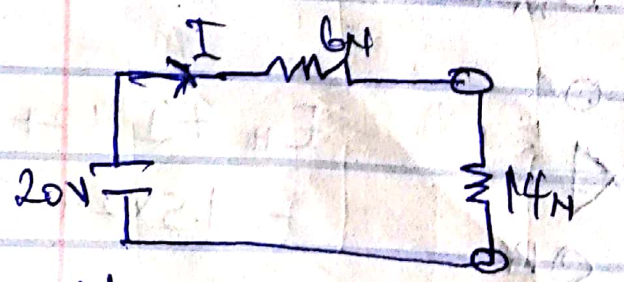
Total Emf $= 36 - 12 = 24\ V$

$$I' = \frac{24}{12+6} = 4/3$$

$V_{6\Omega} = I' \times 6 = 4/3 \times 6 = 24/3\ V$

$V_{oc} = E_{th} = 12 + \frac{24}{3} = 20\ V$

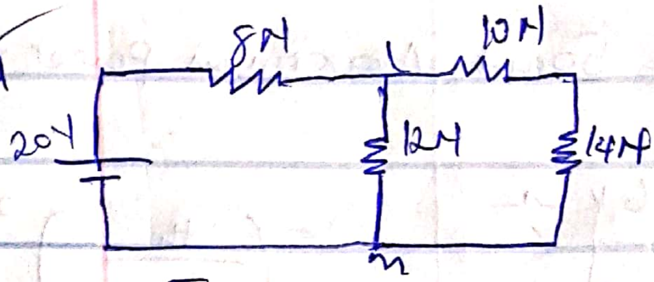
$R_{th} = 12 \| 6 + 2$
$= 6\Omega$

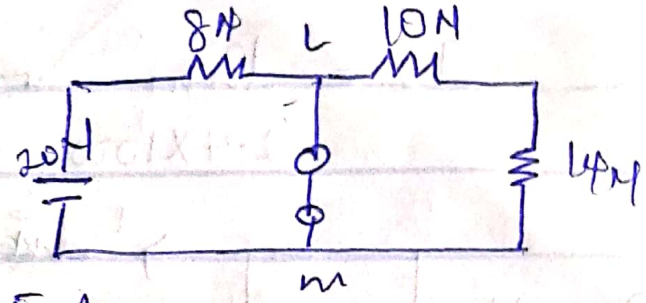


$$V_{14\Omega} = 20 \times \frac{14}{6+14}$$
$= 14\ V$

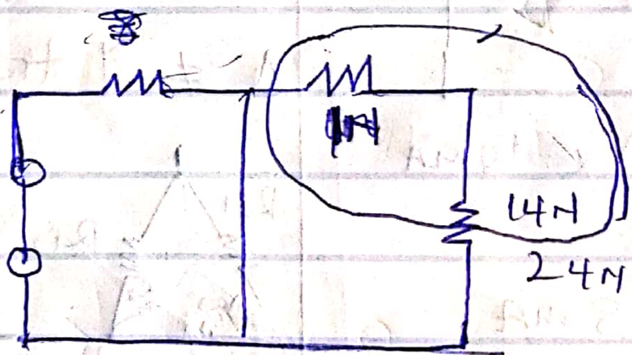
$$I = \frac{20}{6+14} = 1\ A$$

$\cancel{I_N}$

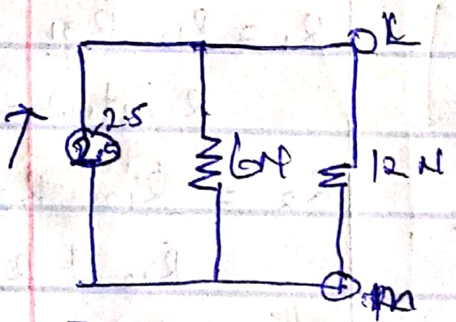




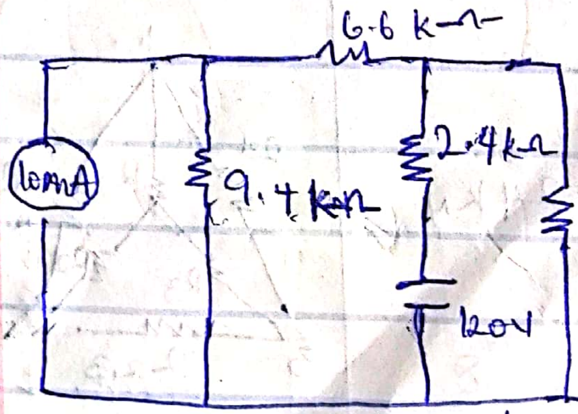
$$I_N = \frac{20}{8} = 2.5\,A$$



$$R_{th} = 8 \parallel 24 = 6\,\Omega$$



$$I_{12\Omega} = \frac{6}{6+12} \times 2.5 = 0.833\,A$$



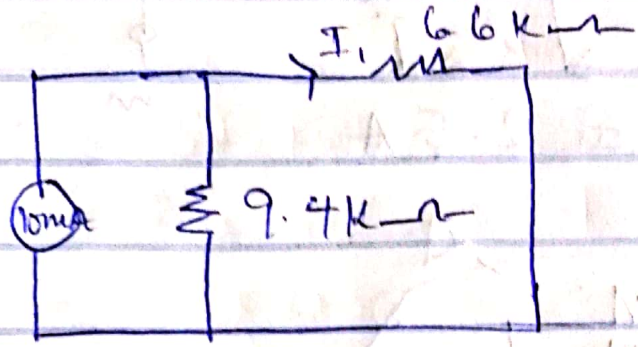
$$I_N = I_1 + I_2$$

$$I_N = 5.8\,mA + 50\,mA = 55.8\,mA$$

$$I_1 = \frac{9.4}{6.6+9.4} \times 10\,mA = 5.8\,mA$$

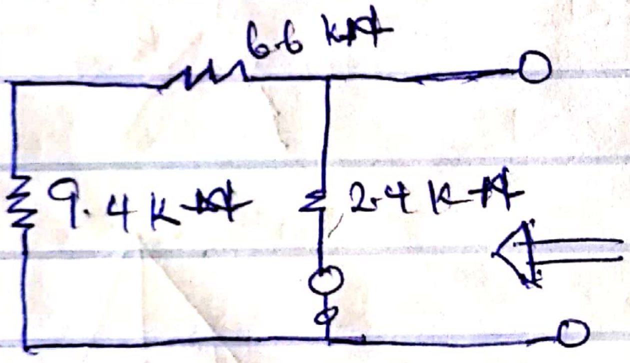
$$I_2 = \frac{120}{2.4 \times 1000} = 50\,mA$$

Back ward



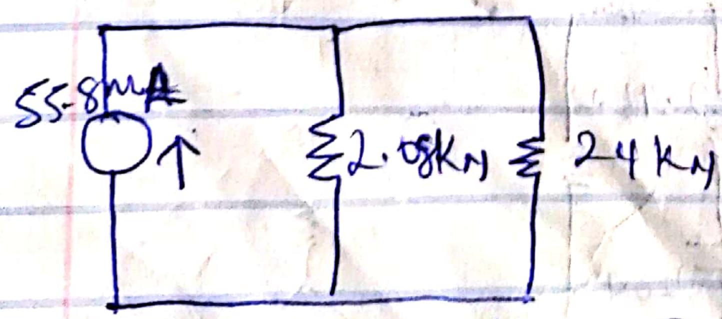
$$I_1 = \left(\frac{9.4}{66+9.4}\right) \times 10\,mA$$

$$= 5.8\,mA$$



$$R_{th} = 2.4 // (9.4 + 6.6)$$

$$= 2.084$$



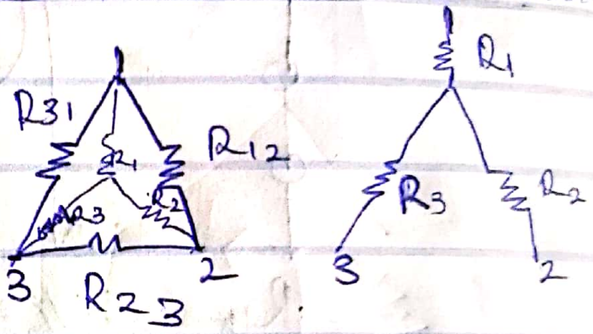
$$I_{24} = 55.8 \times \frac{2.08}{2.08 \times 24}$$

$$= 4.45A$$

$$\text{Maximum power} = \frac{E_{th}^2}{4R_L}$$

$$= \left(\frac{E_{th}}{R_L + R_L}\right)^2$$

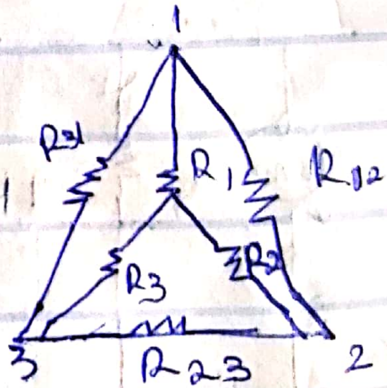
$\Delta \neq Y$ transformation



$$R_1 = \frac{R_{12}\,R_{31}}{R_{12} + R_{23} + R_{31}}$$

$$R_2 = \frac{R_{12}\,R_{23}}{R_{12} + R_{23} + R_{31}}$$

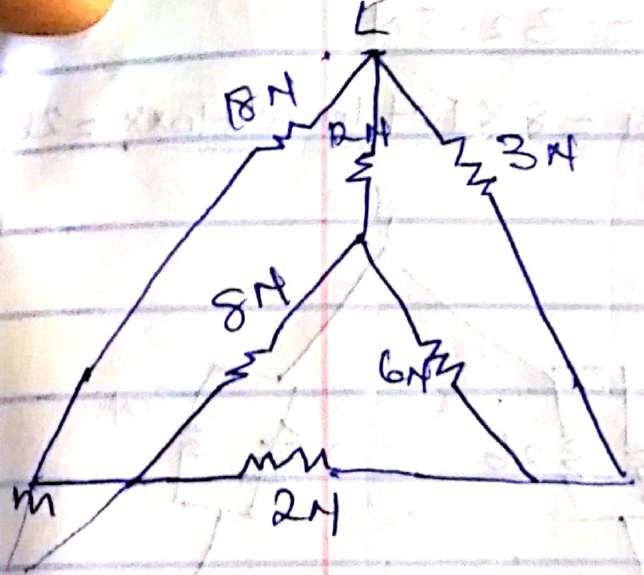
$$R_3 = \frac{R_{23}\,R_{31}}{R_{12} + R_{23} + R_{31}}$$



$$R_{12} = \frac{R_1 R_2 + R_2 R_3 + R_3 R_1}{R_3}$$

$$R_{23} = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_1}$$

$$R_{31} = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_2}$$



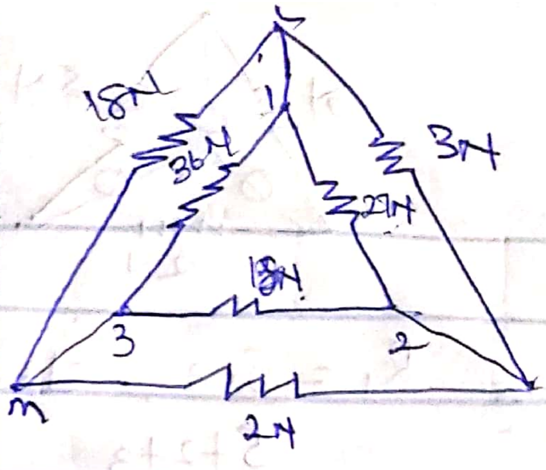
$$R_{12} = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_3}$$

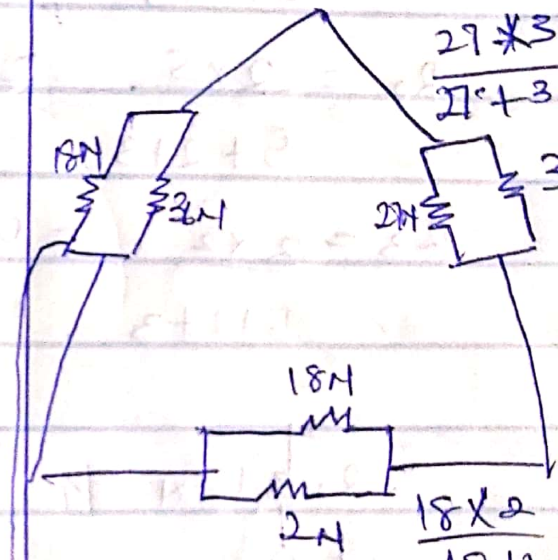
$$R_{12} = \frac{12\times6 + 6\times8 + 8\times12}{8} = 27\Omega.$$

$$R_{23} = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_1}$$

$$= \frac{12\times6 + 6\times8 + 8\times12}{12} = 18\Omega.$$

$$R_{31} = \frac{12\times6 + 6\times8 + 8\times12}{6} = 36\Omega$$

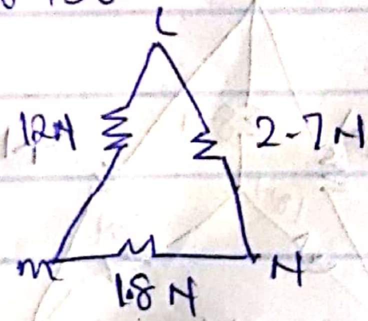




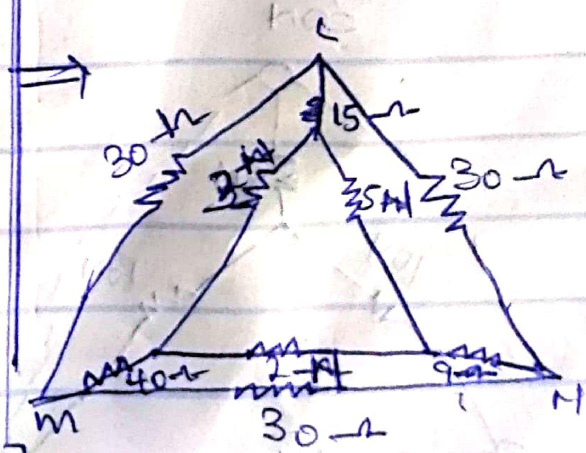
$$\frac{27\times3}{27+3} = 2.7$$

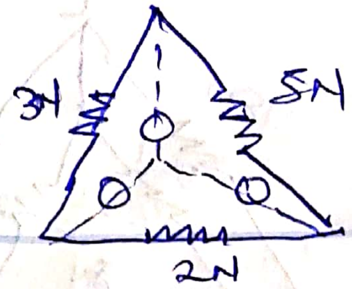
$$\frac{18\times2}{18+2} = 1.8$$

$$\frac{18\times36}{18+36} = 12\Omega$$



$\Longrightarrow$

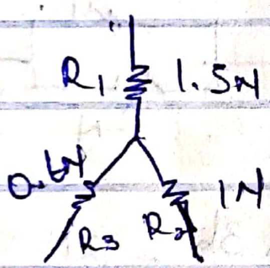


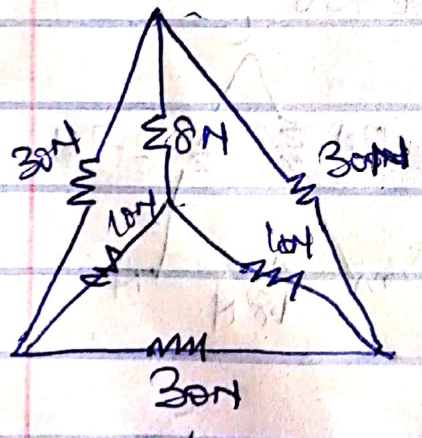


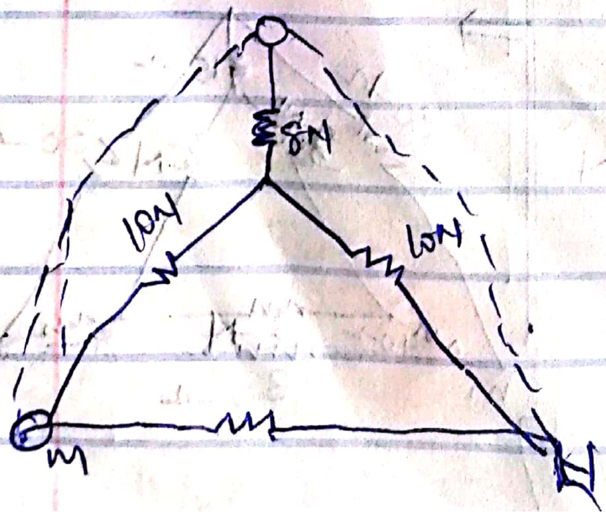
$$R_1 = \frac{5\times 3}{5+2+3} = 1.5\,\Omega$$

$$R_2 = \frac{2\times 5}{5+2+3} = 1\,\Omega$$

$$R_3 = \frac{3\times 2}{5+2+3} = 0.6\,\Omega.$$





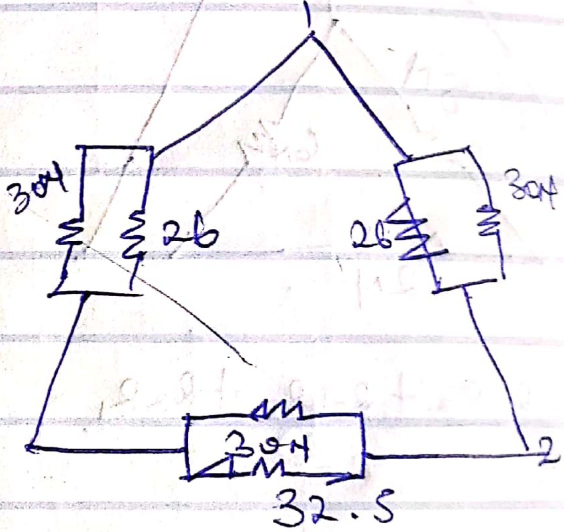


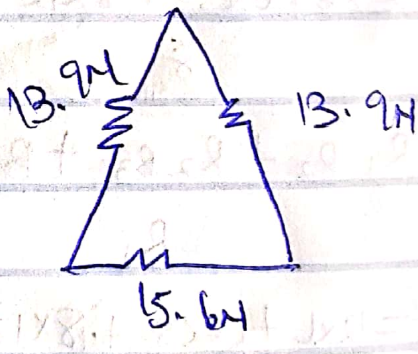
$$R_{12} = \frac{8\times 10 + 10\times 10 + 10\times 8}{10} = 26\,\Omega$$

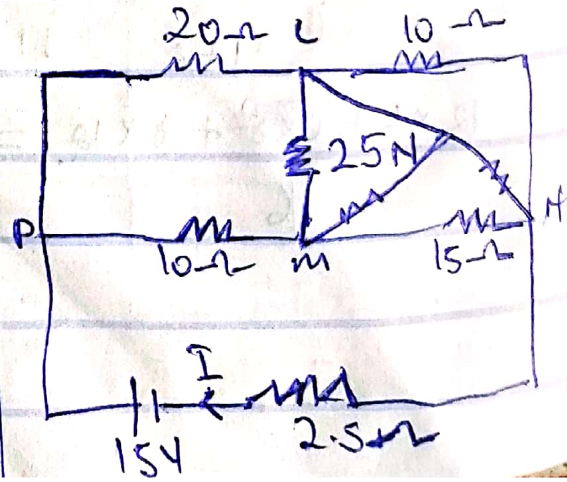
$$R_{23} = \frac{8\times 10 + 10\times 10 + 10\times 8}{8}$$

$$= 32.5\,\Omega$$

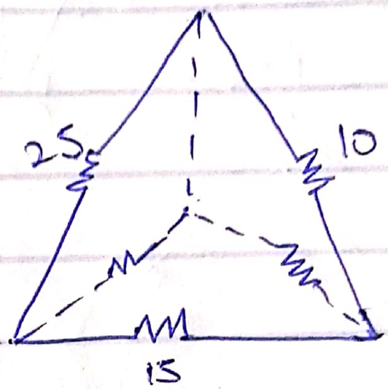
$$R_{31} = \frac{8\times 10 + 10\times 10 + 10\times 8}{10} = 26\,\Omega$$







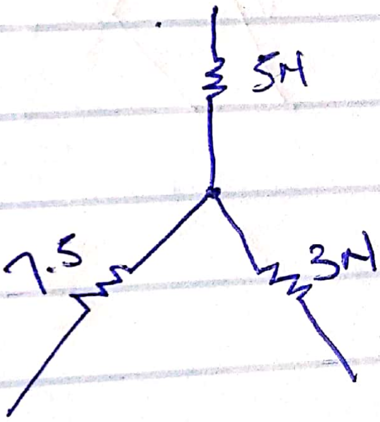
Find the current (I) supplied by the 15V battery using delta-star transformation.

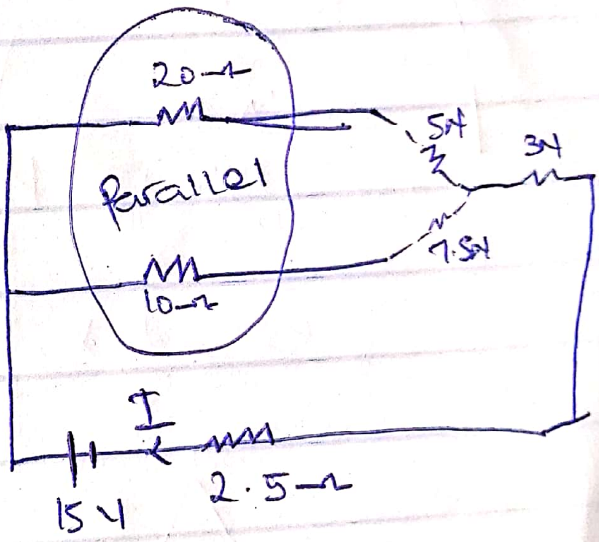


$$R_1 = \frac{10 \times 25}{10+15+25}$$

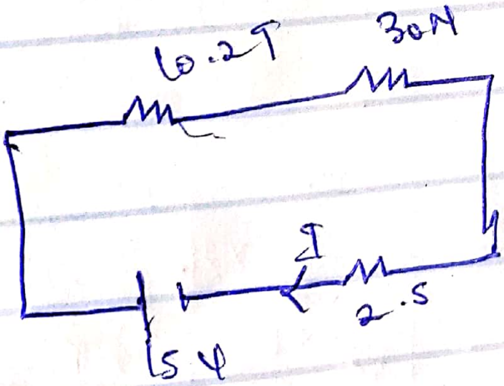
$$R_2 = \frac{15 \times 10}{10+15+25}$$

$$R_3 = \frac{25 \times 15}{10+15+25}$$





$25 // 17.5 = 10.29\,\Omega$



$$I = \frac{15}{15.79}$$

$= 0.95\,A$