Electric current

$$i = \frac{Q}{t} = \frac{dq}{dt}$$

$$q = 1.6 \times 10^{-19} C$$

Electric potential

$$F = \frac{dW}{dQ}$$

$$R = \frac{\rho l}{A}$$

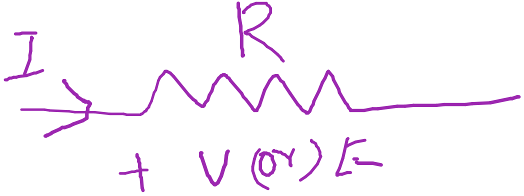
Ω

$A \quad m^2$

$$R = \Omega$$

$G = \frac{1}{R}$ Siemen ℧

$\sigma = \frac{1}{\rho}$ siemen/m



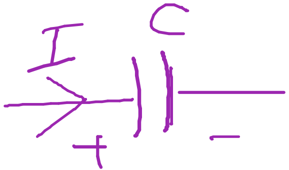
$V = IR$

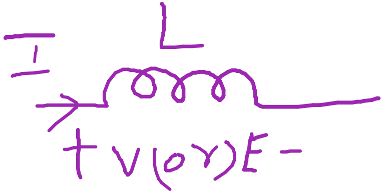
$P = VI = I^2 R = \frac{V^2}{R}$ watts

$$W = P\,dt = \int_0^t I^2 R\,dt = I^2 R t = V I t \ (J)$$

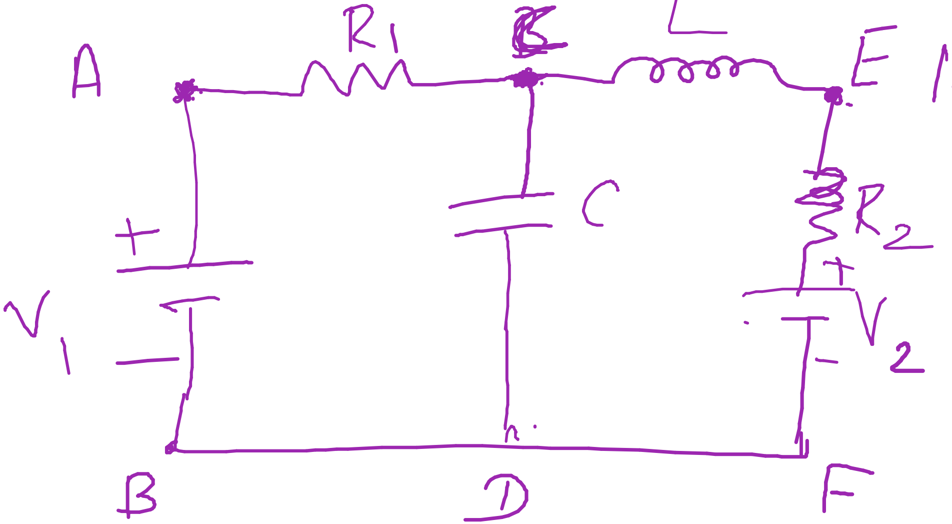
<u>capacitor</u> C (F)

L





H

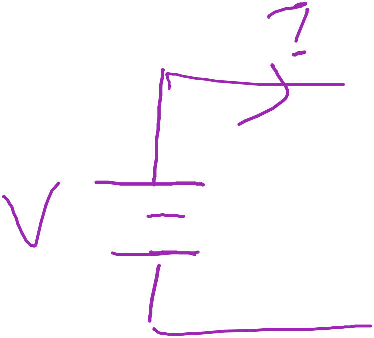


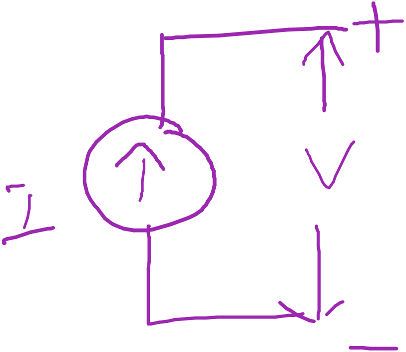
1. Active elements (voltage, I)
2. passive elements (R, L, C)

A-C, C-E, E-F, A-B, C-D . . .

Mesh (or) Loop.

ACDBA, CEFDC,



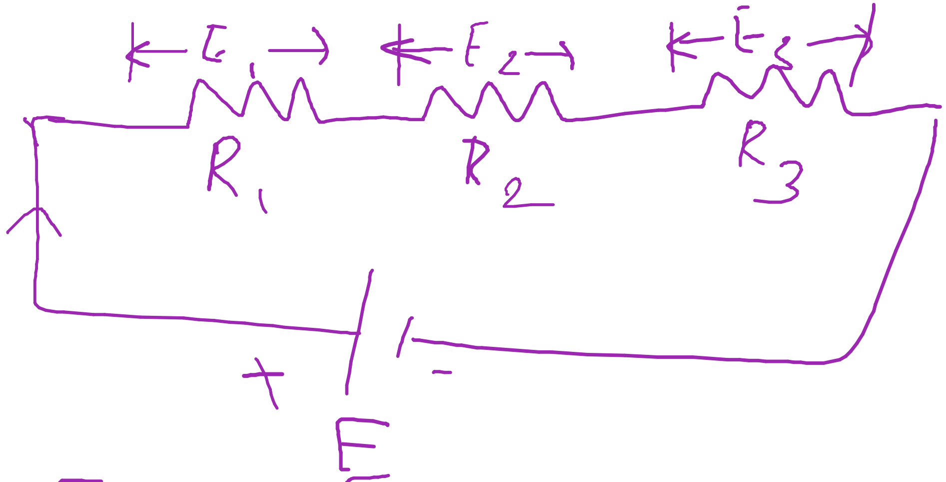


E (or) $V = IR$

$R \rightarrow \Omega$

$E \rightarrow V$

$I \rightarrow A$



$E = E_1 + E_2 + E_3$

$= I(R_1 + R_2 + R_3)$

$E_1 = IR_1$

$E_2 = IR_2$

$E_3 = IR_3$

$$P_1 = I^2 R_1 = \frac{E_1^2}{R_1}$$

$$P_2 = I^2 R_2 = \frac{E_2^2}{R_2}$$

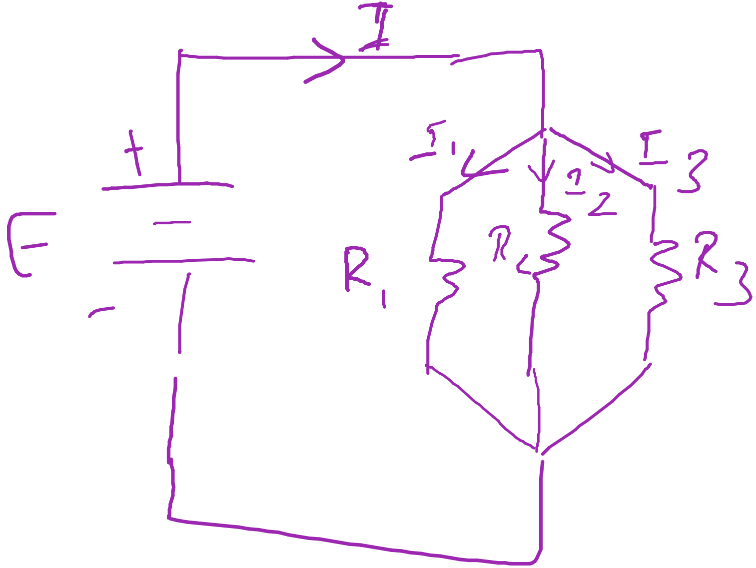
$$P_3 = I^2 R_3 = \frac{E_3^2}{R_3}$$

$$P = P_1 + P_2 + P_3$$

$$= I^2 (R_1 + R_2 + R_3)$$

$$= IE_1 + IE_2 + IE_3$$

$$= IE$$



$$I_1 = \frac{E}{R_1}$$

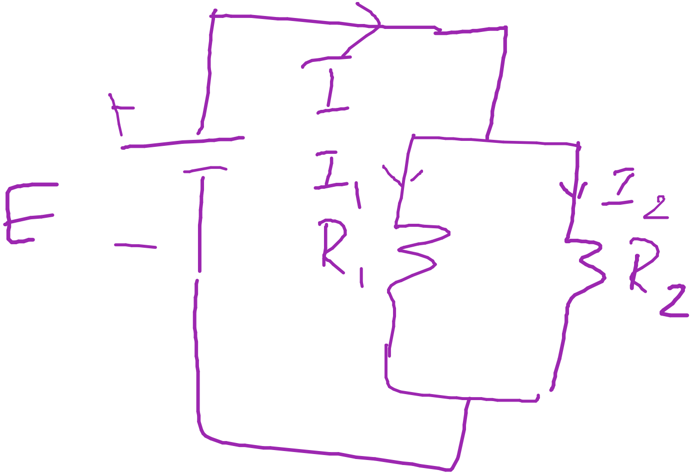
$$I_2 = E/R_2$$

$$I_3 = E/R_3$$

$$I = I_1 + I_2 + I_3$$

$$I = E\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right) = \frac{E}{R_{eff}}$$

$$\frac{1}{R_{eff}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$



$$I = I_1 + I_2$$

$$E = I_1 R_1 = I_2 R_2$$

$$I_1 R_1 = I_2 R_2$$

$$I_2 = \frac{I_1 R_1}{R_2}$$

$$I_1 = \frac{I_2 R_2}{R_1}$$

$$I = I_1 + \frac{I_1 R_1}{R_2}$$

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

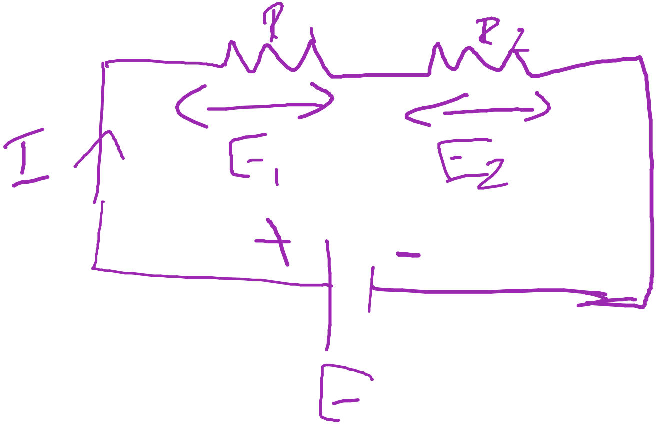
$$I_1 = \frac{I (R_2)}{R_1 + R_2}$$

$$I = I_1 + I_2$$

$$= \frac{I_2 R_2}{R_1} + I_2$$

$$= \frac{I_2 R_2 + I_2 R_1}{R_1} = \frac{I_2 (R_1 + R_2)}{R_1}$$

$$I_2 = I\left(\frac{R_1}{R_1 + R_2}\right)$$



$$E_1 = IR_1 \quad (1)$$

$$E_2 = IR_2 \quad (2)$$

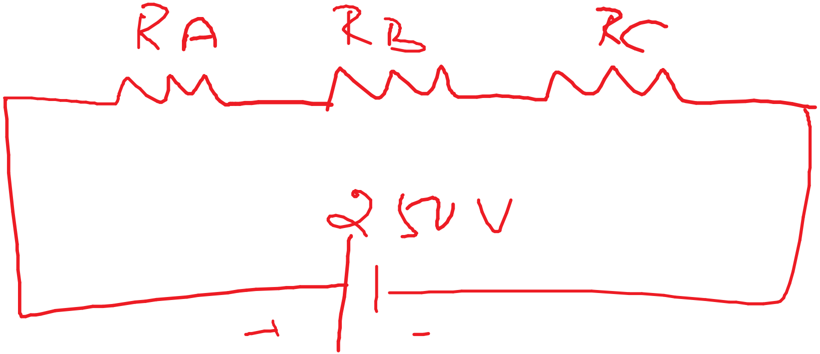
$$E = E_1 + E_2$$

$$E = IR_1 + IR_2$$

$$= I(R_1 + R_2)$$

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

$$E_1 = \frac{E}{R_1 + R_2} R_1 \qquad E_2 = \frac{ER_2}{R_1 + R_2}$$



$R_C = 50\,\Omega$

$E_B = 80V$

$I = 2A$

$R_A + R_B$?

$I R_B = 80$

$R_B = 80/2 = 40\,\Omega$

$$E = I(R_A + R_B + R_C)$$

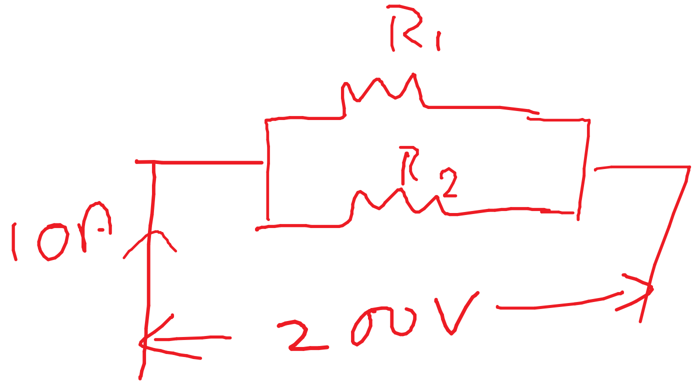
$$250V = 2(R_A + 40 + \overset{50}{\cancel{R_C}})$$

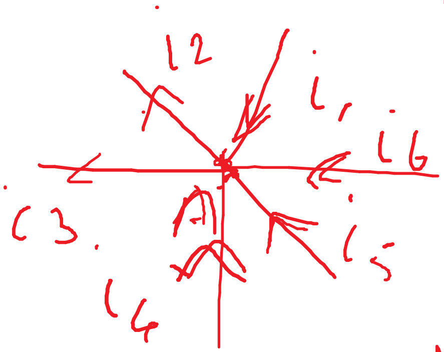
$$R_A + 40 + 50 = \frac{250}{2}$$

$$R_A = 35\,\Omega$$

200V

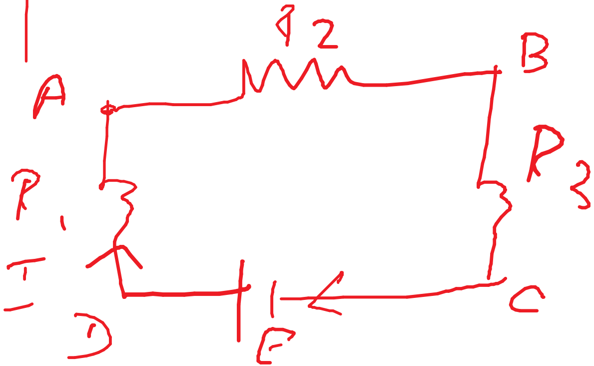
$P_1 = 800W$





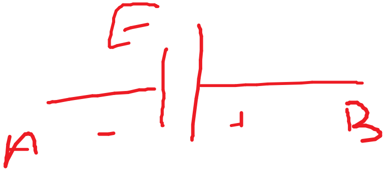
$$i_1 + i_6 + i_5 + i_4 = i_2 + i_3$$

$$i_1 - i_2 + i_3 + i_4 + i_5 + i_6 = 0$$

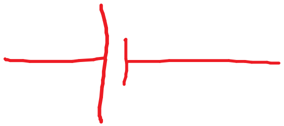


$$E = IR_1 + IR_2 + IR_3$$

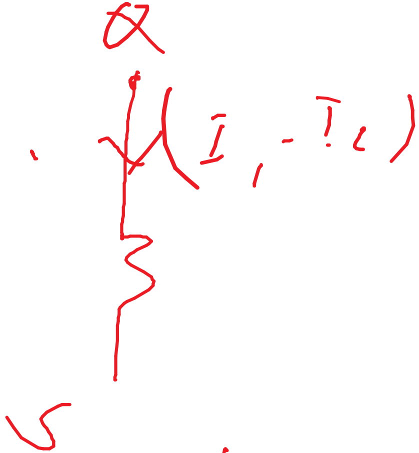
$$= I(R_1 + R_2 + R_3)$$

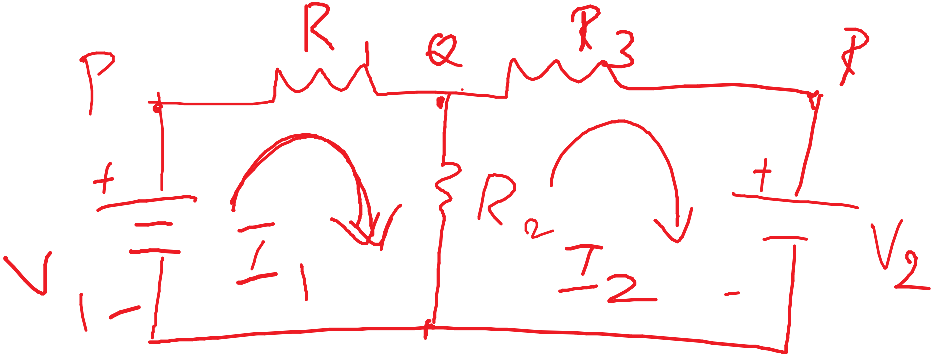


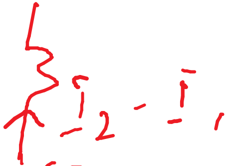
$+E$



$-E$

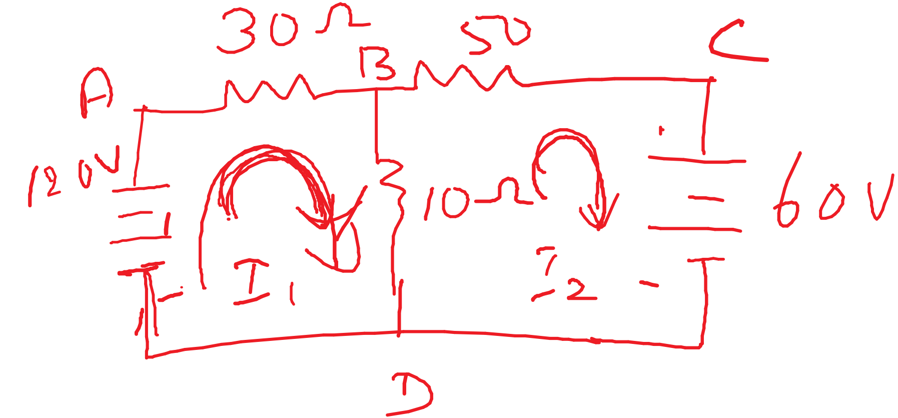






$$V_1 = I_1 R_1 + (I_1 - I_2) R_2$$

$$-V_2 = I_2 R_3 + (I_2 - I_1) R_2$$



For loop ABDA

$120V = 30I_1 + 10(I_1 - I_2)$

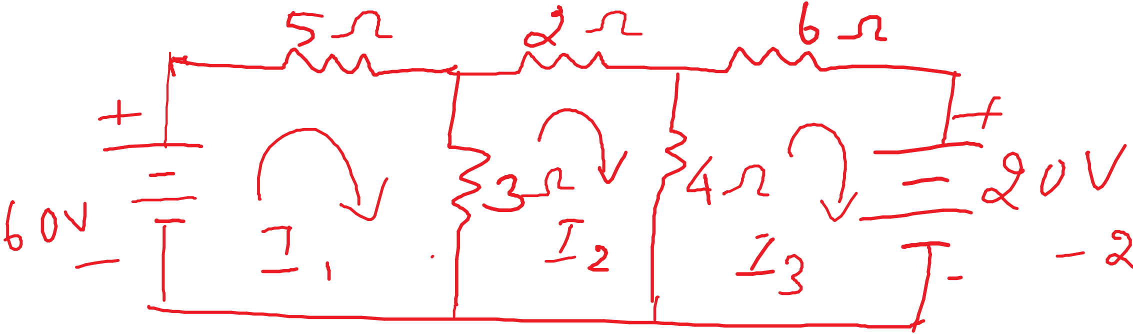
$120 = 40I_1 - 10I_2$ — (1)

$-60 = 10I_2 - 10I_1 + 50I_2$

$-60 = -10I_1 + 60I_2$ — (2)

$I_1 = 2.86$

$I_2 = -0.52$



$$-20 = -4I_3 - 4I_2 + 6I_3$$

$$-20 = -4I_2 + 10I_3 \quad — (3)$$

In loop (1)

$$60 = 5I_1 + 3(I_1 - I_2)$$

$$60 = 8I_1 - 3I_2 \quad — (1)$$

(2)

$$0 = 3I_2 - 3I_1 + 2I_2 + 4I_2 - 4I_3$$

$$0 = -3I_1 + 9I_2 - 4I_3 \quad — (2)$$

$$\begin{bmatrix} 8 & -3 & 0 \\ -3 & 9 & -4 \\ 0 & -4 & 10 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} 60 \\ 0 \\ -20 \end{bmatrix}$$

$$I_1 = \frac{\Delta_1}{\Delta}, \quad I_2 = \frac{\Delta_2}{\Delta}, \quad I_3 = \frac{\Delta_3}{\Delta}$$

$$\Delta = |R|$$

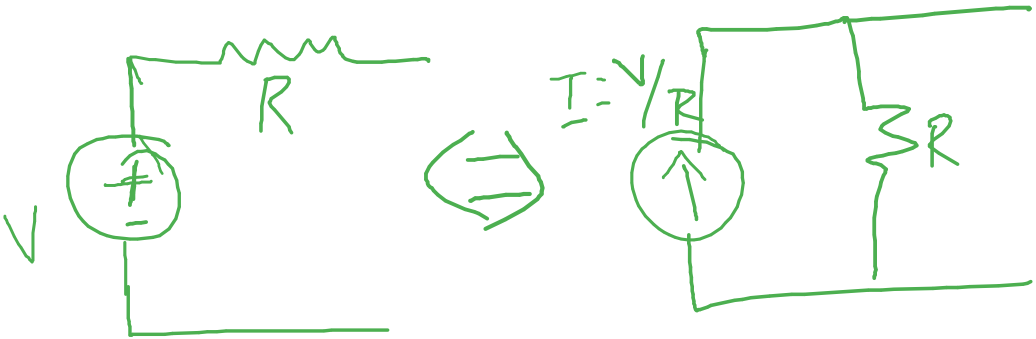
$$\Delta_1 = \begin{vmatrix} 60 & -3 & 0 \\ 0 & 9 & -4 \\ -20 & -4 & 10 \end{vmatrix}$$

$$\Delta_2 = \begin{vmatrix} 8 & 60 & 0 \\ -3 & 0 & -4 \\ 0 & -20 & 10 \end{vmatrix}$$

$$\Delta_3 = \begin{vmatrix} 8 & -3 & 60 \\ -3 & 9 & 0 \\ 0 & -4 & -20 \end{vmatrix}$$

Nodal method.

source transformation -

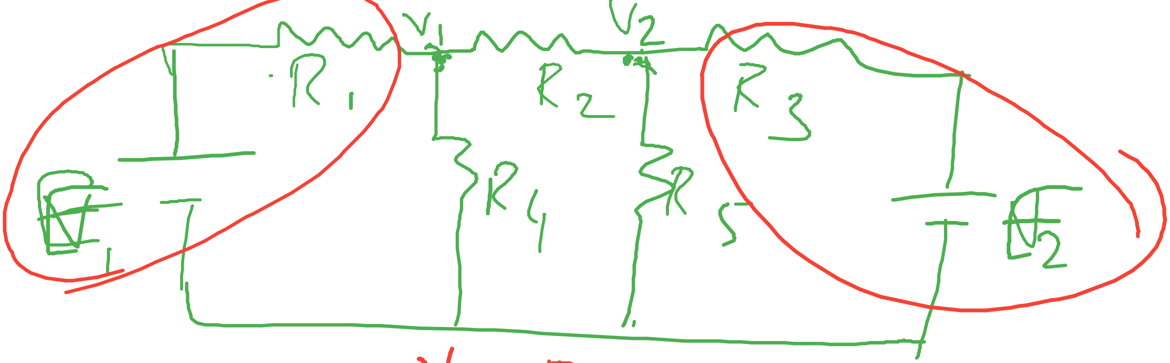


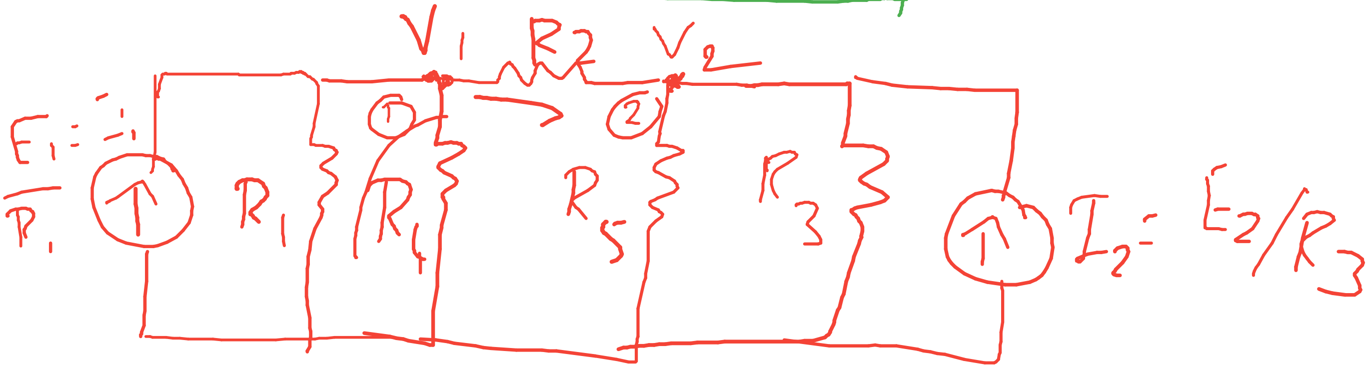
G_{11}

$G_{12} = -ve$ sign

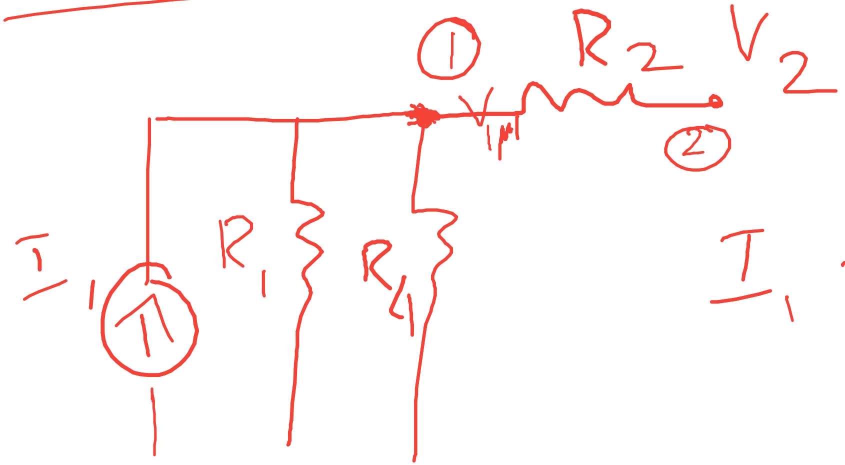
$G_{12} = G_{21}$

1


V1
V2
R1
R2
R3
R4
R5
E1
E2

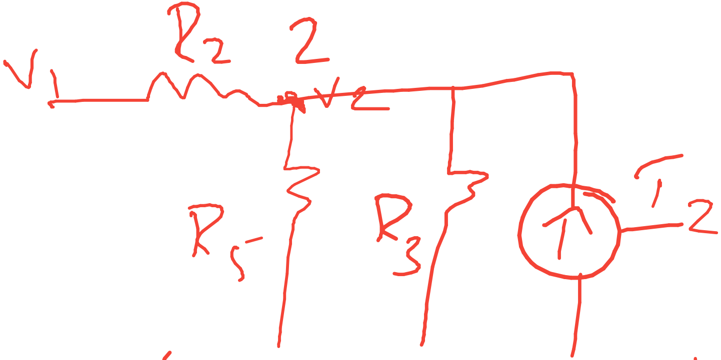

V1
R2
V2
1
2
E1/R1
R1
R4
R5
R3
I2 = E2/R3

At node 1



$$I_1 = \frac{V_1}{R_1} + \frac{V_1}{R_4} + \frac{V_1 - V_2}{R_2}$$

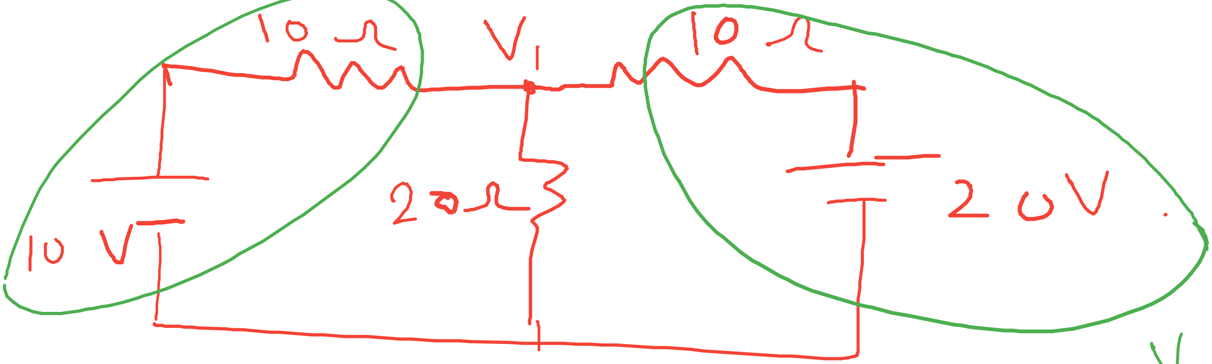
$$I_1 = V_1\left[\frac{1}{R_1} + \frac{1}{R_4} + \frac{1}{R_2}\right] - V_2\left[1/R_2\right]$$

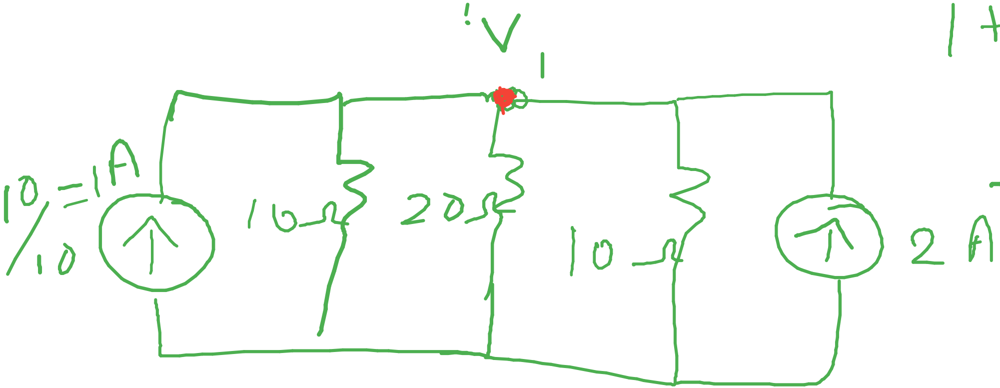


$$I_2 = \frac{V_2}{R_3} + \frac{V_2}{R_5} + \frac{V_2 - V_1}{R_2}$$

$$= V_1\left[-\frac{1}{R_2}\right] + V_2\left[\frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_5}\right]$$

$$\begin{array}{c} G_{11} \qquad\qquad\qquad G_{12} \\ \begin{bmatrix} \frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_4} & -\frac{1}{R_2} \\ -\frac{1}{R_2} & \frac{1}{R_2}+\frac{1}{R_3}+\frac{1}{R_5} \end{bmatrix} \\ G_{21} \qquad\qquad\qquad G_{22} \end{array} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

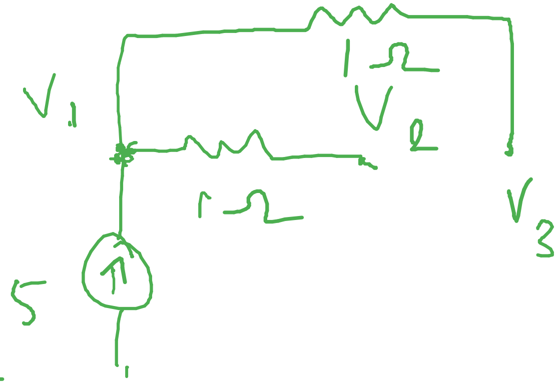




$$1 + 2 = \frac{V_1}{10} + \frac{V_1}{20} + \frac{V_1}{10}$$

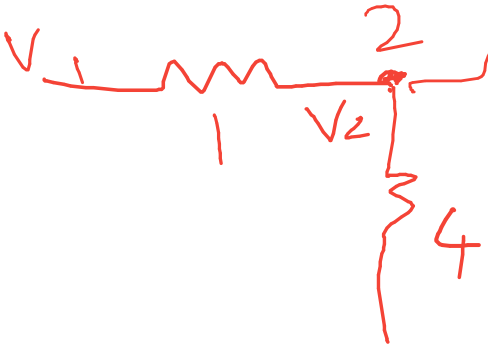
$$V_1 = 12V$$

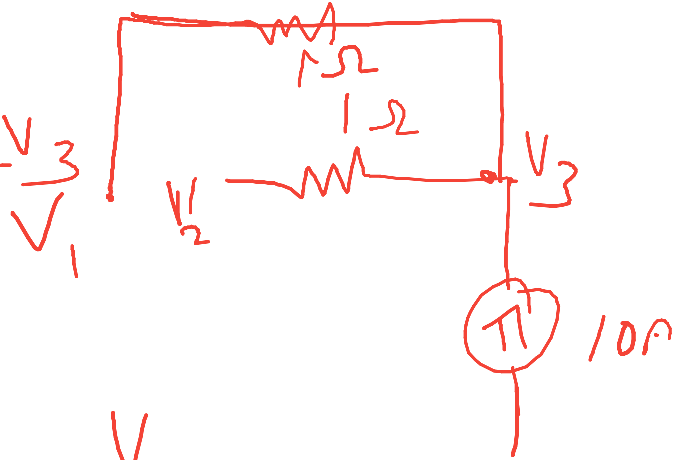
$$\underline{I_{20}} = \frac{12}{20} = 0.6A$$



$$5 = \frac{V_1 - V_2}{1} + \frac{V_1 - V_3}{1}$$

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

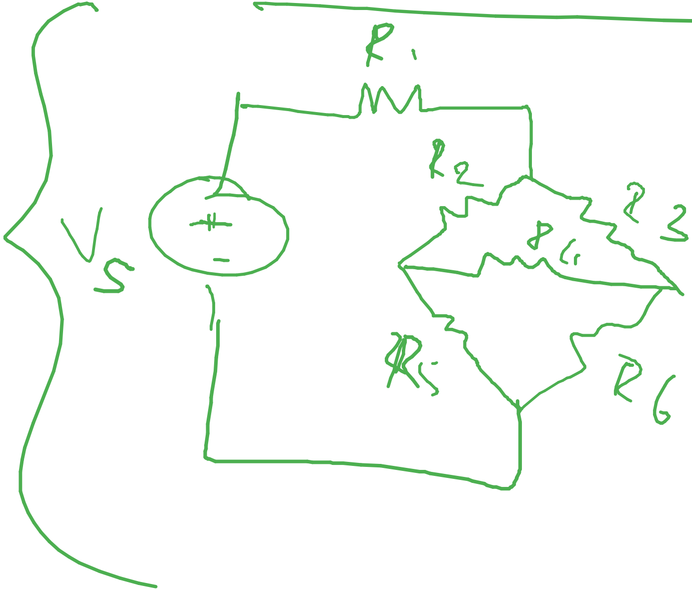




$$0 = \frac{V_2 - V_1}{1} + \frac{V_2 - V_3}{1} + \frac{V_2}{4}$$

$$10 = \frac{V_3 - V_2}{1} + \frac{V_3 - V_1}{1}$$

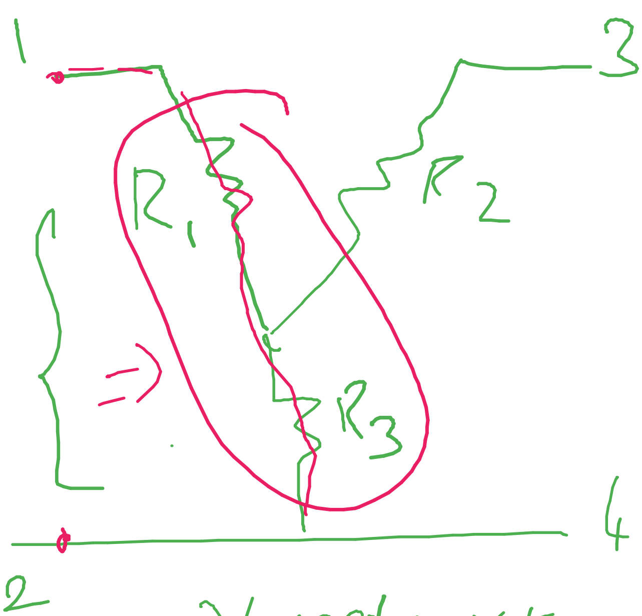
star - delta transformation.



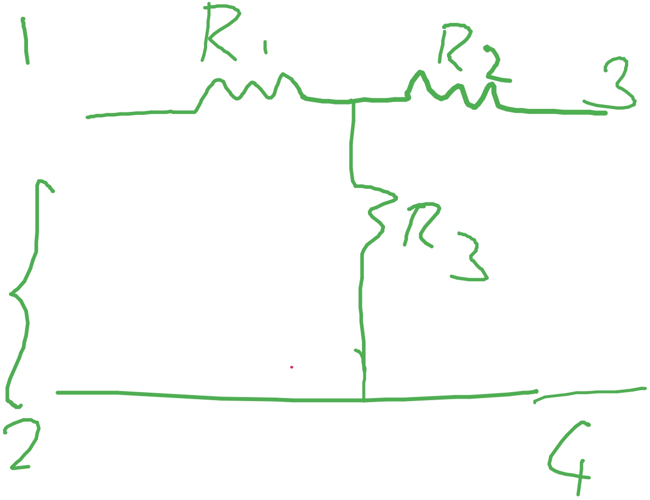
Y (wye), tee

star

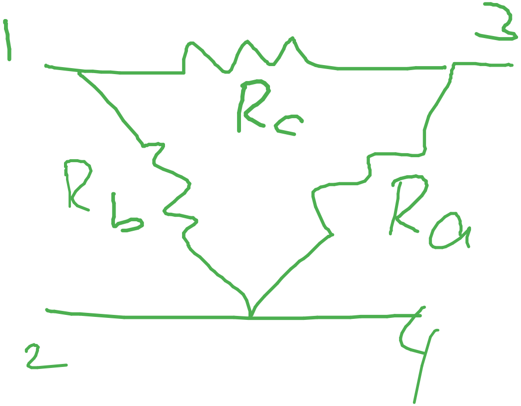
delta Δ con π network



Y network

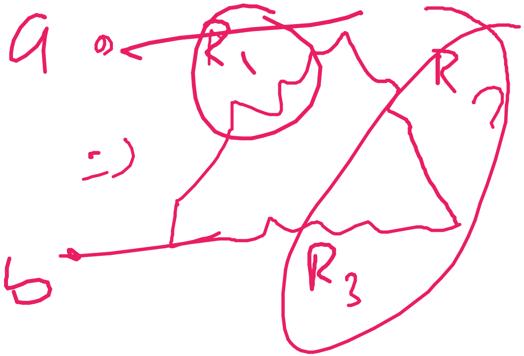


T network.

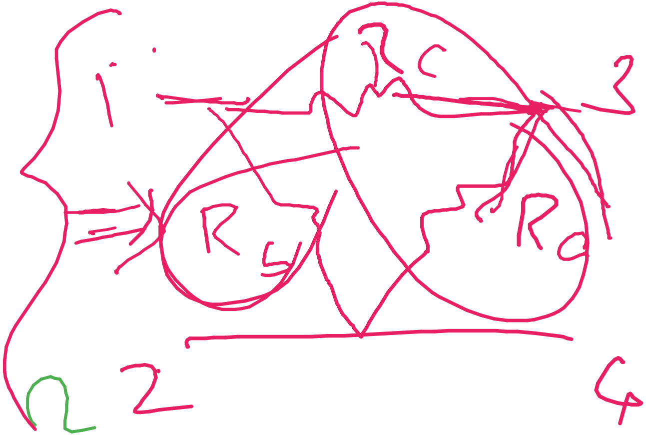


Δ network

Π-network



Delta & star.



$R_{12}(Y) = R_1 + R_3$

$R_{12}(\Delta) : R_b \,||\, (R_a + R_c)$

Δ

$R_{12}(Y) : R_1 + R_3 \qquad R_{12} = (R_c + R_a) \| R_b$

$R_{13}(Y) = R_1 + R_2 \qquad R_{13} = (R_b + R_a) \| R_c$

$R_{34}(Y) : R_2 + R_3 \Rightarrow R_{34} = (R_b + R_c) \| R_a$

$$R_{12} = R_1 + R_3 = R_b \| (R_a + R_c) \quad (1)$$

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

$$\begin{cases} R_1 = \dfrac{R_b R_c}{R_a + R_b + R_c} \\[2ex] R_2 = \dfrac{R_c R_a}{R_a + R_b + R_c} \\[2ex] R_3 = \dfrac{R_a R_b}{R_a + R_b + R_c} \end{cases}$$

R_a, R_b, R_c cintams

$R_1 R_2 R_3$.

$$\frac{R_1R_2 + R_2R_3 + R_3R_1}{R} = \frac{R_aR_bR_c}{R_a + R_b + R_c} \quad \text{--- (2)}$$

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

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

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

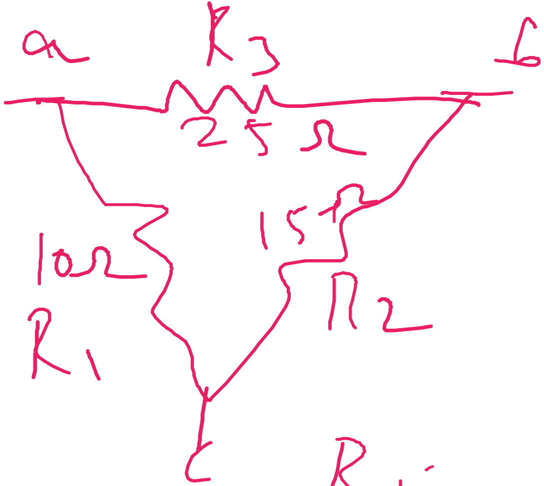
$$R_1 = R_2 = R_3 = R_Y$$

$$R_a = R_b = R_c = R_\Delta$$

$$R_Y = \frac{R_\Delta}{3}$$

$$R_\Delta = 3R_Y$$

$$R_a = \frac{3\cancel{R_1}}{\cancel{R_1}}$$



$R_1 = 5\,\Omega$

$R_3 = 7.5\,\Omega$

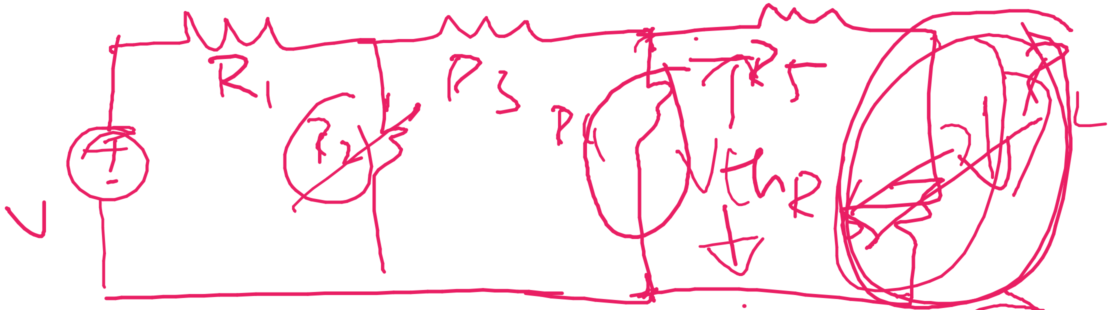
$R_3 = 3\,\Omega$

$R_1 =$

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

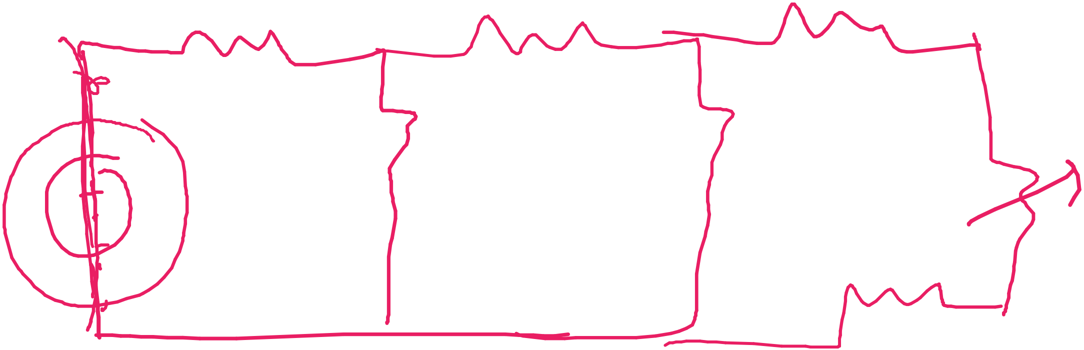
$V_{th} \rightarrow$ Thevonin voltage

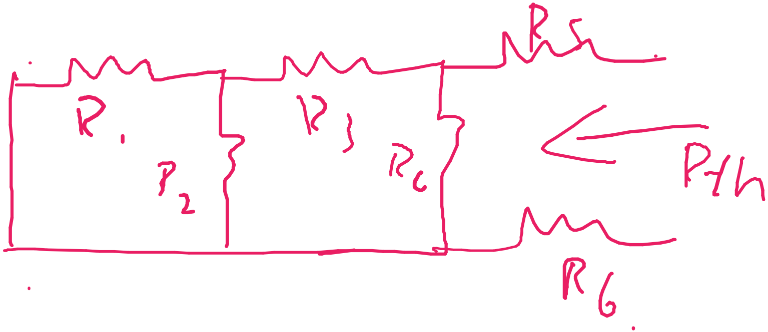
$R_{th} \rightarrow$ ~~Th~~ Thevonin Resistance

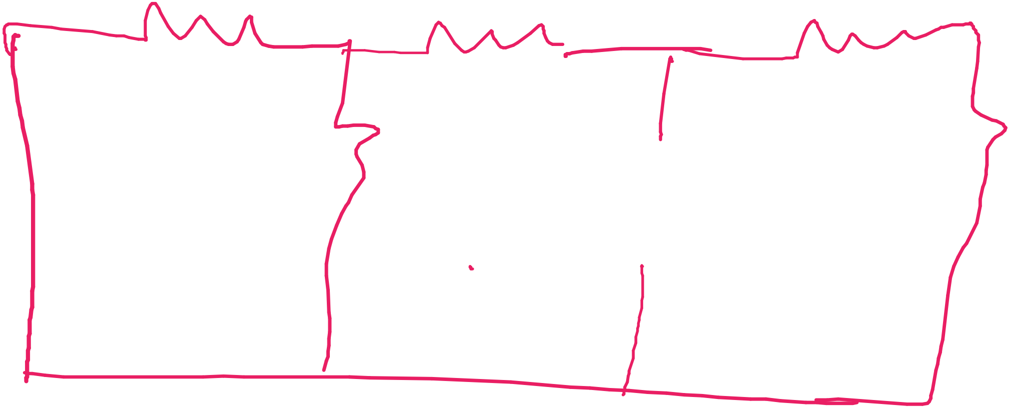


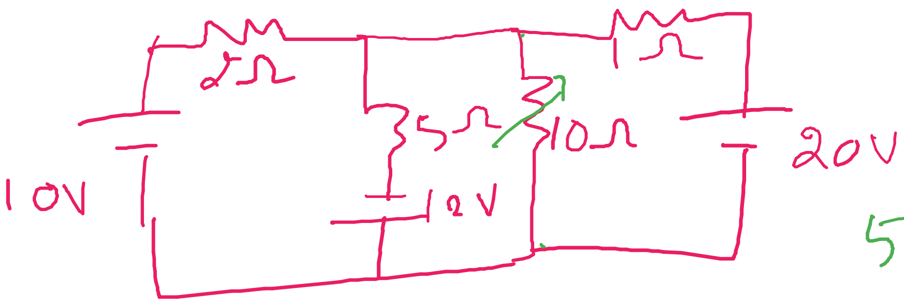
$$i_L = \frac{V_{th}}{R_{th} + R_L}$$

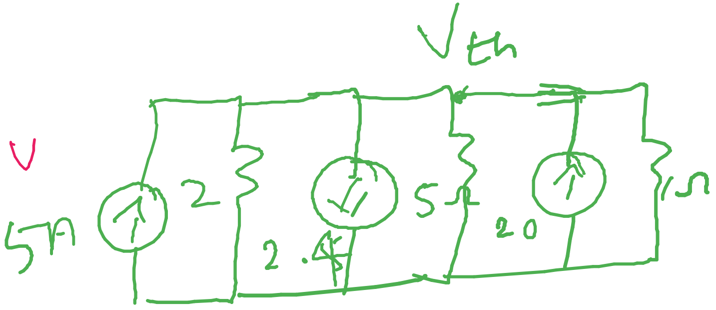
V_{th} (or) V_{oc}.



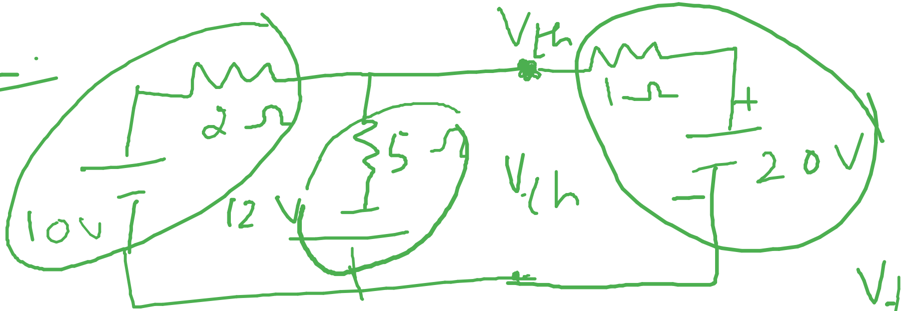

R1
R2
R3
R4
R5
R6
Rth





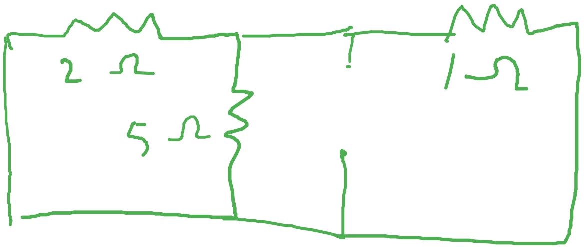


Vth



$$5 - 2.4 + 20 = V_{th}\left[\frac{1}{2} + \frac{1}{5} + \frac{1}{1}\right]$$

$$V_{th} = 13.29V.$$

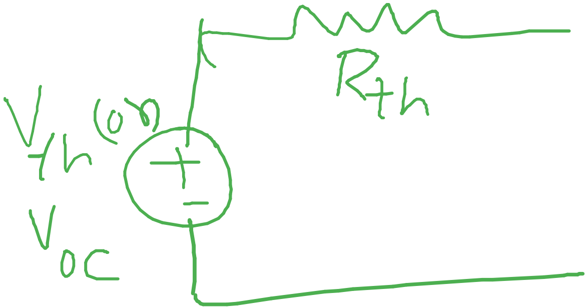


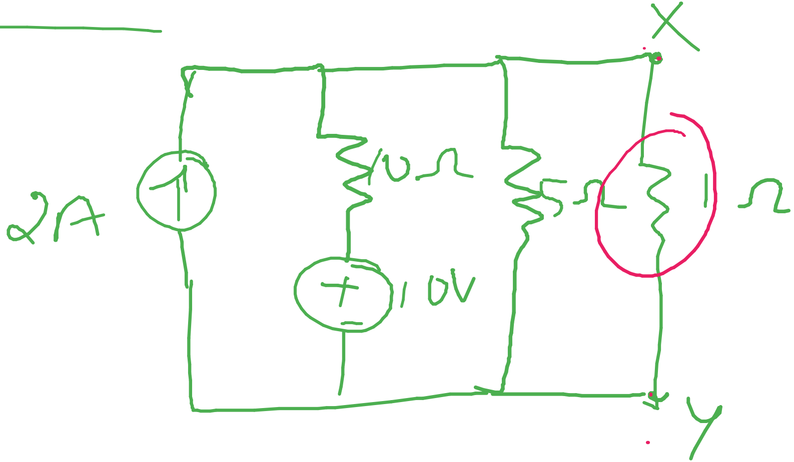
$$R_{th} = \frac{1}{2} + \frac{1}{5} + \frac{1}{1} = \frac{10}{17}$$

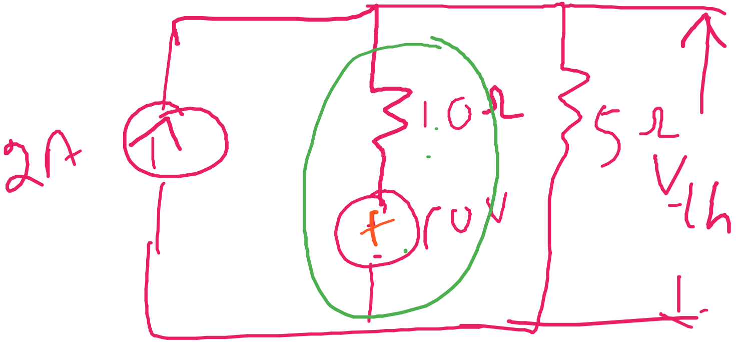
$$P_{max} = \frac{V_{th}^2}{4R_{th}} = \frac{13.29^2}{4 \times 10/17} = \underline{\underline{75W}}.$$

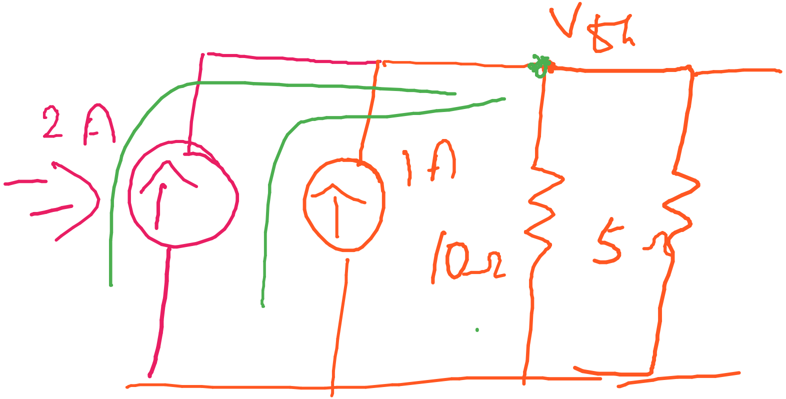
$$I_L = \frac{V_{th}}{R_{th} + R_L} = \frac{13.29}{\frac{10}{17} + 10} = 1.26A.$$

Thevenin's theorem





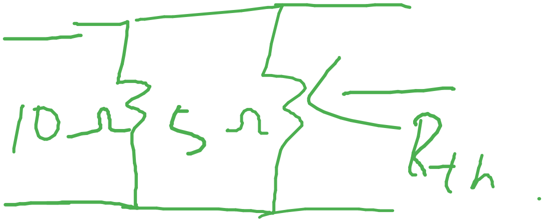


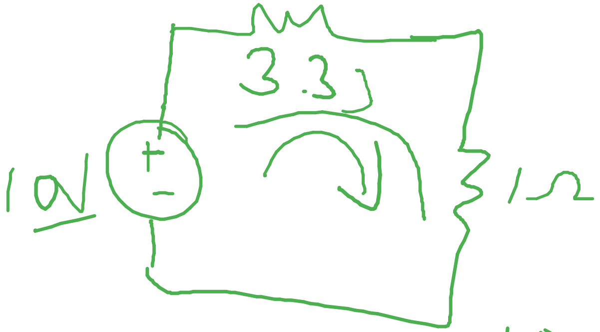


$$2+1 = \frac{V_{th}}{10} + \frac{V_{th}}{5} \Rightarrow 3 = \left(\frac{1}{10} + \frac{1}{5}\right) V_{th}$$

$$\boxed{V_{th} = 10\,V.}$$

R_{th}.

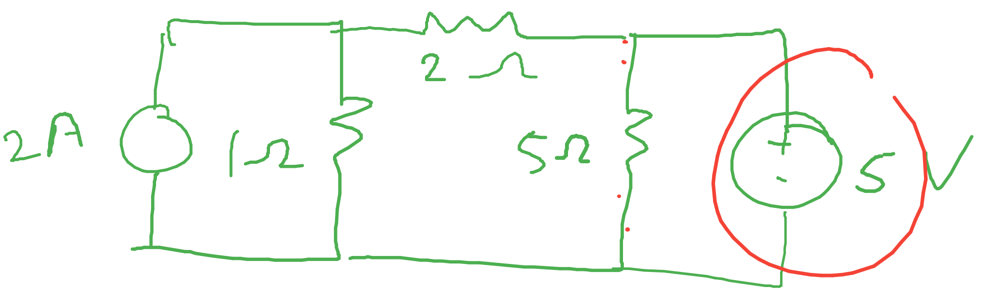




$$R_{th} = \frac{1}{10} + \frac{1}{5} = \frac{10}{3} = 3.33\,\Omega$$

$$I_{th} = \frac{10}{4.33} = 2.31\,\Omega.$$

$$(2.31)^2 \times 1 = \underline{\underline{5.33\,W}}.$$



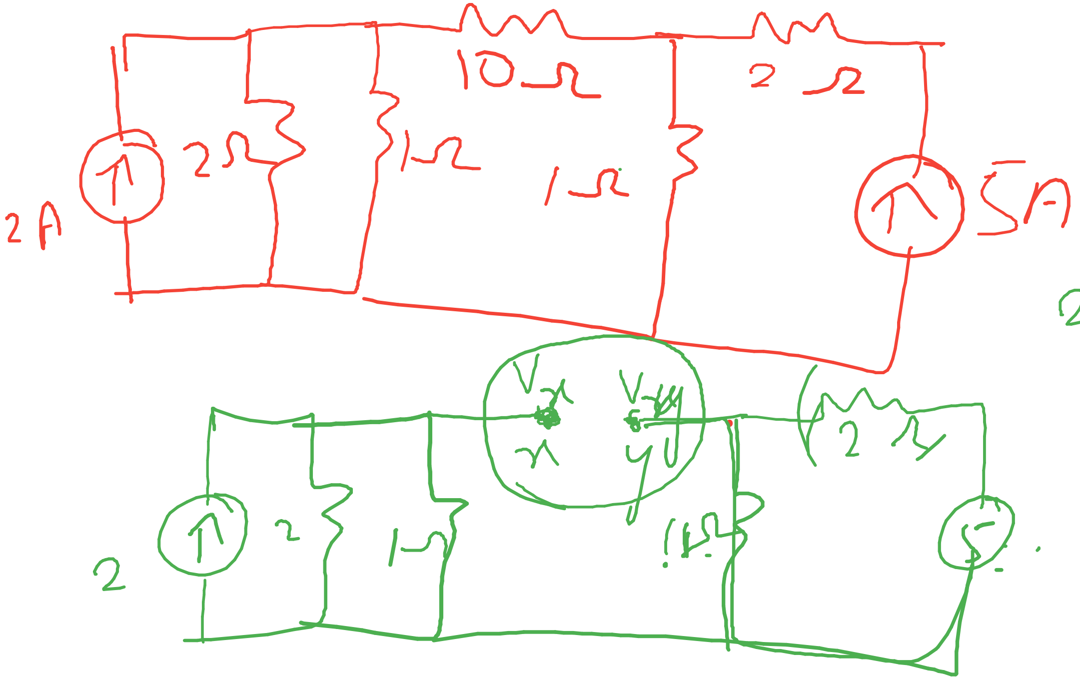
$$V_{oc} = V_{th} = 5\,V.$$

$$R_{th} = 0.$$

$$I_{th} = \frac{V_{th}}{R_{th} + R_L}$$

R_L: 1Ω

$$= \frac{1}{1} = 1\,A.$$



$$V_{xy} = V_x - V_y$$

$$2 = \frac{V_x}{2} + \frac{V_x}{1} = 4/3$$

$$V_x = 1.33$$

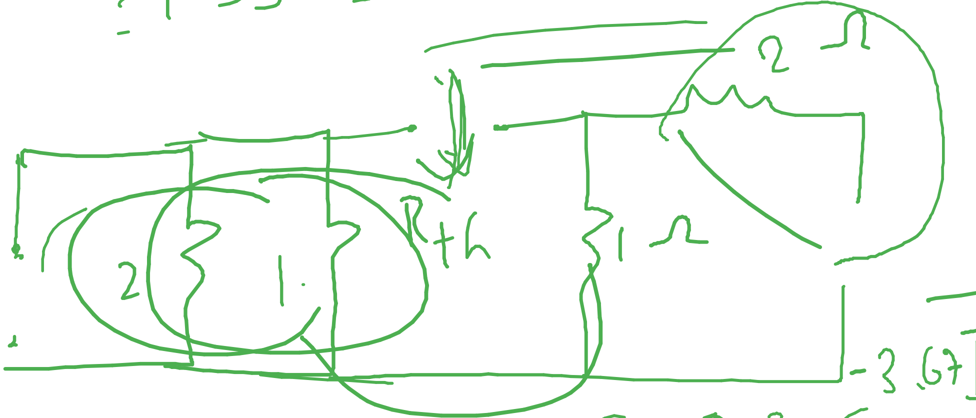
$$V_y = 5$$

$V_{xy} = V_x - V_y$

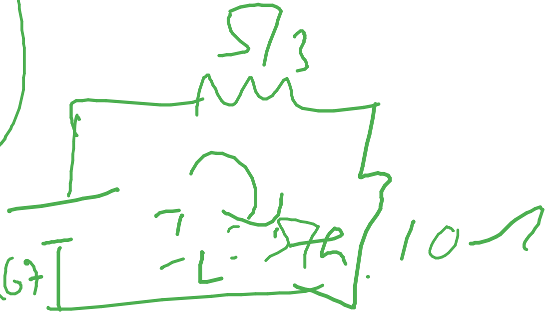
$= 1.33 - 5 = -3.67\,V$

$R_{th} = 1 + \frac{2 \times 1}{2+1}$

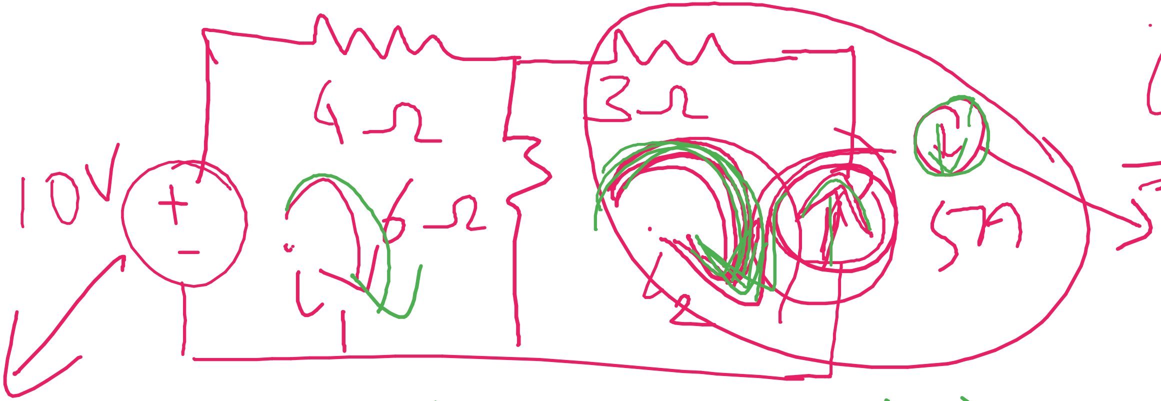
$= 5/3$



$= -0.315$



Mesh analysis with current source

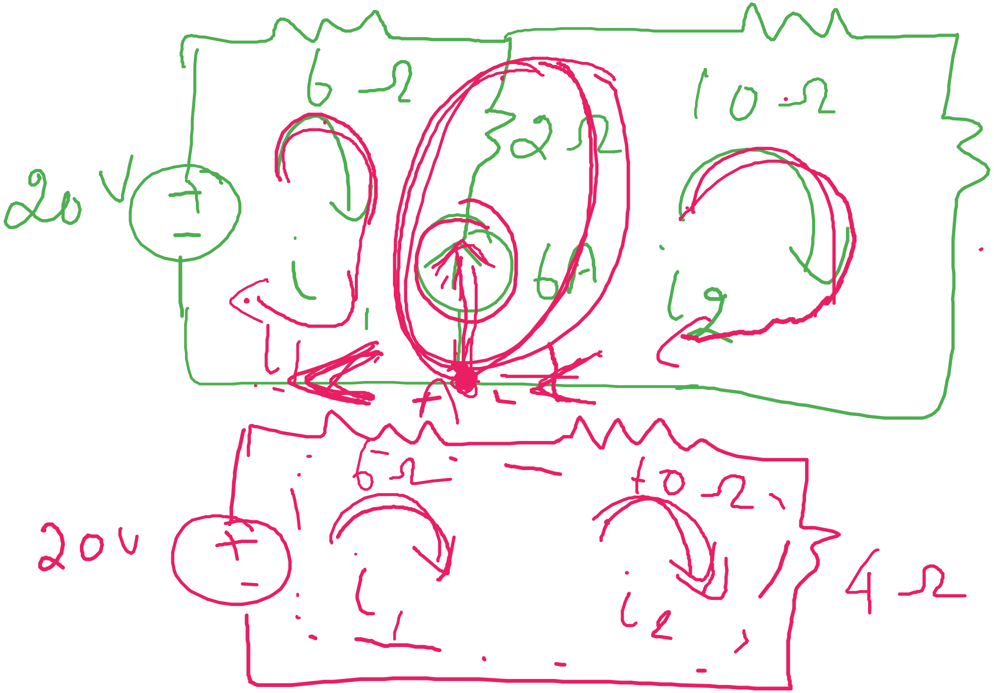


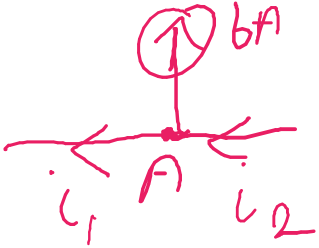
$i_2 = -5A$

$i_2 = 5A$

$$10 = 4i_1 + 6(i_1 - i_2)$$

$\underline{i_1 = -2A}$

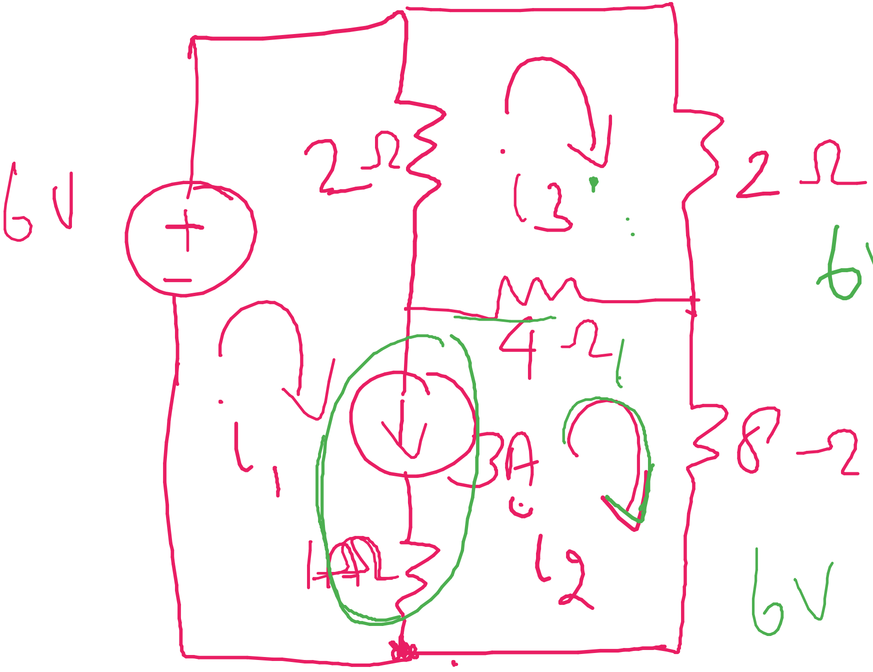


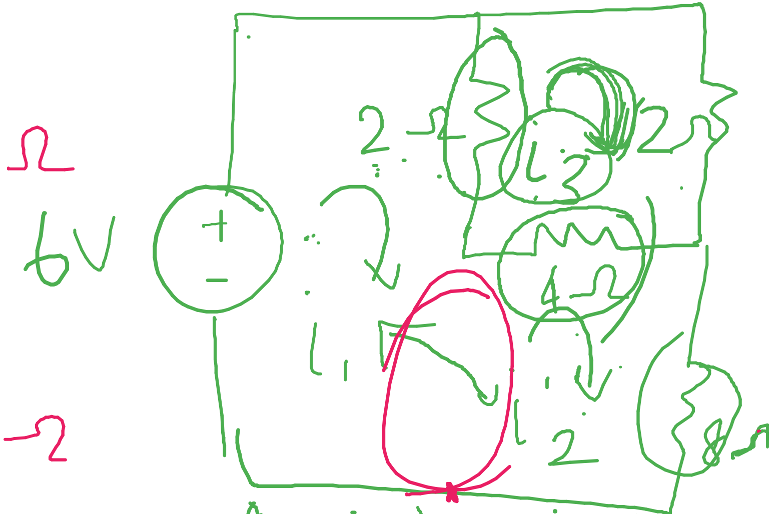


$$20 = 6i_1 + 10i_2 + 4i_2 \quad (1)$$

At node

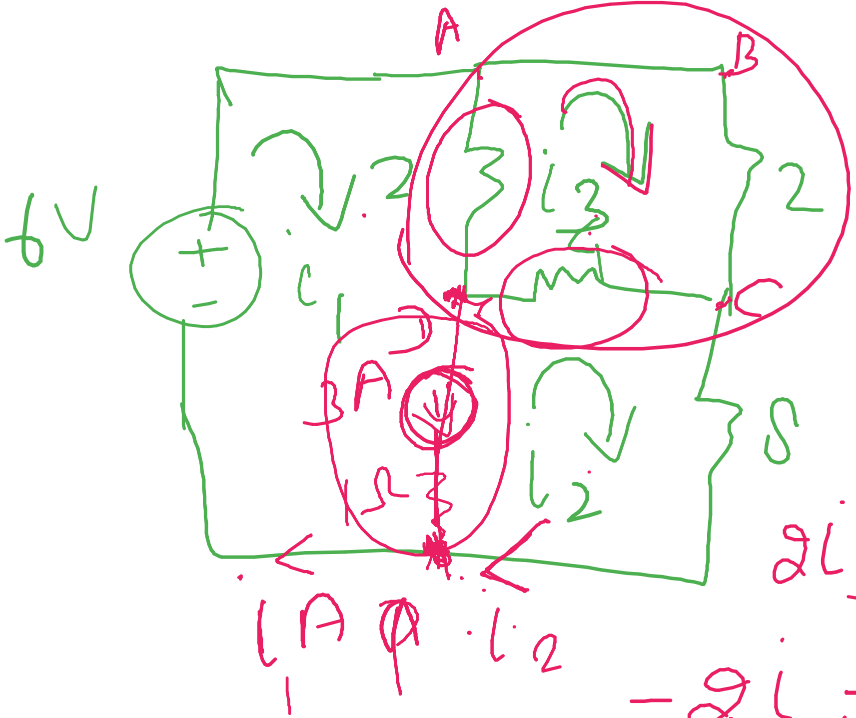
$$i_2 = i_1 + 6$$





$$6V = 2(i_1 - i_3) + 4(i_2 - i_3) + 8(2)$$

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

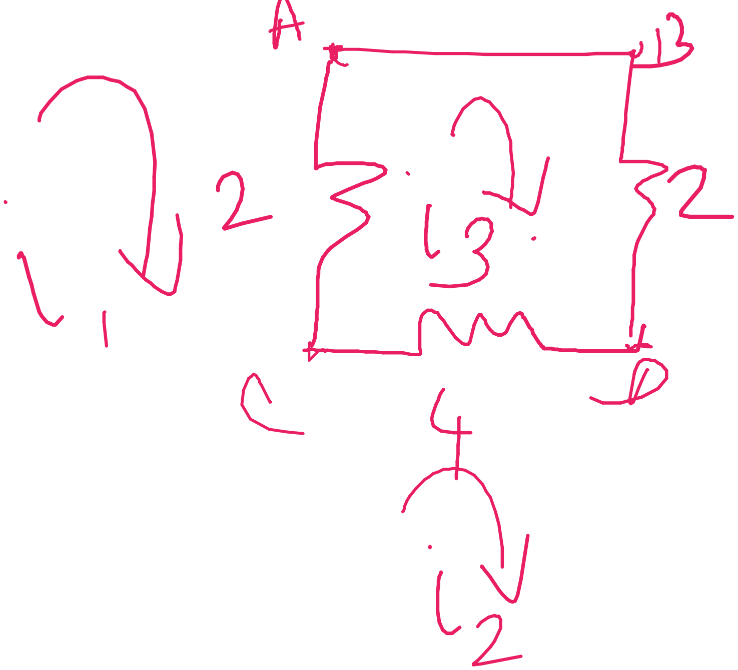


$$0 = 2(i_3 - i_1) + 4(i_3 - i_2) + 2i_3$$

$$i_1 = i_2 + 3 \quad (1)$$

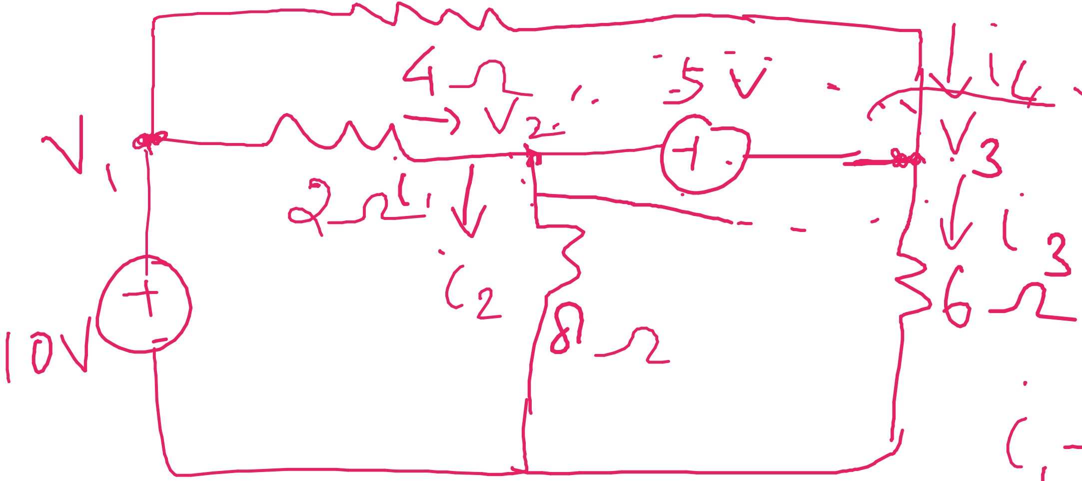
$$2i_3 - 2i_1 + 4i_3 - 4i_2 + 2i_3 = 0$$

$$-2i_1 - 4i_2 + 8i_3 = 0 \quad (2)$$

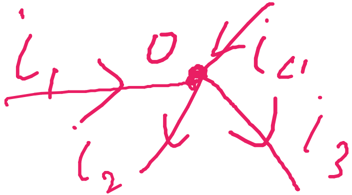


ABCDA

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

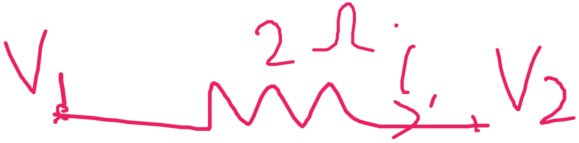


super node



$$i_1 + i_4 = i_2 + i_3 \quad (1)$$

$$V_1 = 10 \quad (2)$$

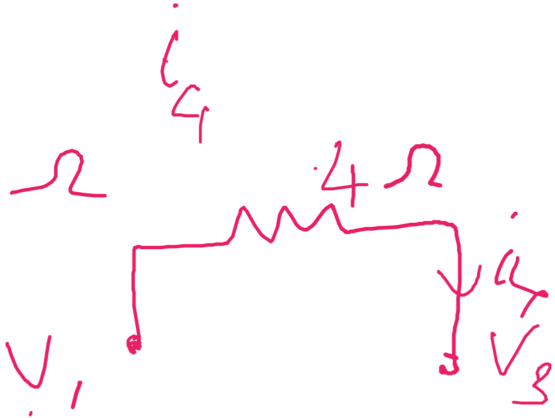


$$i_1 = \frac{V_1 - V_2}{2}$$

$$i_2 = \frac{V_2}{8}$$

$i_3 =$

$$i_3 = V_3/6$$



$$i_4 = \frac{V_1 - V_3}{4}$$

$$i_1 + i_4 = i_2 + i_3$$

$$\frac{V_1 - V_2}{2} + \frac{V_1 - V_3}{4} = \frac{V_2}{8} + \frac{V_3}{6} \quad \text{—— } 2$$

$$-V_2 + 5 + V_3 = 0 \qquad V_2 - V_3 = 5 \quad \text{—— } 3$$

$5 \cdot V_3$

$4 \cdot 1$

$V_2 \quad V_3$

$V_2 = 46/5$ $V_1 = 10$

$V_3 = 21/5$