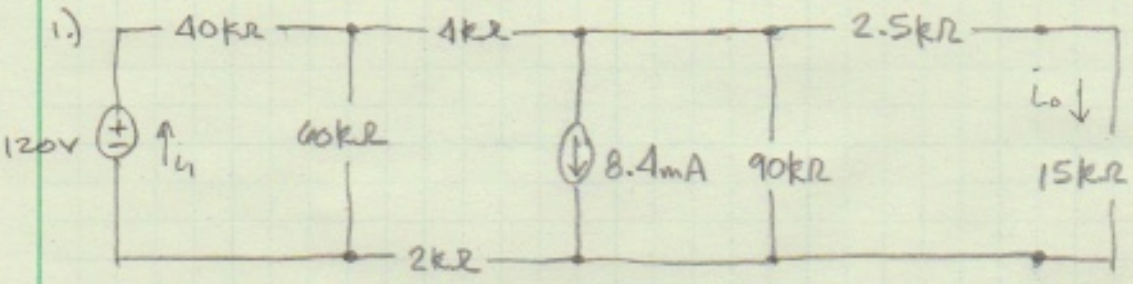
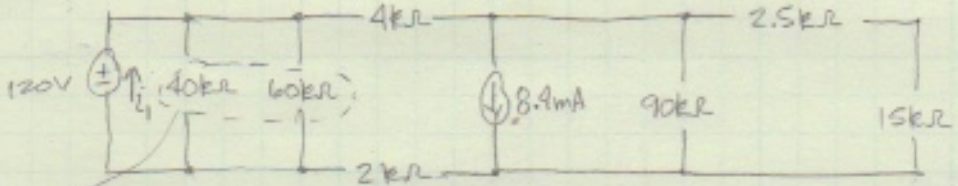
CIRCUITS
HW 9

XAVIER BENALLY

1.)

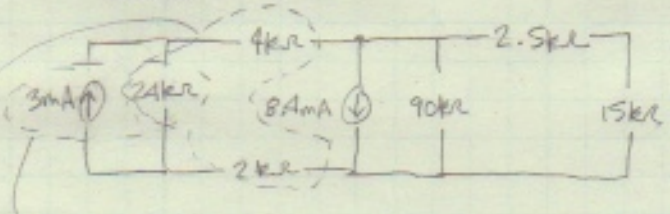


(i) USE SEVERAL SOURCE TRANSFORMATIONS TO FIND VALUE OF CURRENT FLOWING IN 15kΩ.



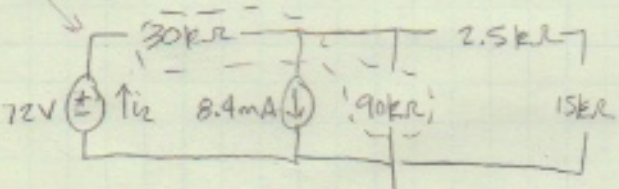
$$i_1 = \frac{120}{40\times10^3} = 0.003A = 3mA$$

$$R_1 = \frac{40(60)}{40+60} = 24k\Omega$$



$$v_1 = 3mA(24k\Omega)$$

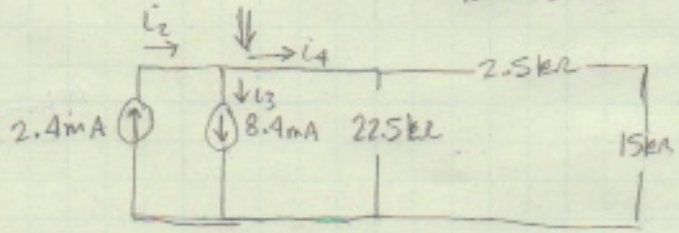
$$v_1 = 72V$$



$$i_2 = \frac{72}{30\times10^3} = 2.4mA$$

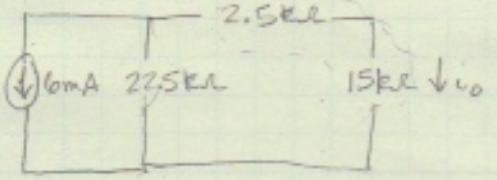
PARALLEL

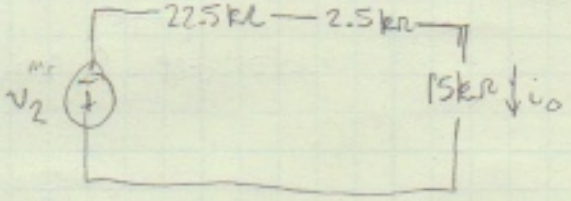
$$R_2 = \frac{(90\times10^3)(30\times10^3)}{90\times10^3+30\times10^3} = 22.5k\Omega$$



$$i_2 = i_3 - i_4 \Rightarrow i_4 = i_3 - i_2 \Rightarrow i_4 = 8.4 - 2.4$$

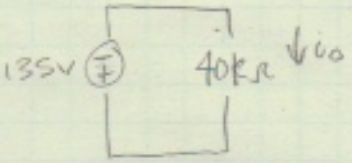
$$\therefore i_4 = 6mA$$





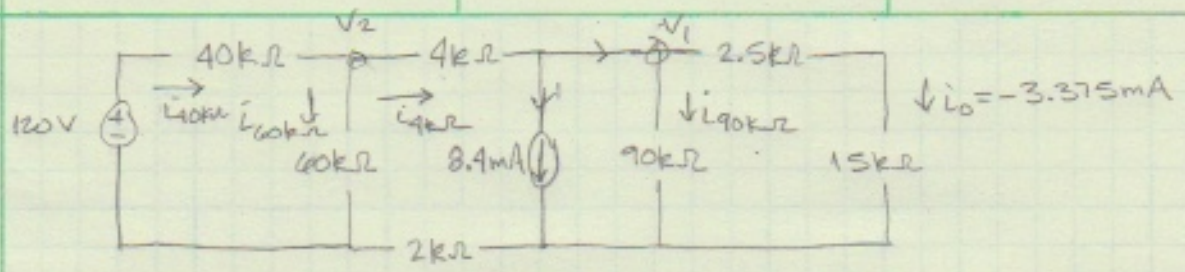
$$v_2 = (6mA)(22.5k\Omega)$$

$$v_2 = 135V$$



$$i_o = \frac{135}{40\times10^3}$$

$$i_o = -3.375mA$$



(ii) VOLTAGE DROP ACROSS 90kΩ

$$V_1 = (-3.375\times10^{-3})(2.5\times10^{3} + 15\times10^{3})$$

$$\boxed{V_1 = -59\ V}$$

$V = iR$

$$i_{90k\Omega} = \frac{V_1}{90\times10^{3}}$$

$$= \frac{-59}{90\times10^{3}}$$

$$= -6.55\times10^{-4} = 0.000655$$

$$\boxed{i_{90k\Omega} = -0.655\ mA}$$

CURRENT FLOWING THROUGH 4kΩ

$$i_{4k\Omega} = 8.4\times10^{-3} - 0.655\times10^{-3} - 3.375\times10^{-3}$$

$$\boxed{i_{4k\Omega} = 4.37\times10^{-3}\ A}$$

VOLTAGE DROP ACROSS 60kΩ

$$V_2 = i_{4k\Omega}(4\times10^{3} + 2\times10^{3}) + V_1$$

$$= 4.37\times10^{-3}(6\times10^{3}) - 59$$

$$\boxed{V_2 = -32.8\ V}$$

$$i_{60k\Omega} = \frac{-32.8}{60\times10^{3}}$$

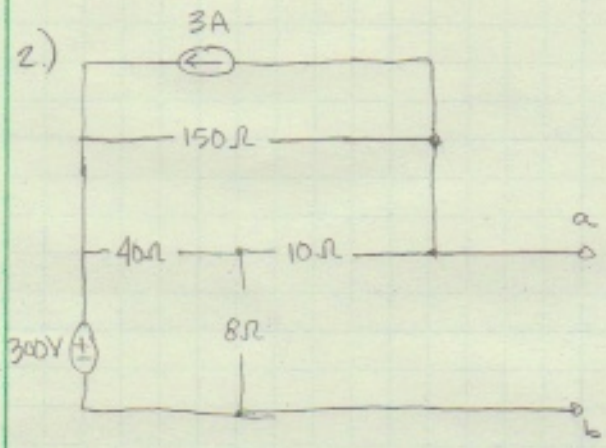
$$i_{60k\Omega} = -0.548\times10^{-3}\ A$$

$$i_{40k\Omega} = i_{60k\Omega} + i_{4k\Omega} \Rightarrow i_{40k\Omega} = -0.548\times10^{-3} + 4.37\times10^{-3}$$

$$\boxed{i_{40k\Omega} = 3.82\times10^{-3}\ A}$$

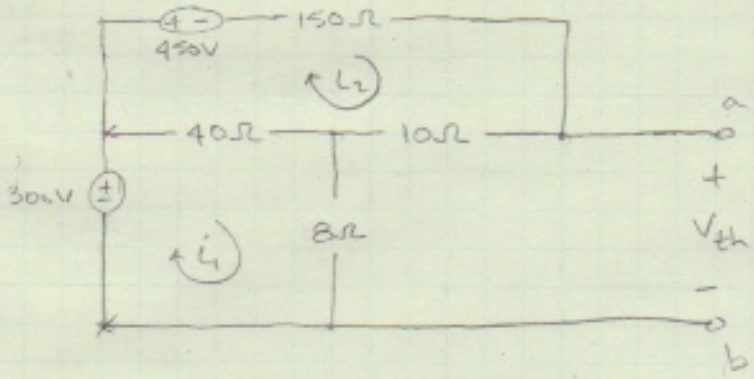
← CURRENT FLOWING IN LH PART OF CIRCUIT

2.)



$V = (3)(150)$

$V = 450\,V$



mesh current i_1

$-300 + 40(i_1 - i_2) + 8i_1 = 0$

$40i_1 - 40i_2 + 8i_1 = 300$

(1) $48i_1 - 40i_2 = 300$

mesh current i_2:

$450 + 150i_2 + 10i_2 + 40(i_2 - i_1) = 0$

$160i_2 + 40i_2 - 40i_1 = -450$

(2) $-40i_1 + 200i_2 = -450$

$i_1 = 5.25\,A$

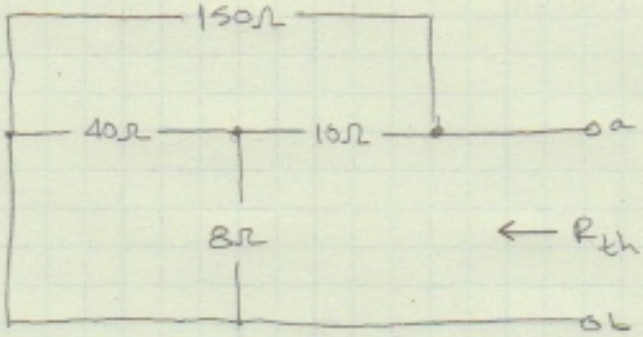
$i_2 = -1.2\,A$

$v_{th} = 10i_2 + 8i_1$

$= 10(-1.2) + 8(5.25)$

$= -12 + 42$

$v_{th} = 30\,V$

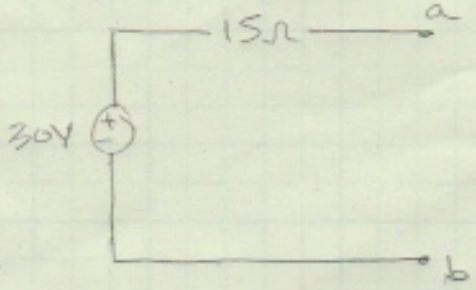


$$R_{th} = \frac{40 \times 8}{40+8} + 10$$

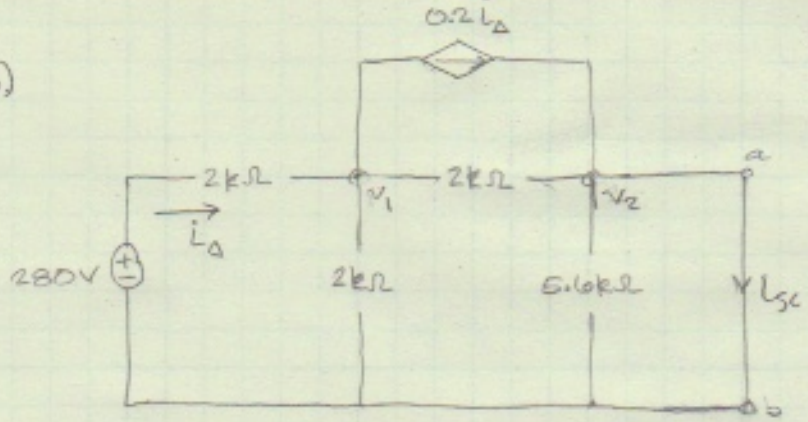
$$= \frac{20}{3} + 10$$

$$R_{th} = \frac{\frac{50}{3}(150)}{\frac{50}{3} + 150}$$

$$\boxed{R_{th} = 15\Omega}$$



3)



$$i_\Delta = \frac{280 - v_1}{2\times10^3}$$

$v_2 = 0$

KVL @ v_1:

$$\frac{v_1 - 280}{2\times10^3} + \frac{v_1}{2\times10^3} + \frac{v_1 - v_2}{2\times10^3} + 0.2i_\Delta = 0$$

$$v_1\left(\frac{1}{2\times10^3} + \frac{1}{2\times10^3} + \frac{1}{2\times10^3}\right) - \frac{280}{2\times10^3} - \frac{v_2}{2\times10^3} = -0.2i_\Delta$$

$$2\times10^3\left(\frac{3v_1}{2\times10^3} - \frac{280}{2\times10^3} - \frac{v_2}{2\times10^3}\right) = (-0.2i_\Delta)2\times10^3$$

$$3v_1 - 280 - v_2 = -400\,i_\Delta$$

$$\left[i_\Delta = \frac{280 - v_1}{2\times10^3},\ v_2 = 0\right]$$

$$3v_1 - 280 = -400\left(\frac{280 - v_1}{2\times10^3}\right) \rightarrow \frac{-400(280)}{2000} + \frac{400v_1}{2000}$$

$$3v_1 - 280 = -56 + \frac{v_1}{5}$$

$$-\frac{v_1}{5} + 280 \quad +280 \quad -\frac{v_1}{5}$$

$$5\left(3v_1 - \frac{1}{5}v_1\right) = 224$$

$$\frac{5}{14}\left(\frac{14}{5}v_1\right) = (224)\frac{5}{14}$$

$$v_1 = 80\text{V}$$

$$i_\Delta = \frac{280 - v_1}{2000}$$

$$[v_1 = 80]$$

$$i_\Delta = \frac{280 - 80}{2000}$$

$$i_\Delta = 0.1\text{A}$$

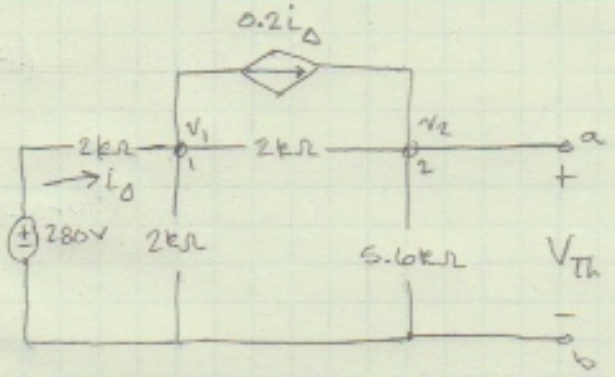
KVL @ v_2:

$$i_{sc} = 0.2i_\Delta + \frac{v_1 - v_2}{2000} + \frac{v_2}{5600}$$

$$\begin{bmatrix} i_\Delta = 0.1 \\ v_1 = 80 \\ v_2 = 0 \end{bmatrix}$$

$$i_{sc} = 0.2(0.1) + \frac{80 - 0}{2000} + \frac{0}{5600}$$

$$\therefore i_{sc} = 0.06\text{A}$$



$$i_\Delta = \frac{280 - v_1}{2000}$$

KCL @ 1:

$$\frac{v_1 - 280}{2000} + \frac{v_1}{2000} + \frac{v_1 - v_2}{2000} + 0.2 i_\Delta = 0$$

$$\left(\frac{1}{2000} + \frac{1}{2000} + \frac{1}{2000}\right) v_1 - \frac{280}{2000} - \frac{v_2}{2000} = -0.2 i_\Delta$$

$$2000\left(\frac{3v_1}{2000} - \frac{280}{2000} - \frac{v_2}{2000}\right) = (-0.2 i_\Delta)\,2000$$

$$3v_1 - 280 - v_2 = -400 i_\Delta$$

$$\left[i_\Delta = \frac{280 - v_1}{2000}\right]$$

$$3v_1 - 280 - v_2 = -400\left(\frac{280 - v_1}{2000}\right)$$

$$3v_1 - 280 - v_2 = -\frac{400(280)}{2000} + \frac{400(v_1)}{2000}$$

$$3v_1 - 280 - v_2 = -56 + \frac{v_1}{5}$$

$$+280 + v_2 \qquad + \frac{v_1}{5}$$

$$-\frac{v_1}{5}$$

$$\frac{3v_1}{1} + \frac{v_1}{5} = 224 + v_2$$

$$\frac{5}{14}\left(\frac{14}{5} v_1\right) = (224 + v_2)\frac{5}{14}$$

$$= \frac{224}{1}\left(\frac{5}{14}\right) + \frac{5v_2}{14}$$

$$v_1 = 80 + \frac{5v_2}{14}$$

KCL @ 2:

$$\frac{v_2 - v_1}{2000} + \frac{v_2}{5.6 \times 10^3} - 0.2 i_\Delta = 0$$

$$\left[\frac{v_2}{2000} - \frac{v_1}{2000} + \frac{v_2}{5600}\right] = \left[-0.2 i_\Delta\right]$$

$$v_2\left(\frac{1}{2000} + \frac{1}{5600}\right) - \frac{v_1}{2000} = 0.2 i_\Delta$$

$$\left(\frac{14 + 5}{28{,}000}\right) v_2 - \frac{v_1}{2000} = 0.2 i_\Delta$$

$$28000\left[\frac{19v_2}{28{,}000} - \frac{14v_1}{28000}\right] = \left[0.2 i_\Delta\right] 28{,}000$$

$$19v_2 - 14v_1 = 5600 i_\Delta$$

$$\left[i_\Delta = \frac{280 - v_1}{2000}\right]$$

$$19v_2 - 14v_1 = 5600\left(\frac{280 - v_1}{2000}\right)$$

$$19v_2 - 14v_1 = 784 - 2.8v_1$$

$$+2.8v_1 \qquad +2.8v_1$$

$$19v_2 - 11.2v_1 = 784 \qquad \left[v_1 = 80 + \frac{5v_2}{14}\right]$$

$$19v_2 - 11.2\left(80 + \frac{5v_2}{14}\right) = 784$$

$$19v_2 - 896 - 4v_2 = 784$$

$$15v_2 = 1680$$

$$v_2 = 112\,V \qquad V_{Th} = 112\,V$$

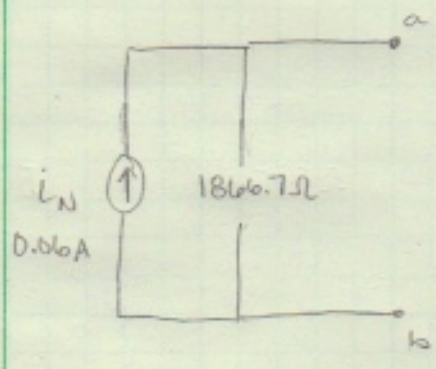
NORTON RESISTANCE

$$R_N = \frac{V_{Th}}{I_{sc}}$$

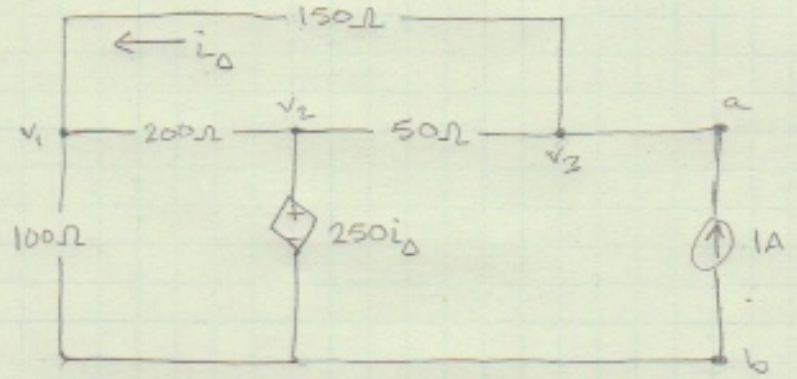
$$\begin{bmatrix} V_{Th} = 112V \\ I_{sc} = 0.06A \end{bmatrix}$$

$$R_N = \frac{112}{0.06}$$

$$R_N = 1866.7\,\Omega$$



4.)



$R_{Th} = \frac{V_s}{1A} = \frac{150V}{1A}$

$R_{Th} = 150\Omega$

$i_\Delta = \frac{v_3 - v_1}{150}$

$v_2 = 250 i_\Delta$

$v_2 = 250\left(\frac{v_3 - v_1}{150}\right)$

$v_2 = \frac{5}{3}(v_3 - v_1)$

KCL @ v_1

$600\left[\frac{v_1}{100} + \frac{v_1 - v_2}{200} + \frac{v_1 - v_3}{150}\right] = [0]\,600$

$6v_1 + 3(v_1 - v_2) + 4(v_1 - v_3) = 0$

$6v_1 + 3v_1 - 3v_2 + 4v_1 - 4v_3 = 0$

$13v_1 - 3v_2 - 4v_3 = 0$

$\left[v_2 = \frac{5}{3}(v_3 - v_1)\right]$

$13v_1 - 3\left(\frac{5}{3}(v_3 - v_1)\right) - 4v_3 = 0$

$13v_1 - 5v_3 + 5v_1 - 4v_3 = 0$

$18v_1 - 9v_3 = 0$

$+9v_3 \quad +9v_3$

$\frac{18v_1}{18} = \frac{9v_3}{18}$

$v_1 = \frac{v_3}{2}$

KCL @ v_3

$\frac{v_3 - v_2}{50} + \frac{v_3 - v_1}{150} - 1 = 0$

$150\left[\frac{v_3 - v_2}{50} + \frac{v_3 - v_1}{150}\right] = [+]\,150$

$3(v_3 - v_2) + v_3 - v_1 = 150$

$3v_3 - 3v_2 + v_3 - v_1 = 150$

$-v_1 - 3v_2 + 4v_3 = 150$

$\left[v_2 = \frac{5}{3}(v_3 - v_1)\right]$

$-v_1 - 3\left[\frac{5}{3}(v_3 - v_1)\right] + 4v_3 = 150$

$-v_1 - 5v_3 + 5v_1 + 4v_3 = 150$

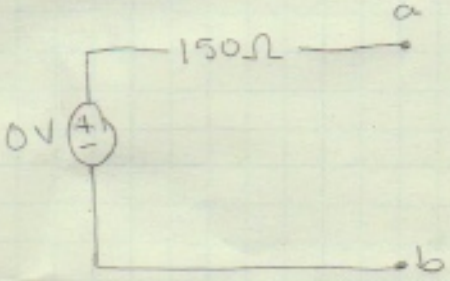
$4v_1 - v_3 = 150$

$\left[v_1 = \frac{v_3}{2}\right]$

$4\left(\frac{v_3}{2}\right) - v_3 = 150$

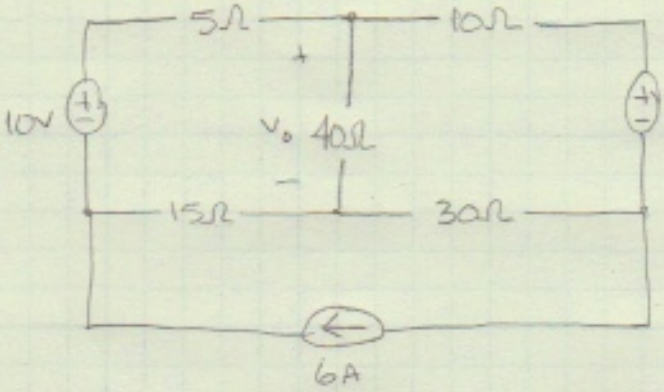
$2v_3 - v_3 = 150$

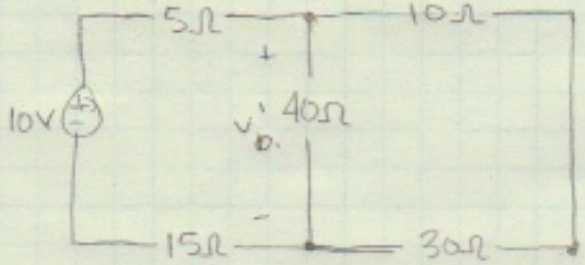
$v_3 = 150V$



Thevenin's voltage is zero because there is no independent voltage source

5)

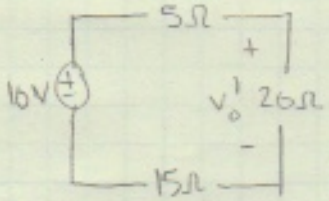




$R = (10+30) \| 40$

$= \frac{40(40)}{40+40}$

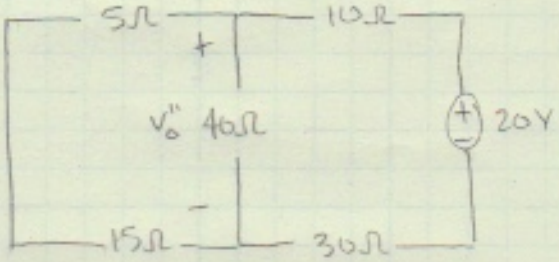
$R = 20\Omega$



VOLTAGE DIVISION

$V_o' = \frac{20}{20+15+5}(10)$

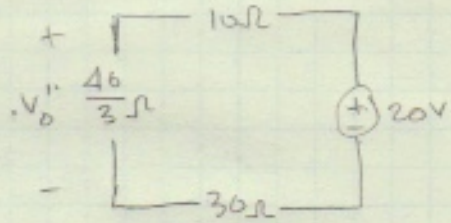
$V_o' = 5V$



$R = (5+15) \| 40$

$= \frac{20(40)}{20+40}$

$R = \frac{40}{3}\Omega$



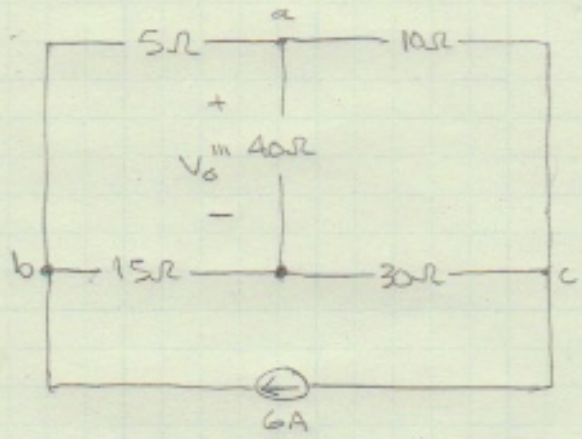
$V_o'' = \frac{\frac{40}{3}}{\frac{40}{3}+10+30}(20)$

$\frac{40}{3} + \frac{30}{3} + \frac{90}{3}$

$= \frac{160}{3}$

$= \frac{\frac{40}{3}}{\frac{160}{3}}(20) = \frac{20}{4}$

$V_o'' = 5V$



KCL @ a:

$$40\left[\frac{V_o'''}{40} + \frac{V_o''' - V_c}{10} + \frac{V_o''' - V_b}{5}\right] = [0]40$$

$$V_o''' + 4V_o''' - 4V_c + 8V_o''' - 8V_b = 0$$

(1) $$13V_o''' - 8V_b - 4V_c = 0$$ ✱

KCL @ b:

$$\frac{V_b - V_o'''}{5} + \frac{V_b}{15} - 6 = 0$$

$$15\left[\frac{V_b - V_o'''}{5} + \frac{V_b}{15}\right] = (6)15$$

$$3V_b - 3V_o''' + V_b = 90$$

$$-3V_o''' + 4V_b = 90$$

$$\frac{4V_b}{4} = \frac{90 + 3V_o'''}{4}$$

(2) $$V_b = \frac{90 + 3V_o'''}{4}$$ ✱

KCL @ c:

$$\frac{V_c - V_o'''}{10} + \frac{V_c}{30} + 6 = 0$$

$$30\left[\frac{V_c - V_o'''}{10} + \frac{V_c}{30}\right] = [-6]30$$

$$3V_c - 3V_o''' + V_c = -180$$

$$-3V_o''' + 4V_c = -180$$

$$\frac{4V_c}{4} = \frac{3V_o''' - 180}{4}$$

✱ $$V_c = \frac{3V_o''' - 180}{4}$$ (3)

PLUG (2) & (3) INTO (1):

$$13V_o''' - 8\left(\frac{90 + 3V_o'''}{4}\right) - 4\left(\frac{3V_o''' - 180}{4}\right) = 0$$

$$13V_o''' - 180 - 6V_o''' - 3V_o''' + 180 = 0$$

$$4V_o''' = 0$$

$$V_o''' = 0V$$

PRINCIPLE OF SUPERPOSITION:

$$V_o = V_o' + V_o'' + V_o'''$$

$$= 5 + 5 + 0$$

$$\boxed{V_o = 10V}$$