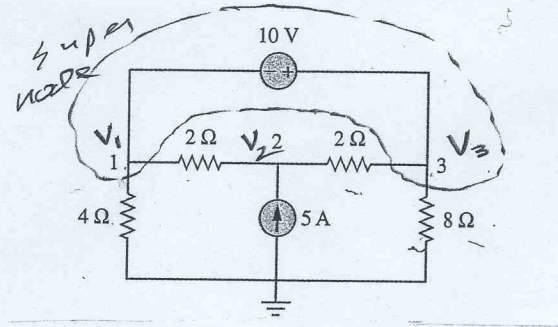


3.18
wlg

3.18 Determine the node voltages in the circuit of Fig. 3.67 using nodal analysis.



$$\frac{V_1 - V_2}{2} + \frac{V_1}{4} + \frac{V_3 - V_2}{2} + \frac{V_3}{8} = 0$$

x8

$$4V_1 - 4V_2 + 2V_1 + 4V_3 - 4V_2 + V_3 = 0$$

$$6V_1 - 8V_2 + 5V_3 = 0$$

At 2

$$\frac{V_2 - V_1}{2} + \frac{V_2 - V_3}{2} - 5 = 0$$

x2

$$V_2 - V_1 + V_2 - V_3 = 10$$

$$-V_1 + 2V_2 - V_3 = 10$$

Constraint Equation:

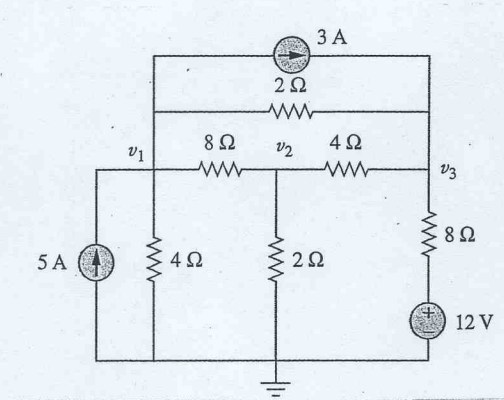
$$V_1 + 10 - V_3 = 0$$

$$V_1 + 0V_2 - V_3 = -10$$

$$\begin{bmatrix} 6 & -8 & 5 \\ -1 & 2 & -1 \\ 1 & 0 & -1 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 0 \\ 10 \\ -10 \end{bmatrix}$$

$$V_1 = 10V, \quad V_2 = 20V, \quad V_3 = 20V$$

3.19 Use nodal analysis to find V_1, V_2, V_3 .



At V_1

$$\frac{V_1}{4} + \frac{V_1 - V_2}{8} + \frac{V_1 - V_3}{2} + 3 - 5 = 0$$

$$2V_1 + V_1 - V_2 + 4V_1 - 4V_3 = 16$$

$$7V_1 - V_2 - 4V_3 = 16$$

At V_2

$$\frac{V_2 - V_1}{8} + \frac{V_2}{2} + \frac{V_2 - V_3}{4} = 0$$

$$V_2 - V_1 + 4V_2 + 2V_2 - 2V_3 = 0$$

$$-V_1 + 7V_2 - 2V_3 = 0$$

At V_3

$$\frac{V_3 - V_2}{4} + \frac{V_3 - V_1}{2} - 3 + \frac{V_3 - 12}{8} = 0$$

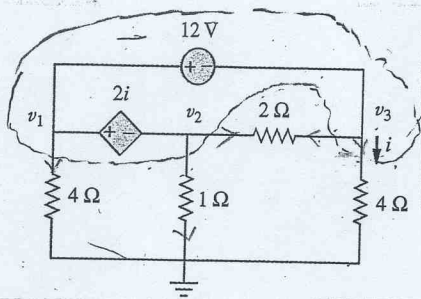
$$2V_3 - 2V_2 + 4V_3 - 4V_1 + V_3 = 36$$

$$-4V_1 - 2V_2 + 7V_3 = 36$$

$$\begin{bmatrix} 7 & -1 & -4 \\ -1 & 7 & -2 \\ -4 & -2 & 7 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 16 \\ 0 \\ 36 \end{bmatrix}$$

$$\underline{V_1 = 10V}, \quad \underline{V_2 = 4.93V}, \quad \underline{V_3 = 12.27V}$$

3.20 Use nodal analysis to find V_1, V_2, V_3 .



Double Super Node:

$$\frac{V_1}{4} + \frac{V_2}{1} + \frac{V_2 - V_3}{2} + \frac{V_3}{4} + \frac{V_3 - V_2}{2} = 0$$

$$V_1 + 4V_2 + 2V_2 - 2V_3 + V_3 + 2V_3 - 2V_2 = 0$$

$$V_1 + 4V_2 + V_3 = 0$$

Constraint 1

$$V_1 - 2i - V_2 = 0 \quad ; \quad i = \frac{V_3}{4}$$

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

$$4V_1 - 4V_2 - 2V_3 = 0$$

Constraint 2

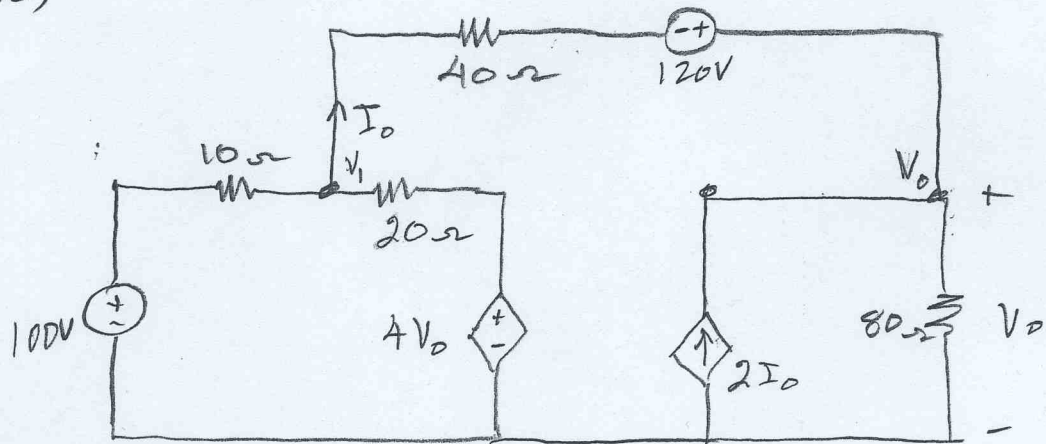
$$V_1 - 12 - V_3 = 0$$

$$V_1 + 0V_2 - V_3 = 12$$

$$\begin{bmatrix} 1 & 4 & 1 \\ 4 & -4 & -2 \\ 1 & 0 & -1 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 12 \end{bmatrix}$$

$$V_1 = -3V, \quad V_2 = 4.5V, \quad V_3 = -15V$$

(3.30)



At V_1

$$\frac{V_1 - 100}{10} + \frac{V_1 - 4V_0}{20} + \frac{V_1 + 120 - V_0}{40} = 0$$

x4

$$4V_1 - 400 + 2V_1 - 8V_0 + V_1 + 120 - V_0 = 0$$

$$\boxed{-9V_0 + 7V_1 = 280} \quad (1)$$

At V_0

$$\frac{V_0 - 120 - V_1}{40} + \frac{V_0}{80} - 2I_0 = 0$$

but

$$I_0 = \frac{V_1 + 120 - V_0}{40}$$

so

$$\frac{V_0 - 120 - V_1}{40} + \frac{V_0}{80} - 2 \left[\frac{V_1 + 120 - V_0}{40} \right] = 0$$

$$2V_0 - 240 - 2V_1 + V_0 - 4V_1 - 480 + 4V_0 = 0$$

$$\boxed{7V_0 - 6V_1 = 720} \quad (2)$$

(3.30) cont.

From Equations (1) and (2)

$$\begin{bmatrix} -9 & 7 \\ 7 & -6 \end{bmatrix} \begin{bmatrix} V_0 \\ V_1 \end{bmatrix} = \begin{bmatrix} -280 \\ 720 \end{bmatrix}$$

$$V_0 = -1344 \text{ V}$$

$$V_1 = -1688 \text{ V}$$

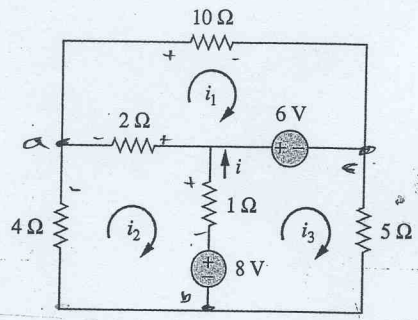
$$I_D = \frac{V_1 + 120 - V_0}{40}$$

$$I_D = \frac{-1688 + 120 + 1344}{40}$$

$$I_D = -5.6 \text{ A}$$

Verified by PSpice.

3.41 Apply mesh analysis to find i .



At a

$$10i_1 - 6 + 2(i_1 - i_2) = 0$$

$$12i_1 - 2i_2 + 0i_3 = 6$$

At b

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

$$-2i_1 + 7i_2 - i_3 = -8$$

At c

$$5i_3 - 8 - 1(i_2 - i_3) + 6 = 0$$

$$0i_1 - i_2 + 6i_3 = 2$$

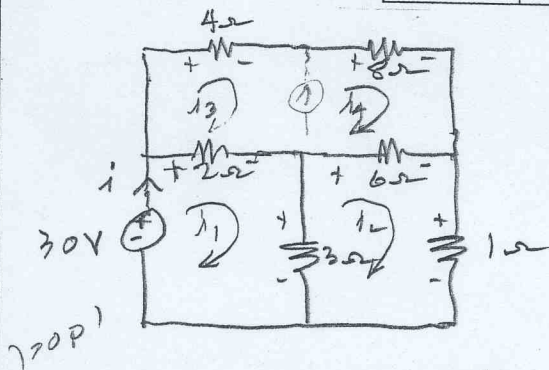
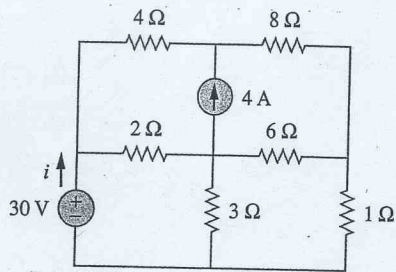
$$\begin{bmatrix} 12 & -2 & 0 \\ -2 & 7 & -1 \\ 0 & -1 & 6 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix} = \begin{bmatrix} 6 \\ -8 \\ 2 \end{bmatrix}$$

$$i_1 = 0.329 \quad i_2 = +1.026 \quad i_3 = 0.162$$

$$i = i_3 - i_2 = 0.162 - (-1.026)$$

$$i = 1.188 \text{ A}$$

3.45 Find the current i use mesh.



$$2(i_1 - i_3) + 3(i_1 - i_2) = 30$$

$$5i_1 - 3i_2 - 2i_3 + 0i_4 = 30$$

Loop 2

$$-3(i_1 - i_2) + 6(i_2 - i_4) + 1 \times i_2 = 0$$

$$-3i_1 + 10i_2 + 0i_3 - 6i_4 = 0$$

Mixed loop

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

$$-2i_1 - 6i_2 + 6i_3 + 14i_4 = 0$$

$$i_4 - i_3 = 4$$

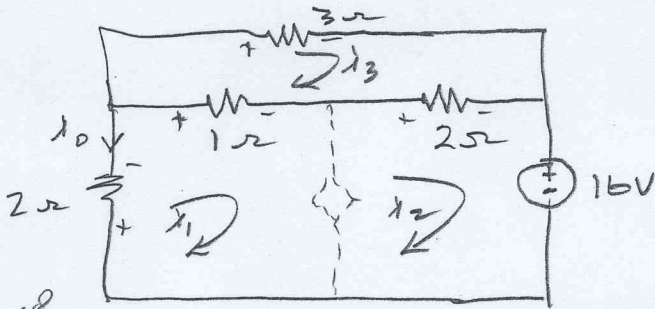
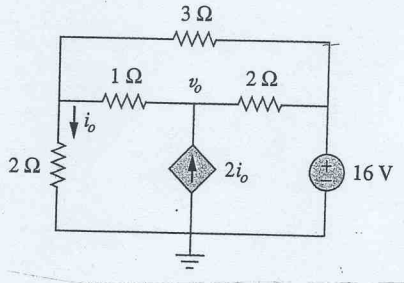
$$0i_1 + 0i_2 - i_3 + i_4 = 4$$

$$\begin{bmatrix} 5 & -3 & -2 & 0 \\ -3 & 10 & 0 & -6 \\ -2 & -6 & 6 & 14 \\ 0 & 0 & -1 & 1 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \\ i_4 \end{bmatrix} = \begin{bmatrix} 30 \\ 0 \\ 0 \\ 4 \end{bmatrix}$$

$$i_1 = i = 8.56 \text{ A}, \quad i_2 = 1.64 \text{ A}, \quad i_3 = -0.553$$

$$i_4 = 3.45 \text{ A}$$

3.49

Find V_o and i_o using mesh.

Mixed

$$2i_1 + 1(i_1 - i_3) + 2(i_2 - i_3) = -16$$

$$3i_1 + 2i_2 - 3i_3 = -16$$

loop 3

$$3i_3 - 2(i_2 - i_3) - 1(i_1 - i_3) = 0$$

$$-i_1 - 2i_2 + 6i_3 = 0$$

Constraint

$$i_2 - i_1 = 2i_o = -2i_1 \quad ; \quad i_o = -i_1$$

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

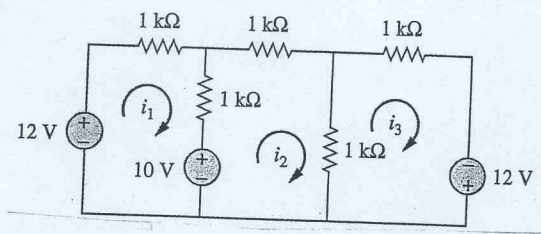
$$\begin{bmatrix} 3 & 2 & -3 \\ -1 & -2 & 6 \\ 1 & 1 & 0 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix} = \begin{bmatrix} -16 \\ 0 \\ 0 \end{bmatrix}$$

$$i_1 = -10.67 \text{ A}, \quad i_2 = 10.67 \text{ A}, \quad i_3 = 1.78 \text{ A}$$

$$i_o = -i_1 = 10.67 \text{ A}$$

$$-V_o + 2(i_2 - i_3) + 16 = 0 \Rightarrow V_o = 33.78 \text{ V}$$

3.54 Find the currents i_1, i_2, i_3 using mesh.



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

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

$$-1(i_1 - i_2) + 1i_2 + 1(i_2 - i_3) = 10$$

$$-i_1 + 3i_2 - i_3 = 10$$

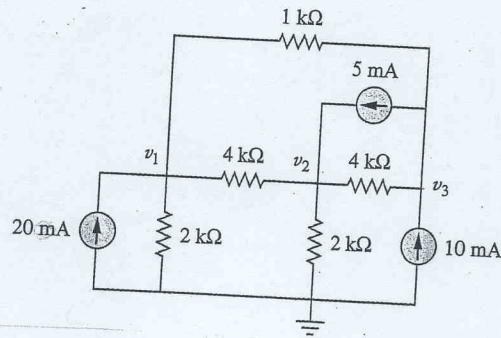
$$-1(i_2 - i_3) + 1i_3 = 12$$

$$0i_1 - i_2 + 2i_3 = 12$$

$$\times 10 \quad \begin{bmatrix} 2 & -1 & 0 \\ -1 & 3 & -1 \\ 0 & -1 & 2 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix} = \begin{bmatrix} 2 \\ 10 \\ 12 \end{bmatrix}$$

$$i_1 = 5.25 \text{ mA}, \quad i_2 = 8.5 \text{ mA}, \quad i_3 = 10.25 \text{ mA}$$

(3.69) write nodal equations by inspection.
solve.



$$\times 10^{-3} \begin{bmatrix} 1.75 & -.25 & -1 \\ -.25 & 1 & -.25 \\ -1 & -.25 & .75 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 20 \\ 5 \\ 5 \end{bmatrix} \times 10^{-3}$$

$$G_{11} = \frac{1}{2k} + \frac{1}{4k} + \frac{1}{k} = .5 \times 10^{-3} + .25 \times 10^{-3} + 1 \times 10^{-3} = 1.75 \times 10^{-3}$$

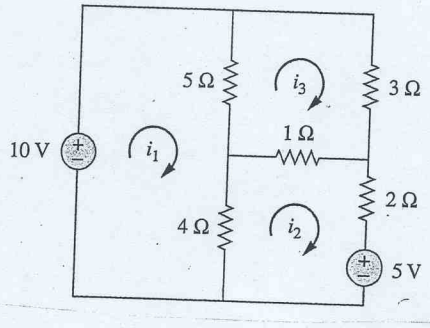
$$G_{12} = -\frac{1}{4k} = -.25 \times 10^{-3}; \quad G_{13} = -\frac{1}{k} = -1 \times 10^{-3}$$

$$G_{22} = \frac{1}{4k} + \frac{1}{2k} + \frac{1}{4k} = (.25 + .5 + .25) \times 10^{-3}$$

$$G_{23} = -\frac{1}{4k} = -.25 \times 10^{-3}$$

$$G_{33} = \frac{1}{4k} + \frac{1}{2k} = .25 + .5$$

3.71

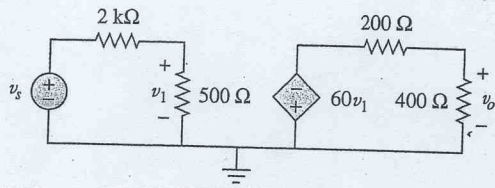


Find i_1 , i_2 , i_3 by inspection.

$$\begin{bmatrix} 7 & -4 & -5 \\ -4 & 7 & -1 \\ -5 & -1 & 9 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix} = \begin{bmatrix} 10 \\ -5 \\ 0 \end{bmatrix}$$

$$i_1 = 5.53 \text{ A} \quad i_2 = 2.93 \text{ A} \quad i_3 = 3.4 \text{ A}$$

3.87 Find the gain V_o/V_s .



By voltage division

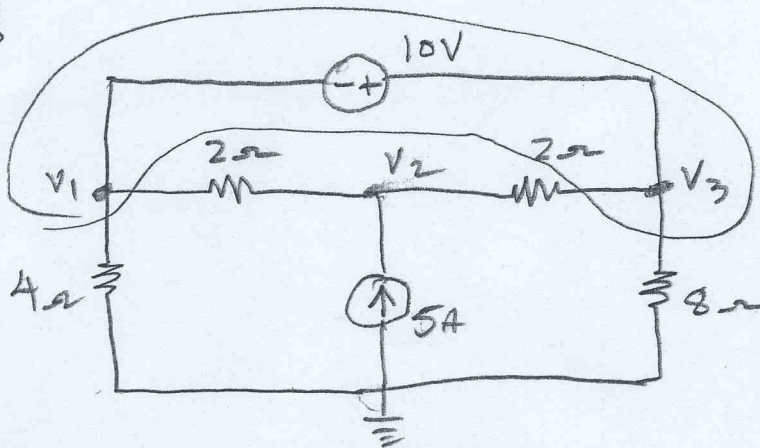
$$V_o = - \frac{60V_1 \times 400}{400 + 200} = - \frac{60 \times 400 \times V_1}{600} = - 40V_1$$

$$V_1 = \frac{500 V_s}{2.5K} = 0.2V_s$$

$$V_o = - 40 \times (0.2V_s)$$

$$\frac{V_o}{V_s} = - 8$$

3.18



$$\frac{V_1}{4} + \frac{V_1 - V_2}{2} + \frac{V_3 - V_2}{2} + \frac{V_3}{8} = 0$$

$$2V_1 + 4V_1 - 4V_2 + 4V_3 - 4V_2 + V_3 = 0$$

$$\boxed{6V_1 - 8V_2 + 5V_3 = 0}$$

$$\frac{V_2 - V_1}{2} + \frac{V_2 - V_3}{2} - 5 = 0$$

$$V_2 - V_1 + V_2 - V_3 - 10 = 0$$

$$\boxed{-V_1 + 2V_2 - V_3 = 10}$$

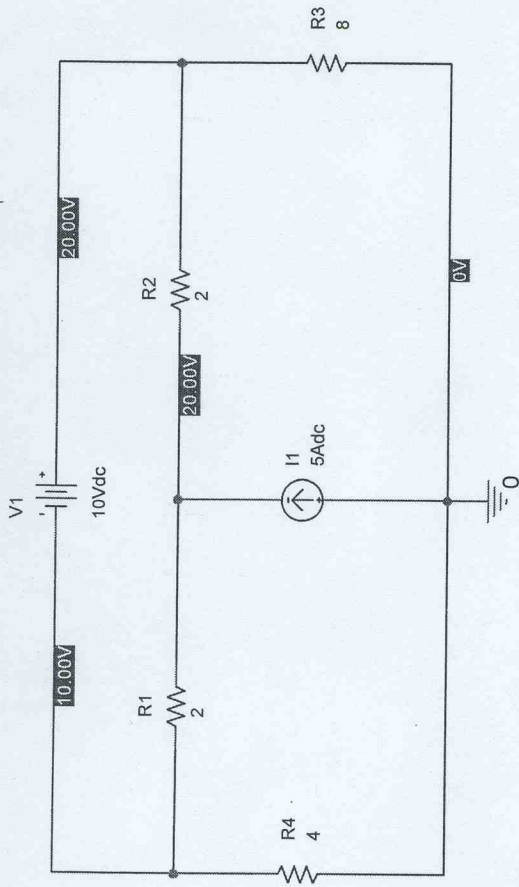
$$V_1 + 10 - V_3 = 0$$

$$\boxed{V_1 + 0V_2 - V_3 = -10}$$

Name
Circuit 3.18

$$\begin{bmatrix} 6 & -8 & 5 \\ -1 & 2 & -1 \\ 1 & 0 & -1 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 0 \\ 10 \\ -10 \end{bmatrix}$$

$$V_1 = 10V \quad V_2 = 20V \quad V_3 = 20V$$



Problem 3.18 3rd

Name: circuit3.18

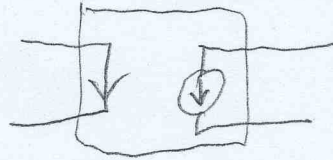
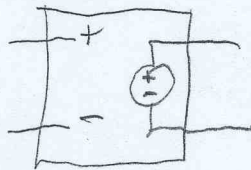
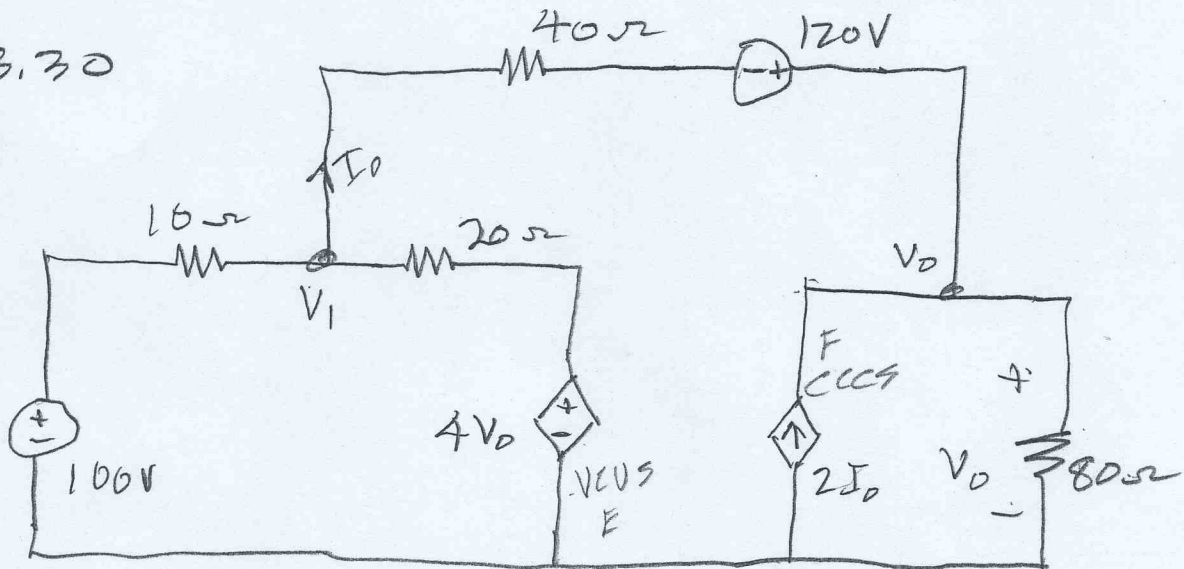
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3.30



$$\frac{V_1 - 100}{10} + \frac{V_1 - 4V_0}{20} + \frac{V_1 + 120 - V_0}{40} = 0$$

$$4V_1 - 400 + 2V_1 - 8V_0 + V_1 + 120 - V_0 = 0$$

$$\boxed{-9V_0 + 7V_1 = 280}$$

480
240
720
240

$$\frac{V_0}{80} + \frac{V_0 - 120 - V_1}{40} - 2 \left(\frac{V_1 + 120 - V_0}{40} \right) = 0$$

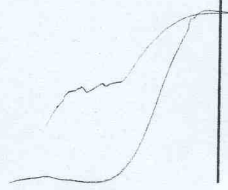
$$V_0 + 2V_0 - 240 - 2V_1 - 4V_1 - 480 + 4V_0 = 0$$

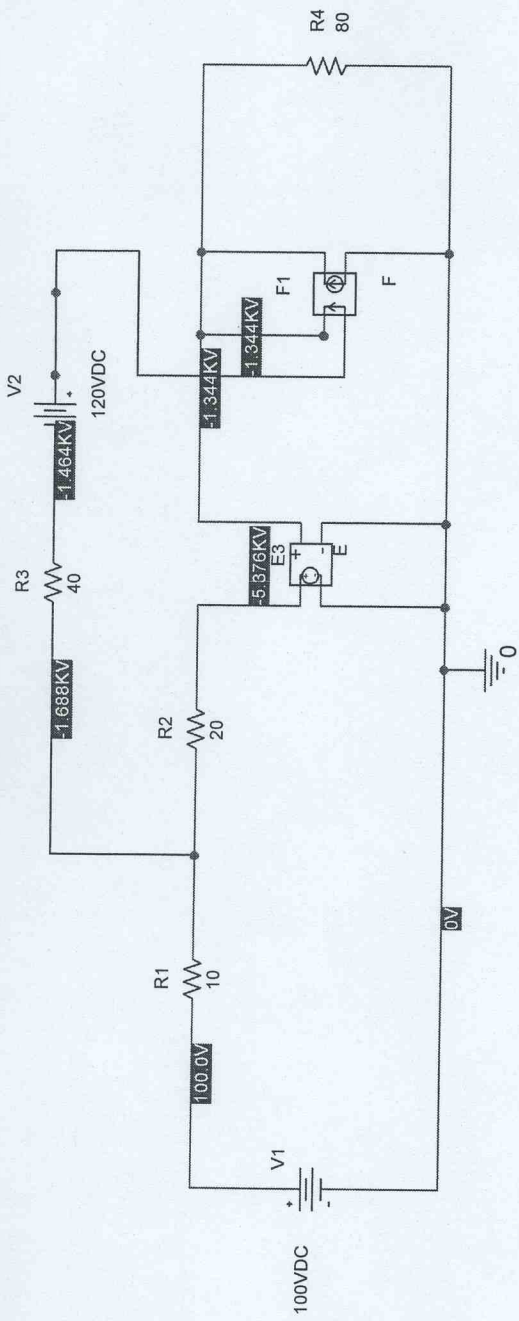
$$7V_0 - 6V_1 - 720 = 0$$

$$\boxed{7V_0 - 6V_1 = 720}$$

$$V_0 = -1344 \text{ V}$$

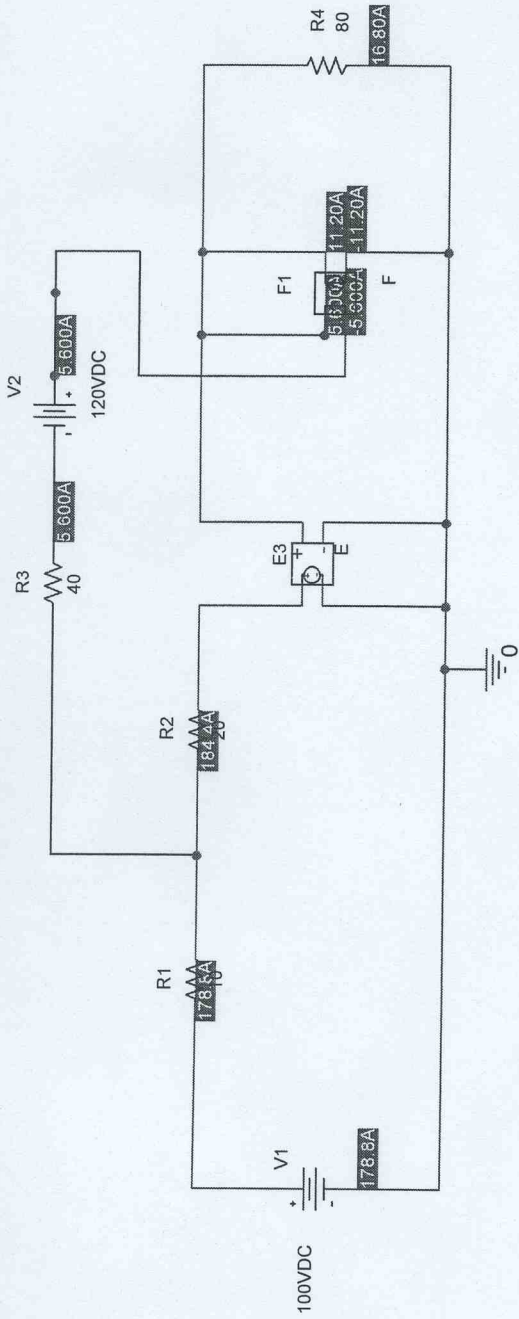
$$V_1 = -1688 \text{ V}$$





Problem 3,30
 checked Analytically
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 Jan 26, 06
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