**Chapter 3, Problem 1.**

Determine $I_x$ in the circuit shown in Fig. 3.50 using nodal analysis.

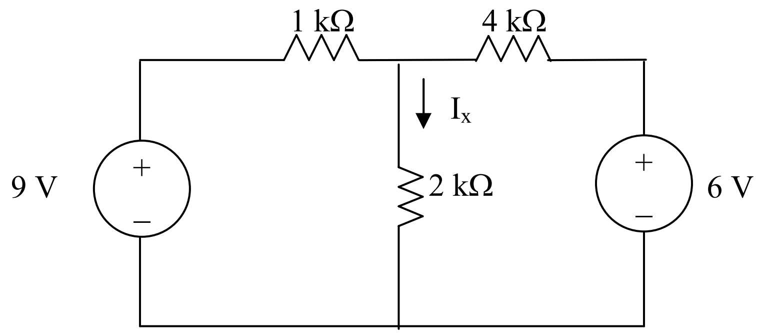



**Figure 3.50 For Prob. 3.1.**

**Chapter 3, Solution 1**

Let $V_x$ be the voltage at the node between 1-kΩ and 4-kΩ resistors.

$$\frac{9-V_x}{1k}+\frac{6-V_x}{4k}=\frac{V_k}{2k} \quad \longrightarrow \quad V_x=6$$

$$I_x=\frac{V_x}{2k}=\underline{3\ \text{mA}}$$

**Chapter 3, Problem 2.**

For the circuit in Fig. 3.51, obtain $\boldsymbol{v_1}$ and $\boldsymbol{v_2}$.

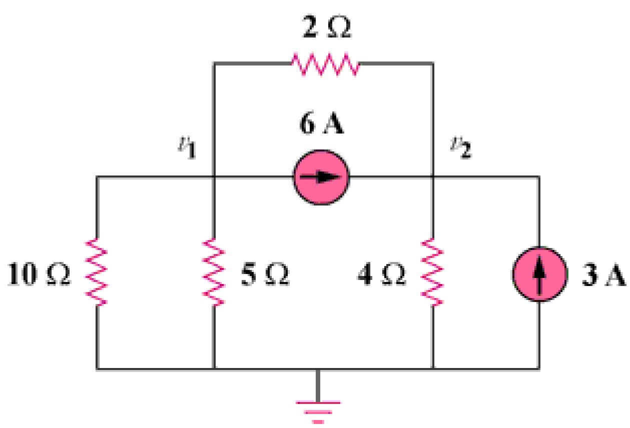



Figure 3.51

**Chapter 3, Solution 2**

At node 1,

$$\frac{-v_1}{10} - \frac{v_1}{5} = 6 + \frac{v_1 - v_2}{2} \longrightarrow 60 = -8v_1 + 5v_2 \qquad (1)$$

At node 2,

$$\frac{v_2}{4} = 3 + 6 + \frac{v_1 - v_2}{2} \longrightarrow 36 = -2v_1 + 3v_2 \qquad (2)$$

Solving (1) and (2),

$v_1$ = **<u>0 V</u>**, $v_2$ = **<u>12 V</u>**

**Chapter 3, Problem 3.**

Find the currents $\boldsymbol{i_1}$ through $\boldsymbol{i_4}$ and the voltage $\boldsymbol{v_o}$ in the circuit in Fig. 3.52.

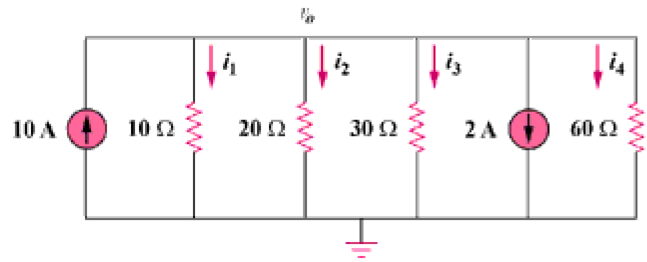



Figure 3.52

**Chapter 3, Solution 3**

Applying KCL to the upper node,

$$10 = \frac{v_0}{10} + \frac{v_o}{20} + \frac{v_o}{30} + 2 + \frac{v_0}{60} \longrightarrow \quad v_0 = \underline{\mathbf{40\ V}}$$

$$i_1 = \frac{v_0}{10} = \underline{\mathbf{4\ A}}\ ,\ i_2 = \frac{v_0}{20} = \underline{\mathbf{2\ A}},\ i_3 = \frac{v_0}{30} = \underline{\mathbf{1.3333\ A}},\ i_4 = \frac{v_0}{60} = \underline{\mathbf{666.7\ mA}}$$

**Chapter 3, Problem 4.**

Given the circuit in Fig. 3.53, calculate the currents $\boldsymbol{i_1}$ through $\boldsymbol{i_4}$.

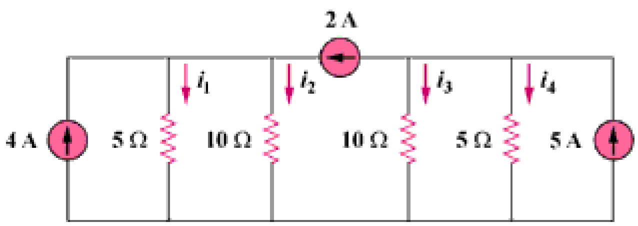
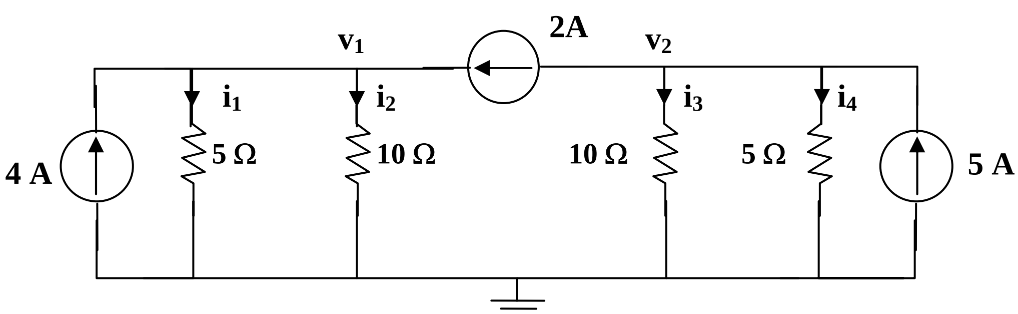



Figure 3.53

**Chapter 3, Solution 4**




At node 1,

$$4 + 2 = v_1/(5) + v_1/(10) \longrightarrow v_1 = 20$$

At node 2,

$$5 - 2 = v_2/(10) + v_2/(5) \longrightarrow v_2 = 10$$

$i_1 = v_1/(5) =$ **<u>4 A</u>**, $i_2 = v_1/(10) =$ **<u>2 A</u>**, $i_3 = v_2/(10) =$ **<u>1 A</u>**, $i_4 = v_2/(5) =$ **<u>2 A</u>**

**Chapter 3, Problem 5.**

Obtain $v_0$ in the circuit of Fig. 3.54.

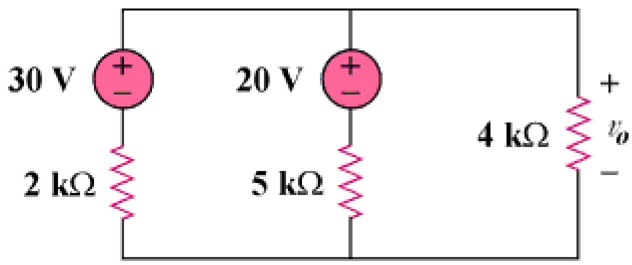



Figure 3.54

**Chapter 3, Solution 5**

Apply KCL to the top node.

$$\frac{30 - v_0}{2k} + \frac{20 - v_0}{5k} = \frac{v_0}{4k} \longrightarrow v_0 = \underline{\mathbf{20\ V}}$$

**Chapter 3, Problem 6.**

Use nodal analysis to obtain $\boldsymbol{v_0}$ in the circuit in Fig. 3.55.

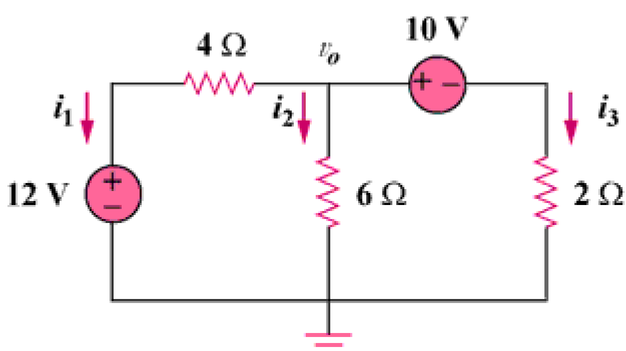



Figure 3.55

**Chapter 3, Solution 6**

$i_1 + i_2 + i_3 = 0$ $$\frac{v_2 - 12}{4} + \frac{v_0}{6} + \frac{v_0 - 10}{2} = 0$$

or $v_0 = \underline{\mathbf{8.727\ V}}$

**Chapter 3, Problem 7.**

Apply nodal analysis to solve for $V_x$ in the circuit in Fig. 3.56.

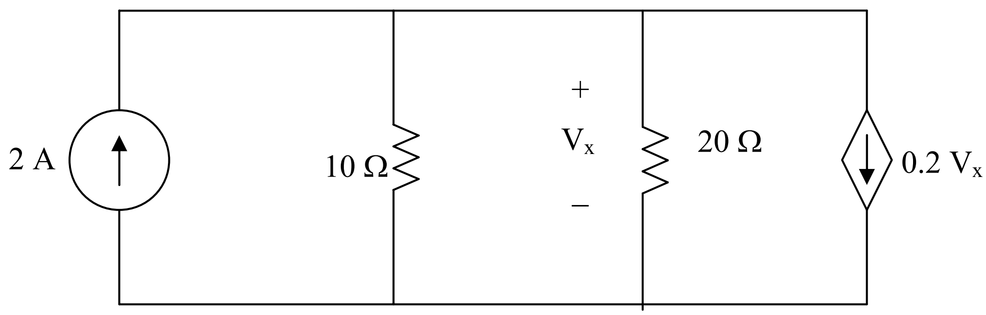



**Figure 3.56 For Prob. 3.7.**

**Chapter 3, Solution 7**

$$-2 + \frac{V_x - 0}{10} + \frac{V_x - 0}{20} + 0.2V_x = 0$$

$0.35V_x = 2$ or $V_x =$ **5.714 V**.

Substituting into the original equation for a check we get,

$$0.5714 + 0.2857 + 1.1428 = 1.9999 \text{ checks!}$$

**Chapter 3, Problem 8.**

Using nodal analysis, find $v_0$ in the circuit in Fig. 3.57.

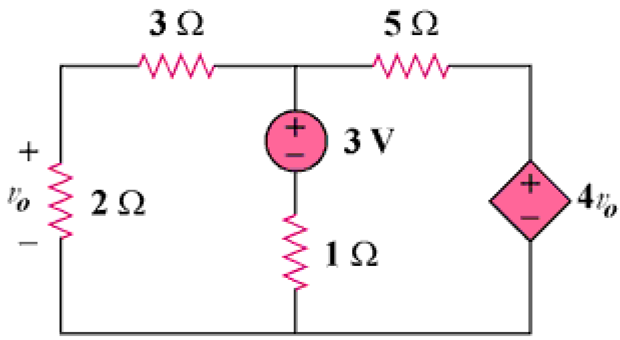
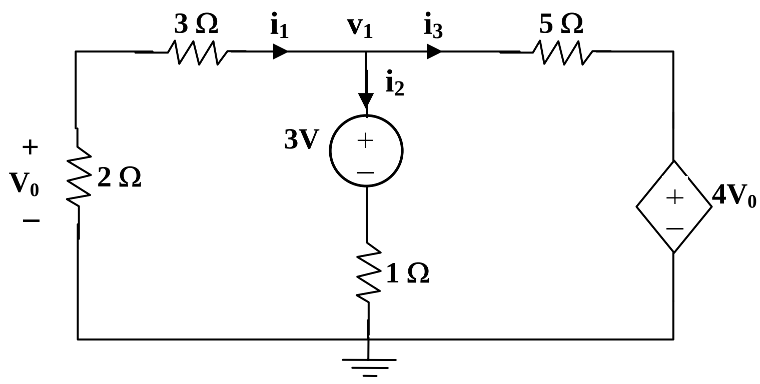



Figure 3.57

**Chapter 3, Solution 8**




$$i_1 + i_2 + i_3 = 0 \longrightarrow \frac{v_1}{5} + \frac{v_1 - 3}{1} + \frac{v_1 - 4v_0}{5} = 0$$

But $v_0 = \frac{2}{5}v_1$ so that $v_1 + 5v_1 - 15 + v_1 - \frac{8}{5}v_1 = 0$

or $v_1 = 15x5/(27) = 2.778$ V, therefore $v_o = 2v_1/5 =$ **1.1111 V**

**Chapter 3, Problem 9.**

Determine $I_b$ in the circuit in Fig. 3.58 using nodal analysis.

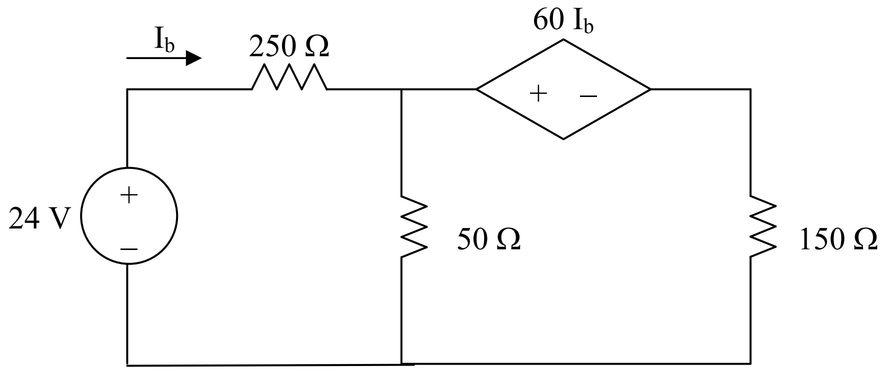



**Figure 3.58 For Prob. 3.9.**

**Chapter 3, Solution 9**

Let $V_1$ be the unknown node voltage to the right of the 250-Ω resistor. Let the ground reference be placed at the bottom of the 50-Ω resistor. This leads to the following nodal equation:

$$\frac{V_1 - 24}{250} + \frac{V_1 - 0}{50} + \frac{V_1 - 60I_b - 0}{150} = 0$$

simplifying we get

$$3V_1 - 72 + 15V_1 + 5V_1 - 300I_b = 0$$

But $I_b = \dfrac{24 - V_1}{250}$. Substituting this into the nodal equation leads to

$$24.2V_1 - 100.8 = 0 \quad \text{or } V_1 = 4.165 \text{ V.}$$

Thus, $I_b = (24 - 4.165)/250 =$ **79.34 mA**.

**Chapter 3, Problem 10.**

Find $i_0$ in the circuit in Fig. 3.59.

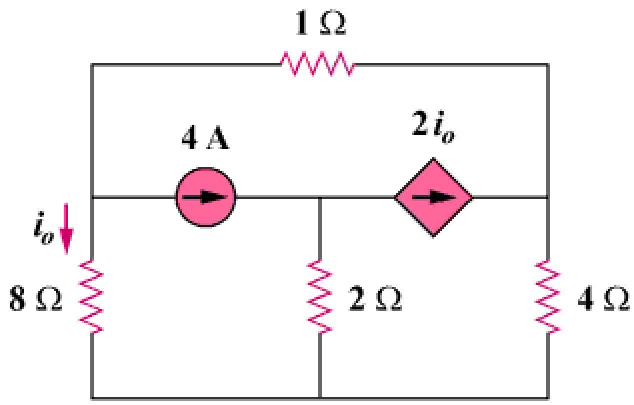
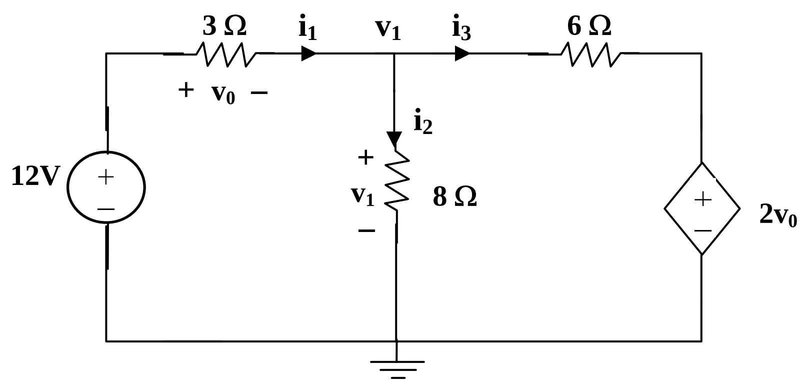



Figure 3.59

**Chapter 3, Solution 10**




At the non-reference node,

$$\frac{12 - v_1}{3} = \frac{v_1}{8} + \frac{v_1 - 2v_0}{6} \qquad (1)$$

But

$$-12 + v_0 + v_1 = 0 \longrightarrow v_0 = 12 - v_1 \qquad (2)$$

Substituting (2) into (1),

$$\frac{12 - v_1}{3} = \frac{v_1}{8} + \frac{3v_1 - 24}{6} \longrightarrow v_0 = \underline{\mathbf{3.652\ V}}$$

**Chapter 3, Problem 11.**

Find $V_o$ and the power dissipated in all the resistors in the circuit of Fig. 3.60.

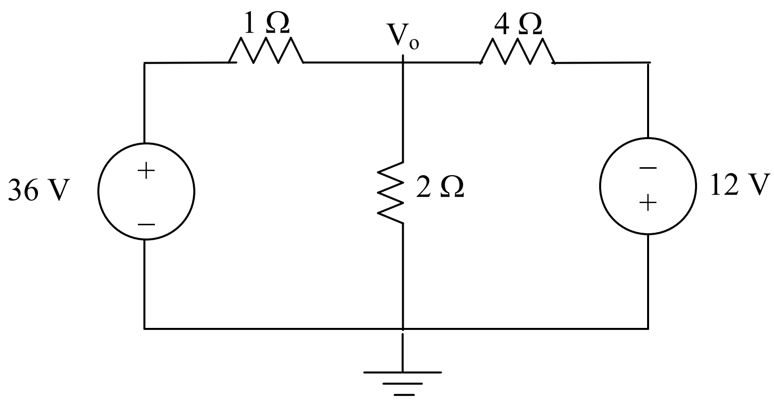



**Figure 3.60 For Prob. 3.11.**

**Chapter 3, Solution 11**

At the top node, KVL gives

$$\frac{V_o - 36}{1} + \frac{V_o - 0}{2} + \frac{V_o - (-12)}{4} = 0$$

$1.75V_o = 33$ or $V_o = 18.857\text{V}$

$P_{1\Omega} = (36–18.857)^2/1 =$ **293.9 W**

$P_{2\Omega} = (V_o)^2/2 = (18.857)^2/2 =$ **177.79 W**

$P_{4\Omega} = (18.857+12)^2/4 =$ **238 W**.

**Chapter 3, Problem 12.**

Using nodal analysis, determine $V_o$ in the circuit in Fig. 3.61.

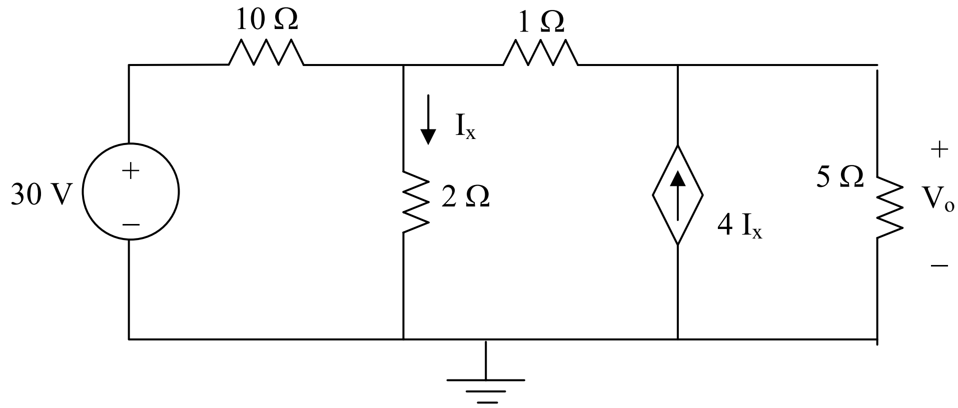
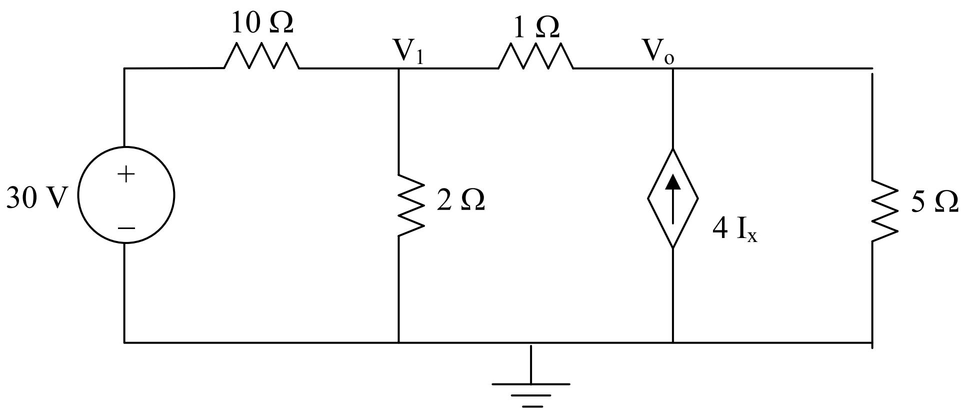



**Figure 3.61 For Prob. 3.12.**

**Chapter 3, Solution 12**

There are two unknown nodes, as shown in the circuit below.




At node 1,

$$\frac{V_1 - 30}{10} + \frac{V_1 - 0}{2} + \frac{V_1 - V_o}{1} = 0 \qquad (1)$$

$$16V_1 - 10V_o = 30$$

At node o,

$$\frac{V_o - V_1}{1} - 4I_x + \frac{V_o - 0}{5} = 0 \qquad (2)$$

$$-5V_1 + 6V_o - 20I_x = 0$$

But $I_x = V_1/2$. Substituting this in (2) leads to

$$-15V_1 + 6V_o = 0 \quad \text{or} \quad V_1 = 0.4V_o \qquad (3)$$

Substituting (3) into 1,

$$16(0.4V_o) - 10V_o = 30 \quad \text{or} \quad V_o = \underline{\mathbf{-8.333\ V}}.$$

**Chapter 3, Problem 13.**

Calculate $v_1$ and $v_2$ in the circuit of Fig. 3.62 using nodal analysis.

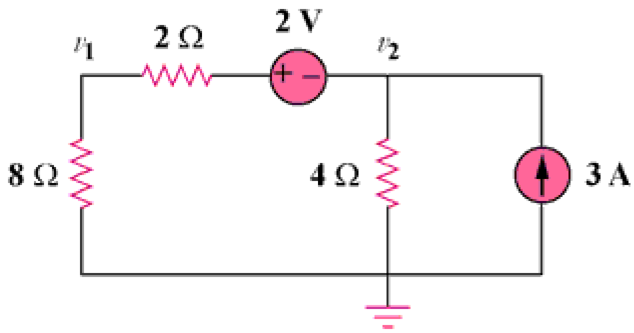



Figure 3.62

**Chapter 3, Solution 13**

At node number 2, $[(v_2 + 2) - 0]/10 + v_2/4 = 3$ or $v_2 =$ **8 volts**

But, $I = [(v_2 + 2) - 0]/10 = (8 + 2)/10 = 1$ amp and $v_1 = 8x1 =$ **8volts**

**Chapter 3, Problem 14.**

Using nodal analysis, find $\boldsymbol{v_o}$ in the circuit of Fig. 3.63.

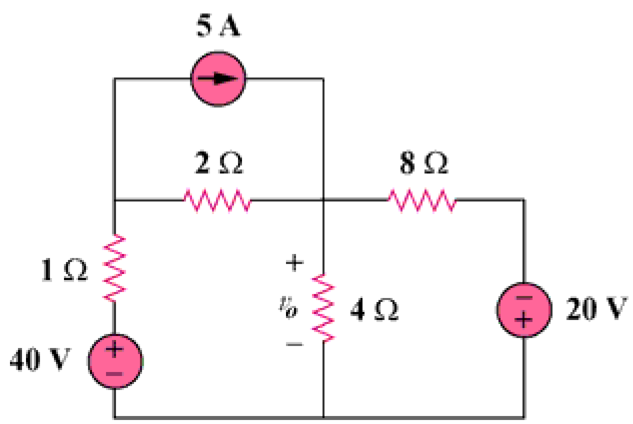
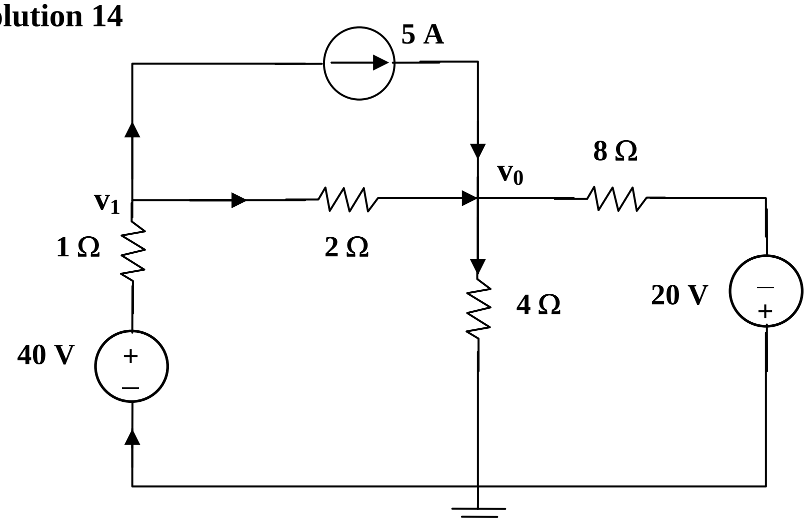



Figure 3.63

**Chapter 3, Solution 14**




At node 1, $\dfrac{v_1 - v_0}{2} + 5 = \dfrac{40 - v_0}{1} \longrightarrow v_1 + v_0 = 70$ (1)

At node 0, $\dfrac{v_1 - v_0}{2} + 5 = \dfrac{v_0}{4} + \dfrac{v_0 + 20}{8} \longrightarrow 4v_1 - 7v_0 = -20$ (2)

Solving (1) and (2), $v_0 =$ <u>**27.27 V**</u>

**Chapter 3, Problem 15.**

Apply nodal analysis to find $i_o$ and the power dissipated in each resistor in the circuit of Fig. 3.64.

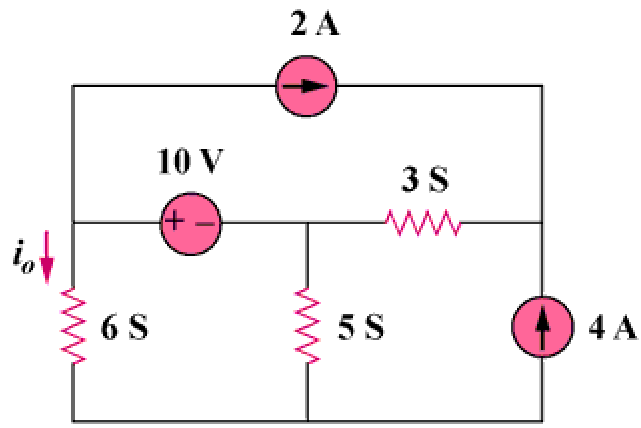
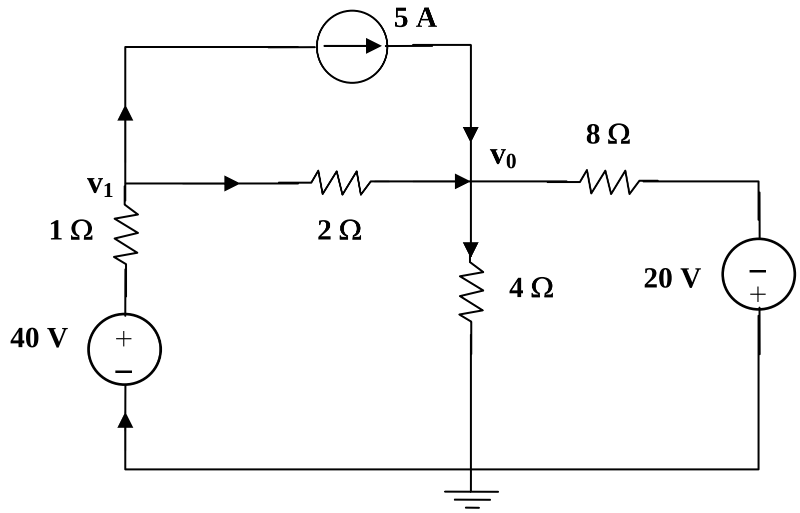



Figure 3.64

**Chapter 3, Solution 15**




Nodes 1 and 2 form a supernode so that $v_1 = v_2 + 10$ (1)

At the supernode, $2 + 6v_1 + 5v_2 = 3\,(v_3 - v_2) \longrightarrow 2 + 6v_1 + 8v_2 = 3v_3$ (2)

At node 3, $2 + 4 = 3\,(v_3 - v_2) \longrightarrow v_3 = v_2 + 2$ (3)

Substituting (1) and (3) into (2),

$$2 + 6v_2 + 60 + 8v_2 = 3v_2 + 6 \longrightarrow v_2 = \frac{-56}{11}$$

$$v_1 = v_2 + 10 = \frac{54}{11}$$

$i_0 = 6v_i =$ **29.45 A**

$$P_{65} = \frac{v_1^2}{R} = v_1^2 G = \left(\frac{54}{11}\right)^2 6 = \underline{\mathbf{144.6\ W}}$$

$$P_{55} = v_2^2 G = \left(\frac{-56}{11}\right)^2 5 = \underline{\mathbf{129.6\ W}}$$

$$P_{35} = (v_L - v_3)^2 G = (2)^2 3 = \underline{\mathbf{12\ W}}$$

**Chapter 3, Problem 16.**

Determine voltages $v_1$ through $v_3$ in the circuit of Fig. 3.65 using nodal analysis.

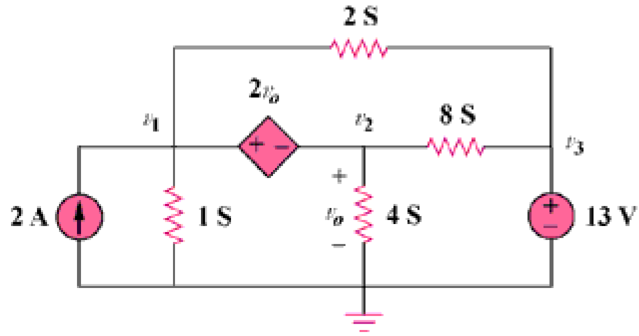
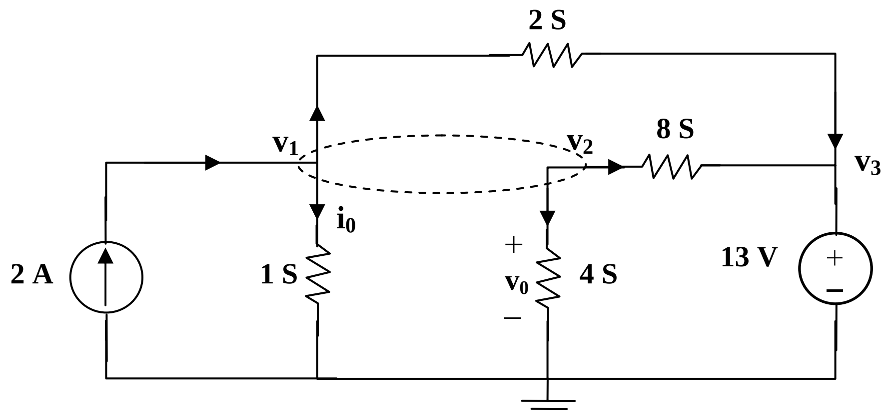



Figure 3.65

**Chapter 3, Solution 16**




At the supernode,

$$2 = v_1 + 2\,(v_1 - v_3) + 8(v_2 - v_3) + 4v_2, \text{ which leads to } 2 = 3v_1 + 12v_2 - 10v_3 \quad (1)$$

But

$v_1 = v_2 + 2v_0$ and $v_0 = v_2$.

Hence

$$v_1 = 3v_2 \quad (2)$$
$$v_3 = 13\text{V} \quad (3)$$

Substituting (2) and (3) with (1) gives,

$v_1$ = **18.858 V**, $v_2$ = **6.286 V**, $v_3$ = **13 V**

**Chapter 3, Problem 17.**

Using nodal analysis, find current $i_o$ in the circuit of Fig. 3.66.

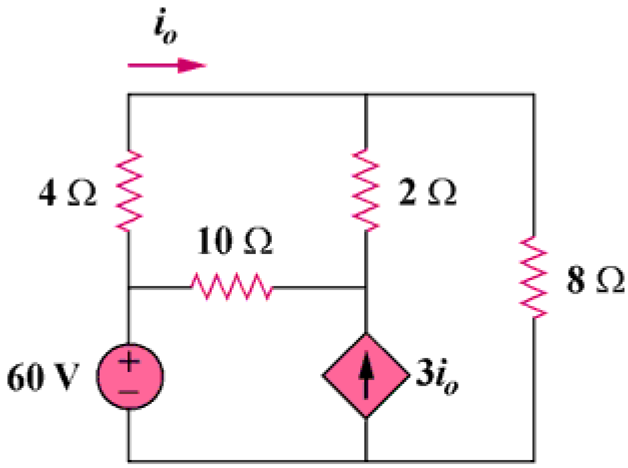
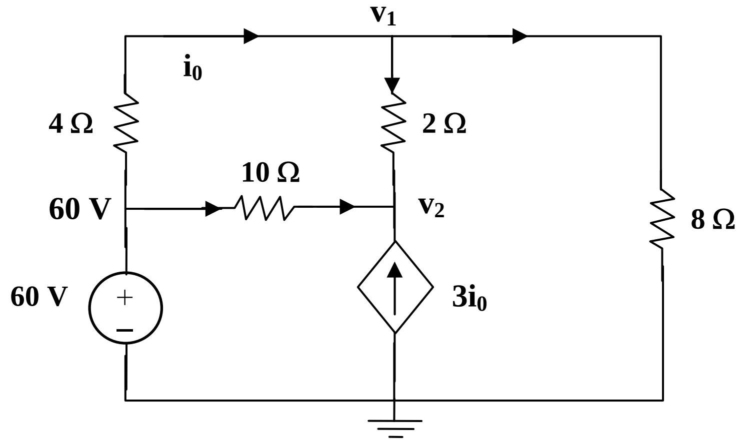



Figure 3.66

## Chapter 3, Solution 17




At node 1, $\dfrac{60-v_1}{4} = \dfrac{v_1}{8} + \dfrac{v_1 - v_2}{2}$ $\qquad 120 = 7v_1 - 4v_2 \qquad (1)$

At node 2, $3i_0 + \dfrac{60-v_2}{10} + \dfrac{v_1 - v_2}{2} = 0$

But $i_0 = \dfrac{60-v_1}{4}$.

Hence

$$\frac{3(60-v_1)}{4} + \frac{60-v_2}{10} + \frac{v_1-v_2}{2} = 0 \longrightarrow 1020 = 5v_1 + 12v_2 \qquad (2)$$

Solving (1) and (2) gives $v_1 = 53.08$ V. Hence $i_0 = \dfrac{60-v_1}{4} =$ **1.73 A**

**Chapter 3, Problem 18.**

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

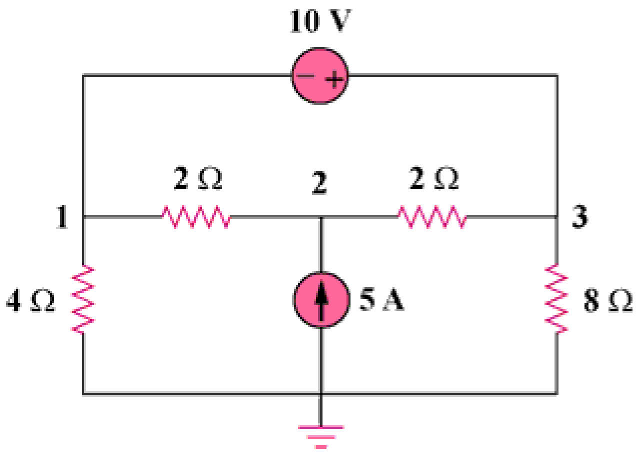
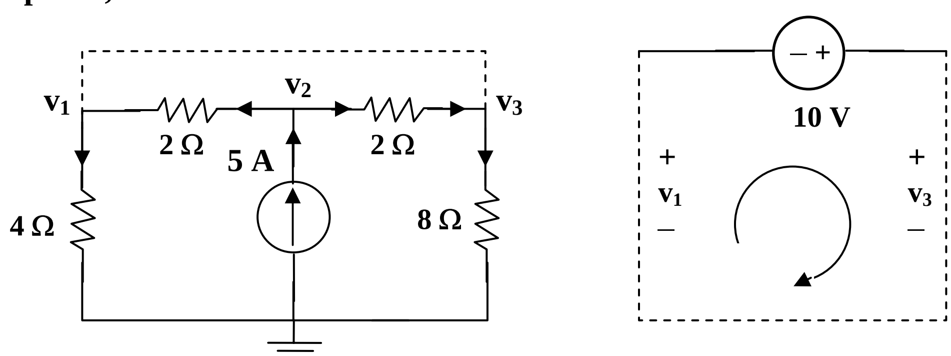



Figure 3.67

**Chapter 3, Solution 18**




(a) (b)

At node 2, in Fig. (a), $5 = \frac{v_2 - v_1}{2} + \frac{v_2 - v_3}{2} \longrightarrow 10 = -v_1 + 2v_2 - v_3$ (1)

At the supernode, $\frac{v_2 - v_1}{2} + \frac{v_2 - v_3}{2} = \frac{v_1}{4} + \frac{v_3}{8} \longrightarrow 40 = 2v_1 + v_3$ (2)

From Fig. (b), $-v_1 - 10 + v_3 = 0 \longrightarrow v_3 = v_1 + 10$ (3)

Solving (1) to (3), we obtain $v_1 =$ **<u>10 V</u>**, $v_2 =$ **<u>20 V</u>** $= v_3$

**Chapter 3, Problem 19.**

Use nodal analysis to find $v_1$, $v_2$, and $v_3$ in the circuit in Fig. 3.68.

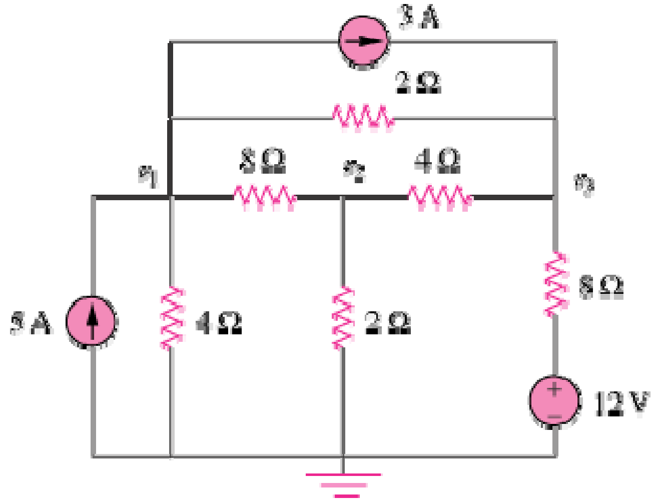



Figure 3.68

**Chapter 3, Solution 19**

At node 1,

$$5 = 3 + \frac{V_1 - V_3}{2} + \frac{V_1 - V_2}{8} + \frac{V_1}{4} \quad \longrightarrow \quad 16 = 7V_1 - V_2 - 4V_3 \qquad (1)$$

At node 2,

$$\frac{V_1 - V_2}{8} = \frac{V_2}{2} + \frac{V_2 - V_3}{4} \quad \longrightarrow \quad 0 = -V_1 + 7V_2 - 2V_3 \qquad (2)$$

At node 3,

$$3 + \frac{12 \ - V_3}{8} + \frac{V_1 - V_3}{2} + \frac{V_2 - V_3}{4} = 0 \quad \longrightarrow \quad -36 = 4V_1 + 2V_2 - 7V_3 \quad (3)$$

From (1) to (3),

$$\begin{pmatrix} 7 & -1 & -4 \\ -1 & 7 & -2 \\ 4 & 2 & -7 \end{pmatrix} \begin{pmatrix} V_1 \\ V_2 \\ V_3 \end{pmatrix} = \begin{pmatrix} 16 \\ 0 \\ -36 \end{pmatrix} \quad \longrightarrow \quad AV = B$$

Using MATLAB,

$$V = A^{-1}B = \begin{bmatrix} 10 \\ 4.933 \\ 12.267 \end{bmatrix} \quad \longrightarrow \quad \underline{V_1 = 10\text{ V},\ V_2 = 4.933\text{ V},\ V_3 = 12.267\text{ V}}$$

**Chapter 3, Problem 20.**

For the circuit in Fig. 3.69, find $v_1$, $v_2$, and $v_3$ using nodal analysis.

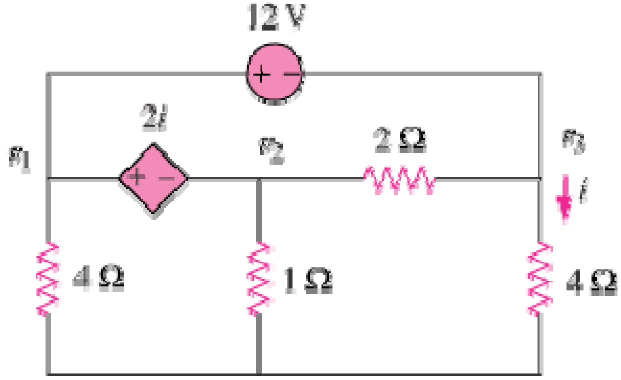
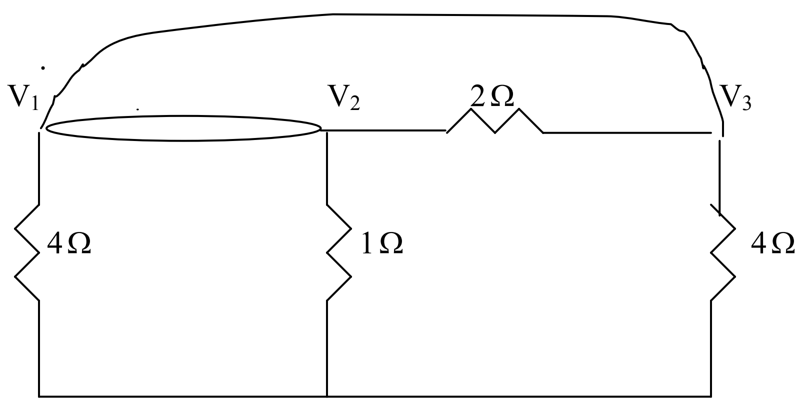



Figure 3.69

**Chapter 3, Solution 20**

Nodes 1 and 2 form a supernode; so do nodes 1 and 3. Hence

$$\frac{V_1}{4}+\frac{V_2}{1}+\frac{V_3}{4}=0 \qquad \longrightarrow \qquad V_1+4V_2+V_3=0 \qquad (1)$$




Between nodes 1 and 3,

$$-V_1+12+V_3=0 \qquad \longrightarrow \qquad V_3=V_1-12 \qquad (2)$$

Similarly, between nodes 1 and 2,

$$V_1=V_2+2i \qquad (3)$$

But $i=V_3/4$. Combining this with (2) and (3) gives

$$V_2=6+V_1/2 \qquad (4)$$

Solving (1), (2), and (4) leads to

$$\underline{V_1=-3\text{V}, \quad V_2=4.5\text{V}, V_3=-15\text{V}}$$

**Chapter 3, Problem 21.**

For the circuit in Fig. 3.70, find $v_1$ and $v_2$ using nodal analysis.

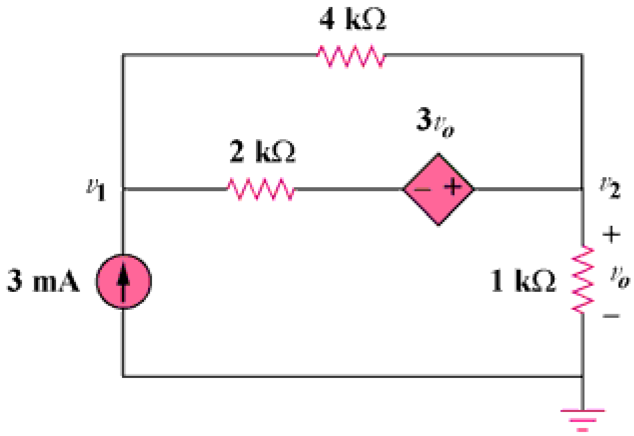
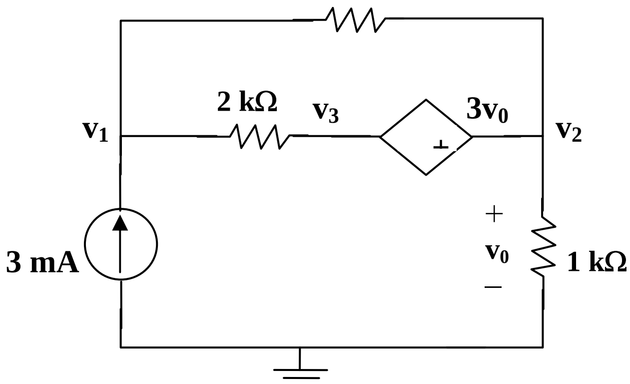
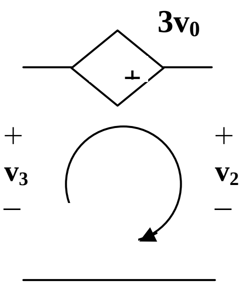



Figure 3.70

**Chapter 3, Solution 21**




(a)




(b)

Let $v_3$ be the voltage between the 2kΩ resistor and the voltage-controlled voltage source. At node 1,

$$3x10^{-3} = \frac{v_1 - v_2}{4000} + \frac{v_1 - v_3}{2000} \longrightarrow 12 = 3v_1 - v_2 - 2v_3 \qquad (1)$$

At node 2,

$$\frac{v_1 - v_2}{4} + \frac{v_1 - v_3}{2} = \frac{v_2}{1} \longrightarrow 3v_1 - 5v_2 - 2v_3 = 0 \qquad (2)$$

Note that $v_0 = v_2$. We now apply KVL in Fig. (b)

$$- v_3 - 3v_2 + v_2 = 0 \longrightarrow v_3 = - 2v_2 \qquad (3)$$

From (1) to (3),

$v_1 =$ **1 V**, $v_2 =$ **3 V**

**Chapter 3, Problem 22.**

Determine $\boldsymbol{v_1}$ and $\boldsymbol{v_2}$ in the circuit in Fig. 3.71.

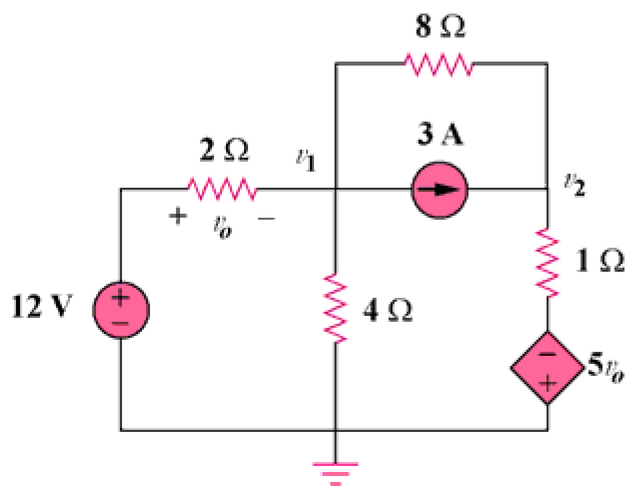



Figure 3.71

**Chapter 3, Solution 22**

At node 1, $\dfrac{12 - v_0}{2} = \dfrac{v_1}{4} + 3 + \dfrac{v_1 - v_0}{8} \longrightarrow 24 = 7v_1 - v_2$ (1)

At node 2, $3 + \dfrac{v_1 - v_2}{8} = \dfrac{v_2 + 5v_2}{1}$

But, $v_1 = 12 - v_1$

Hence, $24 + v_1 - v_2 = 8\ (v_2 + 60 + 5v_1) = 4$ V

$456 = 41v_1 - 9v_2$ (2)

Solving (1) and (2),

$v_1 =$ **<u>- 10.91 V</u>**, $v_2 =$ **<u>- 100.36 V</u>**

**Chapter 3, Problem 23.**

Use nodal analysis to find $V_o$ in the circuit of Fig. 3.72.

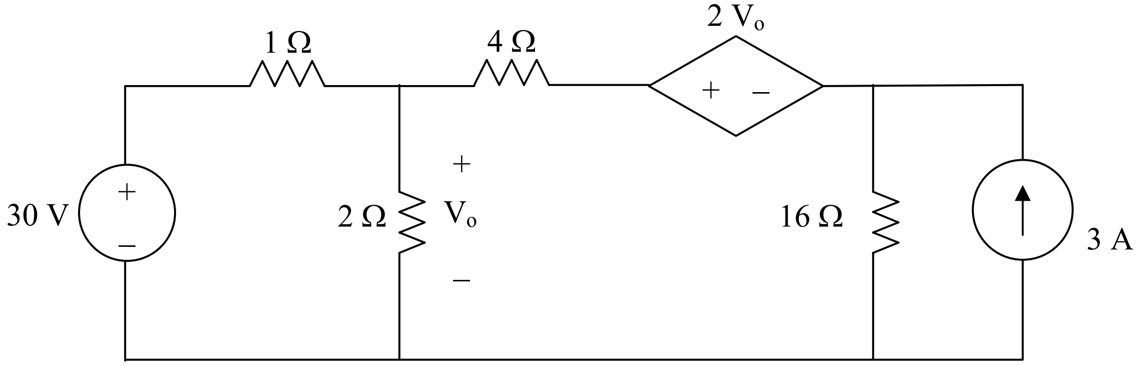
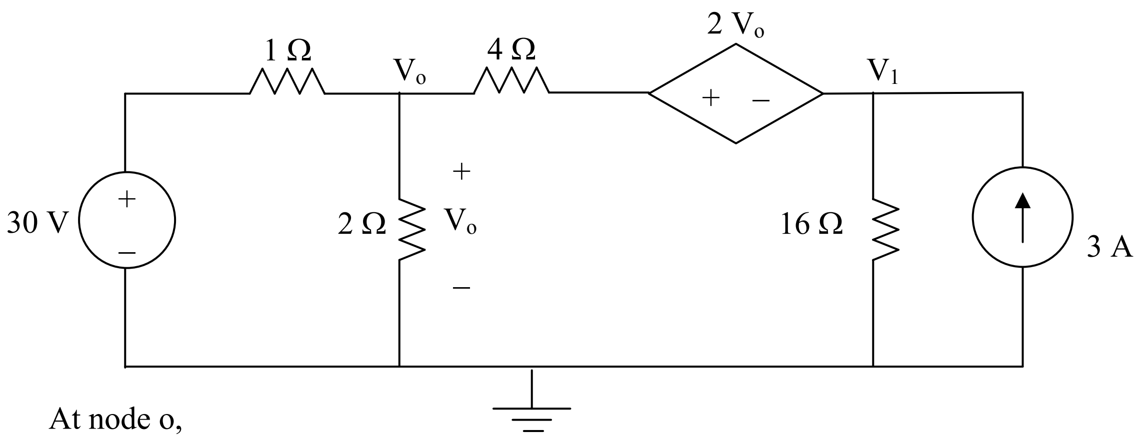



**Figure 3.72 For Prob. 3.23.**

**Chapter 3, Solution 23**

We apply nodal analysis to the circuit shown below.




At node o,

$$\frac{V_o - 30}{1} + \frac{V_o - 0}{2} + \frac{V_o - (2V_o + V_1)}{4} = 0 \rightarrow 1.25V_o - 0.25V_1 = 30$$
(1)

At node 1,

$$\frac{(2V_o + V_1) - V_o}{4} + \frac{V_1 - 0}{16} - 3 = 0 \rightarrow 5V_1 + 4V_o = 48 \qquad (2)$$

From (1), $V_1 = 5V_o - 120$. Substituting this into (2) yields
$29V_o = 648$ or $V_o =$ **22.34 V**.

**Chapter 3, Problem 24.**

Use nodal analysis and MATLAB to find $V_o$ in the circuit in Fig. 3.73.

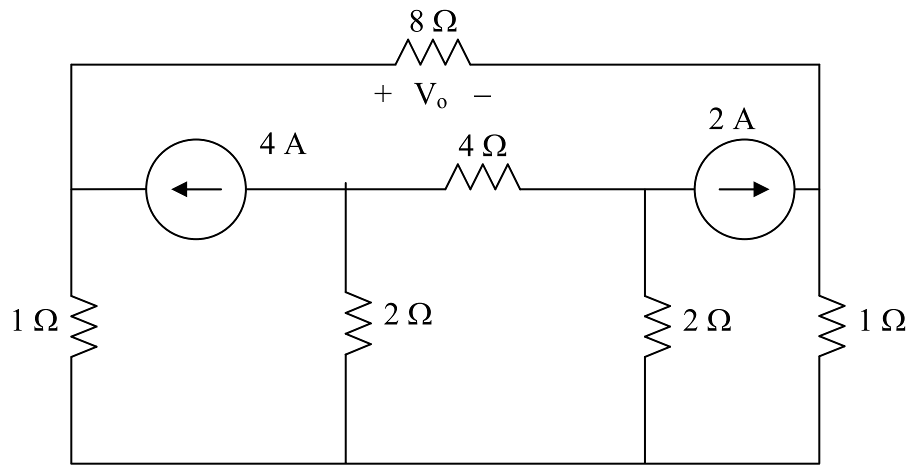
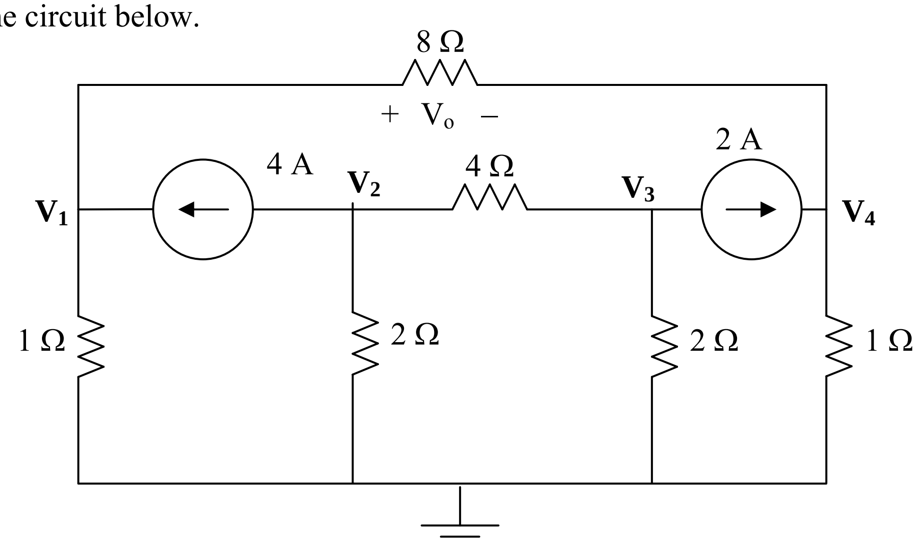



**Figure 3.73 For Prob. 3.24.**

**Chapter 3, Solution 24**

Consider the circuit below.



$$\frac{V_1 - 0}{1} - 4 + \frac{V_1 - V_4}{8} = 0 \rightarrow 1.125V_1 - 0.125V_4 = 4 \qquad (1)$$

$$+4 + \frac{V_2 - 0}{2} + \frac{V_2 - V_3}{4} = 0 \rightarrow 0.75V_2 - 0.25V_3 = -4 \qquad (2)$$

$$\frac{V_3 - V_2}{4} + \frac{V_3 - 0}{2} + 2 = 0 \rightarrow -0.25V_2 + 0.75V_3 = -2 \qquad (3)$$

$$-2 + \frac{V_4 - V_1}{8} + \frac{V_4 - 0}{1} = 0 \rightarrow -0.125V_1 + 1.125V_4 = 2 \qquad (4)$$

$$\begin{bmatrix} 1.125 & 0 & 0 & -0.125 \\ 0 & 0.75 & -0.25 & 0 \\ 0 & -0.25 & 0.75 & 0 \\ -0.125 & 0 & 0 & 1.125 \end{bmatrix} V = \begin{bmatrix} 4 \\ -4 \\ -2 \\ 2 \end{bmatrix}$$

Now we can use MATLAB to solve for the unknown node voltages.

```
>> Y=[1.125,0,0,-0.125;0,0.75,-0.25,0;0,-0.25,0.75,0;-0.125,0,0,1.125]

Y =
    1.1250         0         0   -0.1250
         0    0.7500   -0.2500         0
         0   -0.2500    0.7500         0
   -0.1250         0         0    1.1250

>> I=[4,-4,-2,2]'

I =
     4
    -4
    -2
     2

>> V=inv(Y)*I

V =
    3.8000
   -7.0000
   -5.0000
    2.2000
```

$V_o = V_1 - V_4 = 3.8 - 2.2 =$ **<u>1.6 V</u>**.

**Chapter 3, Problem 25.**

Use nodal analysis along with MATLAB to determine the node voltages in Fig. 3.74.

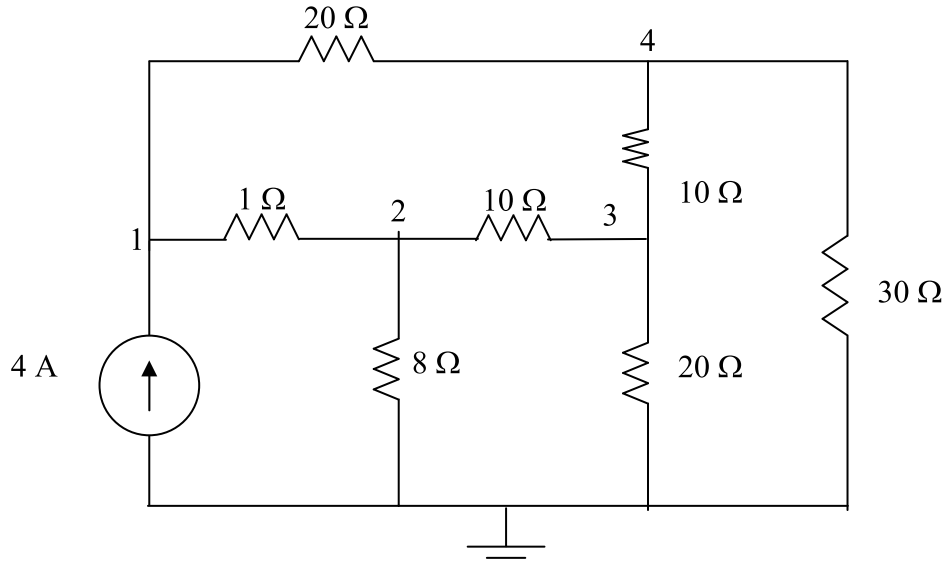
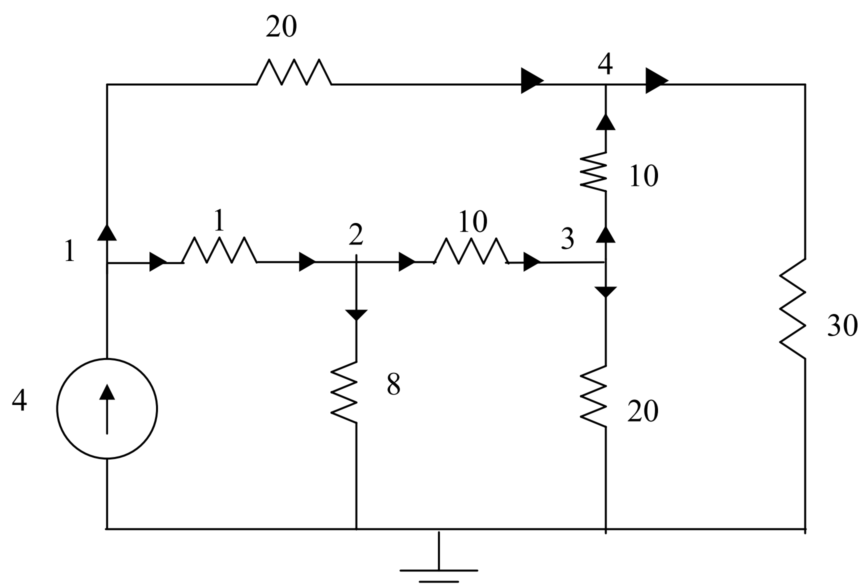



**Figure 3.74 For Prob. 3.25.**

**Chapter 3, Solution 25**

Consider the circuit shown below.



At node 1.

$$4 = \frac{V_1 - V_2}{1} + \frac{V_1 - V_4}{20} \longrightarrow 80 = 21V_1 - 20V_2 - V_4 \qquad (1)$$

At node 2,

$$\frac{V_1 - V_2}{1} = \frac{V_2}{8} + \frac{V_2 - V_3}{10} \longrightarrow 0 = -80V_1 + 98V_2 - 8V_3 \qquad (2)$$

At node 3,

$$\frac{V_2 - V_3}{10} = \frac{V_3}{20} + \frac{V_3 - V_4}{10} \longrightarrow 0 = -2V_2 + 5V_3 - 2V_4 \qquad (3)$$

At node 4,

$$\frac{V_1 - V_4}{20} + \frac{V_3 - V_4}{10} = \frac{V_4}{30} \longrightarrow 0 = 3V_1 + 6V_3 - 11V_4 \qquad (4)$$

Putting (1) to (4) in matrix form gives:

$$\begin{bmatrix} 80 \\ 0 \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} 21 & -20 & 0 & -1 \\ -80 & 98 & -8 & 0 \\ 0 & -2 & 5 & -2 \\ 3 & 0 & 6 & -11 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \\ V_4 \end{bmatrix}$$

$$B = A\ V \longrightarrow V = A^{-1} B$$

Using MATLAB leads to

$V_1$ = **<u>25.52 V</u>**, $V_2$ = **<u>22.05 V</u>**, $V_3$ = **<u>14.842 V</u>**, $V_4$ = **<u>15.055 V</u>**

**Chapter 3, Problem 26.**

Calculate the node voltages $v_1$, $v_2$, and $v_3$ in the circuit of Fig. 3.75.

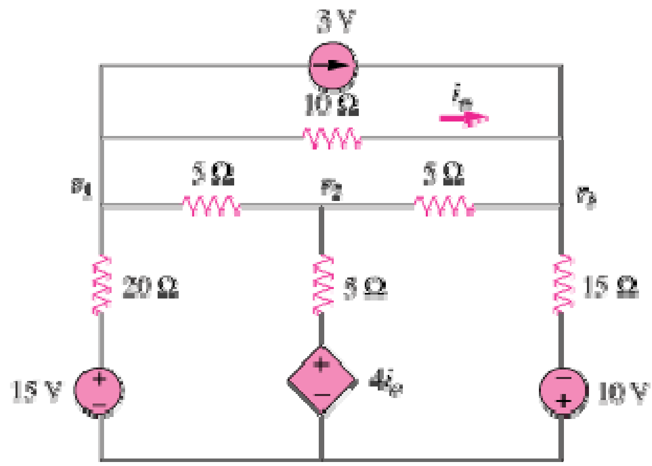



Figure 3.75

**Chapter 3, Solution 26**

At node 1,

$$\frac{15-V_1}{20} = 3 + \frac{V_1 - V_3}{10} + \frac{V_1 - V_2}{5} \longrightarrow -45 = 7V_1 - 4V_2 - 2V_3 \qquad (1)$$

At node 2,

$$\frac{V_1 - V_2}{5} + \frac{4I_o - V_2}{5} = \frac{V_2 - V_3}{5} \qquad (2)$$

But $I_o = \dfrac{V_1 - V_3}{10}$. Hence, (2) becomes

$$0 = 7V_1 - 15V_2 + 3V_3 \qquad (3)$$

At node 3,

$$3 + \frac{V_1 - V_3}{10} + \frac{-10 - V_3}{15} + \frac{V_2 - V_3}{5} = 0 \longrightarrow 70 = -3V_1 - 6V_2 + 11V_3 \qquad (4)$$

Putting (1), (3), and (4) in matrix form produces

$$\begin{pmatrix} 7 & -4 & -2 \\ 7 & -15 & 3 \\ -3 & -6 & 11 \end{pmatrix} \begin{pmatrix} V_1 \\ V_2 \\ V_3 \end{pmatrix} = \begin{pmatrix} -45 \\ 0 \\ 70 \end{pmatrix} \longrightarrow AV = B$$

Using MATLAB leads to

$$V = A^{-1}B = \begin{pmatrix} -7.19 \\ -2.78 \\ 2.89 \end{pmatrix}$$

Thus,

$V_1$ = **<u>–7.19V</u>**; $V_2$ = **<u>–2.78V</u>**; $V_3$ = **<u>2.89V</u>**.

**Chapter 3, Problem 27.**

Use nodal analysis to determine voltages $v_1$, $v_2$, and $v_3$ in the circuit in Fig. 3.76.

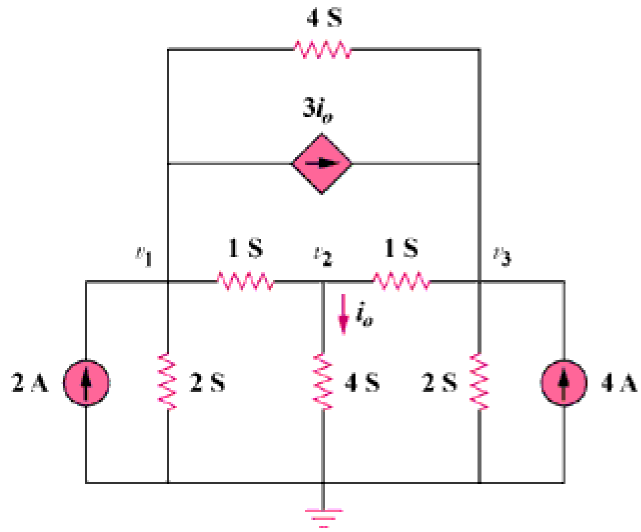



Figure 3.76

**Chapter 3, Solution 27**

At node 1,

$$2 = 2v_1 + v_1 - v_2 + (v_1 - v_3)4 + 3i_0, \quad i_0 = \ 4v_2. \text{ Hence,}$$

$$2 = 7v_1 + 11v_2 - 4v_3 \qquad (1)$$

At node 2,

$$v_1 - v_2 = 4v_2 + v_2 - v_3 \longrightarrow 0 = -\ v_1 + 6v_2 - v_3 \qquad (2)$$

At node 3,

$$2v_3 = 4 + v_2 - v_3 + 12v_2 + 4(v_1 - v_3)$$

or

$$-4 = 4v_1 + 13v_2 - 7v_3 \qquad (3)$$

In matrix form,

$$\begin{bmatrix} 7 & 11 & -4 \\ 1 & -6 & 1 \\ 4 & 13 & -7 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \\ v_3 \end{bmatrix} = \begin{bmatrix} 2 \\ 0 \\ -4 \end{bmatrix}$$

$$\Delta = \begin{vmatrix} 7 & 11 & -4 \\ 1 & -6 & 1 \\ 4 & 13 & -7 \end{vmatrix} = 176, \quad \Delta_1 = \begin{vmatrix} 2 & 11 & -4 \\ 0 & -6 & 1 \\ -4 & 13 & -7 \end{vmatrix} = 110$$

$$\Delta_2 = \begin{vmatrix} 7 & 2 & -4 \\ 1 & 0 & 1 \\ 4 & -4 & -7 \end{vmatrix} = 66, \quad \Delta_3 = \begin{vmatrix} 7 & 11 & 2 \\ 1 & -6 & 0 \\ 4 & 13 & -4 \end{vmatrix} = 286$$

$$v_1 = \frac{\Delta_1}{\Delta} = \frac{110}{176} = 0.625\text{V}, \quad v_2 = \frac{\Delta_2}{\Delta} = \frac{66}{176} = 0.375\text{V}$$

$$v_3 = \frac{\Delta_3}{\Delta} = \frac{286}{176} = 1.625\text{V}.$$

$v_1$ = **625 mV**, $v_2$ = **375 mV**, $v_3$ = **1.625 V**.

**Chapter 3, Problem 28.**

Use *MATLAB* to find the voltages at nodes *a*, *b*, *c*, and *d* in the circuit of Fig. 3.77.

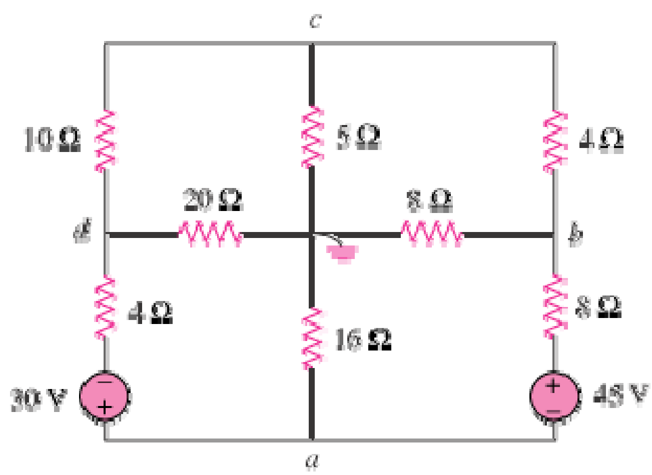



Figure 3.77

## Chapter 3, Solution 28

At node c,

$$\frac{V_d - V_c}{10} = \frac{V_c - V_b}{4} + \frac{V_c}{5} \longrightarrow 0 = -5V_b + 11V_c - 2V_d \qquad (1)$$

At node b,

$$\frac{V_a + 45 - V_b}{8} + \frac{V_c - V_b}{4} = \frac{V_b}{8} \longrightarrow -45 = V_a - 4V_b + 2V_c \qquad (2)$$

At node a,

$$\frac{V_a - 30 - V_d}{4} + \frac{V_a}{16} + \frac{V_a + 45 - V_b}{8} = 0 \longrightarrow 30 = 7V_a - 2V_b - 4V_d \quad (3)$$

At node d,

$$\frac{V_a - 30 - V_d}{4} = \frac{V_d}{20} + \frac{V_d - V_c}{10} \longrightarrow 150 = 5V_a + 2V_c - 7V_d \qquad (4)$$

In matrix form, (1) to (4) become

$$\begin{pmatrix} 0 & -5 & 11 & -2 \\ 1 & -4 & 2 & 0 \\ 7 & -2 & 0 & -4 \\ 5 & 0 & 2 & -7 \end{pmatrix} \begin{pmatrix} V_a \\ V_b \\ V_c \\ V_d \end{pmatrix} = \begin{pmatrix} 0 \\ -45 \\ 30 \\ 150 \end{pmatrix} \longrightarrow AV = B$$

We use MATLAB to invert A and obtain

$$V = A^{-1}B = \begin{pmatrix} -10.14 \\ 7.847 \\ -1.736 \\ -29.17 \end{pmatrix}$$

Thus,

$$\underline{V_a = -10.14\text{ V},\ \ V_b = 7.847\text{ V},\ \ V_c = -1.736\text{ V},\ V_d = -29.17\text{ V}}$$

**Chapter 3, Problem 29.**

Use *MATLAB* to solve for the node voltages in the circuit of Fig. 3.78.

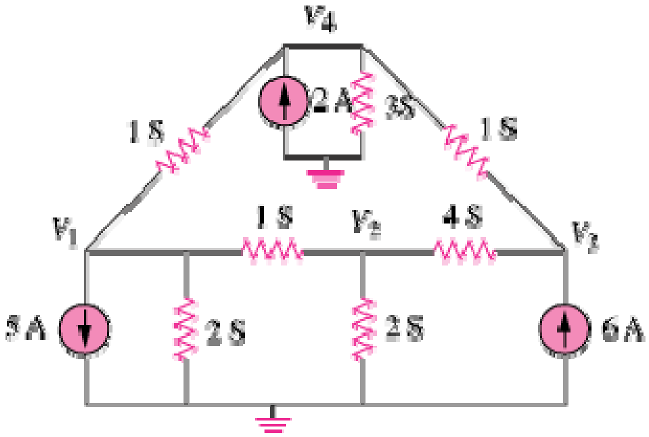



Figure 3.78

**Chapter 3, Solution 29**

At node 1,

$$5 + V_1 - V_4 + 2V_1 + V_1 - V_2 = 0 \quad \longrightarrow \quad -5 = 4V_1 - V_2 - V_4 \qquad (1)$$

At node 2,

$$V_1 - V_2 = 2V_2 + 4(V_2 - V_3) = 0 \quad \longrightarrow \quad 0 = -V_1 + 7V_2 - 4V_3 \qquad (2)$$

At node 3,

$$6 + 4(V_2 - V_3) = V_3 - V_4 \quad \longrightarrow \quad 6 = -4V_2 + 5V_3 - V_4 \qquad (3)$$

At node 4,

$$2 + V_3 - V_4 + V_1 - V_4 = 3V_4 \quad \longrightarrow \quad 2 = -V_1 - V_3 + 5V_4 \qquad (4)$$

In matrix form, (1) to (4) become

$$\begin{pmatrix} 4 & -1 & 0 & -1 \\ -1 & 7 & -4 & 0 \\ 0 & -4 & 5 & -1 \\ -1 & 0 & -1 & 5 \end{pmatrix} \begin{pmatrix} V_1 \\ V_2 \\ V_3 \\ V_4 \end{pmatrix} = \begin{pmatrix} -5 \\ 0 \\ 6 \\ 2 \end{pmatrix} \quad \longrightarrow \quad AV = B$$

Using MATLAB,

$$V = A^{-1}B = \begin{pmatrix} -0.7708 \\ 1.209 \\ 2.309 \\ 0.7076 \end{pmatrix}$$

i.e.

$$\underline{V_1 = -0.7708\text{ V},\ V_2 = 1.209\text{ V},\ V_3 = 2.309\text{ V},\ V_4 = 0.7076\text{ V}}$$

**Chapter 3, Problem 30.**

Using nodal analysis, find $v_o$ and $i_o$ in the circuit of Fig. 3.79.

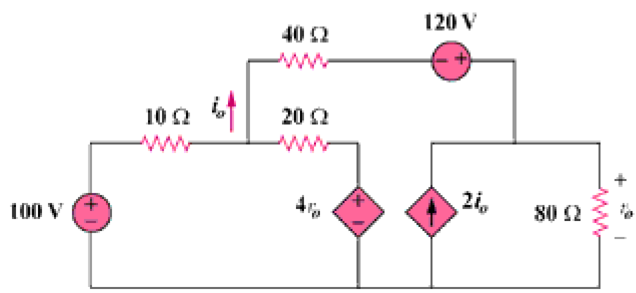
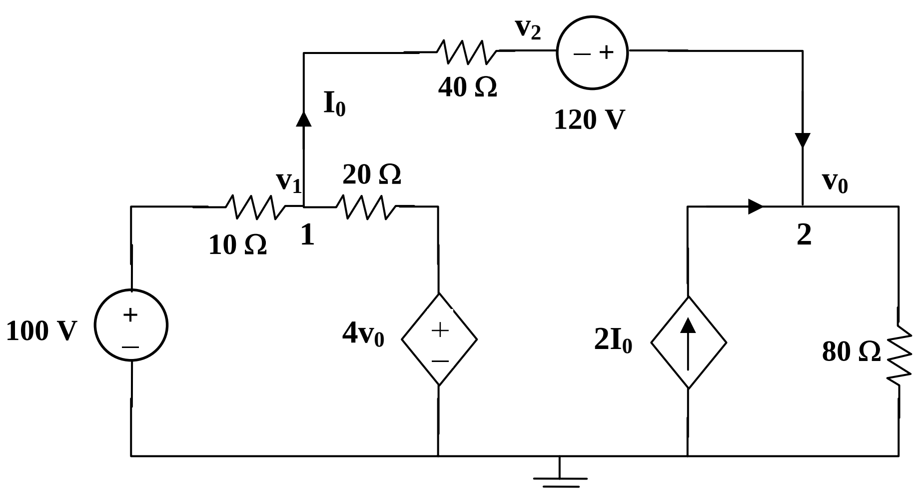



Figure 3.79

**Chapter 3, Solution 30**



At node 1,

$$\frac{v_1 - v_2}{40} = \frac{100 - v_1}{10} + \frac{4v_o - v_1}{20} \qquad (1)$$

But, $v_o = 120 + v_2 \longrightarrow v_2 = v_o - 120$. Hence (1) becomes

$$7v_1 - 9v_o = 280 \qquad (2)$$

At node 2,

$$I_o + 2I_o = \frac{v_o - 0}{80}$$

$$3\left(\frac{v_1 + 120 - v_o}{40}\right) = \frac{v_o}{80}$$

or

$$6v_1 - 7v_o = -720 \qquad (3)$$

from (2) and (3),

$$\begin{bmatrix} 7 & -9 \\ 6 & -7 \end{bmatrix}\begin{bmatrix} v_1 \\ v_o \end{bmatrix} = \begin{bmatrix} 280 \\ -720 \end{bmatrix}$$

$$\Delta = \begin{vmatrix} 7 & -9 \\ 6 & -7 \end{vmatrix} = -49 + 54 = 5$$

$$\Delta_1 = \begin{vmatrix} 280 & -9 \\ -720 & -7 \end{vmatrix} = -8440, \quad \Delta_2 = \begin{vmatrix} 7 & 280 \\ 6 & -720 \end{vmatrix} = -6720$$

$$v_1 = \frac{\Delta_1}{\Delta} = \frac{-8440}{5} = -1688, \quad v_o = \frac{\Delta_2}{\Delta} = \frac{-6720}{5} - 1344\text{V}$$

$$I_o = \underline{\mathbf{-5.6\ A}}$$

**Chapter 3, Problem 31.**

Find the node voltages for the circuit in Fig. 3.80.

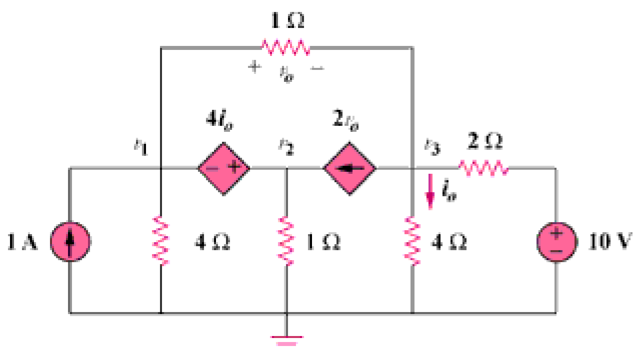
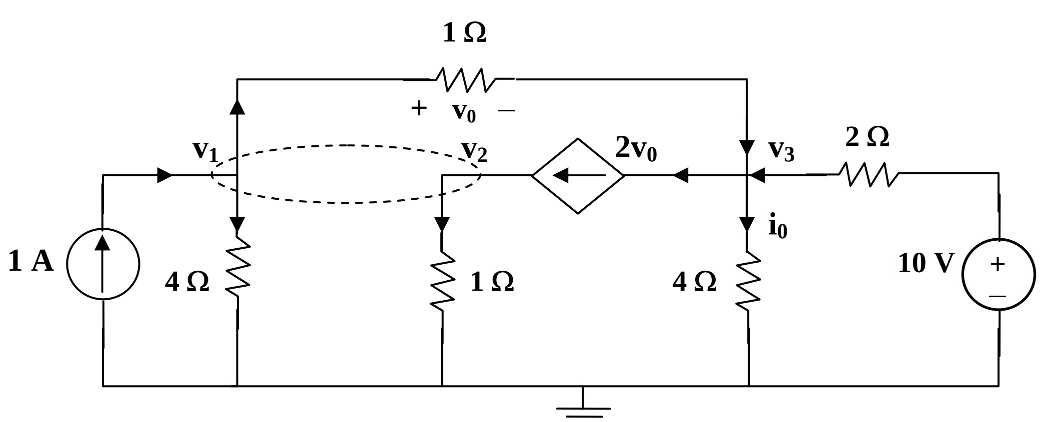



Figure 3.80

**Chapter 3, Solution 31**



At the supernode,

$$1 + 2v_0 = \frac{v_1}{4} + \frac{v_2}{1} + \frac{v_1 - v_3}{1} \qquad (1)$$

But $v_o = v_1 - v_3$. Hence (1) becomes,

$$4 = -3v_1 + 4v_2 + 4v_3 \qquad (2)$$

At node 3,

$$2v_o + \frac{v_3}{4} = v_1 - v_3 + \frac{10 - v_3}{2}$$

or

$$20 = 4v_1 + 0v_2 - v_3 \qquad (3)$$

At the supernode, $v_2 = v_1 + 4i_o$. But $i_o = \frac{v_3}{4}$. Hence,

$$v_2 = v_1 + v_3 \qquad (4)$$

Solving (2) to (4) leads to,

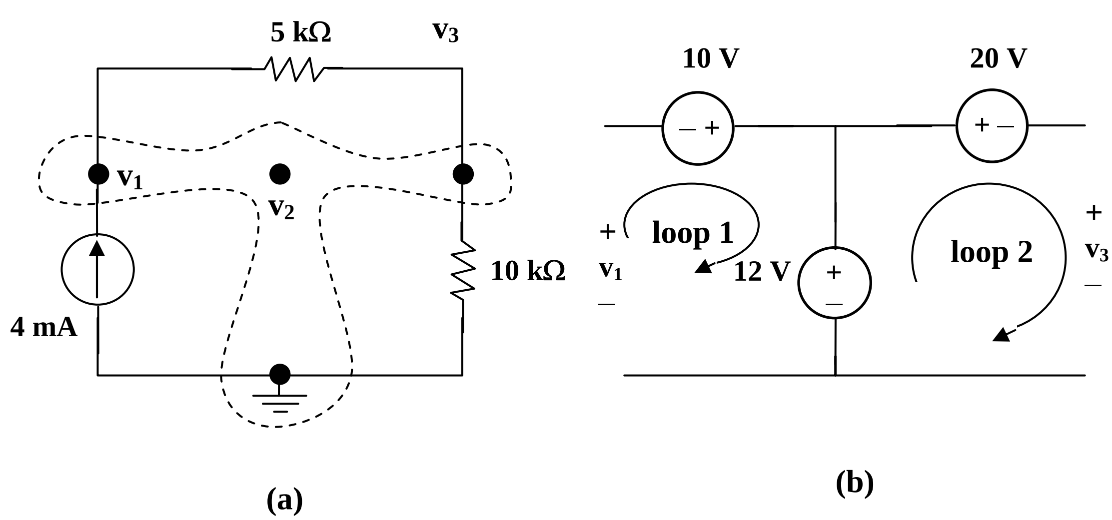
$v_1 =$ **4.97V**, $v_2 =$ **4.85V**, $v_3 =$ **–0.12V**.

**Chapter 3, Problem 32.**

Obtain the node voltages $v_1$, $v_2$, and $v_3$ in the circuit of Fig. 3.81.

Figure 3.81

**Chapter 3, Solution 32**



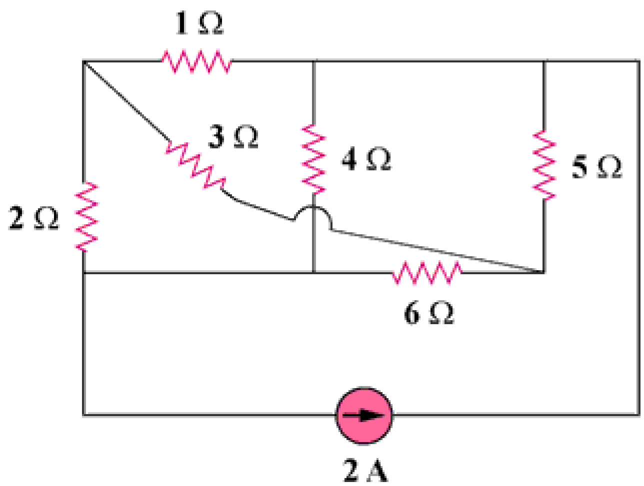

We have a supernode as shown in figure (a). It is evident that $v_2$ = 12 V, Applying KVL to loops 1and 2 in figure (b), we obtain,

$$-v_1 - 10 + 12 = 0 \text{ or } v_1 = 2 \text{ and } -12 + 20 + v_3 = 0 \text{ or } v_3 = -8 \text{ V}$$

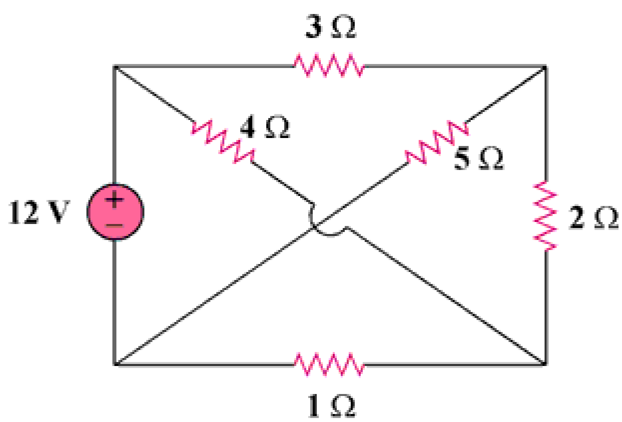
Thus, $v_1$ = **2 V**, $v_2$ = **12 V**, $v_3$ = **-8V**.

**Chapter 3, Problem 33.**

Which of the circuits in Fig. 3.82 is planar? For the planar circuit, redraw the circuits with no crossing branches.




(a)

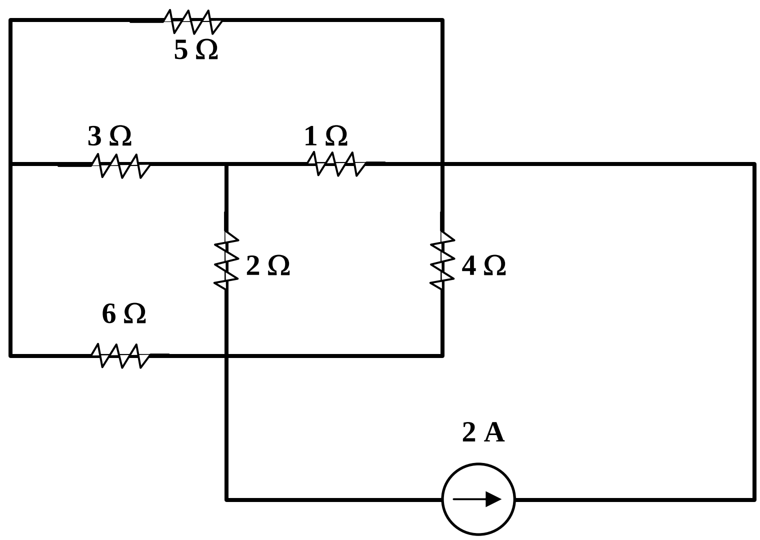



(b)

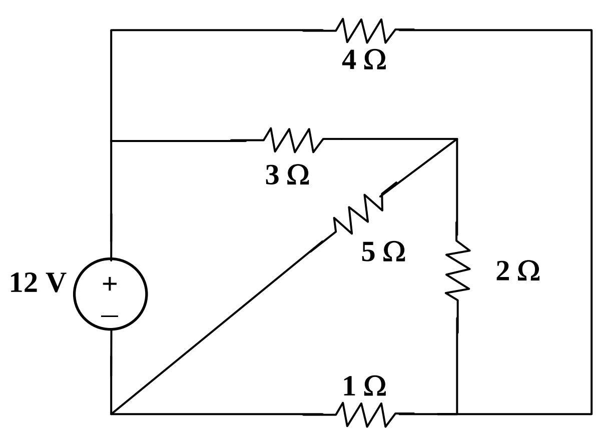
Figure 3.82

**Chapter 3, Solution 33**

**(a)** This is a **planar** circuit. It can be redrawn as shown below.




**(b)** This is a **planar** circuit. It can be redrawn as shown below.



**Chapter 3, Problem 34.**

Determine which of the circuits in Fig. 3.83 is planar and redraw it with no crossing branches.

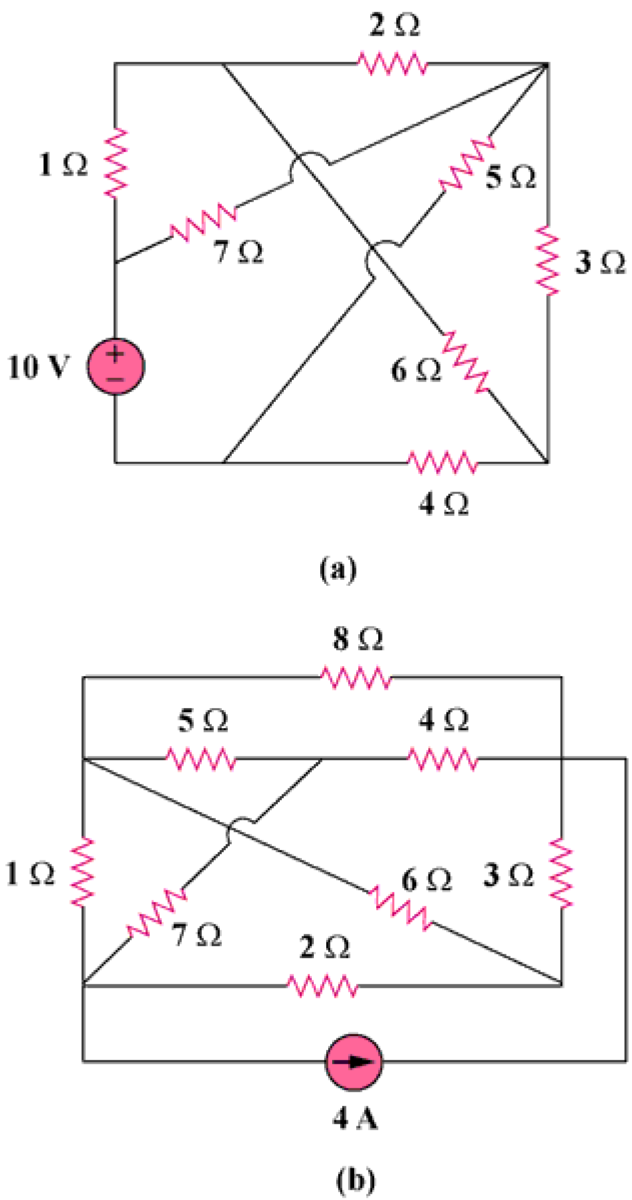
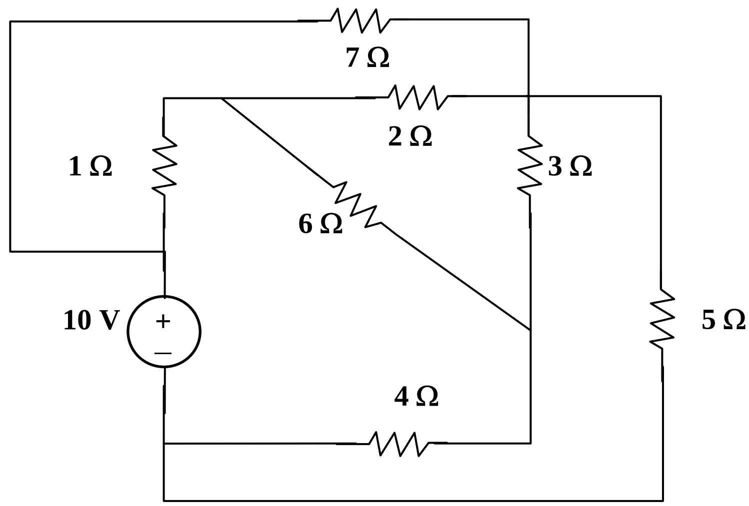



Figure 3.83

**Chapter 3, Solution 34**

(a) This is a **planar** circuit because it can be redrawn as shown below,




(b) This is a **non-planar** circuit.

**Chapter 3, Problem 35.**

Rework Prob. 3.5 using mesh analysis.

Chapter 3, Problem 5

Obtain $v_0$ in the circuit of Fig. 3.54.

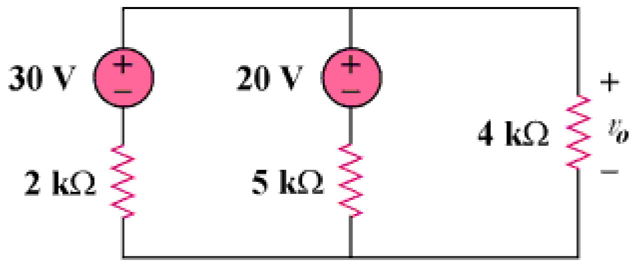
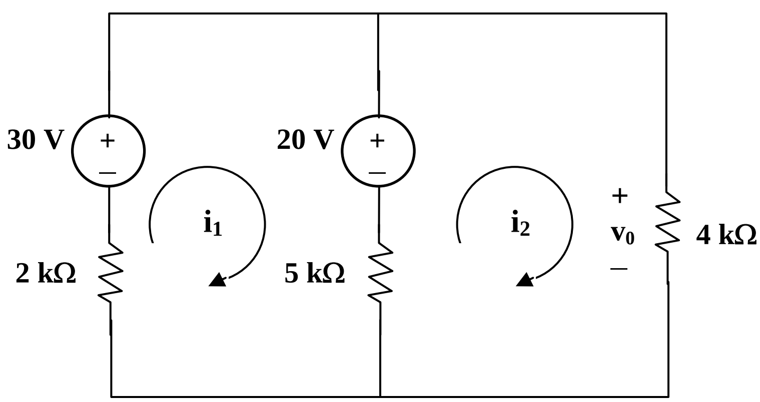



Figure 3.54

**Chapter 3, Solution 35**




Assume that $i_1$ and $i_2$ are in mA. We apply mesh analysis. For mesh 1,

$$-30 + 20 + 7i_1 - 5i_2 = 0 \quad \text{or} \quad 7i_1 - 5i_2 = 10 \qquad (1)$$

For mesh 2,

$$-20 + 9i_2 - 5i_1 = 0 \quad \text{or} \quad -5i_1 + 9i_2 = 20 \qquad (2)$$

Solving (1) and (2), we obtain, $i_2 = 5$.

$$v_0 = 4i_2 = \underline{\textbf{20 volts}}.$$

**Chapter 3, Problem 36.**

Rework Prob. 3.6 using mesh analysis.

Chapter 3, Problem 6

Use nodal analysis to obtain $\boldsymbol{v_0}$ in the circuit in Fig. 3.55.

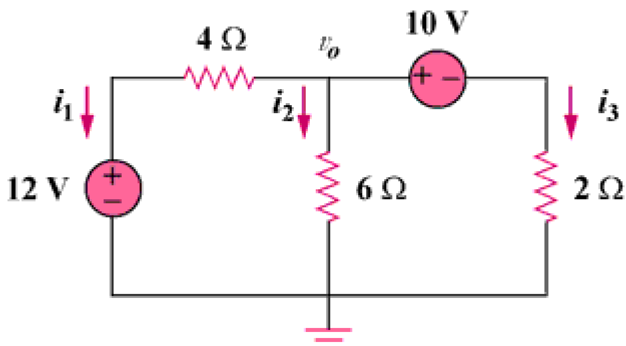
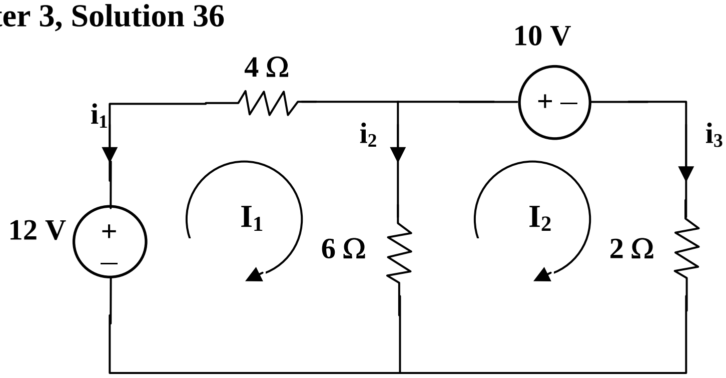



Figure 3.55

**Chapter 3, Solution 36**




Applying mesh analysis gives,

$$12 = 10I_1 - 6I_2$$

$$-10 = -6I_1 + 8I_2$$

or
$$\begin{bmatrix} 6 \\ -5 \end{bmatrix} = \begin{bmatrix} 5 & -3 \\ -3 & 4 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

$$\Delta = \begin{vmatrix} 5 & -3 \\ -3 & 4 \end{vmatrix} = 11, \quad \Delta_1 = \begin{vmatrix} 6 & -3 \\ -5 & 4 \end{vmatrix} = 9, \quad \Delta_2 = \begin{vmatrix} 5 & 6 \\ -3 & -5 \end{vmatrix} = -7$$

$$I_1 = \frac{\Delta_1}{\Delta} = \frac{9}{11}, \quad I_2 = \frac{\Delta_2}{\Delta} = \frac{-7}{11}$$

$i_1 = -I_1 = -9/11 = -0.8181$ A, $i_2 = I_1 - I_2 = 10/11 = 1.4545$ A.

$v_o = 6i_2 = 6\text{x}1.4545 =$ **8.727 V**.

**Chapter 3, Problem 37.**

Rework Prob. 3.8 using mesh analysis.

Chapter 3, Problem 8

Using nodal analysis, find $\boldsymbol{v_0}$ in the circuit in Fig. 3.57.

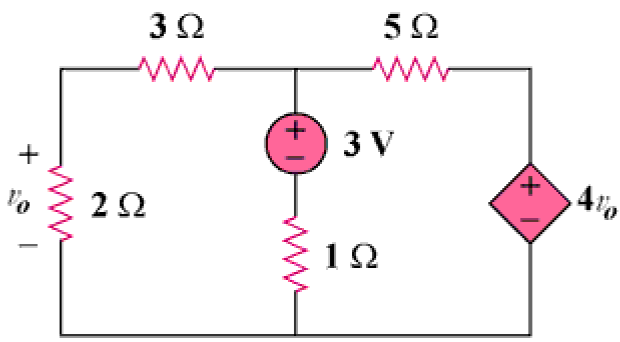
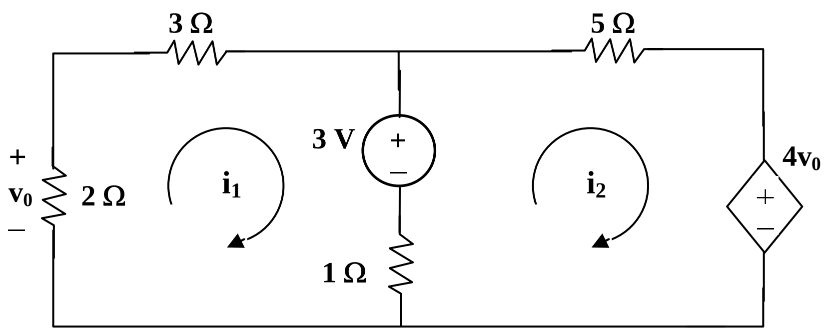



Figure 3.57

**Chapter 3, Solution 37**




Applying mesh analysis to loops 1 and 2, we get,

$6i_1 - 1i_2 + 3 = 0$ which leads to $i_2 = 6i_1 + 3$ (1)

$-1i_1 + 6i_2 - 3 + 4v_0 = 0$ (2)

But, $v_0 = -2i_1$ (3)

Using (1), (2), and (3) we get $i_1 = -5/9$.

Therefore, we get $v_0 = -2i_1 = -2(-5/9) =$ **1.1111 volts**

**Chapter 3, Problem 38.**
Apply mesh analysis to the circuit in Fig. 3.84 and obtain $I_o$.

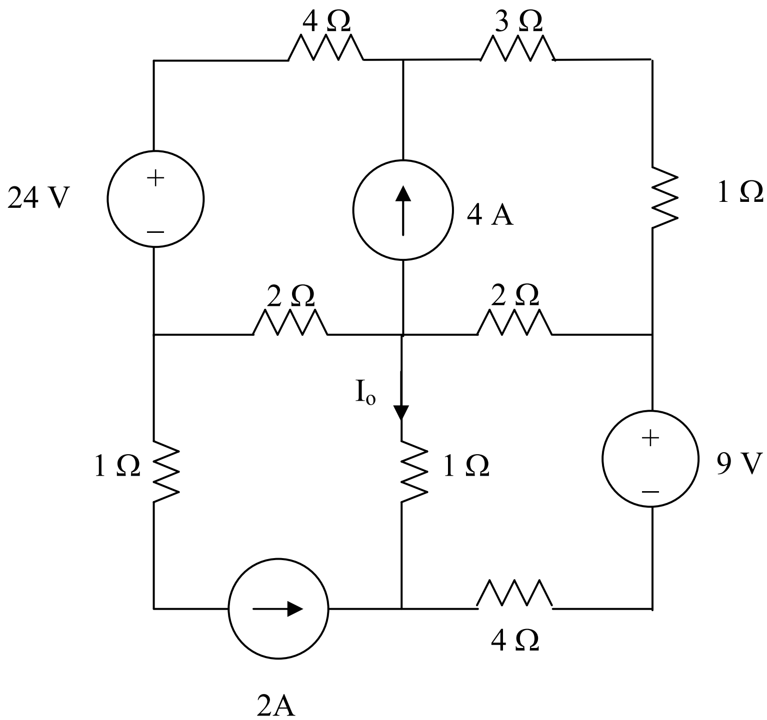
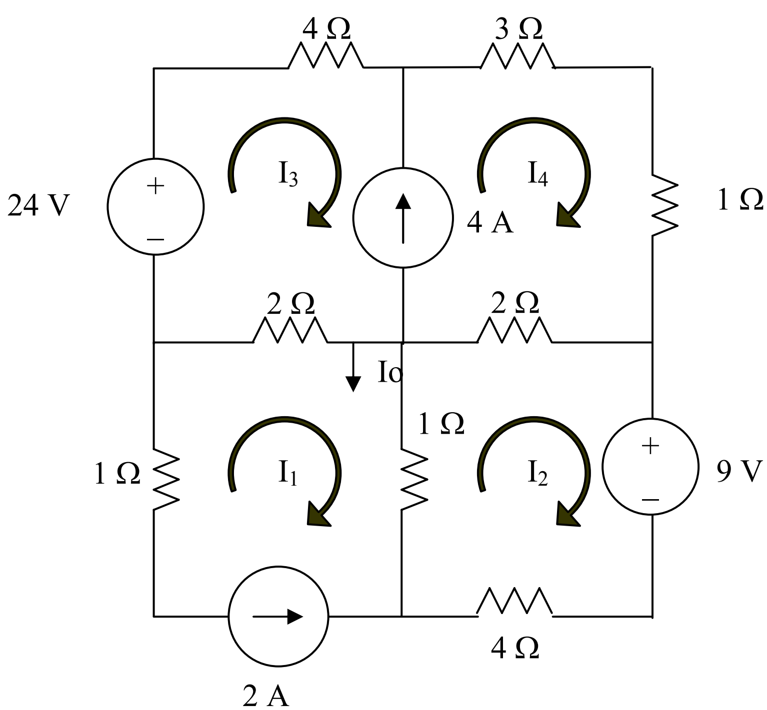



**Figure 3.84 For Prob. 3.38.**

**Chapter 3, Solution 38**
Consider the circuit below with the mesh currents.



$I_1$ =-2 A (1)

$1(I_2–I_1) + 2(I_2–I_4) + 9 + 4I_2 = 0$
$7I_2 – I_4 = –11$ (2)

$–24 + 4I_3 + 3I_4 + 1I_4 + 2(I_4–I_2) + 2(I_3 – I_1) = 0$ (super mesh)
$–2I_2 + 6\ I_3 + 6I_4 = +24 – 4 = 20$ (3)

But, we need one more equation, so we use the constraint equation $–I_3 + I_4 = 4$. This now gives us three equations with three unknowns.

$$\begin{bmatrix} 7 & 0 & -1 \\ -2 & 6 & 6 \\ 0 & -1 & 1 \end{bmatrix}\begin{bmatrix} I_2 \\ I_3 \\ I_4 \end{bmatrix} = \begin{bmatrix} -11 \\ 20 \\ 4 \end{bmatrix}$$

We can now use MATLAB to solve the problem.

```
>> Z=[7,0,-1;-2,6,6;0,-1,0]

Z =

     7     0    -1
    -2     6     6
     0    -1     0
>> V=[-11,20,4]'

V =

   -11
    20
     4
>> I=inv(Z)*V

I =

   -0.5500
   -4.0000
    7.1500
```

$I_o = I_1 – I_2 = –2 – 4 =$ **<u>–6 A</u>**.

Check using the super mesh (equation (3)): 1.1 – 24 + 42.9 = 20!

**Chapter 3, Problem 39.**

Determine the mesh currents $i_1$ and $i_2$ in the circuit shown in Fig. 3.85.

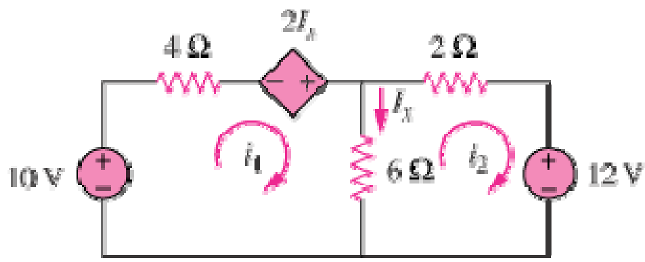



Figure 3.85

**Chapter 3, Solution 39**

For mesh 1,

$$-10 - 2I_x + 10I_1 - 6I_2 = 0$$

But $I_x = I_1 - I_2$. Hence,

$10 = -2I_1 + 2I_2 + 10I_1 - 6I_2 \longrightarrow 5 = 4I_1 - 2I_2$ (1)

For mesh 2,

$12 + 8I_2 - 6I_1 = 0 \longrightarrow 6 = 3I_1 - 4I_2$ (2)

Solving (1) and (2) leads to

$\underline{I_1 = 0.8\text{ A},\ \ I_2 = \text{-}0.9\text{A}}$

**Chapter 3, Problem 40.**

For the bridge network in Fig. 3.86, find $I_o$ using mesh analysis.

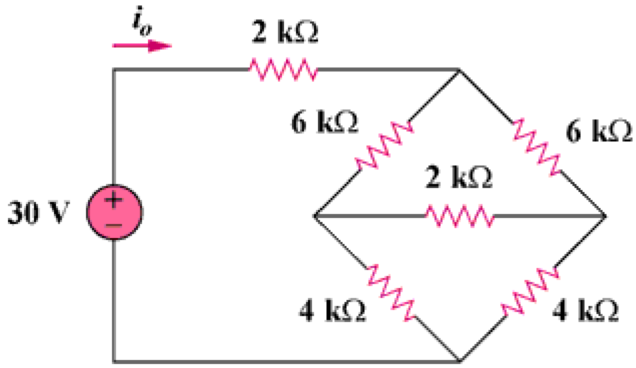
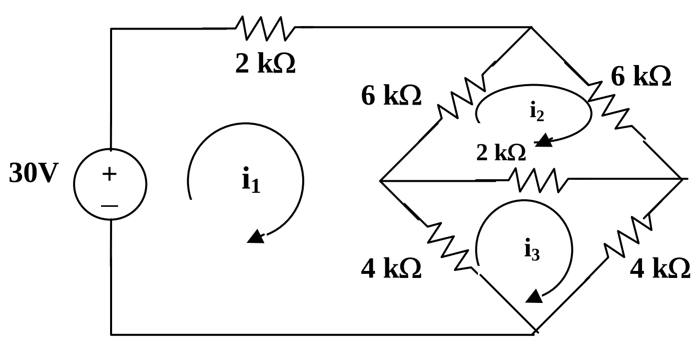



Figure 3.86

**Chapter 3, Solution 40**




Assume all currents are in mA and apply mesh analysis for mesh 1.

$$30 = 12i_1 - 6i_2 - 4i_3 \longrightarrow 15 = 6i_1 - 3i_2 - 2i_3 \quad (1)$$

for mesh 2,

$$0 = -6i_1 + 14i_2 - 2i_3 \longrightarrow 0 = -3i_1 + 7i_2 - i_3 \quad (2)$$

for mesh 2,

$$0 = -4i_1 - 2i_2 + 10i_3 \qquad 0 = -2i_1 - i_2 + 5i_3 \quad (3)$$

Solving (1), (2), and (3), we obtain,

$i_o = i_1 =$ **4.286 mA**.

**Chapter 3, Problem 41.**

Apply mesh analysis to find $\boldsymbol{i_o}$ in Fig. 3.87.

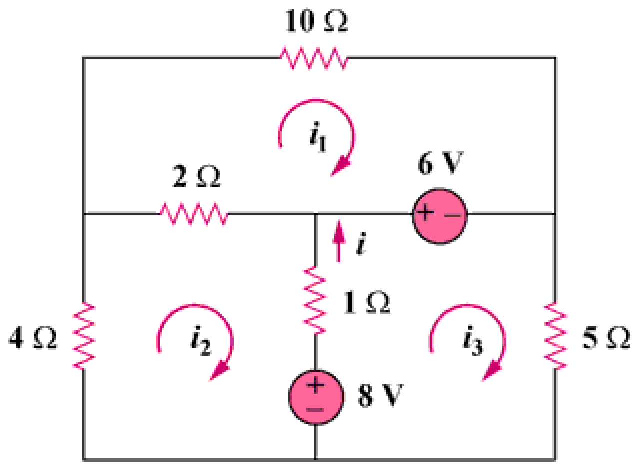
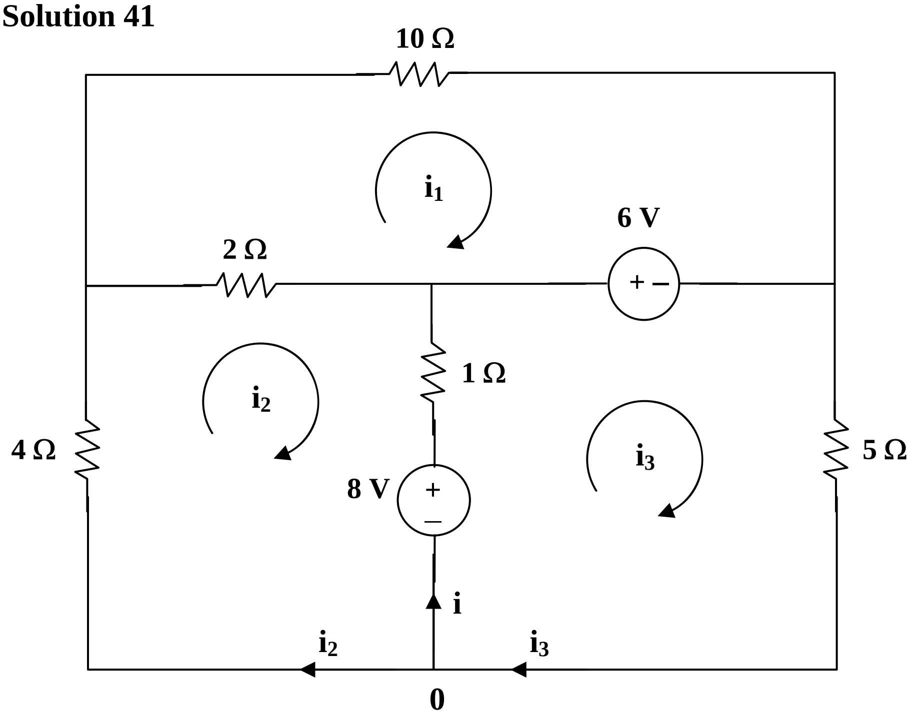



Figure 3.87

**Chapter 3, Solution 41**




For loop 1,

$$6 = 12i_1 - 2i_2 \longrightarrow 3 = 6i_1 - i_2 \qquad (1)$$

For loop 2,

$$-8 = -2i_1 + 7i_2 - i_3 \qquad (2)$$

For loop 3,

$$-8 + 6 + 6i_3 - i_2 = 0 \longrightarrow 2 = -i_2 + 6i_3 \qquad (3)$$

We put (1), (2), and (3) in matrix form,

$$\begin{bmatrix} 6 & -1 & 0 \\ 2 & -7 & 1 \\ 0 & -1 & 6 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix} = \begin{bmatrix} 3 \\ 8 \\ 2 \end{bmatrix}$$

$$\Delta = \begin{vmatrix} 6 & -1 & 0 \\ 2 & -7 & 1 \\ 0 & -1 & 6 \end{vmatrix} = -234, \quad \Delta_2 = \begin{vmatrix} 6 & 3 & 0 \\ 2 & 8 & 1 \\ 0 & 2 & 6 \end{vmatrix} = 240$$

$$\Delta_3 = \begin{vmatrix} 6 & -1 & 3 \\ 2 & -7 & 8 \\ 0 & -1 & 2 \end{vmatrix} = -38$$

At node 0, $i + i_2 = i_3$ or $i = i_3 - i_2 = \dfrac{\Delta_3 - \Delta_2}{\Delta} = \dfrac{-38 - 240}{-234} =$ **1.188 A**

**Chapter 3, Problem 42.**

Determine the mesh currents in the circuit of Fig. 3.88.

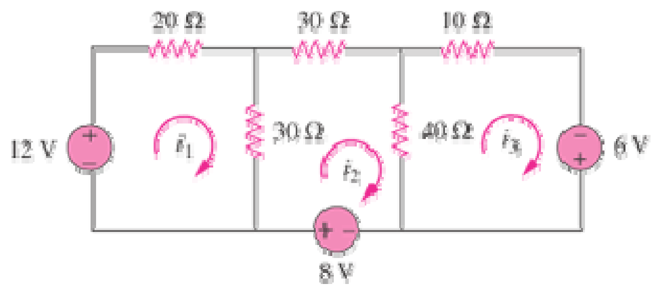



Figure 3.88

**Chapter 3, Solution 42**

For mesh 1,

$$-12 + 50I_1 - 30I_2 = 0 \longrightarrow 12 = 50I_1 - 30I_2 \quad (1)$$

For mesh 2,

$$-8 + 100I_2 - 30I_1 - 40I_3 = 0 \longrightarrow 8 = -30I_1 + 100I_2 - 40I_3 \quad (2)$$

For mesh 3,

$$-6 + 50I_3 - 40I_2 = 0 \longrightarrow 6 = -40I_2 + 50I_3 \quad (3)$$

Putting eqs. (1) to (3) in matrix form, we get

$$\begin{pmatrix} 50 & -30 & 0 \\ -30 & 100 & -40 \\ 0 & -40 & 50 \end{pmatrix}\begin{pmatrix} I_1 \\ I_2 \\ I_3 \end{pmatrix} = \begin{pmatrix} 12 \\ 8 \\ 6 \end{pmatrix} \longrightarrow AI = B$$

Using Matlab,

$$I = A^{-1}B = \begin{pmatrix} 0.48 \\ 0.40 \\ 0.44 \end{pmatrix}$$

i.e. $I_1 = 0.48$ A, $I_2 = 0.4$ A, $I_3 = 0.44$ A

**Chapter 3, Problem 43.**

Use mesh analysis to find $v_{ab}$ and $i_o$ in the circuit in Fig. 3.89.

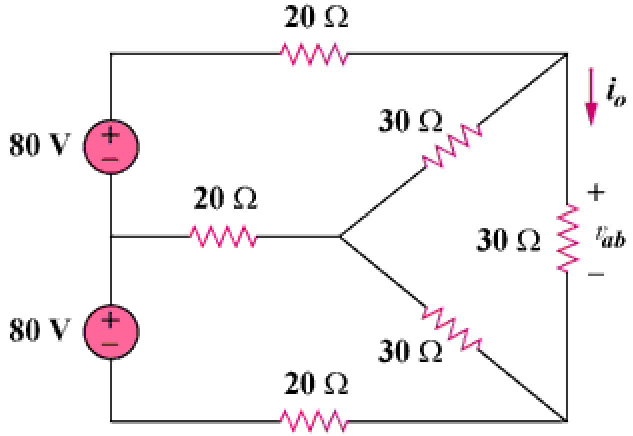
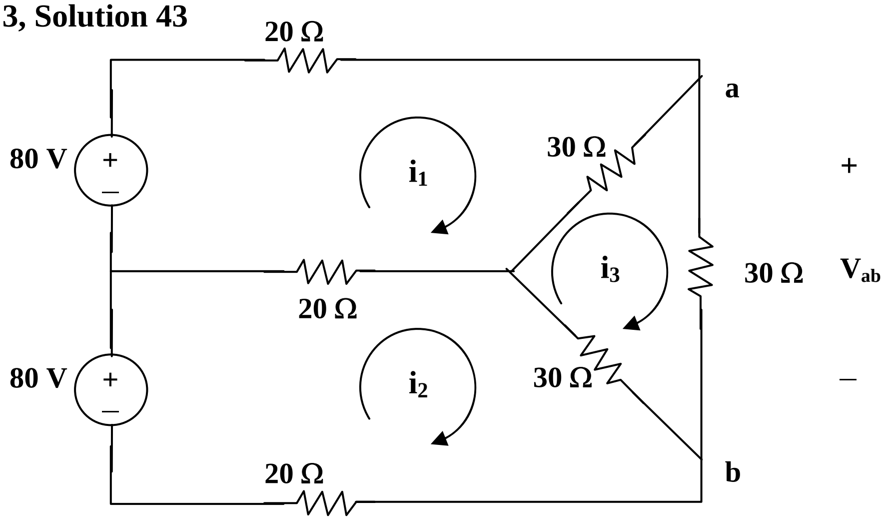



Figure 3.89

**Chapter 3, Solution 43**




For loop 1,

$$80 = 70i_1 - 20i_2 - 30i_3 \longrightarrow 8 = 7i_1 - 2i_2 - 3i_3 \qquad (1)$$

For loop 2,

$$80 = 70i_2 - 20i_1 - 30i_3 \longrightarrow 8 = -2i_1 + 7i_2 - 3i_3 \qquad (2)$$

For loop 3,

$$0 = -30i_1 - 30i_2 + 90i_3 \longrightarrow 0 = i_1 + i_2 - 3i_3 \qquad (3)$$

Solving (1) to (3), we obtain $i_3 = 16/9$

$$I_o = i_3 = 16/9 = \underline{\textbf{1.7778 A}}$$

$$V_{ab} = 30i_3 = \underline{\textbf{53.33 V}}.$$

**Chapter 3, Problem 44.**

Use mesh analysis to obtain $i_o$ in the circuit of Fig. 3.90.

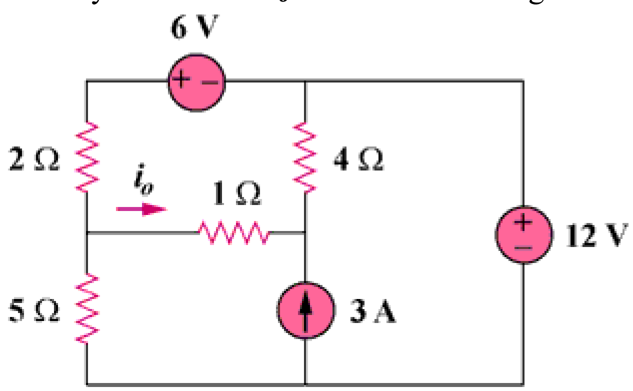
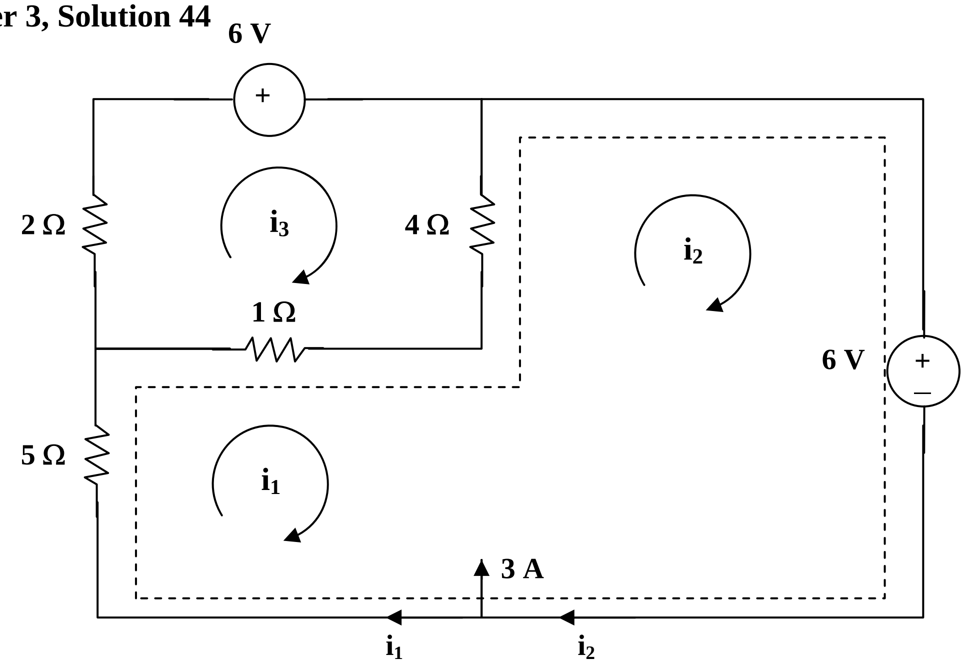



Figure 3.90

**Chapter 3, Solution 44**




Loop 1 and 2 form a supermesh. For the supermesh,

$$6i_1 + 4i_2 - 5i_3 + 12 = 0 \qquad (1)$$

For loop 3,

$$-i_1 - 4i_2 + 7i_3 + 6 = 0 \qquad (2)$$

Also,

$$i_2 = 3 + i_1 \qquad (3)$$

Solving (1) to (3), $i_1 = -3.067$, $i_3 = -1.3333$; $i_o = i_1 - i_3 =$ **$\underline{-1.7333\text{ A}}$**

**Chapter 3, Problem 45.**

Find current $\boldsymbol{i}$ in the circuit in Fig. 3.91.

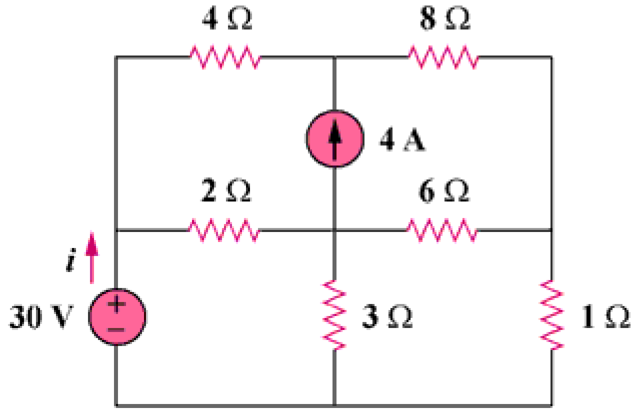
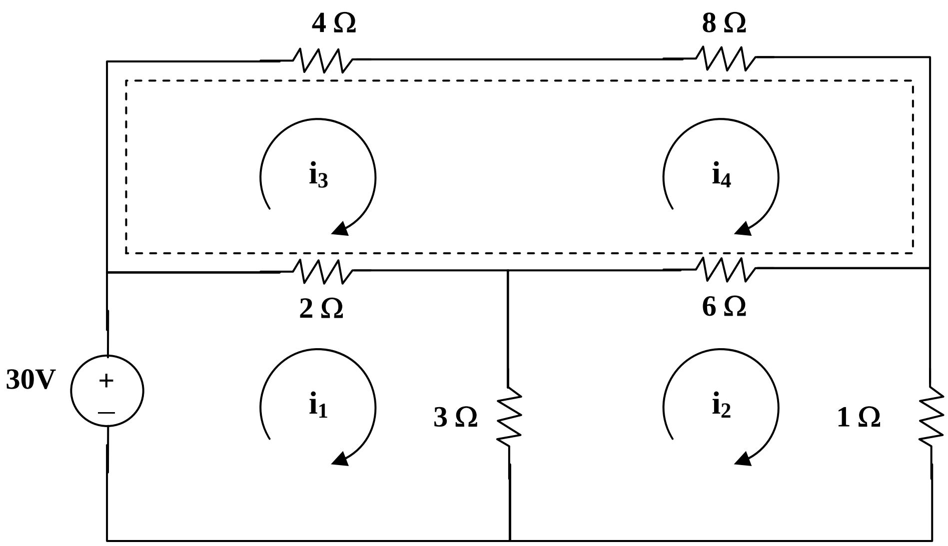



Figure 3.91

**Chapter 3, Solution 45**




For loop 1, $\quad 30 = 5i_1 - 3i_2 - 2i_3 \qquad (1)$

For loop 2, $\quad 10i_2 - 3i_1 - 6i_4 = 0 \qquad (2)$

For the supermesh, $\quad 6i_3 + 14i_4 - 2i_1 - 6i_2 = 0 \qquad (3)$

But $\quad i_4 - i_3 = 4$ which leads to $i_4 = i_3 + 4 \qquad (4)$

Solving (1) to (4) by elimination gives $i = i_1 =$ <u>**8.561 A**</u>.

**Chapter 3, Problem 46.**

Calculate the mesh currents $i_1$ and $i_2$ in Fig. 3.92.

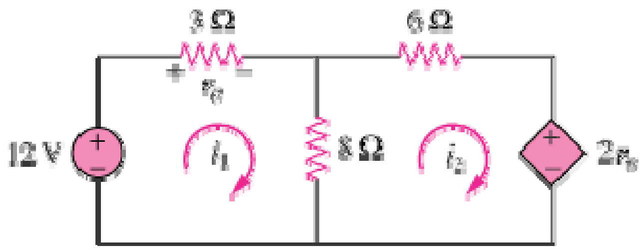



Figure 3.92

**Chapter 3, Solution 46**

For loop 1,

$-12 + 11i_1 - 8i_2 = 0 \quad \longrightarrow \quad 11i_1 - 8i_2 = 12 \qquad (1)$

For loop 2,

$-8i_1 + 14i_2 + 2v_o = 0$

But $v_o = 3i_1$,

$-8i_1 + 14i_2 + 6i_1 = 0 \quad \longrightarrow \quad i_1 = 7i_2 \qquad (2)$

Substituting (2) into (1),

$77i_2 - 8i_2 = 12 \quad \longrightarrow \quad \underline{i_2 = 0.1739 \text{ A}}$ and $\underline{i_1 = 7i_2 = 1.217 \text{ A}}$

**Chapter 3, Problem 47.**

Rework Prob. 3.19 using mesh analysis.

Chapter 3, Problem 3.19

Use nodal analysis to find $\mathbf{V_1}$, $\mathbf{V_2}$, and $\mathbf{V_3}$ in the circuit in Fig. 3.68.

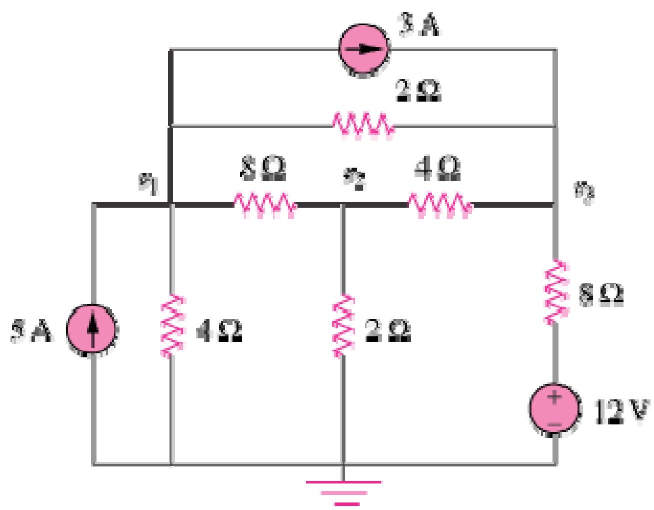
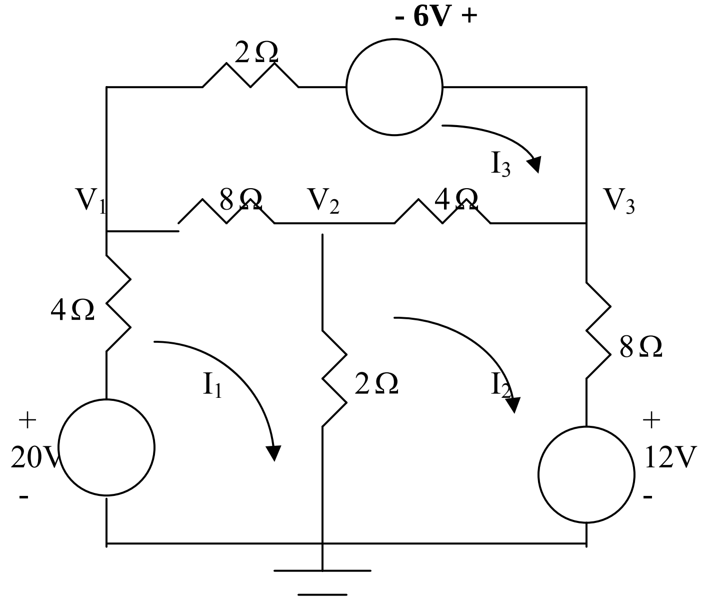



Figure 3.68

**Chapter 3, Solution 47**

First, transform the current sources as shown below.




For mesh 1,

$$-20+14I_1-2I_2-8I_3=0 \quad\longrightarrow\quad 10=7I_1-I_2-4I_3 \qquad (1)$$

For mesh 2,

$$12+14I_2-2I_1-4I_3=0 \quad\longrightarrow\quad -6=-I_1+7I_2-2I_3 \qquad (2)$$

For mesh 3,

$$-6+14I_3-4I_2-8I_1=0 \quad\longrightarrow\quad 3=-4I_1-2I_2+7I_3 \qquad (3)$$

Putting (1) to (3) in matrix form, we obtain

$$\begin{pmatrix} 7 & -1 & -4 \\ -1 & 7 & -2 \\ -4 & -2 & 7 \end{pmatrix}\begin{pmatrix} I_1 \\ I_2 \\ I_3 \end{pmatrix}=\begin{pmatrix} 10 \\ -6 \\ 3 \end{pmatrix} \quad\longrightarrow\quad AI=B$$

Using MATLAB,

$$I=A^{-1}B=\begin{bmatrix} 2 \\ 0.0333 \\ 1.8667 \end{bmatrix} \quad\longrightarrow\quad \underline{\;}I_1=2.5,\; I_2=0.0333, I_3=1.8667$$

But

$$I_1=\frac{20-V}{4} \quad\longrightarrow\quad V_1=20-4I_1=10\text{ V}$$

$$V_2=2(I_1-I_2)=4.933\text{ V}$$

Also,

$$I_2=\frac{V_3-12}{8} \quad\longrightarrow\quad V_3=12+8I_2=12.267\text{V}$$

**Chapter 3, Problem 48.**

Determine the current through the 10-kΩ resistor in the circuit in Fig. 3.93 using mesh analysis.

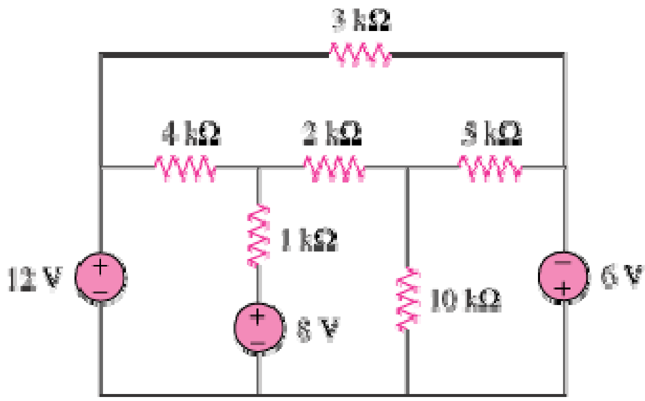
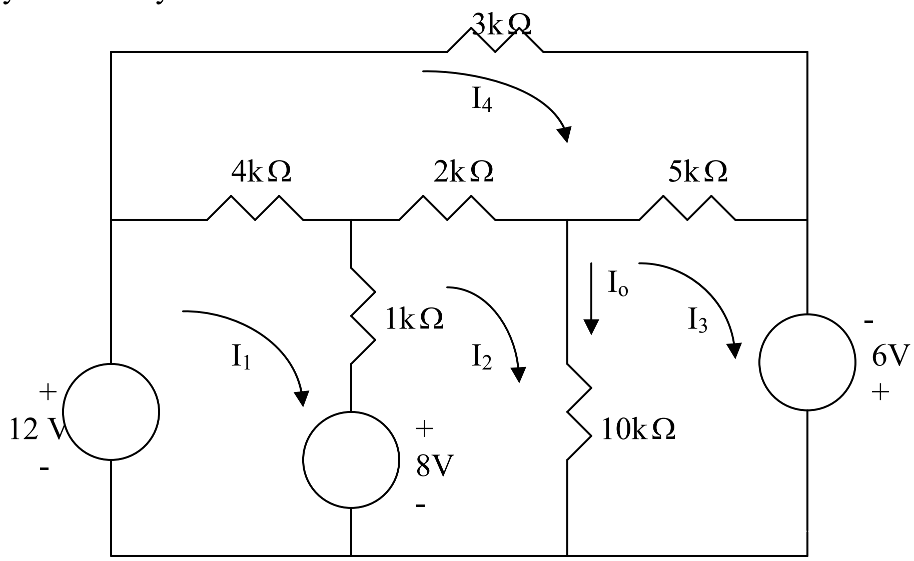



Figure 3.93

**Chapter 3, Solution 48**

We apply mesh analysis and let the mesh currents be in mA.




For mesh 1,

$$-12+8+5I_1-I_2-4I_4=0 \longrightarrow 4=5I_1-I_2-4I_4 \qquad (1)$$

For mesh 2,

$$-8+13I_2-I_1-10I_3-2I_4=0 \longrightarrow 8=-I_1+13I_2-10I_3-2I_4 \qquad (2)$$

For mesh 3,

$$-6+15I_3-10I_2-5I_4=0 \longrightarrow 6=-10I_2+15I_3-5I_4 \qquad (3)$$

For mesh 4,

$$-4I_1-2I_2-5I_3+14I_4=0 \qquad (4)$$

Putting (1) to (4) in matrix form gives

$$\begin{pmatrix} 5 & -1 & 0 & -4 \\ -1 & 13 & -10 & -2 \\ 0 & -10 & 15 & -5 \\ -4 & -2 & -5 & 14 \end{pmatrix}\begin{pmatrix} I_1 \\ I_2 \\ I_3 \\ I_4 \end{pmatrix}=\begin{pmatrix} 4 \\ 8 \\ 6 \\ 0 \end{pmatrix} \longrightarrow \quad AI=B$$

Using MATLAB,

$$I=A^{-1}B=\begin{pmatrix} 7.217 \\ 8.087 \\ 7.791 \\ 6 \end{pmatrix}$$

The current through the $10k\Omega$ resistor is $I_o = I_2 - I_3$ = <u>0.2957 mA</u>

**Chapter 3, Problem 49.**

Find $v_o$ and $i_o$ in the circuit of Fig. 3.94.

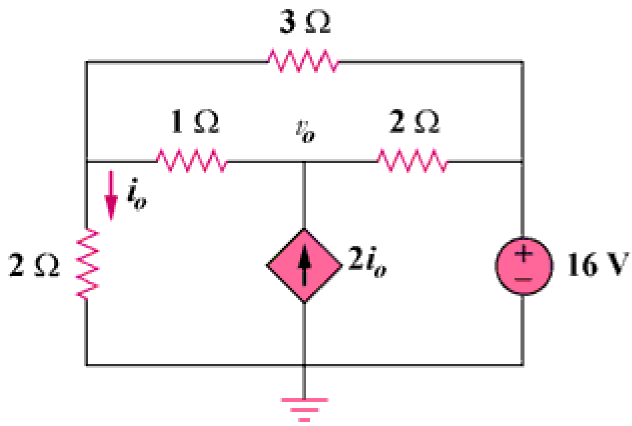
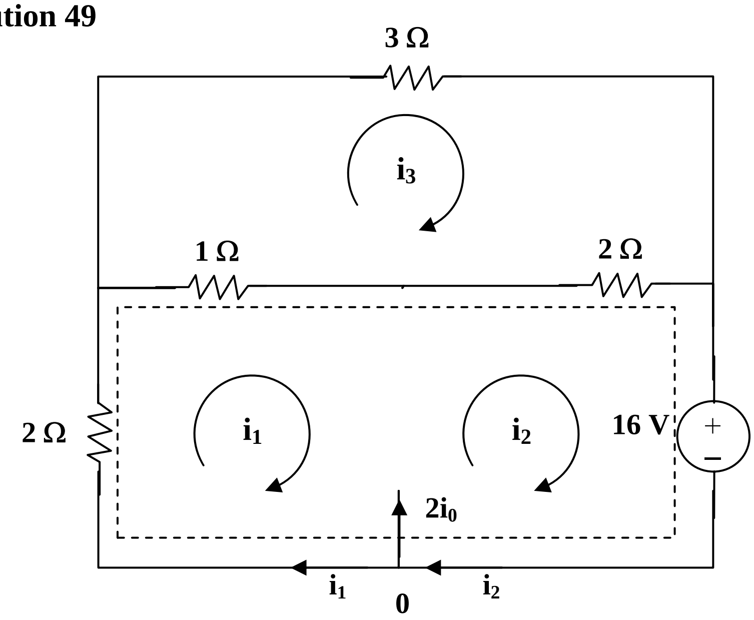
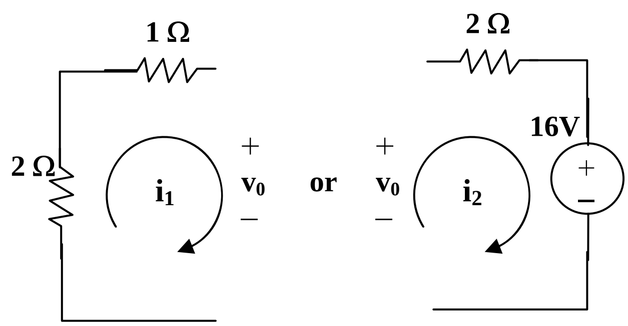



Figure 3.94

**Chapter 3, Solution 49**




(a)




(b)

For the supermesh in figure (a),

$$3i_1 + 2i_2 - 3i_3 + 16 = 0 \qquad (1)$$

At node 0, $\quad i_2 - i_1 = 2i_0$ and $i_0 = -i_1$ which leads to $i_2 = -i_1 \qquad (2)$

For loop 3, $\quad -i_1 - 2i_2 + 6i_3 = 0$ which leads to $6i_3 = -i_1 \qquad (3)$

Solving (1) to (3), $i_1 = (-32/3)\text{A}$, $i_2 = (32/3)\text{A}$, $i_3 = (16/9)\text{A}$

$i_0 = -i_1 =$ **<u>10.667 A</u>**, from fig. (b), $v_0 = i_3 - 3i_1 = (16/9) + 32 =$ **<u>33.78 V</u>**.

**Chapter 3, Problem 50.**

Use mesh analysis to find the current $i_o$ in the circuit in Fig. 3.95.

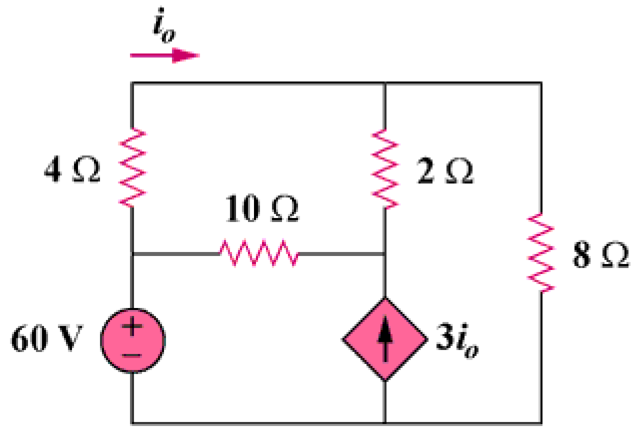
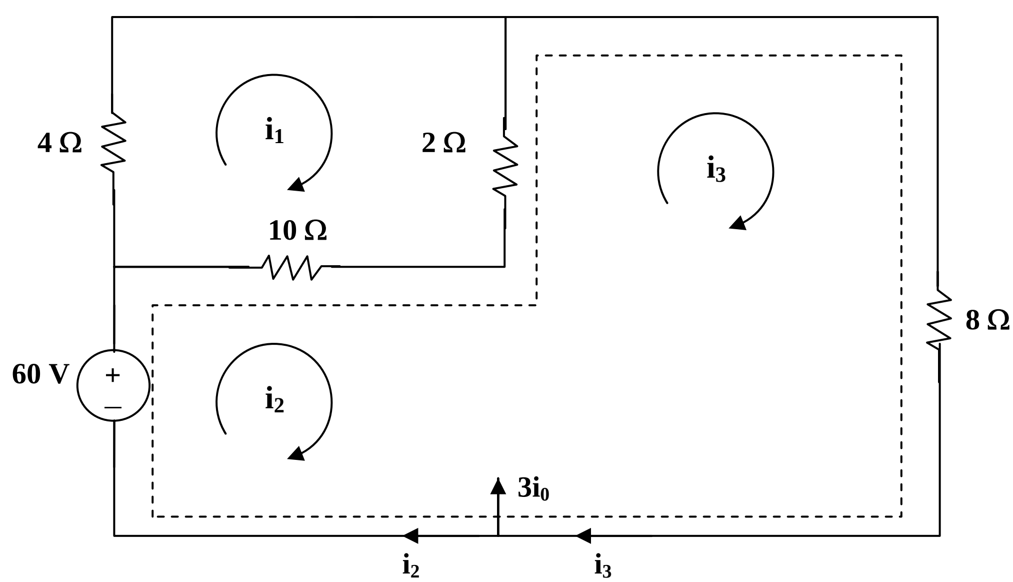



Figure 3.95

**Chapter 3, Solution 50**




For loop 1, $16i_1 - 10i_2 - 2i_3 = 0$ which leads to $8i_1 - 5i_2 - i_3 = 0$ (1)

For the supermesh, $-60 + 10i_2 - 10i_1 + 10i_3 - 2i_1 = 0$

or $-6i_1 + 5i_2 + 5i_3 = 30$ (2)

Also, $3i_0 = i_3 - i_2$ and $i_0 = i_1$ which leads to $3i_1 = i_3 - i_2$ (3)

Solving (1), (2), and (3), we obtain $i_1 = 1.731$ and $i_0 = i_1 =$ **1.731 A**

**Chapter 3, Problem 51.**

Apply mesh analysis to find $v_o$ in the circuit in Fig. 3.96.

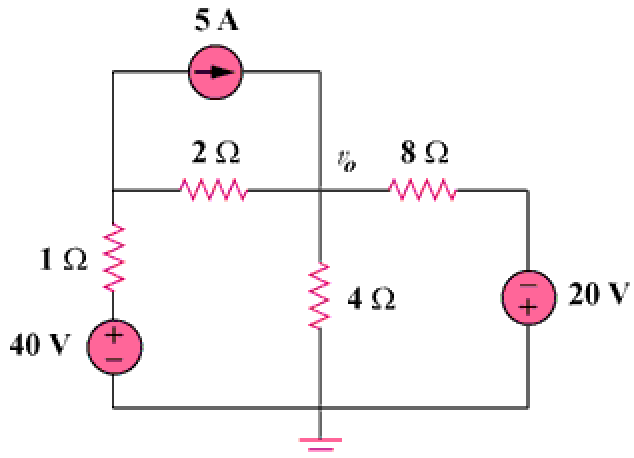
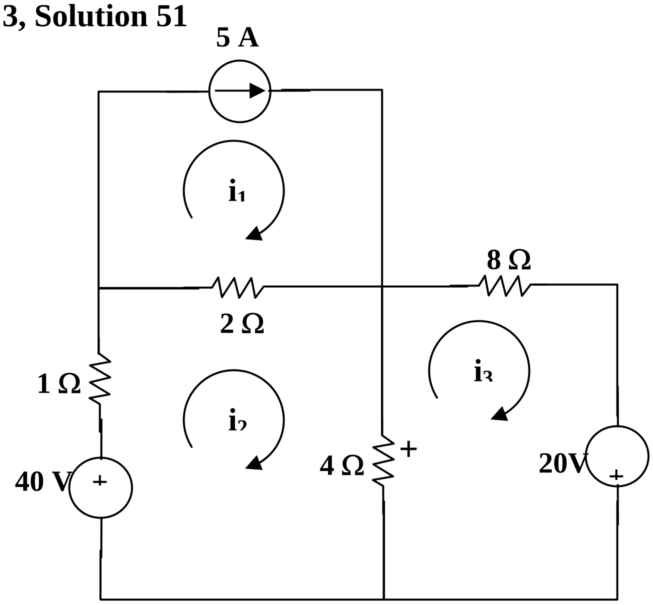



Figure 3.96

**Chapter 3, Solution 51**




For loop 1, $\quad i_1 = 5A \qquad (1)$

For loop 2, $\quad -40 + 7i_2 - 2i_1 - 4i_3 = 0$ which leads to $50 = 7i_2 - 4i_3 \qquad (2)$

For loop 3, $\quad -20 + 12i_3 - 4i_2 = 0$ which leads to $5 = -i_2 + 3i_3 \qquad (3)$

Solving with (2) and (3), $\quad i_2 = 10$ A, $i_3 = 5$ A

And, $\quad v_0 = 4(i_2 - i_3) = 4(10 - 5) =$ **20 V**.

**Chapter 3, Problem 52.**

Use mesh analysis to find $\boldsymbol{i_1}$, $\boldsymbol{i_2}$, and $\boldsymbol{i_3}$ in the circuit of Fig. 3.97.

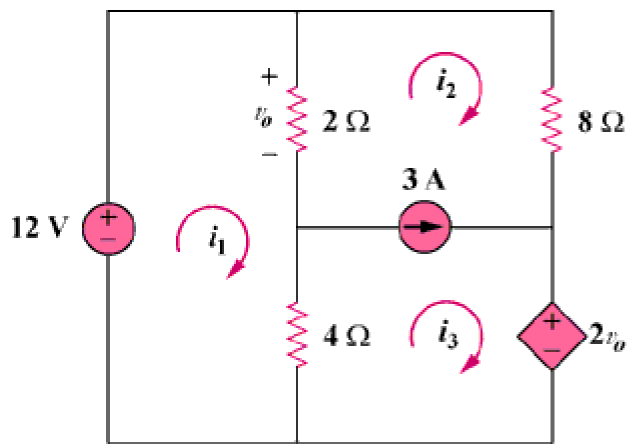
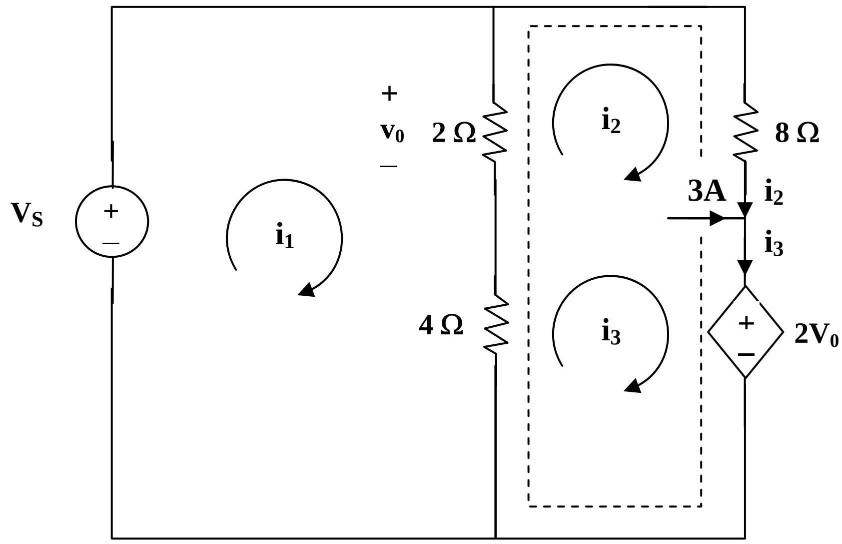



Figure 3.97

**Chapter 3, Solution 52**




For mesh 1,

$$2(i_1 - i_2) + 4(i_1 - i_3) - 12 = 0 \quad \text{which leads to} \quad 3i_1 - i_2 - 2i_3 = 6 \qquad (1)$$

For the supermesh, $2(i_2 - i_1) + 8i_2 + 2v_0 + 4(i_3 - i_1) = 0$

But $v_0 = 2(i_1 - i_2)$ which leads to $-i_1 + 3i_2 + 2i_3 = 0$ (2)

For the independent current source, $i_3 = 3 + i_2$ (3)

Solving (1), (2), and (3), we obtain,

$i_1 =$ **3.5 A**, $i_2 =$ **-0.5 A**, $i_3 =$ **2.5 A**.

**Chapter 3, Problem 53.**

Find the mesh currents in the circuit of Fig. 3.98 using MATLAB.

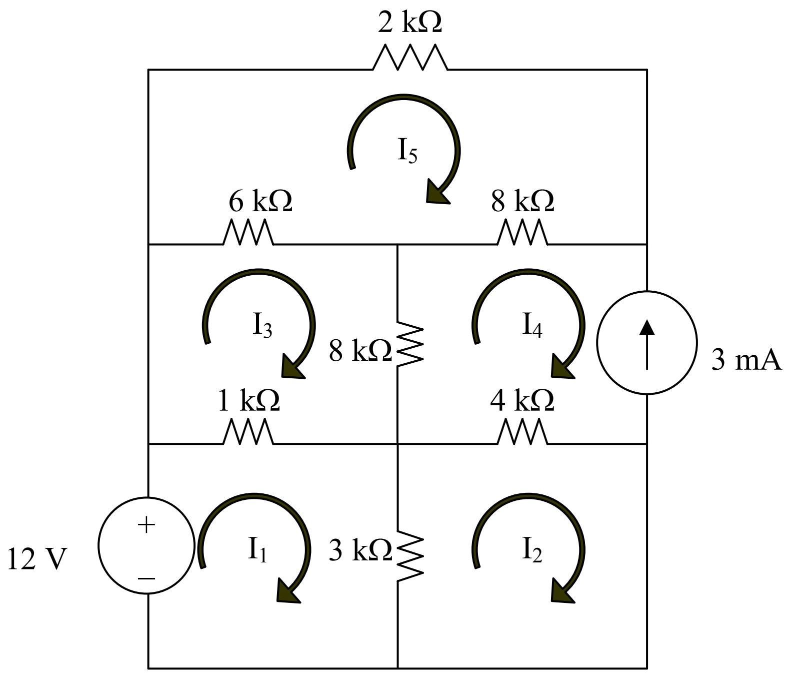



**Figure 3.98 For Prob. 3.53.**

**Chapter 3, Solution 53**

Applying mesh analysis leads to;

$$-12 + 4kI_1 - 3kI_2 - 1kI_3 = 0 \quad (1)$$
$$-3kI_1 + 7kI_2 - 4kI_4 = 0$$
$$-3kI_1 + 7kI_2 = -12 \quad (2)$$
$$-1kI_1 + 15kI_3 - 8kI_4 - 6kI_5 = 0$$
$$-1kI_1 + 15kI_3 - 6k = -24 \quad (3)$$
$$I_4 = -3mA \quad (4)$$
$$-6kI_3 - 8kI_4 + 16kI_5 = 0$$
$$-6kI_3 + 16kI_5 = -24 \quad (5)$$

Putting these in matrix form (having substituted $I_4$ = 3mA in the above),

$$\begin{bmatrix} 4 & -3 & -1 & 0 \\ -3 & 7 & 0 & 0 \\ -1 & 0 & 15 & -6 \\ 0 & 0 & -6 & 16 \end{bmatrix} k \begin{bmatrix} I_1 \\ I_2 \\ I_3 \\ I_5 \end{bmatrix} = \begin{bmatrix} 12 \\ -12 \\ -24 \\ -24 \end{bmatrix}$$

ZI = V

Using MATLAB,

```
>> Z = [4,-3,-1,0;-3,7,0,0;-1,0,15,-6;0,0,-6,16]

Z =

     4    -3    -1     0
    -3     7     0     0
    -1     0    15    -6
     0     0    -6    16

>> V = [12,-12,-24,-24]'

V =

    12
   -12
   -24
   -24
```

We obtain,

```
>> I = inv(Z)*V

        I =
```

**<u>1.6196 mA</u>**
**<u>–1.0202 mA</u>**
**<u>–2.461 mA</u>**
**<u>3 mA</u>**
**<u>–2.423 mA</u>**

**Chapter 3, Problem 54.**

Find the mesh currents $i_1$, $i_2$, and $i_3$ in the circuit in Fig. 3.99.

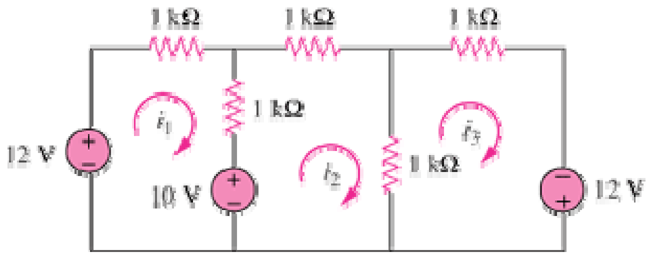



Figure 3.99

**Chapter 3, Solution 54**

Let the mesh currents be in mA. For mesh 1,

$$-12 + 10 + 2I_1 - I_2 = 0 \longrightarrow 2 = 2I_1 - I_2 \qquad (1)$$

For mesh 2,

$$-10 + 3I_2 - I_1 - I_3 = 0 \longrightarrow 10 = -I_1 + 3I_2 - I_3 \qquad (2)$$

For mesh 3,

$$-12 + 2I_3 - I_2 = 0 \longrightarrow 12 = -I_2 + 2I_3 \qquad (3)$$

Putting (1) to (3) in matrix form leads to

$$\begin{pmatrix} 2 & -1 & 0 \\ -1 & 3 & -1 \\ 0 & -1 & 2 \end{pmatrix}\begin{pmatrix} I_1 \\ I_2 \\ I_3 \end{pmatrix} = \begin{pmatrix} 2 \\ 10 \\ 12 \end{pmatrix} \longrightarrow AI = B$$

Using MATLAB,

$$I = A^{-1}B = \begin{bmatrix} 5.25 \\ 8.5 \\ 10.25 \end{bmatrix} \longrightarrow \underline{I_1 = 5.25\,\text{mA},\ I_2 = 8.5\,\text{mA}, I_3 = 10.25\,\text{mA}}$$

**Chapter 3, Problem 55.**

In the circuit of Fig. 3.100, solve for $\boldsymbol{i}_1$, $\boldsymbol{i}_2$, and $\boldsymbol{i}_3$.

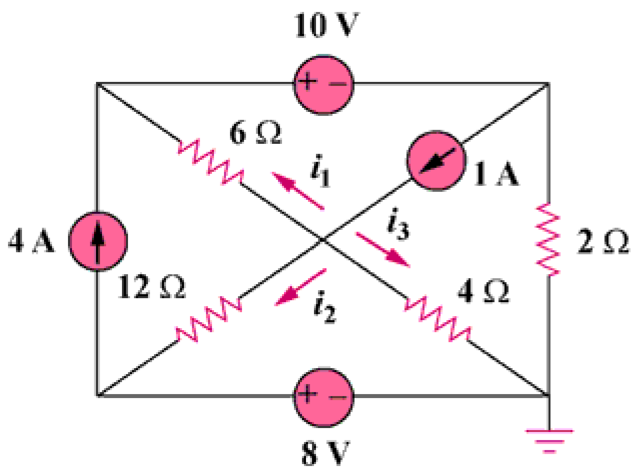
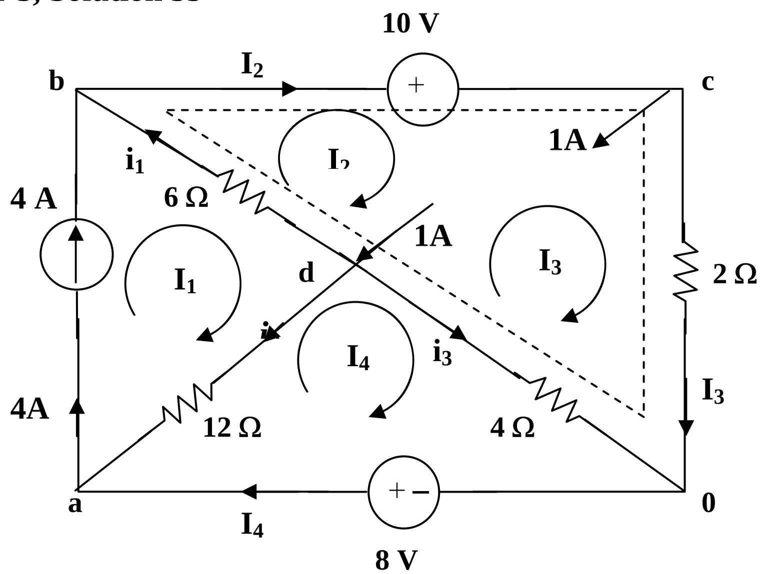



Figure 3.100

**Chapter 3, Solution 55**




It is evident that $I_1 = 4$ (1)

For mesh 4, $12(I_4 - I_1) + 4(I_4 - I_3) - 8 = 0$ (2)

For the supermesh $6(I_2 - I_1) + 10 + 2I_3 + 4(I_3 - I_4) = 0$
or $-3I_1 + 3I_2 + 3I_3 - 2I_4 = -5$ (3)

At node c, $I_2 = I_3 + 1$ (4)

Solving (1), (2), (3), and (4) yields, $I_1 = 4A$, $I_2 = 3A$, $I_3 = 2A$, and $I_4 = 4A$

At node b, $i_1 = I_2 - I_1 =$ **-1A**

At node a, $i_2 = 4 - I_4 =$ **0A**

At node 0, $i_3 = I_4 - I_3 =$ **2A**

**Chapter 3, Problem 56.**

Determine $\boldsymbol{v_1}$ and $\boldsymbol{v_2}$ in the circuit of Fig. 3.101.

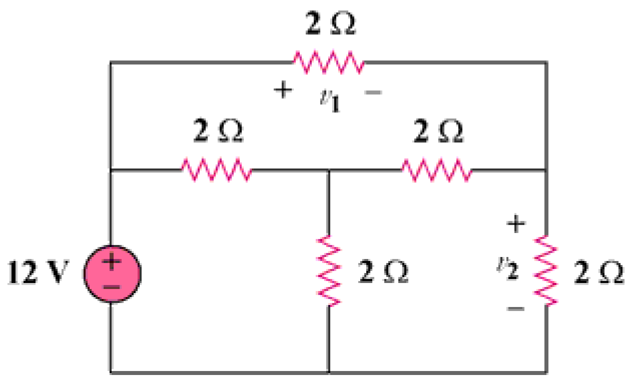
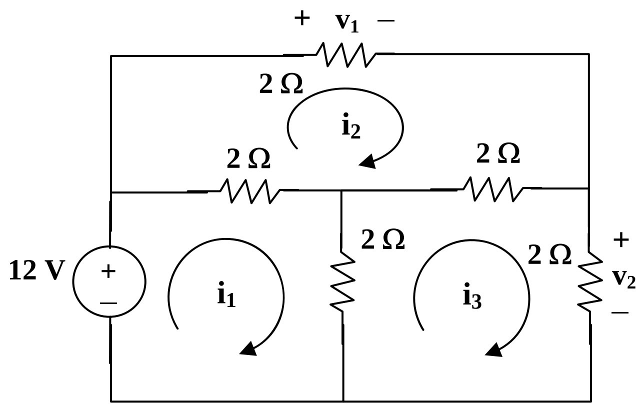



Figure 3.101

**Chapter 3, Solution 56**




For loop 1, $12 = 4i_1 - 2i_2 - 2i_3$ which leads to $6 = 2i_1 - i_2 - i_3$ (1)

For loop 2, $0 = 6i_2 - 2i_1 - 2\,i_3$ which leads to $0 = -i_1 + 3i_2 - i_3$ (2)

For loop 3, $0 = 6i_3 - 2i_1 - 2i_2$ which leads to $0 = -i_1 - i_2 + 3i_3$ (3)

In matrix form (1), (2), and (3) become,

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

$$\Delta = \begin{vmatrix} 2 & -1 & -1 \\ -1 & 3 & -1 \\ -1 & -1 & 3 \end{vmatrix} = 8, \quad \Delta_2 = \begin{vmatrix} 2 & 6 & -1 \\ -1 & 3 & -1 \\ -1 & 0 & 3 \end{vmatrix} = 24$$

$$\Delta_3 = \begin{vmatrix} 2 & -1 & 6 \\ -1 & 3 & 0 \\ -1 & -1 & 0 \end{vmatrix} = 24 \text{ , therefore } i_2 = i_3 = 24/8 = 3\text{A},$$

$v_1 = 2i_2 =$ **6 volts**, $v = 2i_3 =$ **6 volts**

**Chapter 3, Problem 57.**

In the circuit in Fig. 3.102, find the values of $R$, $V_1$, and $V_2$ given that $i_o = 18$ mA.

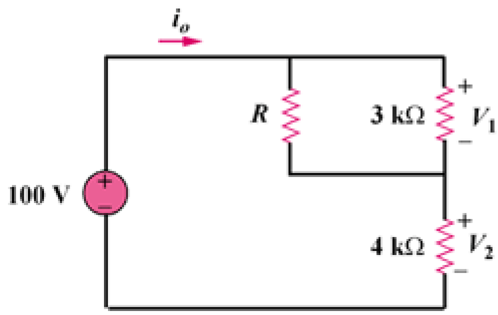



Figure 3.102

**Chapter 3, Solution 57**

Assume R is in kilo-ohms.

$V_2 = 4k\Omega x18mA = \underline{72V}$, $\qquad V_1 = 100 - V_2 = 100 - 72 = \underline{28V}$

Current through R is

$$i_R = \frac{3}{3+R} i_{o,} \qquad V_1 = i_R R \qquad \longrightarrow \qquad 28 = \frac{3}{3+R}(18)R$$

This leads to R = 84/26 = **<u>3.23 kΩ</u>**

**Chapter 3, Problem 58.**

Find $\mathbf{i_1}$, $i_2$, and $i_3$ the circuit in Fig. 3.103.

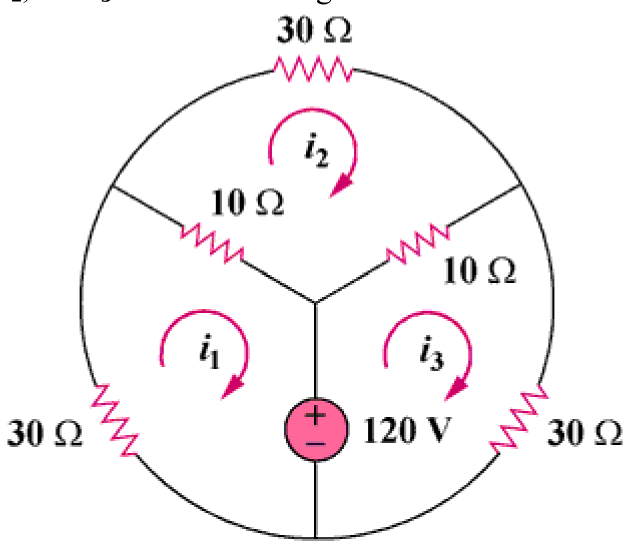
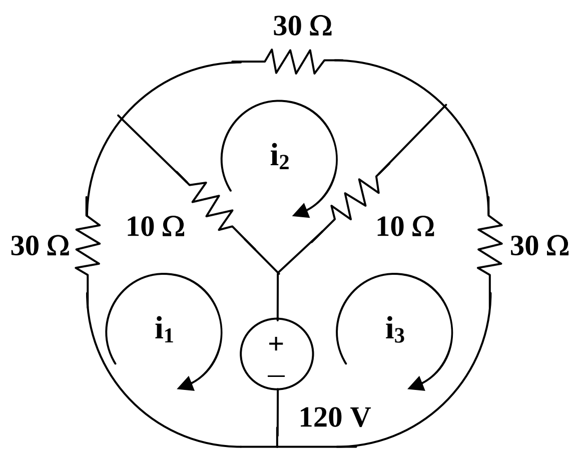



Figure 3.103

**Chapter 3, Solution 58**




For loop 1, $120 + 40i_1 - 10i_2 = 0$, which leads to $-12 = 4i_1 - i_2$ (1)

For loop 2, $50i_2 - 10i_1 - 10i_3 = 0$, which leads to $-i_1 + 5i_2 - i_3 = 0$ (2)

For loop 3, $-120 - 10i_2 + 40i_3 = 0$, which leads to $12 = -i_2 + 4i_3$ (3)

Solving (1), (2), and (3), we get, $i_1$ = **-3A**, $i_2$ = **0**, and $i_3$ = **3A**

**Chapter 3, Problem 59.**

Rework Prob. 3.30 using mesh analysis.

Chapter 3, Problem 30.

Using nodal analysis, find $\boldsymbol{v_o}$ and $\boldsymbol{i_o}$ in the circuit of Fig. 3.79.

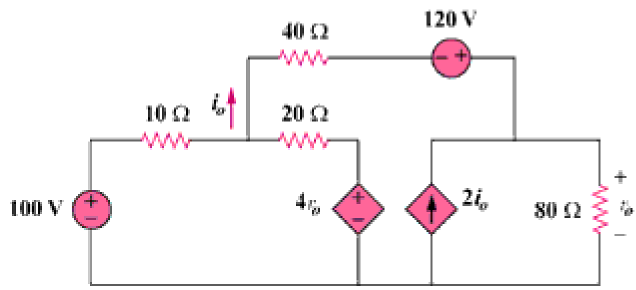
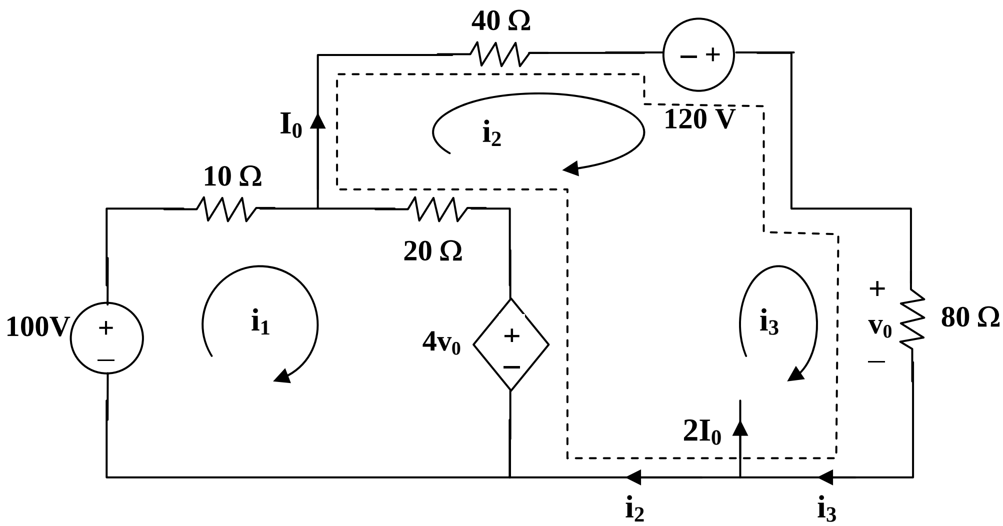



Figure 3.79

**Chapter 3, Solution 59**




For loop 1, $-100 + 30i_1 - 20i_2 + 4v_0 = 0$, where $v_0 = 80i_3$

or $5 = 1.5i_1 - i_2 + 16i_3$ (1)

For the supermesh, $60i_2 - 20i_1 - 120 + 80i_3 - 4\,v_0 = 0$, where $v_0 = 80i_3$

or $6 = -i_1 + 3i_2 - 12i_3$ (2)

Also, $2I_0 = i_3 - i_2$ and $I_0 = i_2$, hence, $3i_2 = i_3$ (3)

From (1), (2), and (3),
$$\begin{bmatrix} 3 & -2 & 32 \\ -1 & 3 & -12 \\ 0 & 3 & -1 \end{bmatrix}\begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix} = \begin{bmatrix} 10 \\ 6 \\ 0 \end{bmatrix}$$

$$\Delta = \begin{vmatrix} 3 & -2 & 32 \\ -1 & 3 & -12 \\ 0 & 3 & -1 \end{vmatrix} = 5,\ \Delta_2 = \begin{vmatrix} 3 & 10 & 32 \\ -1 & 6 & -12 \\ 0 & 0 & -1 \end{vmatrix} = -28,\ \Delta_3 = \begin{vmatrix} 3 & -2 & 10 \\ -1 & 3 & 6 \\ 0 & 3 & 0 \end{vmatrix} = -84$$

$I_0 = i_2 = \Delta_2/\Delta = -28/5 =$ **<u>-5.6 A</u>**

$v_0 = 8i_3 = (-84/5)80 =$ **<u>-1.344 kvolts</u>**

**Chapter 3, Problem 60.**

Calculate the power dissipated in each resistor in the circuit in Fig. 3.104.

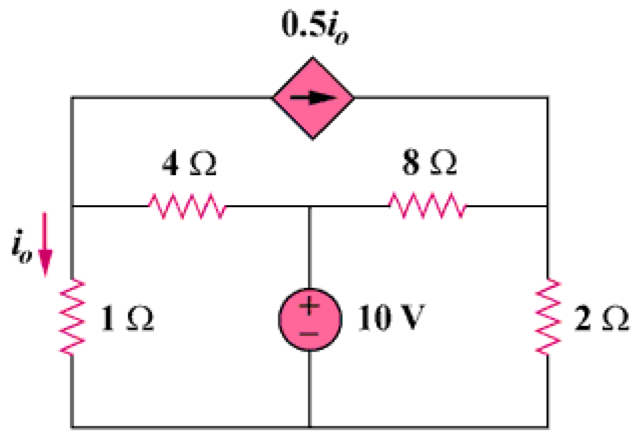
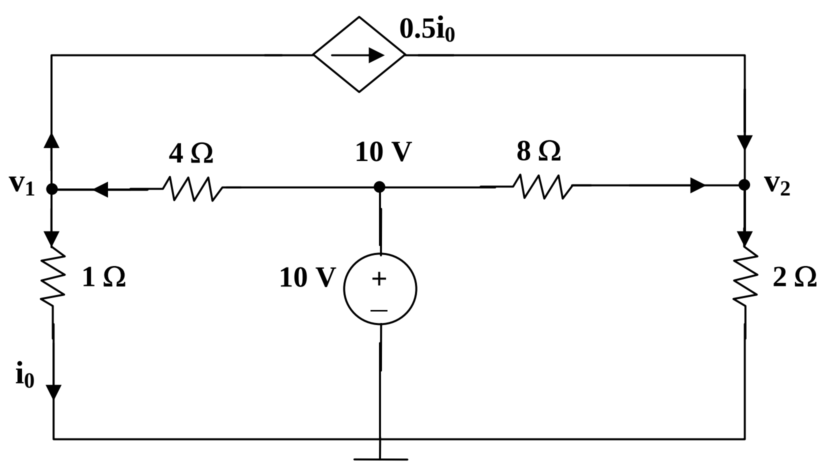



Figure 3.104

**Chapter 3, Solution 60**




At node 1, $(v_1/1) + (0.5v_1/1) = (10 - v_1)/4$, which leads to $v_1 = 10/7$

At node 2, $(0.5v_1/1) + ((10 - v_2)/8) = v_2/2$ which leads to $v_2 = 22/7$

$P_{1\Omega} = (v_1)^2/1 =$ **2.041 watts**, $P_{2\Omega} = (v_2)^2/2 =$ **4.939 watts**

$P_{4\Omega} = (10 - v_1)^2/4 =$ **18.38 watts**, $P_{8\Omega} = (10 - v_2)^2/8 =$ **5.88 watts**

**Chapter 3, Problem 61.**

Calculate the current gain $i_o/i_s$ in the circuit of Fig. 3.105.

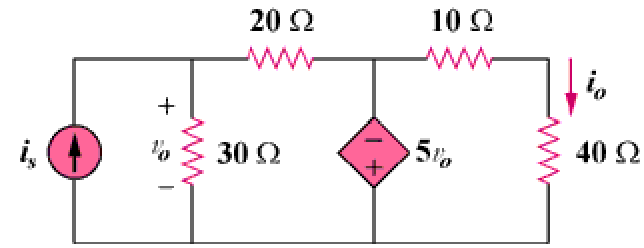
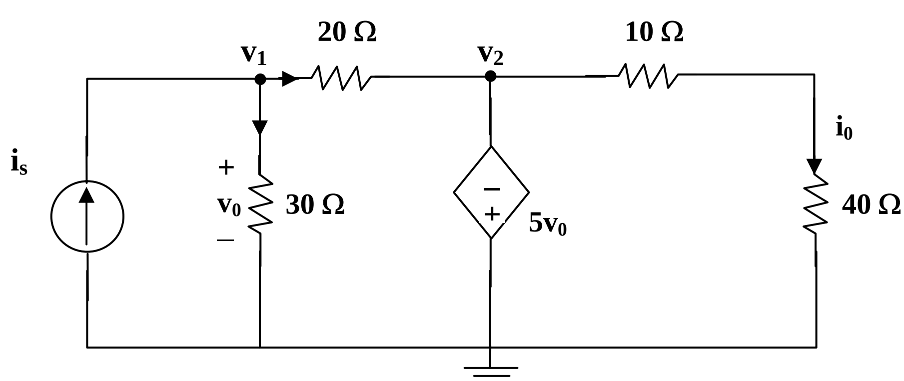



Figure 3.105

**Chapter 3, Solution 61**




At node 1, $i_s = (v_1/30) + ((v_1 - v_2)/20)$ which leads to $60i_s = 5v_1 - 3v_2$ (1)

But $v_2 = -5v_0$ and $v_0 = v_1$ which leads to $v_2 = -5v_1$

Hence, $60i_s = 5v_1 + 15v_1 = 20v_1$ which leads to $v_1 = 3i_s$, $v_2 = -15i_s$

$i_0 = v_2/50 = -15i_s/50$ which leads to $i_0/i_s = -15/50 = \underline{\mathbf{-0.3}}$

**Chapter 3, Problem 62.**

Find the mesh currents $\boldsymbol{i_1}$, $\boldsymbol{i_2}$, and $\boldsymbol{i_3}$ in the network of Fig. 3.106.

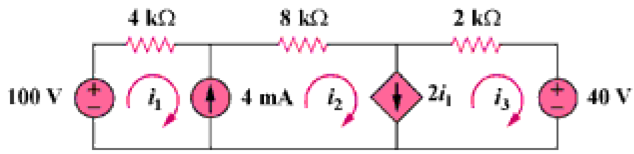
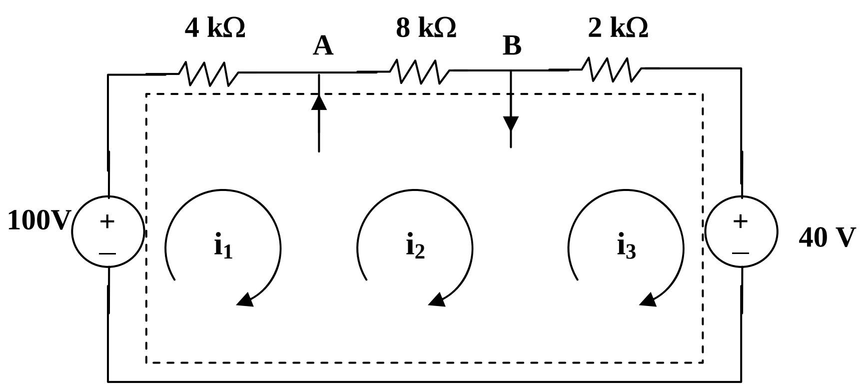



Figure 3.106

**Chapter 3, Solution 62**




We have a supermesh. Let all R be in kΩ, i in mA, and v in volts.

For the supermesh, $-100 + 4i_1 + 8i_2 + 2i_3 + 40 = 0$ or $30 = 2i_1 + 4i_2 + i_3$ (1)

At node A, $i_1 + 4 = i_2$ (2)

At node B, $i_2 = 2i_1 + i_3$ (3)

Solving (1), (2), and (3), we get $i_1 =$ **2 mA**, $i_2 =$ **6 mA**, and $i_3 =$ **2 mA**.

**Chapter 3, Problem 63.**

Find $\boldsymbol{v_x}$, and $\boldsymbol{i_x}$ in the circuit shown in Fig. 3.107.

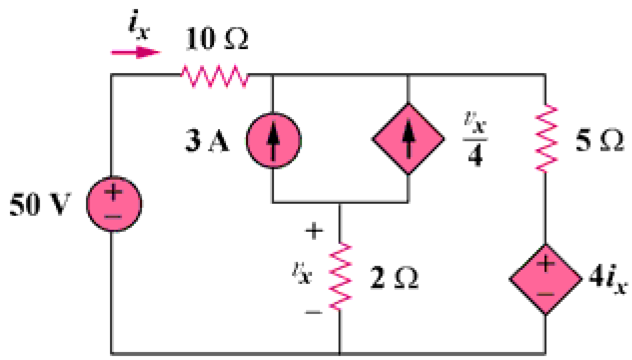
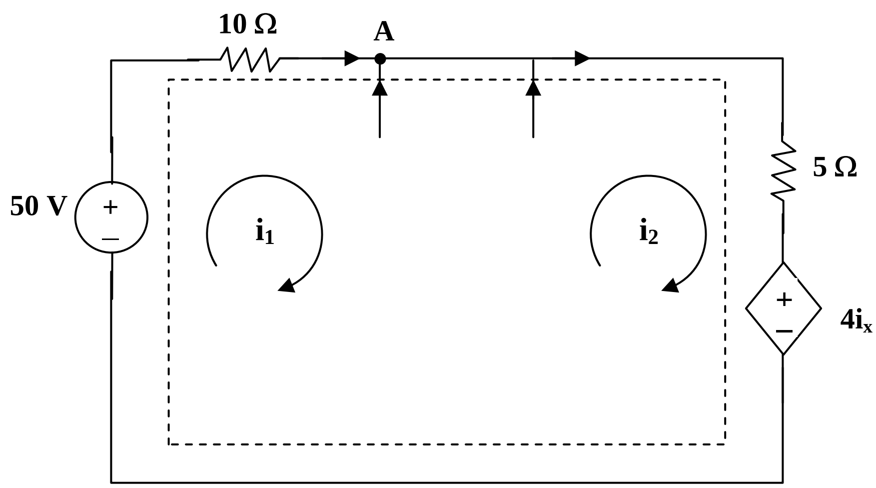



Figure 3.107

**Chapter 3, Solution 63**




For the supermesh, $-50 + 10i_1 + 5i_2 + 4i_x = 0$, but $i_x = i_1$. Hence,

$$50 = 14i_1 + 5i_2 \qquad (1)$$

At node A, $i_1 + 3 + (v_x/4) = i_2$, but $v_x = 2(i_1 - i_2)$, hence, $i_1 + 2 = i_2$ (2)

Solving (1) and (2) gives $i_1 = 2.105$ A and $i_2 = 4.105$ A

$v_x = 2(i_1 - i_2) =$ <u>**–4 volts**</u> and $i_x = i_2 - 2 =$ <u>**2.105 amp**</u>

**Chapter 3, Problem 64.**

Find $v_o$, and $i_o$ in the circuit of Fig. 3.108.

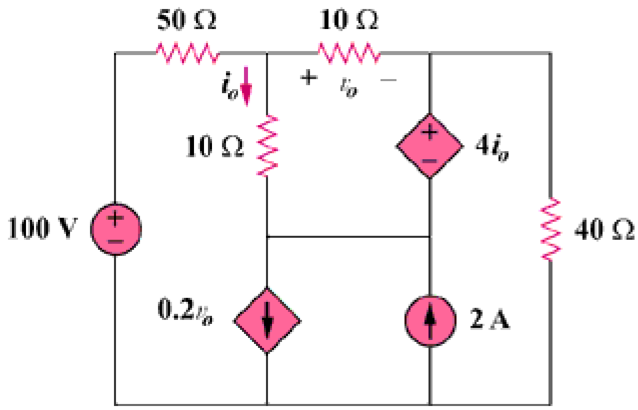
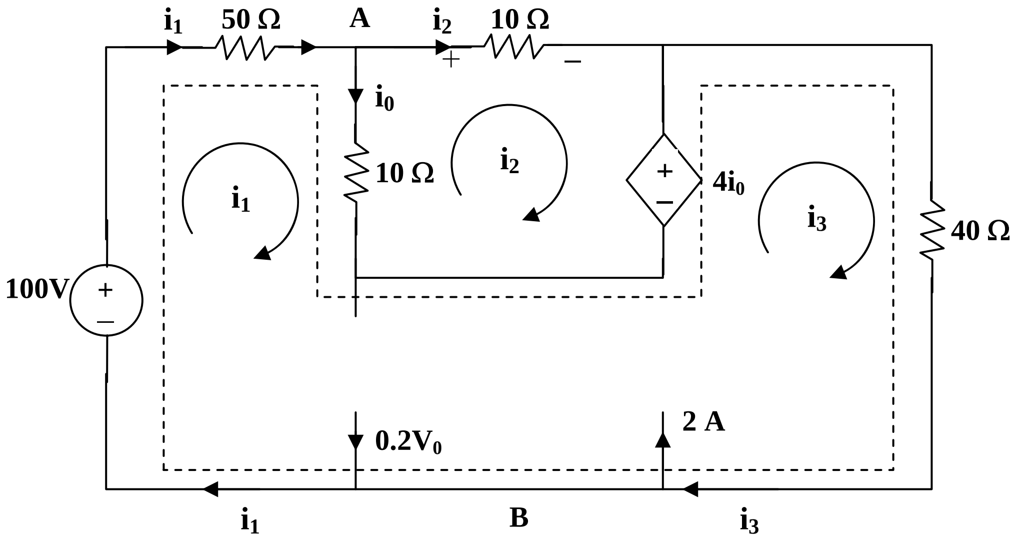



Figure 3.108

## Chapter 3, Solution 64




For mesh 2, $\quad 20i_2 - 10i_1 + 4i_0 = 0 \quad$ (1)

But at node A, $i_o = i_1 - i_2$ so that (1) becomes $i_1 = (16/6)i_2 \quad$ (2)

For the supermesh, $-100 + 50i_1 + 10(i_1 - i_2) - 4i_0 + 40i_3 = 0$

or $\quad 50 = 28i_1 - 3i_2 + 20i_3 \quad$ (3)

At node B, $\quad i_3 + 0.2v_0 = 2 + i_1 \quad$ (4)

But, $\quad v_0 = 10i_2$ so that (4) becomes $i_3 = 2 + (2/3)i_2 \quad$ (5)

Solving (1) to (5), $i_2 = 0.11764$,

$v_0 = 10i_2 =$ **1.1764 volts**, $\quad i_0 = i_1 - i_2 = (5/3)i_2 =$ **196.07 mA**

## Chapter 3, Problem 65.

Use *MATLAB* to solve for the mesh currents in the circuit of Fig. 3.109.

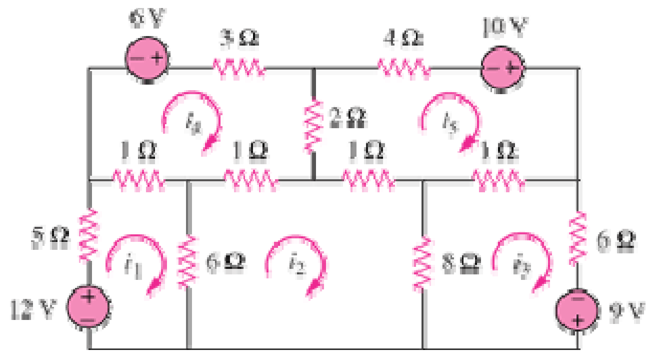



Figure 3.109

## Chapter 3, Solution 65

For mesh 1,

$$-12 + 12I_1 - 6I_2 - I_4 = 0 \text{ or}$$
$$12 = 12I_1 - 6I_2 - I_4 \qquad (1)$$

For mesh 2,

$$-6I_1 + 16I_2 - 8I_3 - I_4 - I_5 = 0 \qquad (2)$$

For mesh 3,

$$-8I_2 + 15I_3 - I_5 - 9 = 0 \text{ or}$$
$$9 = -8I_2 + 15I_3 - I_5 \qquad (3)$$

For mesh 4,

$$-I_1 - I_2 + 7I_4 - 2I_5 - 6 = 0 \text{ or}$$
$$6 = -I_1 - I_2 + 7I_4 - 2I_5 \qquad (4)$$

For mesh 5,

$$-I_2 - I_3 - 2I_4 + 8I_5 - 10 = 0 \text{ or}$$
$$10 = -I_2 - I_3 - 2I_4 + 8I_5 \qquad (5)$$

Casting (1) to (5) in matrix form gives

$$\begin{pmatrix} 12 & -6 & 0 & 1 & 0 \\ -6 & 16 & -8 & -1 & -1 \\ 0 & -8 & 15 & 0 & -1 \\ -1 & -1 & 0 & 7 & -2 \\ 0 & -1 & -1 & -2 & 8 \end{pmatrix} \begin{pmatrix} I_1 \\ I_2 \\ I_3 \\ I_4 \\ I_5 \end{pmatrix} = \begin{pmatrix} 12 \\ 0 \\ 9 \\ 6 \\ 10 \end{pmatrix} \quad \longrightarrow \quad AI = B$$

Using MATLAB we input:
Z=[12,-6,0,-1,0;-6,16,-8,-1,-1;0,-8,15,0,-1;-1,-1,0,7,-2;0,-1,-1,-2,8]
and V=[12;0;9;6;10]

This leads to

```
>> Z=[12,-6,0,-1,0;-6,16,-8,-1,-1;0,-8,15,0,-1;-1,-1,0,7,-2;0,-1,-1,-2,8]

Z =
    12   -6    0   -1    0
    -6   16   -8   -1   -1
     0   -8   15    0   -1
    -1   -1    0    7   -2
     0   -1   -1   -2    8

>> V=[12;0;9;6;10]

V =
    12
     0
     9
     6
    10

>> I=inv(Z)*V

I =
    2.1701
    1.9912
    1.8119
    2.0942
    2.2489
```

Thus,

**I** = **[2.17, 1.9912, 1.8119, 2.094, 2.249] A**.

**Chapter 3, Problem 66.**

Write a set of mesh equations for the circuit in Fig. 3.110. Use MATLAB to determine the mesh currents.

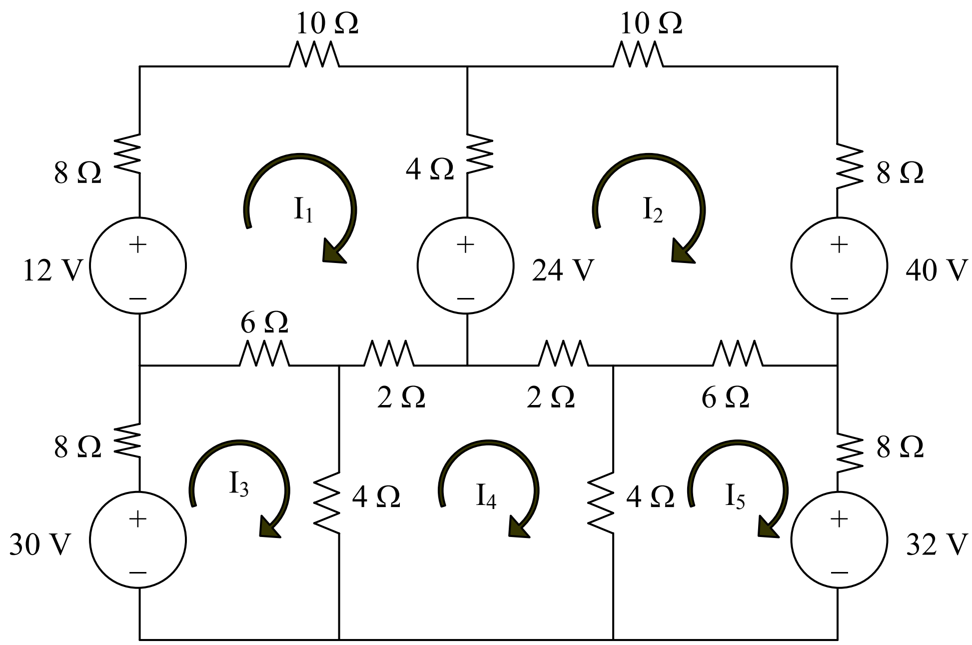



**Figure 3.110 For Prob. 3.66.**

**Chapter 3, Solution 66**

The mesh equations are obtained as follows.

$$-12 + 24 + 30I_1 - 4I_2 - 6I_3 - 2I_4 = 0$$

or

$$30I_1 - 4I_2 - 6I_3 - 2I_4 = -12 \qquad (1)$$

$$-24 + 40 - 4I_1 + 30I_2 - 2I_4 - 6I_5 = 0$$

or

$$-4I_1 + 30I_2 - 2I_4 - 6I_5 = -16 \qquad (2)$$

$$-6I_1 + 18I_3 - 4I_4 = 30 \qquad (3)$$

$$-2I_1 - 2I_2 - 4I_3 + 12I_4 - 4I_5 = 0 \qquad (4)$$

$$-6I_2 - 4I_4 + 18I_5 = -32 \qquad (5)$$

Putting (1) to (5) in matrix form

$$\begin{bmatrix} 30 & -4 & -6 & -2 & 0 \\ -4 & 30 & 0 & -2 & -6 \\ -6 & 0 & 18 & -4 & 0 \\ -2 & -2 & -4 & 12 & -4 \\ 0 & -6 & 0 & -4 & 18 \end{bmatrix} I = \begin{bmatrix} -12 \\ -16 \\ 30 \\ 0 \\ -32 \end{bmatrix}$$

ZI = V

Using MATLAB,

```
>> Z = [30,-4,-6,-2,0;
-4,30,0,-2,-6;
-6,0,18,-4,0;
-2,-2,-4,12,-4;
0,-6,0,-4,18]

Z =
   30   -4   -6   -2    0
   -4   30    0   -2   -6
   -6    0   18   -4    0
   -2   -2   -4   12   -4
    0   -6    0   -4   18

>> V = [-12,-16,30,0,-32]'

V =
  -12
  -16
   30
    0
  -32

>> I = inv(Z)*V

I =
```

**-0.2779 A**
**-1.0488 A**
**1.4682 A**
**-0.4761 A**
**-2.2332 A**

**Chapter 3, Problem 67.**

Obtain the node-voltage equations for the circuit in Fig. 3.111 by inspection. Then solve for $V_o$.

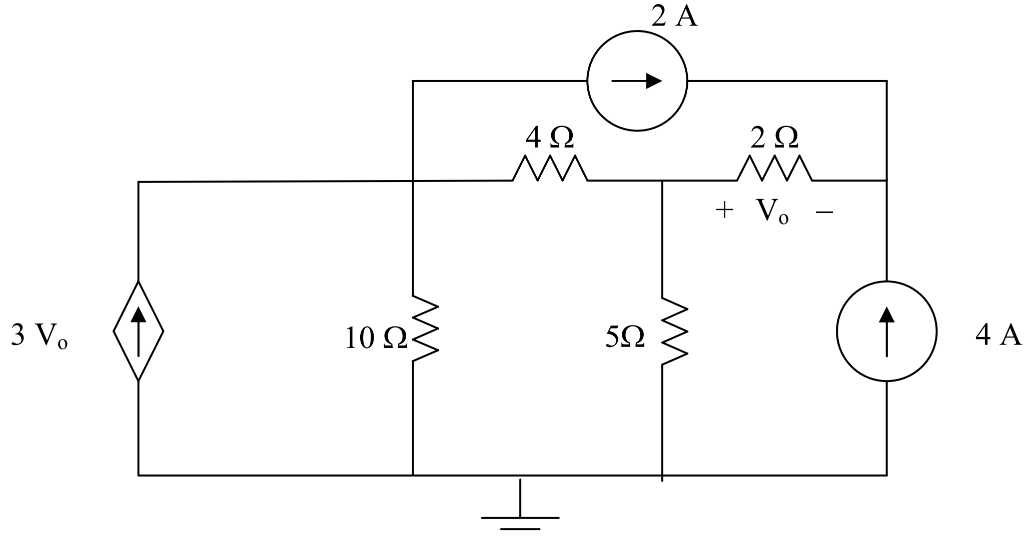
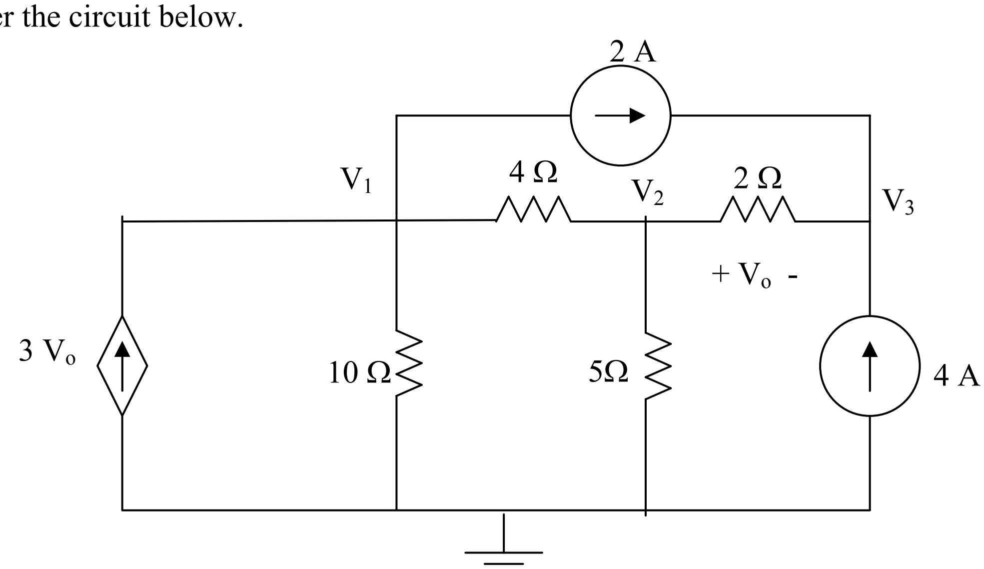



**Figure 3.111 For Prob. 3.67.**

**Chapter 3, Solution 67**

Consider the circuit below.




$$\begin{bmatrix} 0.35 & -0.25 & 0 \\ -0.25 & 0.95 & -0.5 \\ 0 & -0.5 & 0.5 \end{bmatrix} V = \begin{bmatrix} V_o \\ 0 \\ 6 \end{bmatrix}$$

Since we actually have four unknowns and only three equations, we need a constraint equation.

$$V_o = V_2 - V_3$$

Substituting this back into the matrix equation, the first equation becomes,

$$0.35V_1 - 3.25V_2 + 3V_3 = -2$$

This now results in the following matrix equation,

$$\begin{bmatrix} 0.35 & -3.25 & 3 \\ -0.25 & 0.95 & -0.5 \\ 0 & -0.5 & 0.5 \end{bmatrix} V = \begin{bmatrix} -2 \\ 0 \\ 6 \end{bmatrix}$$

Now we can use MATLAB to solve for V.

```
>> Y=[0.35,-3.25,3;-0.25,0.95,-0.5;0,-0.5,0.5]

Y =
   0.3500   -3.2500    3.0000
  -0.2500    0.9500   -0.5000
        0   -0.5000    0.5000

>> I=[-2,0,6]'

I =
   -2
    0
    6

>> V=inv(Y)*I

V =
 -164.2105
  -77.8947
  -65.8947
```

$V_o = V_2 - V_3 = -77.89 + 65.89 =$ <u>**$-12$ V**</u>.

Let us now do a quick check at node 1.

$$-3(-12) + 0.1(-164.21) + 0.25(-164.21+77.89) + 2 =$$
$$+36 - 16.421 - 21.58 + 2 = -0.001;$$ answer checks!

**Chapter 3, Problem 68.**

Find the voltage $V_o$ in the circuit of Fig. 3.112.

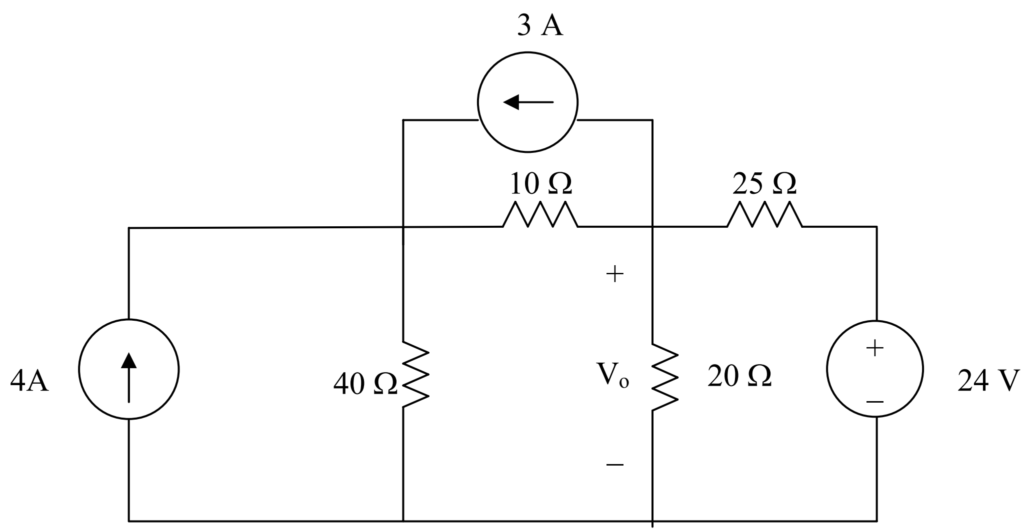
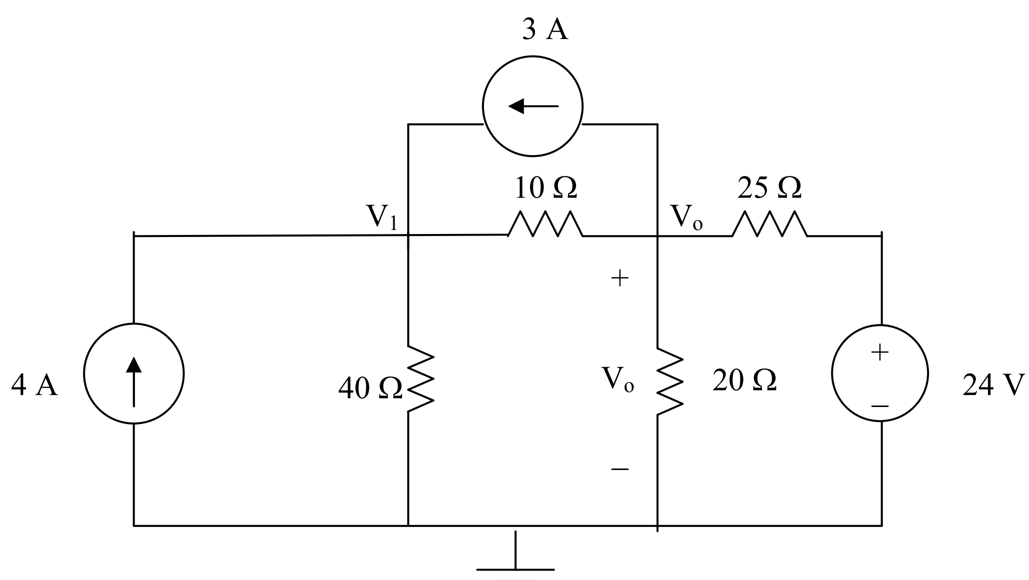



**Figure 3.112 For Prob. 3.68.**

**Chapter 3, Solution 68**

Consider the circuit below. There are two non-reference nodes.



$$\begin{bmatrix} 0.125 & -0.1 \\ -0.1 & 0.19 \end{bmatrix} V = \begin{bmatrix} +4+3 \\ -3+24/25 \end{bmatrix} = \begin{bmatrix} 7 \\ -2.04 \end{bmatrix}$$

Using MATLAB, we get,

```
>> Y=[0.125,-0.1;-0.1,0.19]

Y =

   0.1250   -0.1000
  -0.1000    0.1900

>> I=[7,-2.04]'

I =

   7.0000
  -2.0400

>> V=inv(Y)*I

V =

  81.8909
  32.3636
```

Thus, $V_o$ = **32.36 V**.

We can perform a simple check at node $V_o$,

$3 + 0.1(32.36–81.89) + 0.05(32.36) + 0.04(32.36–24) =$
$3 – 4.953 + 1.618 + 0.3344 = – 0.0004$; answer checks!

**Chapter 3, Problem 69.**

For the circuit in Fig. 3.113, write the node voltage equations by inspection.

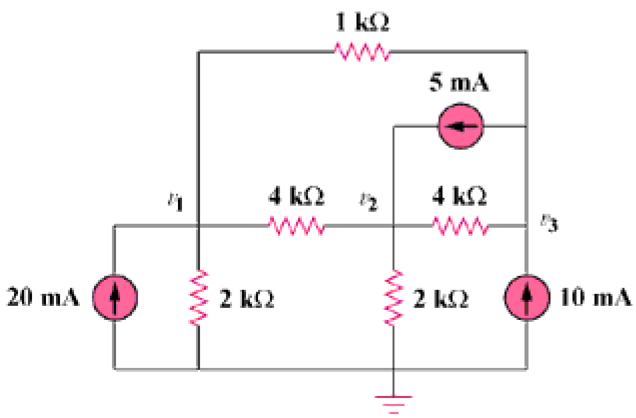



Figure 3.113

**Chapter 3, Solution 69**

Assume that all conductances are in mS, all currents are in mA, and all voltages are in volts.

$G_{11} = (1/2) + (1/4) + (1/1) = 1.75$, $G_{22} = (1/4) + (1/4) + (1/2) = 1$,
$G_{33} = (1/1) + (1/4) = 1.25$, $G_{12} = -1/4 = -0.25$, $G_{13} = -1/1 = -1$,
$G_{21} = -0.25$, $G_{23} = -1/4 = -0.25$, $G_{31} = -1$, $G_{32} = -0.25$

$i_1 = 20$, $i_2 = 5$, and $i_3 = 10 - 5 = 5$

The node-voltage equations are:

$$\begin{bmatrix} 1.75 & -0.25 & -1 \\ -0.25 & 1 & -0.25 \\ -1 & -0.25 & 1.25 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \\ v_3 \end{bmatrix} = \begin{bmatrix} 20 \\ 5 \\ 5 \end{bmatrix}$$

**Chapter 3, Problem 70.**

Write the node-voltage equations by inspection and then determine values of $V_1$ and $V_2$ in the circuit in Fig. 3.114.

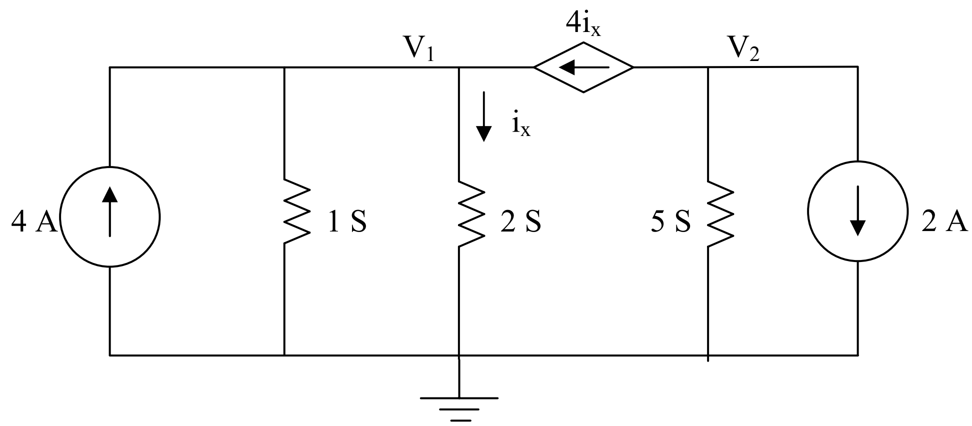



**Figure 3.114 For Prob. 3.70.**

**Chapter 3, Solution 70**

$$\begin{bmatrix} 3 & 0 \\ 0 & 5 \end{bmatrix} V = \begin{bmatrix} 4I_x + 4 \\ -4I_x - 2 \end{bmatrix}$$

With two equations and three unknowns, we need a constraint equation,

$I_x = 2V_1$, thus the matrix equation becomes,

$$\begin{bmatrix} -5 & 0 \\ 8 & 5 \end{bmatrix} V = \begin{bmatrix} 4 \\ -2 \end{bmatrix}$$

This results in $V_1 = 4/(-5) =$ **$-0.8$V** and
$V_2 = [-8(-0.8) - 2]/5 = [6.4 - 2]/5 =$ **0.88 V**.

**Chapter 3, Problem 71.**

Write the mesh-current equations for the circuit in Fig. 3.115. Next, determine the values of $I_1$, $I_2$, and $I_3$.

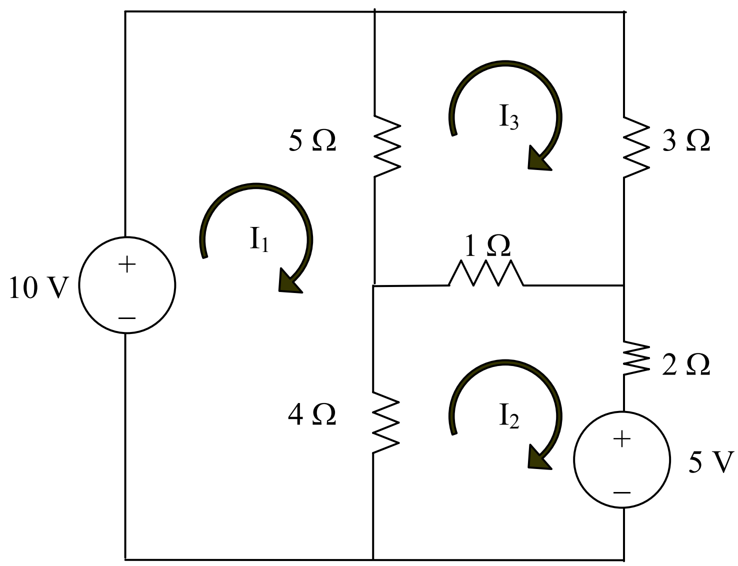



Figure 3.115 For Prob. 3.71.

**Chapter 3, Solution 71**

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

We can now use MATLAB solve for our currents.

```
>> R=[9,-4,-5;-4,7,-1;-5,-1,9]

R =

    9   -4   -5
   -4    7   -1
   -5   -1    9

>> V=[10,-5,0]'

V =

   10
   -5
    0

>> I=inv(R)*V

I =
```

**2.085 A**
**653.3 mA**
**1.2312 A**

**Chapter 3, Problem 72.**

By inspection, write the mesh-current equations for the circuit in Fig. 3.116.

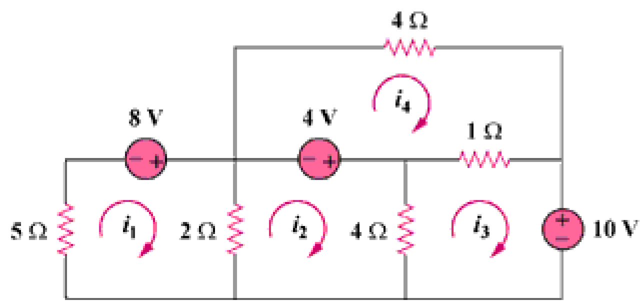



Figure 3.116

**Chapter 3, Solution 72**

$R_{11} = 5 + 2 = 7$, $R_{22} = 2 + 4 = 6$, $R_{33} = 1 + 4 = 5$, $R_{44} = 1 + 4 = 5$, $R_{12} = -2$, $R_{13} = 0 = R_{14}$, $R_{21} = -2$, $R_{23} = -4$, $R_{24} = 0$, $R_{31} = 0$, $R_{32} = -4$, $R_{34} = -1$, $R_{41} = 0 = R_{42}$, $R_{43} = -1$, we note that $R_{ij} = R_{ji}$ for all i not equal to j.

$v_1 = 8$, $v_2 = 4$, $v_3 = -10$, and $v_4 = -4$

Hence the mesh-current equations are:

$$\begin{bmatrix} 7 & -2 & 0 & 0 \\ -2 & 6 & -4 & 0 \\ 0 & -4 & 5 & -1 \\ 0 & 0 & -1 & 5 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \\ i_4 \end{bmatrix} = \begin{bmatrix} 8 \\ 4 \\ -10 \\ -4 \end{bmatrix}$$

**Chapter 3, Problem 73.**

Write the mesh-current equations for the circuit in Fig. 3.117.

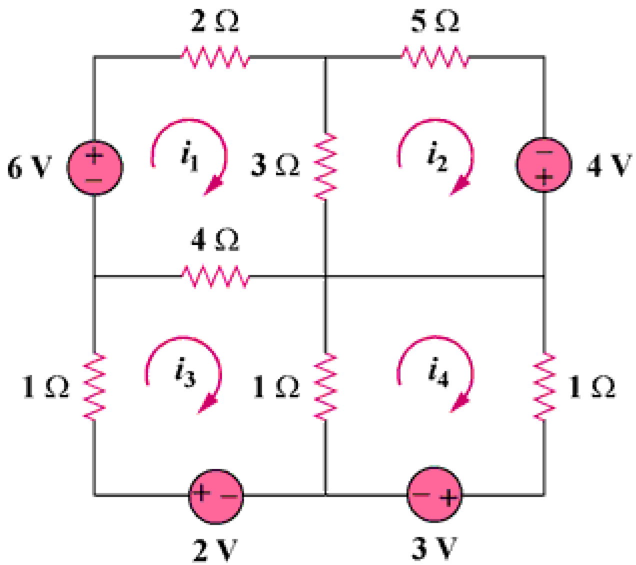



Figure 3.117

**Chapter 3, Solution 73**

$R_{11} = 2 + 3 + 4 = 9$, $R_{22} = 3 + 5 = 8$, $R_{33} = 1 + 1 + 4 = 6$, $R_{44} = 1 + 1 = 2$,
$R_{12} = -3$, $R_{13} = -4$, $R_{14} = 0$, $R_{23} = 0$, $R_{24} = 0$, $R_{34} = -1$

$v_1 = 6$, $v_2 = 4$, $v_3 = 2$, and $v_4 = -3$

Hence,

$$\begin{bmatrix} 9 & -3 & -4 & 0 \\ -3 & 8 & 0 & 0 \\ -4 & 0 & 6 & -1 \\ 0 & 0 & -1 & 2 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \\ i_4 \end{bmatrix} = \begin{bmatrix} 6 \\ 4 \\ 2 \\ -3 \end{bmatrix}$$

**Chapter 3, Problem 74.**

By inspection, obtain the mesh-current equations for the circuit in Fig. 3.11.

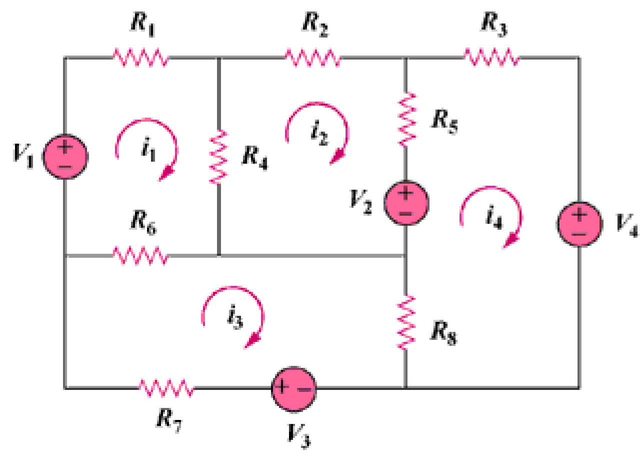



Figure 3.118

**Chapter 3, Solution 74**

$R_{11} = R_1 + R_4 + R_6$, $R_{22} = R_2 + R_4 + R_5$, $R_{33} = R_6 + R_7 + R_8$,
$R_{44} = R_3 + R_5 + R_8$, $R_{12} = -R_4$, $R_{13} = -R_6$, $R_{14} = 0$, $R_{23} = 0$,
$R_{24} = -R_5$, $R_{34} = -R_8$, again, we note that $R_{ij} = R_{ji}$ for all i not equal to j.

The input voltage vector is = $\begin{bmatrix} V_1 \\ -V_2 \\ V_3 \\ -V_4 \end{bmatrix}$

$$\begin{bmatrix} R_1 + R_4 + R_6 & -R_4 & -R_6 & 0 \\ -R_4 & R_2 + R_4 + R_5 & 0 & -R_5 \\ -R_6 & 0 & R_6 + R_7 + R_8 & -R_8 \\ 0 & -R_5 & -R_8 & R_3 + R_5 + R_8 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \\ i_4 \end{bmatrix} = \begin{bmatrix} V_1 \\ -V_2 \\ V_3 \\ -V_4 \end{bmatrix}$$

**Chapter 3, Problem 75.**

Use *PSpice* to solve Prob. 3.58.

Chapter 3, Problem 58

Find $\mathbf{i_1}$, $\boldsymbol{i_2}$, and $\boldsymbol{i_3}$ the circuit in Fig. 3.103.

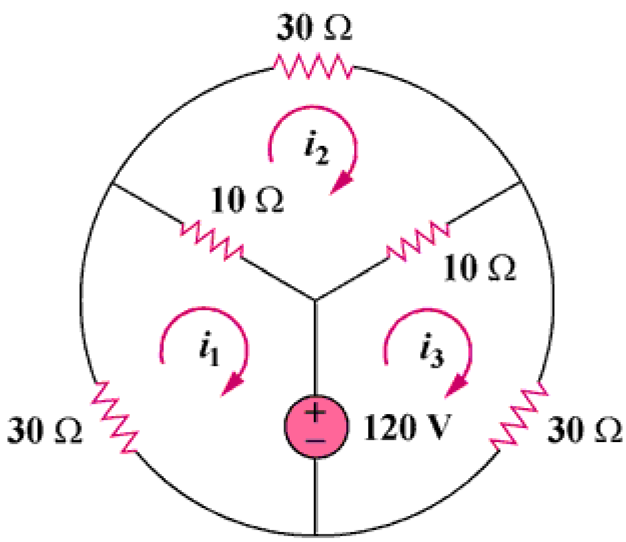
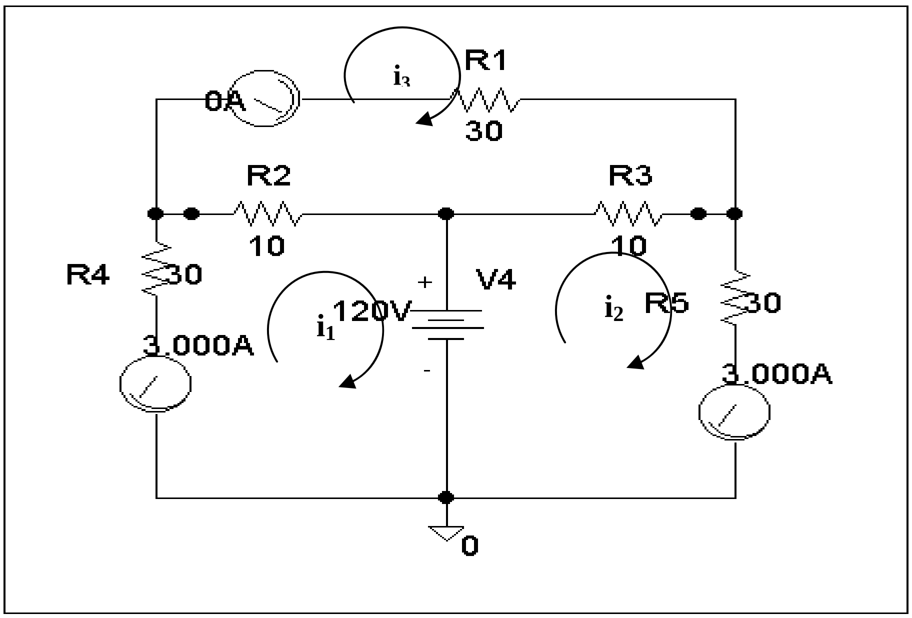



Figure 3.103

**Chapter 3, Solution 75**

```
* Schematics Netlist *

R_R4          $N_0002 $N_0001  30
R_R2          $N_0001 $N_0003  10
R_R1          $N_0005 $N_0004  30
R_R3          $N_0003 $N_0004  10
R_R5          $N_0006 $N_0004  30
V_V4          $N_0003 0 120V
v_V3          $N_0005 $N_0001 0
v_V2          0 $N_0006 0
v_V1          0 $N_0002 0
```




Clearly, $i_1$ = **<u>–3 amps</u>**, $i_2$ = **<u>0 amps</u>**, and $i_3$ = **<u>3 amps</u>**, which agrees with the answers in Problem 3.44.

**Chapter 3, Problem 76.**

Use *PSpice* to solve Prob. 3.27.

Chapter 3, Problem 27

Use nodal analysis to determine voltages $\boldsymbol{v_1}$, $\boldsymbol{v_2}$, and $\boldsymbol{v_3}$ in the circuit in Fig. 3.76.

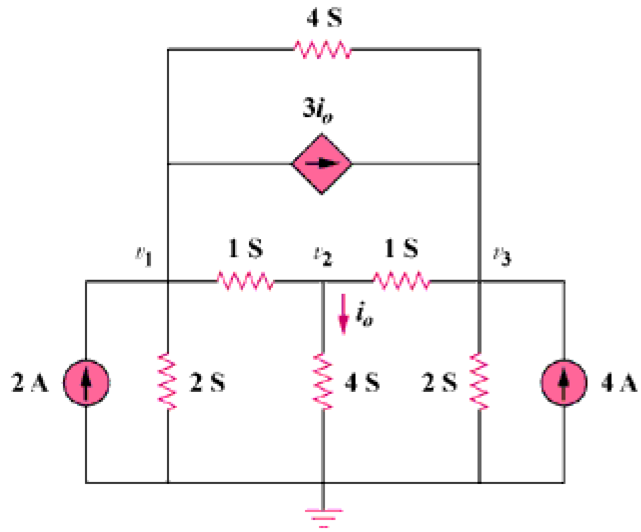
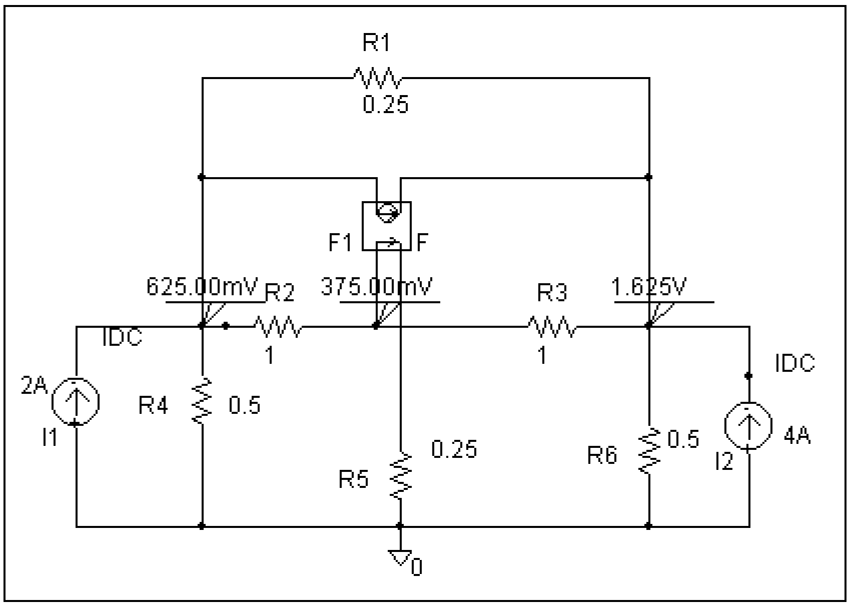



Figure 3.76

**Chapter 3, Solution 76**

```
* Schematics Netlist *

I_I2         0 $N_0001 DC 4A
R_R1         $N_0002 $N_0001  0.25
R_R3         $N_0003 $N_0001  1
R_R2         $N_0002 $N_0003  1
F_F1         $N_0002 $N_0001 VF_F1 3
VF_F1        $N_0003 $N_0004 0V
R_R4         0 $N_0002  0.5
R_R6         0 $N_0001  0.5
I_I1         0 $N_0002 DC 2A
R_R5         0 $N_0004  0.25
```




Clearly, $v_1$ = **625 mVolts**, $v_2$ = **375 mVolts**, and $v_3$ = **1.625 volts**, which agrees with the solution obtained in Problem 3.27.

**Chapter 3, Problem 77.**

Solve for $V_1$ and $V_2$ in the circuit of Fig. 3.119 using PSpice.

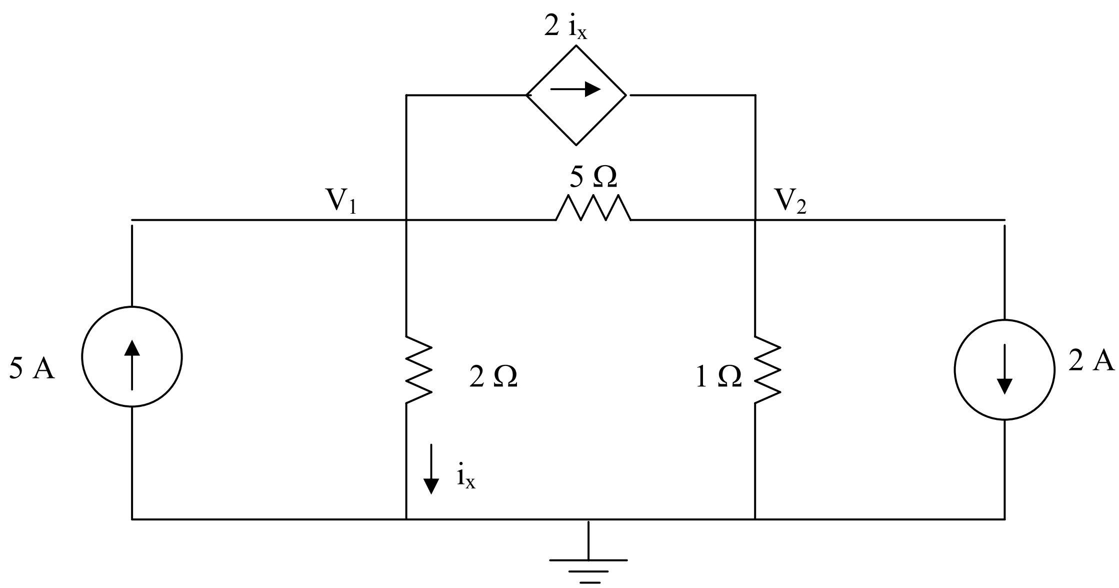
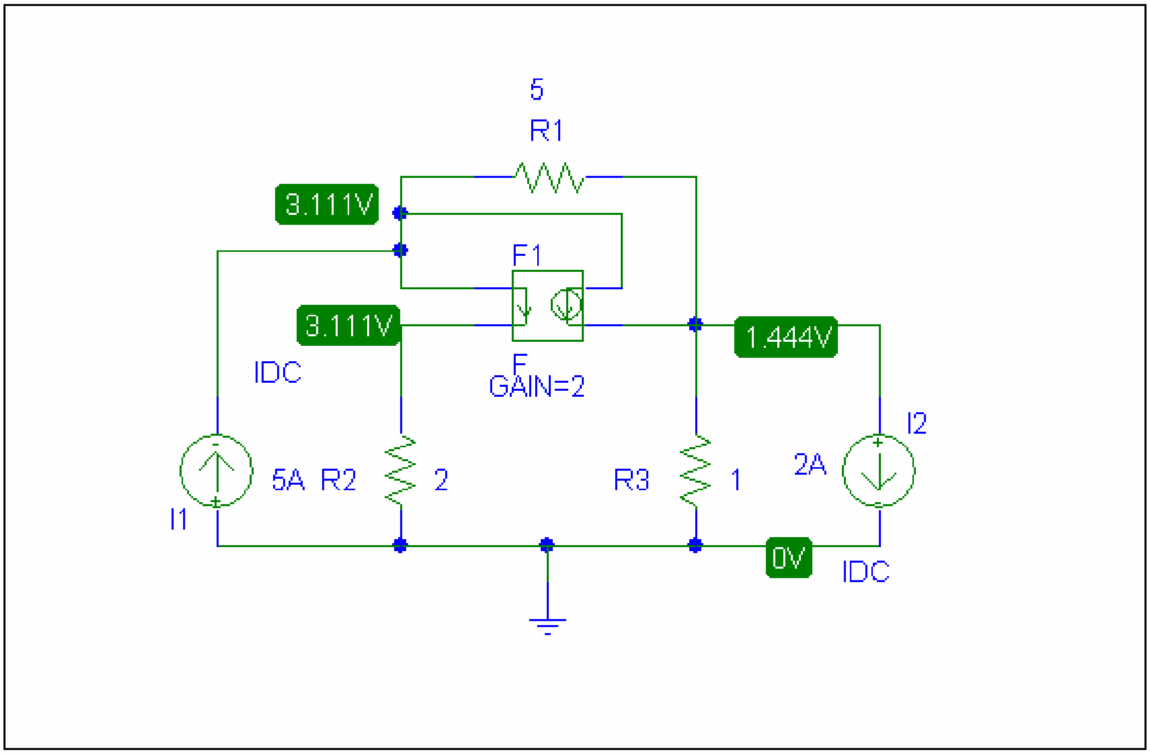



Figure 3.119 For Prob. 3.77.

**Chapter 3, Solution 77**




As a check we can write the nodal equations,

$$\begin{bmatrix} 1.7 & -0.2 \\ -1.2 & 1.2 \end{bmatrix} V = \begin{bmatrix} 5 \\ -2 \end{bmatrix}$$

Solving this leads to $V_1$ = **3.111 V** and $V_2$ = **1.4444 V**. The answer checks!

**Chapter 3, Problem 78.**

Solve Prob. 3.20 using *PSpice*.

Chapter 3, Problem 20

For the circuit in Fig. 3.69, find $V_1$, $V_2$, and $V_3$ using nodal analysis.

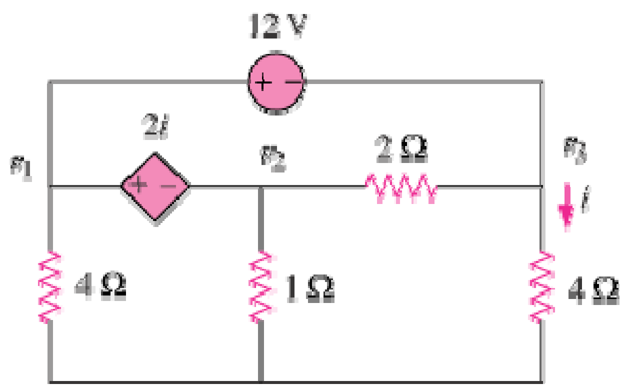
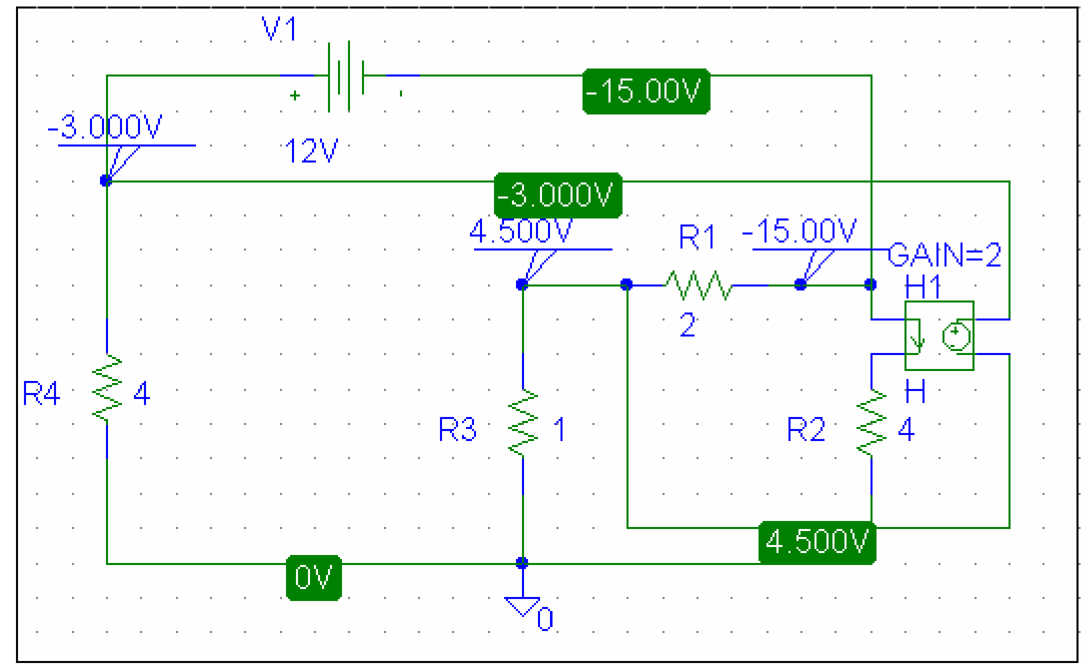



Figure 3.69

**Chapter 3, Solution 78**

The schematic is shown below. When the circuit is saved and simulated the node voltages are displaced on the pseudocomponents as shown. Thus,

$\underline{V_1 = -3\text{V}, \quad V_2 = 4.5\text{V}, V_3 = -15\text{V},}$




**Chapter 3, Problem 79.**

Rework Prob. 3.28 using *PSpice*.

Chapter 3, Problem 28
Use MATLAB to find the voltages at nodes a, b, c, and d in the circuit of Fig. 3.77.

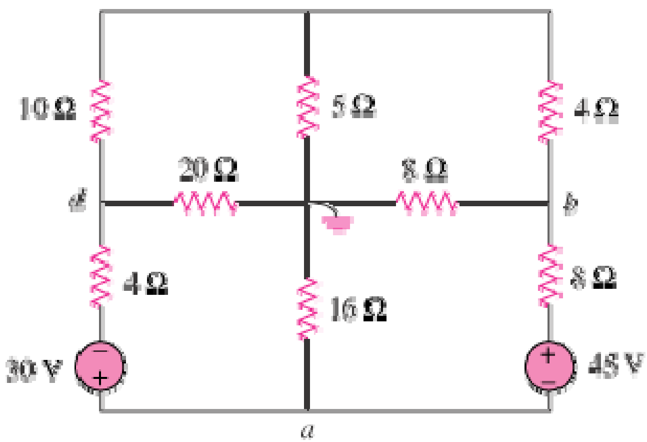
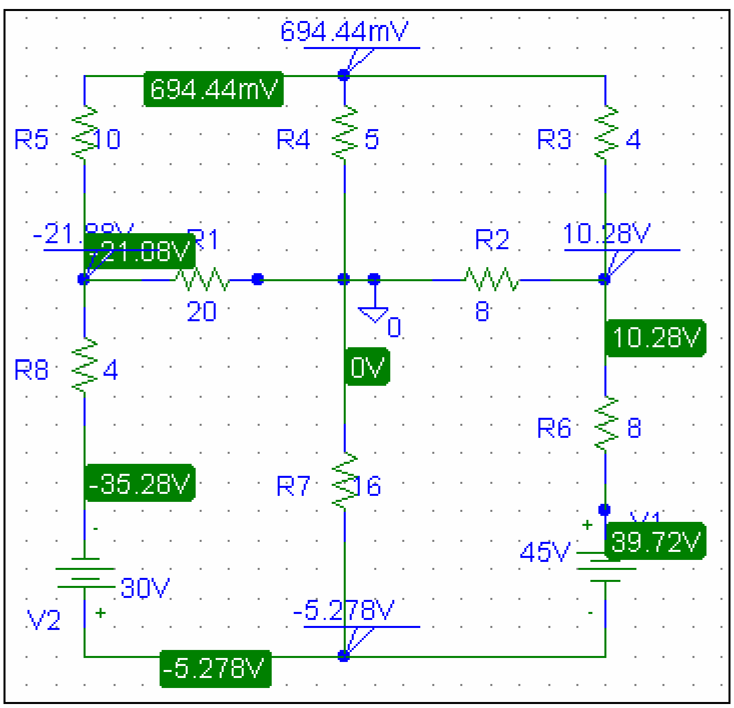



Figure 3.77

**Chapter 3, Solution 79**
The schematic is shown below. When the circuit is saved and simulated, we obtain the node voltages as displaced. Thus,

$$\underline{V_a = -5.278\text{ V},\quad V_b = 10.28\text{ V},\quad V_c = 0.6944\text{ V},\quad V_d = -26.88\text{ V}}$$




**Chapter 3, Problem 80.**

Find the nodal voltage $v_1$ through $v_4$ in the circuit in Fig. 3.120 using *PSpice*.

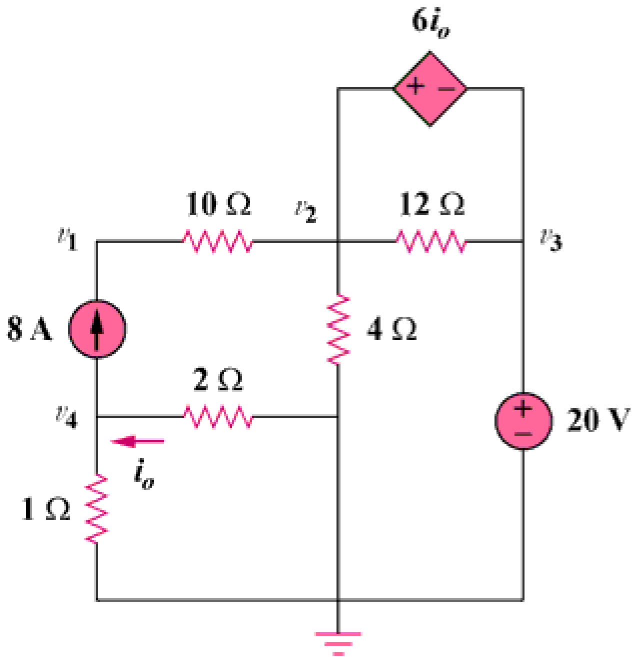
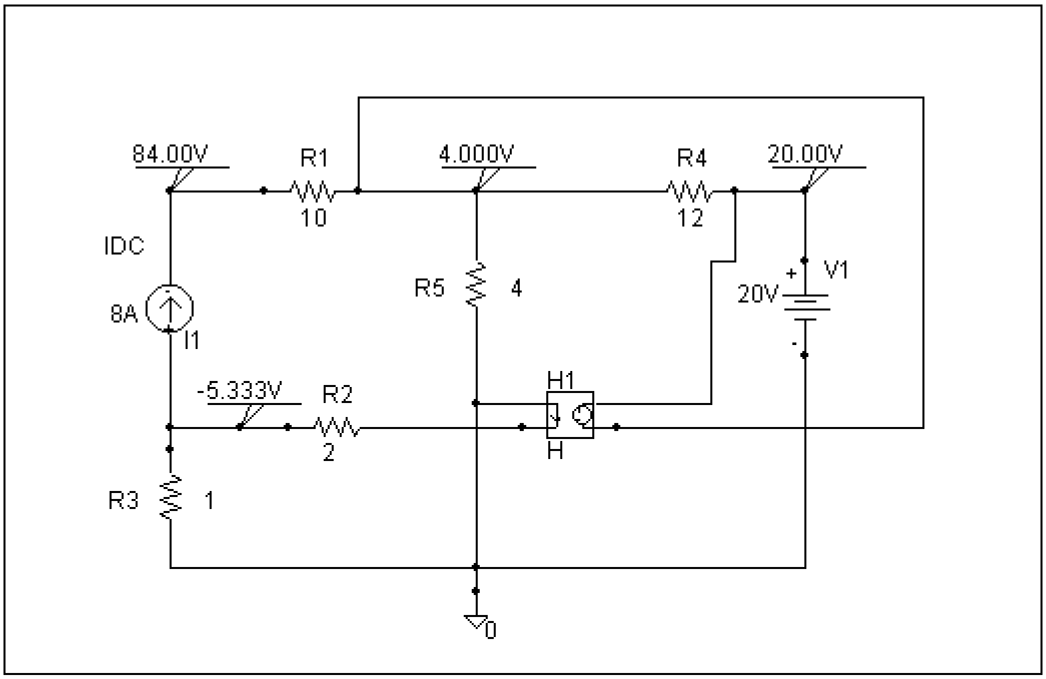



Figure 3.120

**Chapter 3, Solution 80**

```
* Schematics Netlist *

H_H1          $N_0002 $N_0003 VH_H1 6
VH_H1         0 $N_0001 0V
I_I1          $N_0004 $N_0005 DC 8A
V_V1          $N_0002 0 20V
R_R4          0 $N_0003  4
R_R1          $N_0005 $N_0003  10
R_R2          $N_0003 $N_0002  12
R_R5          0 $N_0004  1
R_R3          $N_0004 $N_0001  2
```




Clearly, $v_1$ = **84 volts**, $v_2$ = **4 volts**, $v_3$ = **20 volts**, and $v_4$ = **-5.333 volts**

**Chapter 3, Problem 81.**

Use *PSpice* to solve the problem in Example 3.4

Example 3.4

Find the node voltages in the circuit of Fig. 3.12.

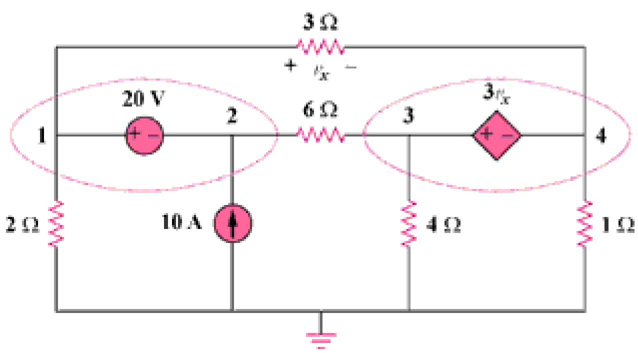
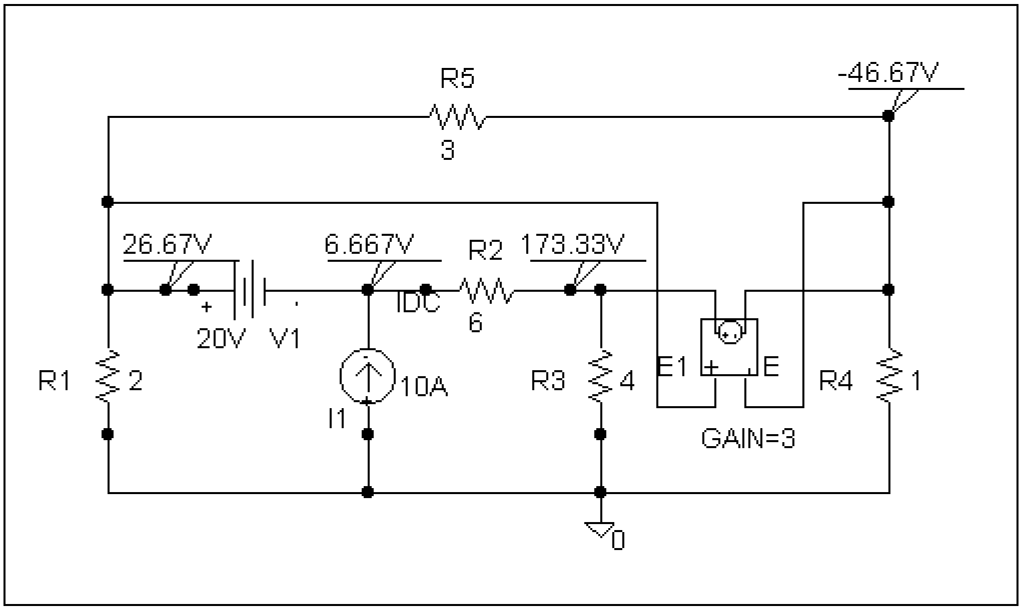



Figure 3.12

**Chapter 3, Solution 81**




Clearly, $v_1$ = **26.67 volts**, $v_2$ = **6.667 volts**, $v_3$ = **173.33 volts**, and $v_4$ = **-46.67 volts** which agrees with the results of Example 3.4.

This is the netlist for this circuit.

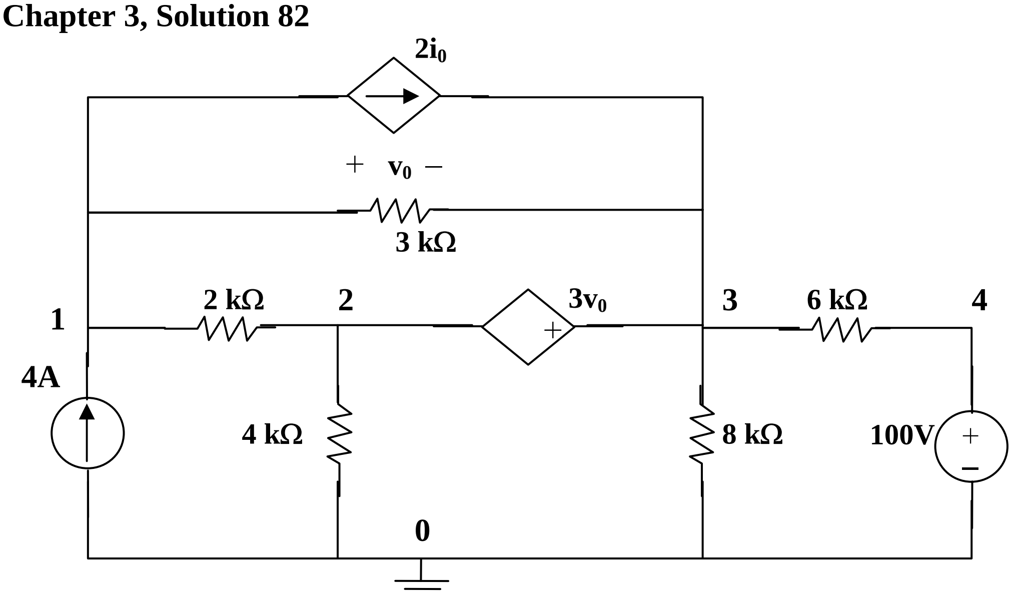
```
* Schematics Netlist *

R_R1          0 $N_0001  2
R_R2          $N_0003 $N_0002  6
R_R3          0 $N_0002  4
R_R4          0 $N_0004  1
R_R5          $N_0001 $N_0004  3
I_I1          0 $N_0003 DC 10A
V_V1          $N_0001 $N_0003 20V
E_E1          $N_0002 $N_0004 $N_0001 $N_0004 3
```

## Chapter 3, Problem 82.

If the Schematics Netlist for a network is as follows, draw the network.

| | | | | | |
|---|---|---|---|---|---|
| R_R1 | 1 | 2 | 2K | | |
| R_R2 | 2 | 0 | 4K | | |
| R_R3 | 2 | 0 | 8K | | |
| R_R4 | 3 | 4 | 6K | | |
| R_R5 | 1 | 3 | 3K | | |
| V_VS | 4 | 0 | DC | 100 | |
| I_IS | 0 | 1 | DC | 4 | |
| F_F1 | 1 | 3 | VF_F1 | 2 | |
| VF_F1 | 5 | 0 | 0V | | |
| E_E1 | 3 | 2 | 1 | 3 | 3 |

**Chapter 3, Solution 82**




This network corresponds to the Netlist.

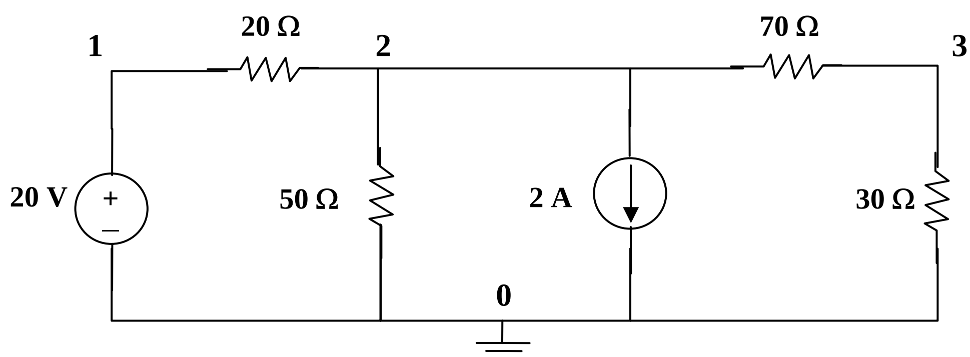
**Chapter 3, Problem 83.**

The following program is the Schematics Netlist of a particular circuit. Draw the circuit and determine the voltage at node 2.

| | | | | |
|---|---|---|---|---|
| R_R1 | 1 | 2 | 20 | |
| R_R2 | 2 | 0 | 50 | |
| R_R3 | 2 | 3 | 70 | |
| R_R4 | 3 | 0 | 30 | |
| V_VS | 1 | 0 | 20V | |
| I_IS | 2 | 0 | DC | 2A |

**Chapter 3, Solution 83**

The circuit is shown below.




When the circuit is saved and simulated, we obtain $v_2 =$ **$-12.5$ volts**

**Chapter 3, Problem 84.**

Calculate $v_o$ and $i_o$ in the circuit of Fig. 3.121.

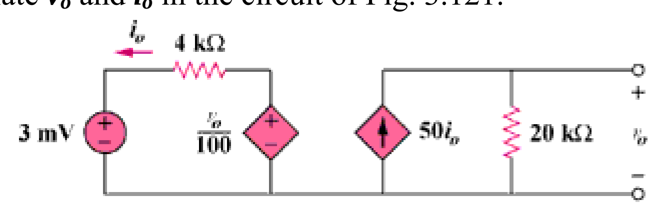



Figure 3.121

**Chapter 3, Solution 84**

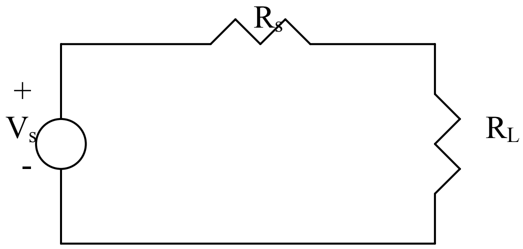
From the output loop, $v_0 = 50i_0 x 20x10^3 = 10^6 i_0$ (1)
From the input loop, $3x10^{-3} + 4000i_0 - v_0/100 = 0$ (2)
From (1) and (2) we get, $i_0 =$ **$0.5\mu A$** and $v_0 =$ **0.5 volt**.

**Chapter 3, Problem 85.**

An audio amplifier with resistance 9Ω supplies power to a speaker. In order that maximum power is delivered, what should be the resistance of the speaker?

**Chapter 3, Solution 85**

The amplifier acts as a source.




For maximum power transfer,

$$R_L = R_s = \underline{9\Omega}$$

**Chapter 3, Problem 86.**

For the simplified transistor circuit of Fig. 3.122, calculate the voltage $\boldsymbol{v_o}$.

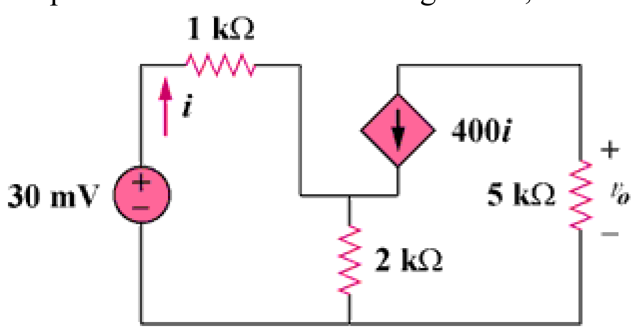



Figure 3.122

**Chapter 3, Solution 86**

Let $v_1$ be the potential across the 2 k-ohm resistor with plus being on top. Then,

$[(0.03 - v_1)/1k] + 400i = v_1/2k$ (1)

Assume that i is in mA. But, $i = (0.03 - v_1)/1$ (2)

Combining (1) and (2) yields,

$v_1 = 29.963$ mVolts and $i = 37.4$ nA, therefore,

$v_0 = -5000x400x37.4x10^{-9} = \underline{\textbf{-74.8 mvolts}}$

**Chapter 3, Problem 87.**

For the circuit in Fig. 3.123, find the gain $\boldsymbol{v_o/v_s}$.

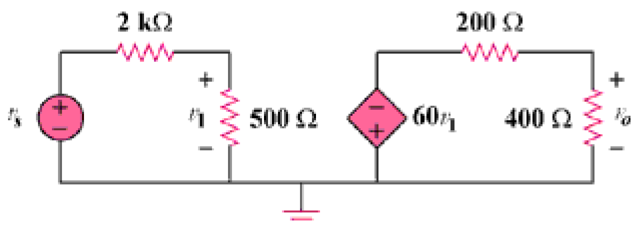



Figure 3.123

**Chapter 3, Solution 87**

$v_1 = 500(v_s)/(500 + 2000) = v_s/5$

$v_0 = -400(60v_1)/(400 + 2000) = -40v_1 = -40(v_s/5) = -8v_s,$

Therefore, $v_0/v_s = \underline{\mathbf{-8}}$

**Chapter 3, Problem 88.**

Determine the gain $\boldsymbol{v_o/v_s}$ of the transistor amplifier circuit in Fig. 3.124.

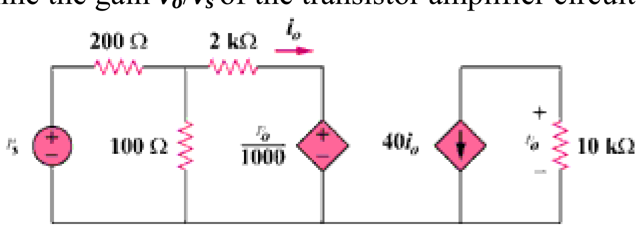



Figure 3.124

**Chapter 3, Solution 88**

Let $v_1$ be the potential at the top end of the 100-ohm resistor.

$$(v_s - v_1)/200 = v_1/100 + (v_1 - 10^{-3}v_0)/2000 \qquad (1)$$

For the right loop, $v_0 = -40i_0(10{,}000) = -40(v_1 - 10^{-3})10{,}000/2000,$

$$\text{or,}\quad v_0 = -200v_1 + 0.2v_0 = -4\text{x}10^{-3}v_0 \qquad (2)$$

Substituting (2) into (1) gives, $(v_s + 0.004v_1)/2 = -0.004v_0 + (-0.004v_1 - 0.001v_0)/20$

This leads to $0.125v_0 = 10v_s$ or $(v_0/v_s) = 10/0.125 = \underline{\mathbf{-80}}$

**Chapter 3, Problem 89.**

For the transistor circuit shown in Fig. 3.125, find $I_B$ and $V_{CE}$. Let $\beta = 100$ and $V_{BE} = 0.7V$.

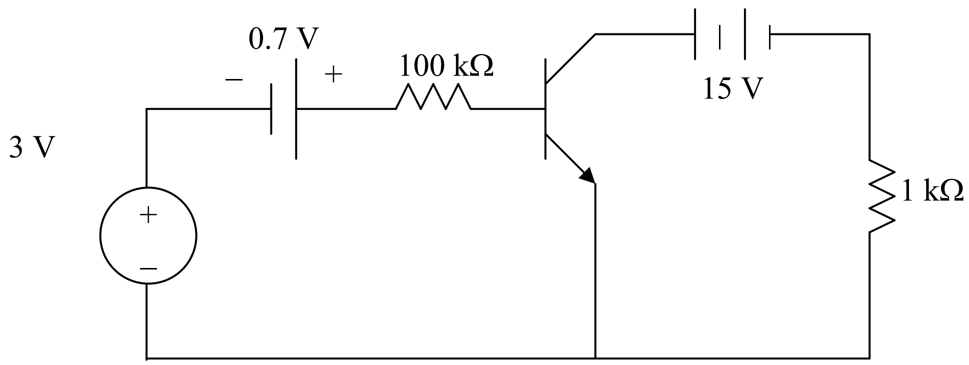
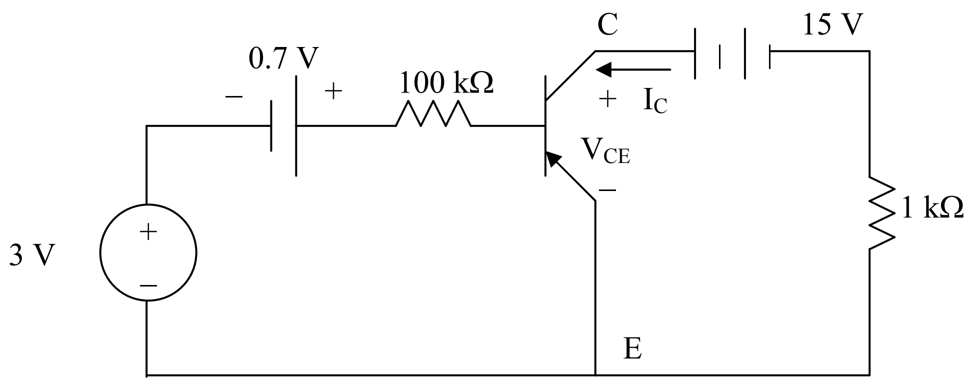



**Figure 3.125 For Prob. 3.89.**

**Chapter 3, Solution 89**

Consider the circuit below.




For the left loop, applying KVL gives

$$-3 - 0.7 + 100x10^3 I_B + V_{BE} = 0 \xrightarrow{V_{BE}=0.7} I_B = \underline{30\ \mu A}$$

For the right loop,

$$-V_{CE} + 15 - I_c(1x10^3) = 0$$

But $I_C = \beta I_B = 100x30\ \mu A = 3\ mA$

$$V_{CE} = 15 - 3x10^{-3}x10^3 = \underline{12\ V}$$

**Chapter 3, Problem 90.**

Calculate $\boldsymbol{v_s}$ for the transistor in Fig. 3.126, given that $\boldsymbol{v_o} = 4$ V, $\beta = 150$, $V_{BE} = 0.7$V.

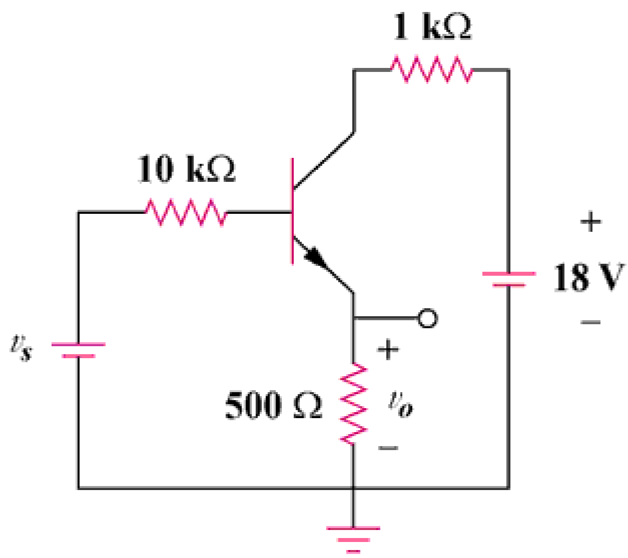
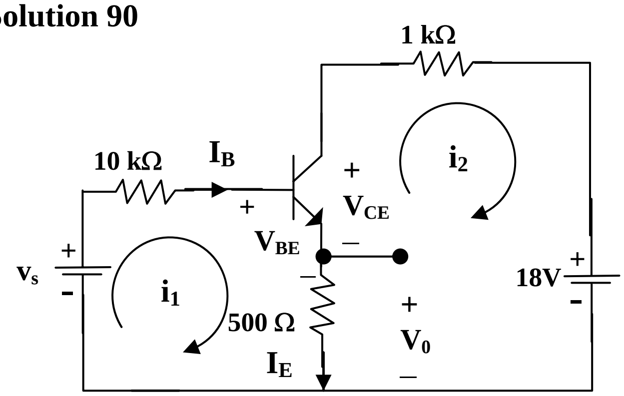



Figure 3.126

**Chapter 3, Solution 90**




For loop 1, $-v_s + 10k(I_B) + V_{BE} + I_E\,(500) = 0 = -v_s + 0.7 + 10{,}000I_B + 500(1 + \beta)I_B$

which leads to $v_s + 0.7 = 10{,}000I_B + 500(151)I_B = 85{,}500I_B$

But, $v_0 = 500I_E = 500\text{x}151I_B = 4$ which leads to $I_B = 5.298\text{x}10^{-5}$

Therefore, $v_s = 0.7 + 85{,}500I_B =$ **<u>5.23 volts</u>**

**Chapter 3, Problem 91.**

For the transistor circuit of Fig. 3.127, find $I_B$, $V_{CE}$, and $v_o$. Take $\beta = 200$, $V_{BE} = 0.7$V.

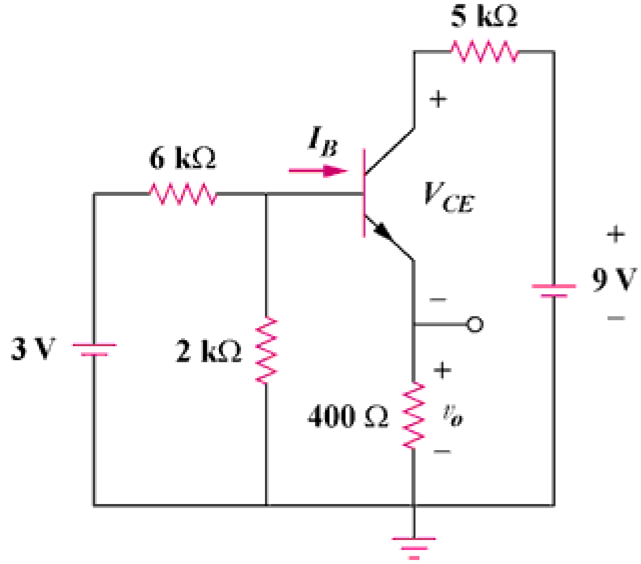
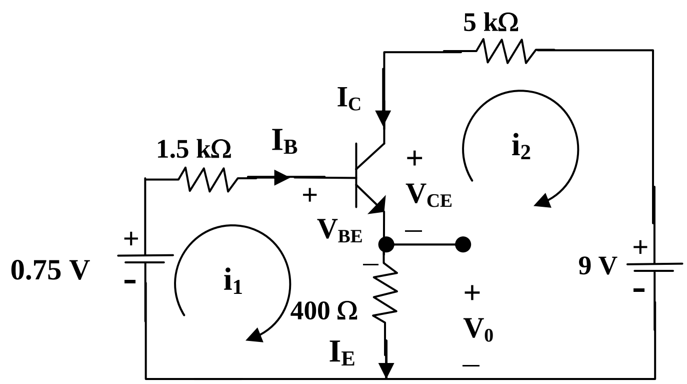



Figure 3.127

**Chapter 3, Solution 91**

We first determine the Thevenin equivalent for the input circuit.

$R_{Th} = 6||2 = 6x2/8 = 1.5$ kΩ and $V_{Th} = 2(3)/(2+6) = 0.75$ volts




For loop 1, $-0.75 + 1.5kI_B + V_{BE} + 400I_E = 0 = -0.75 + 0.7 + 1500I_B + 400(1 + \beta)I_B$

$I_B = 0.05/81{,}900 =$ **<u>0.61 μA</u>**

$v_0 = 400I_E = 400(1 + \beta)I_B =$ **<u>49 mV</u>**

For loop 2, $-400I_E - V_{CE} - 5kI_C + 9 = 0$, but, $I_C = \beta I_B$ and $I_E = (1 + \beta)I_B$

$V_{CE} = 9 - 5k\beta I_B - 400(1 + \beta)I_B = 9 - 0.659 =$ **<u>8.641 volts</u>**

**Chapter 3, Problem 92.**

Find $\boldsymbol{I_B}$ and $\mathbf{V_C}$ for the circuit in Fig. 3.128. Let $\beta = 100$, $V_{BE} = 0.7$V.

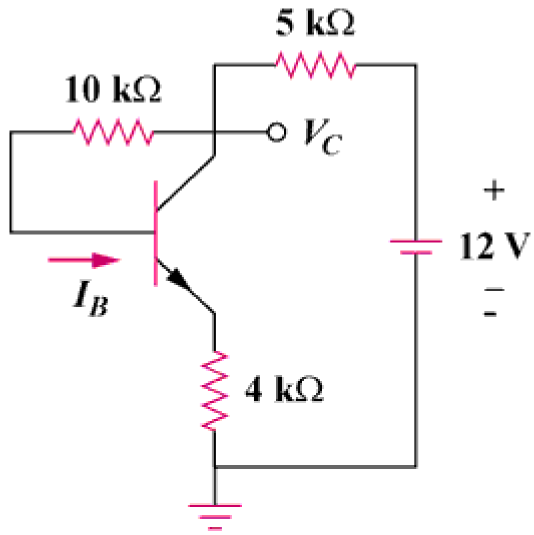
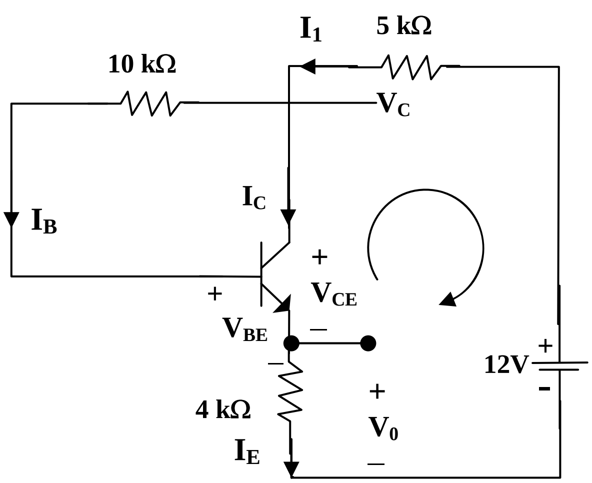



Figure 3.128

**Chapter 3, Solution 92**




$I_1 = I_B + I_C = (1 + \beta)I_B$ and $I_E = I_B + I_C = I_1$

Applying KVL around the outer loop,

$4kI_E + V_{BE} + 10kI_B + 5kI_1 = 12$

$12 – 0.7 = 5k(1 + \beta)I_B + 10kI_B + 4k(1 + \beta)I_B = 919kI_B$

$I_B = 11.3/919k = 12.296\ \mu A$

Also, $12 = 5kI_1 + V_C$ which leads to $V_C = 12 – 5k(101)I_B =$ **5.791 volts**

**Chapter 3, Problem 93**

Rework Example 3.11 with hand calculation.

In the circuit in Fig. 3.34, determine the currents $\boldsymbol{i}_1$, $\boldsymbol{i}_2$, and $\boldsymbol{i}_3$.

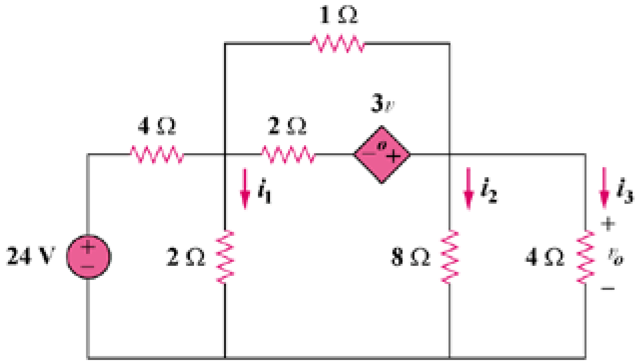
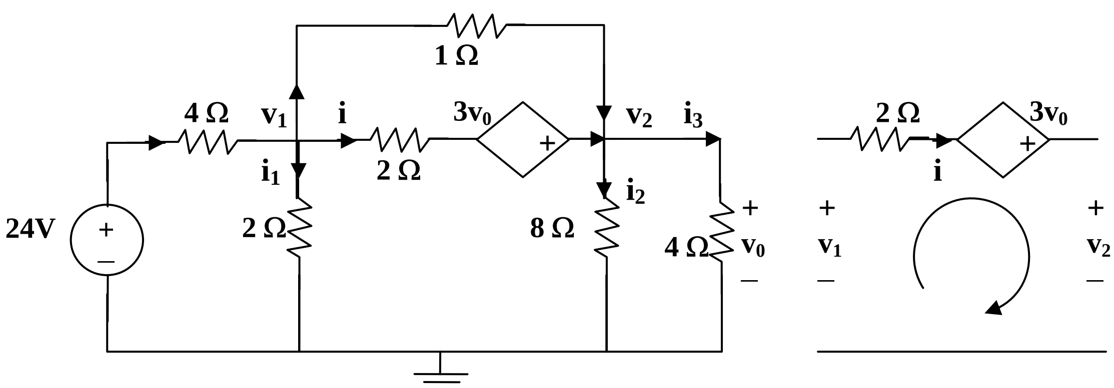



Figure 3.34

**Chapter 3, Solution 93**




**(a)** **(b)**

From (b), $-v_1 + 2i - 3v_0 + v_2 = 0$ which leads to $i = (v_1 + 3v_0 - v_2)/2$

At node 1 in (a), $((24 - v_1)/4) = (v_1/2) + ((v_1 + 3v_0 - v_2)/2) + ((v_1 - v_2)/1)$, where $v_0 = v_2$

or $24 = 9v_1$ which leads to $v_1 =$ **2.667 volts**

At node 2, $((v_1 - v_2)/1) + ((v_1 + 3v_0 - v_2)/2) = (v_2/8) + v_2/4$, $v_0 = v_2$

$v_2 = 4v_1 =$ **10.66 volts**

Now we can solve for the currents, $i_1 = v_1/2 =$ **1.333 A**, $i_2 =$ **1.333 A**, and

$i_3 =$ **2.6667** A.