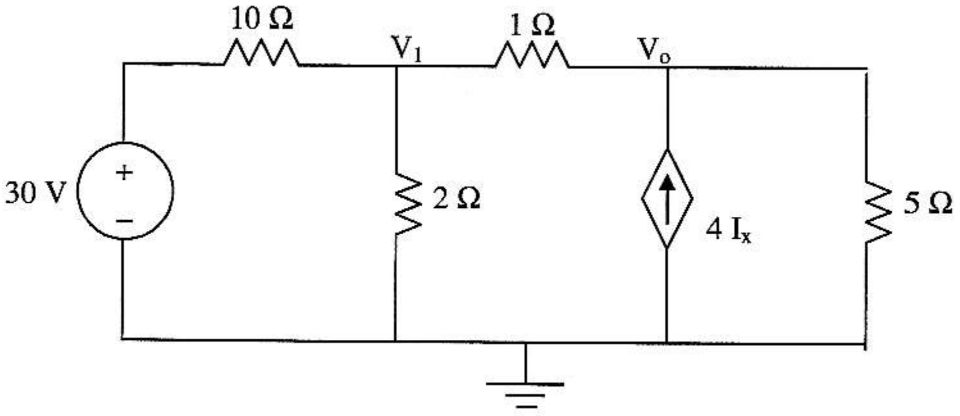
Chapter 3, Solution 12

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

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

Substituting (3) into 1,

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

Chapter 3, Problem 13.

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

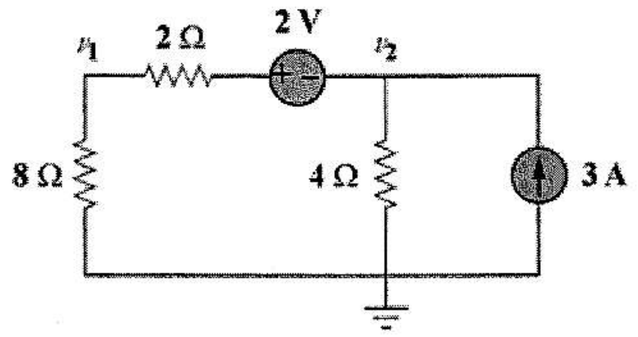


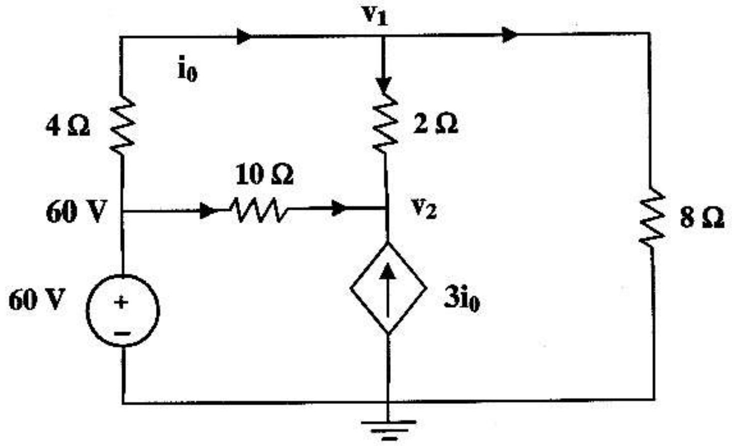
Figure 3.62

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, Solution 17



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

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

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

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 $i_0 = \frac{60 - v_1}{4} =$ **<u>1.73 A</u>**

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

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

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

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

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

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
```

$V_o = V_1 - V_4 = 3.8 - 2.2 = \underline{\mathbf{1.6\ V}}$.

Chapter 3, Problem 31.

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

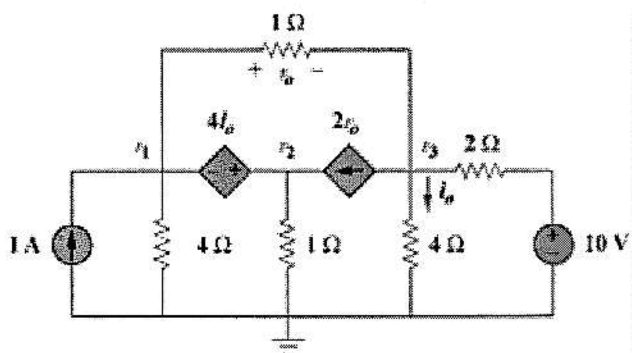
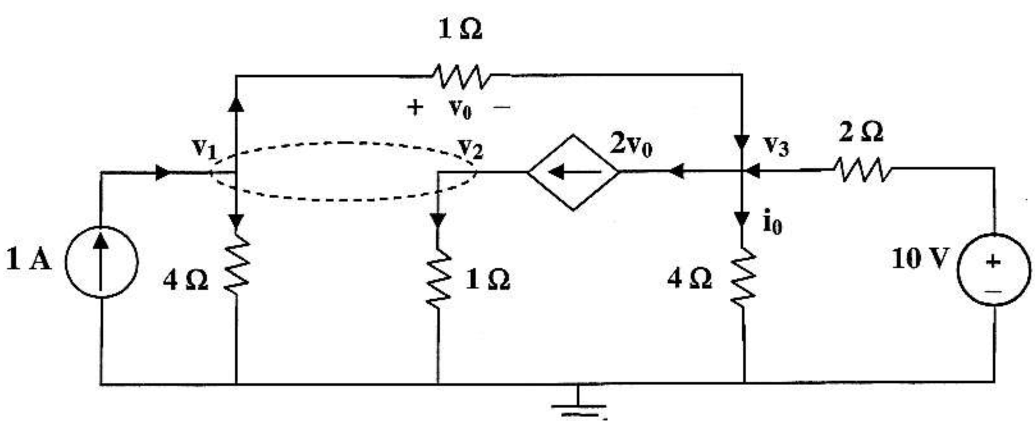


Figure 3.80

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 67.

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

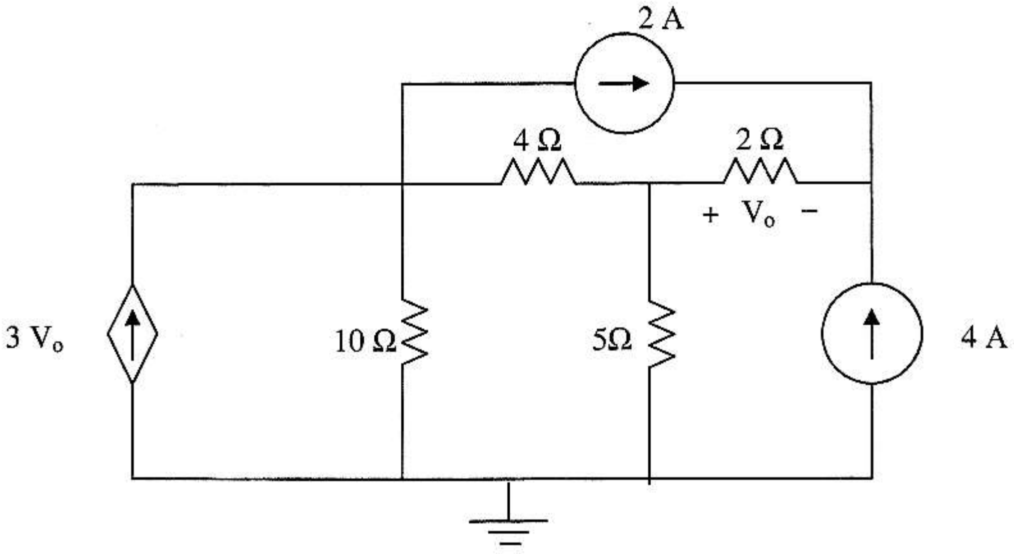
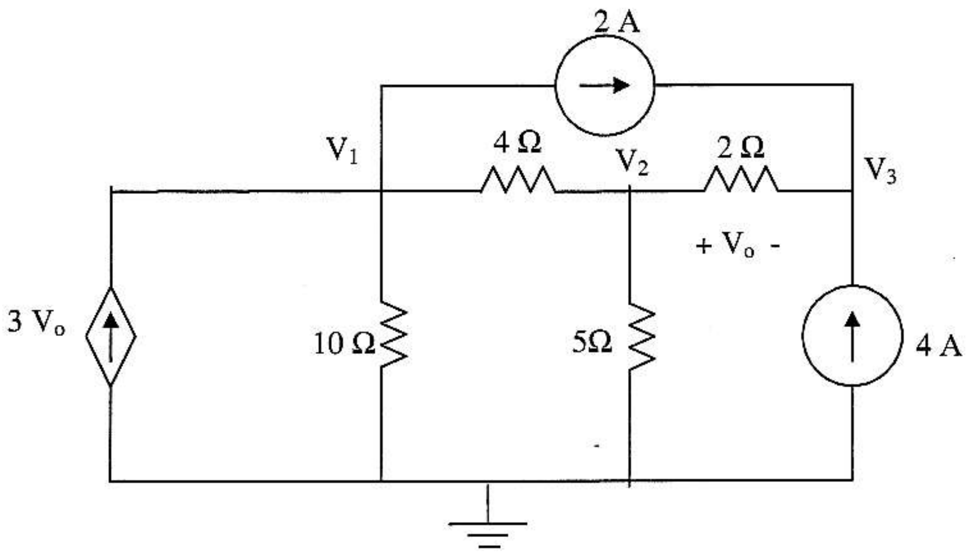


Figure 3.111 For Prob. 3.67.

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
```

$V_o = V_2 - V_3 = -77.89 + 65.89 =$ **-12 V**.

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 39.

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

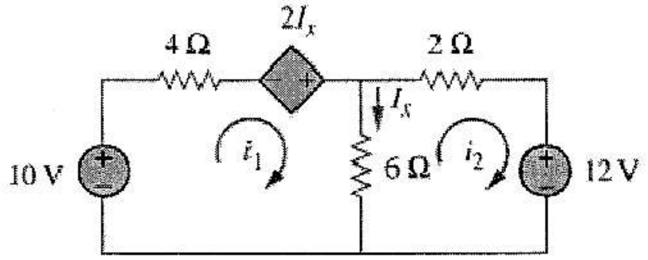


Figure 3.85

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 44.

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

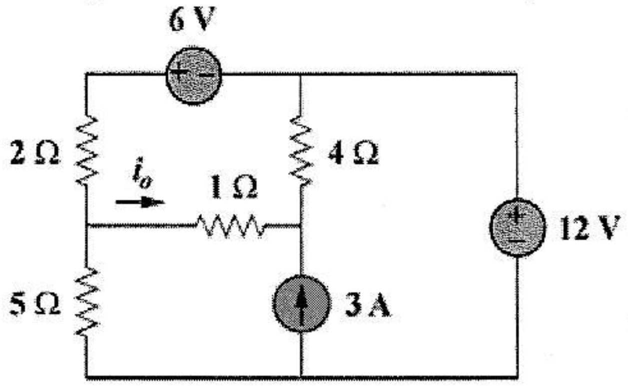
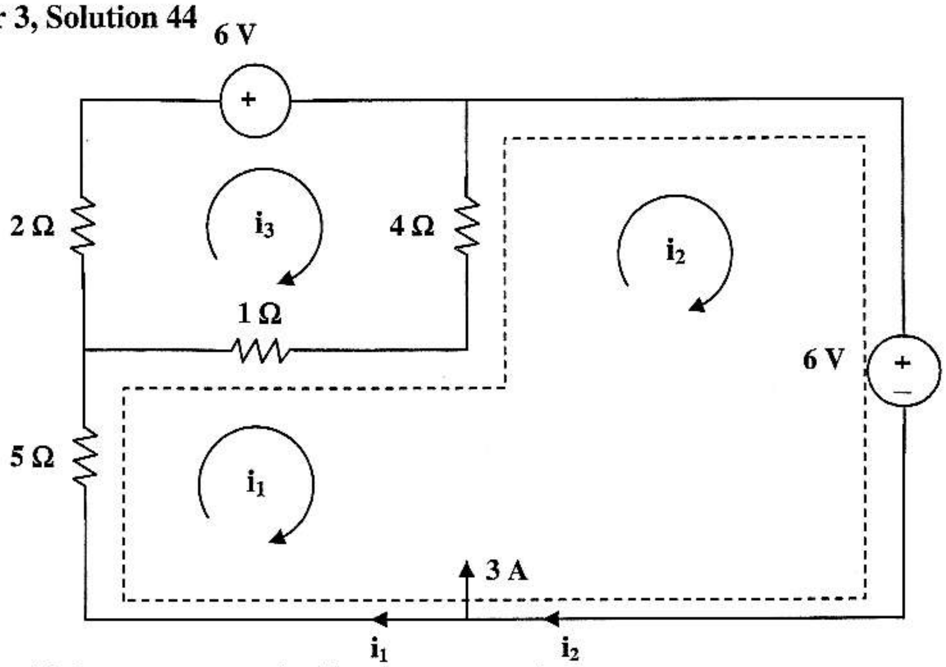


Figure 3.90

Chapter 3, Solution 44



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

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

For loop 3, $$-i_1 - 4i_2 + 7i_3 + 6 = 0 \quad (2)$$

Also, $$i_2 = 3 + i_1 \quad (3)$$

Solving (1) to (3), $i_1 = -3.067$, $i_3 = -1.3333$; $i_o = i_1 - i_3 =$ **-1.7333 A**

Chapter 3, Problem 54.

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

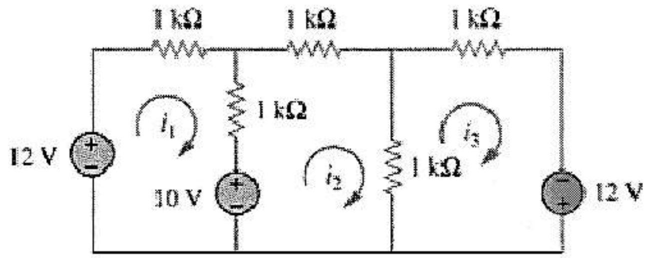


Figure 3.99

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 60.

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

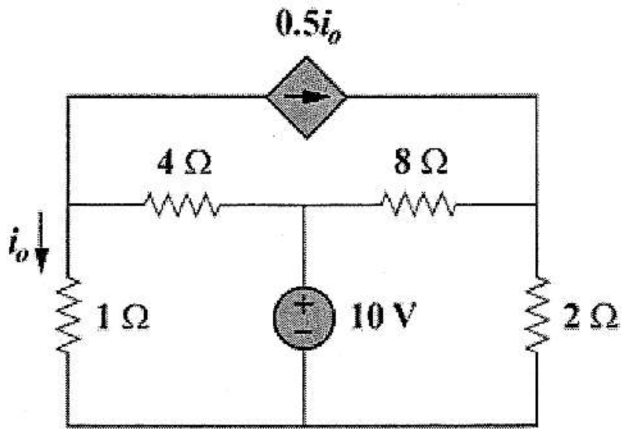
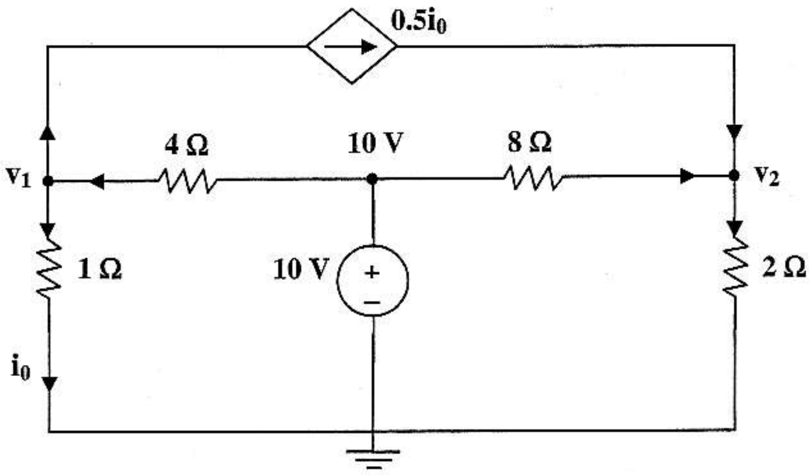


Figure 3.104

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 $v_2 = 22/7$

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

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

Chapter 3, Problem 61.

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

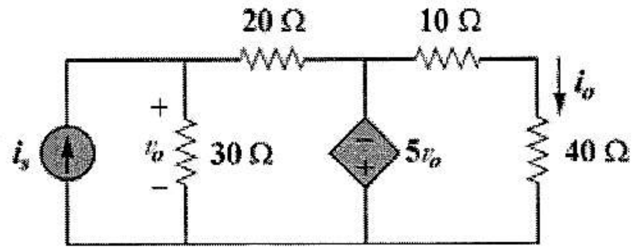
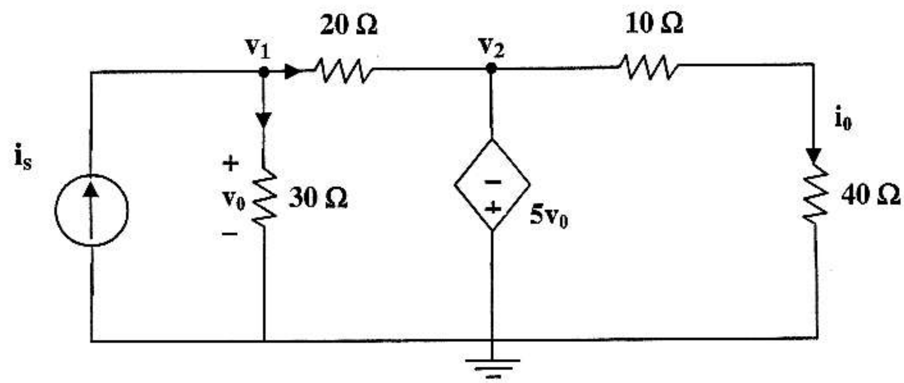


Figure 3.105

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 $i_0/i_s = -15/50 = \underline{-0.3}$

Chapter 3, Problem 73.

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

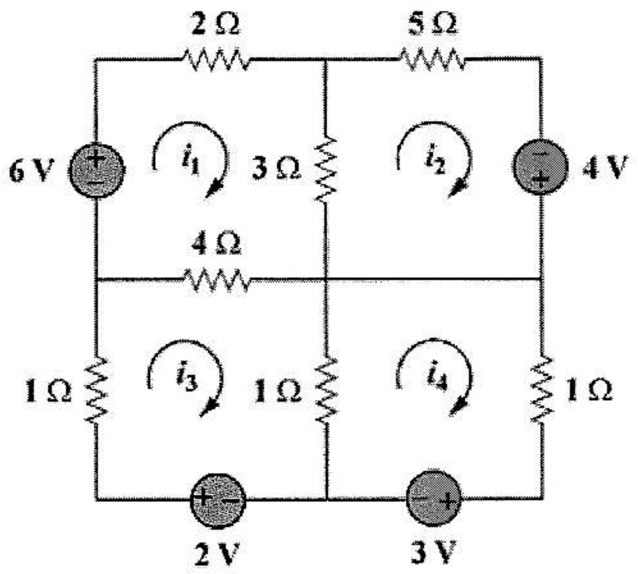


Figure 3.117

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,

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