Chapter 3, Solution 1.

At node 1,
\[ 6 = \frac{v_1}{8} + \frac{v_1 - v_2}{4} \quad 48 = 3v_1 - 2v_2 \quad (1) \]

At node 2,
\[ v_1 - \frac{v_2}{4} = \frac{v_2}{2} + 10 \quad 40 = v_1 - 3v_2 \quad (2) \]

Solving (1) and (2),
\[ v_1 = 9.143 \text{V}, \quad v_2 = -10.286 \text{V} \]

\[ P_{8\Omega} = \frac{v_1^2}{8} = \frac{(9.143)^2}{8} = 10.45 \text{W} \]

\[ P_{4\Omega} = \frac{(v_1 - v_2)^2}{4} = 94.37 \text{W} \]

\[ P_{2\Omega} = \frac{v_2^2}{2} = \frac{(10.286)^2}{2} = 52.9 \text{W} \]

Chapter 3, Solution 2

At node 1,
\[ -\frac{v_1}{10} - \frac{v_1}{5} = 6 + \frac{v_1 - v_2}{2} \quad 60 = -8v_1 + 5v_2 \quad (1) \]

At node 2,
\[ \frac{v_2}{4} = 3 + 6 + \frac{v_1 - v_2}{2} \quad 36 = -2v_1 + 3v_2 \quad (2) \]

Solving (1) and (2),
\[ v_1 = 0 \text{V}, \quad v_2 = 12 \text{V} \]
Chapter 3, Solution 3

Applying KCL to the upper node,

\[
10 = \frac{v_0}{10} + \frac{v_0}{20} + \frac{v_0}{30} + 2 + \frac{v_0}{60} \quad \Rightarrow \quad v_0 = 40 \text{ V}
\]

\[
i_1 = \frac{v_0}{10} = 4 \text{ A}, \quad i_2 = \frac{v_0}{20} = 2 \text{ A}, \quad i_3 = \frac{v_0}{30} = 1.33 \text{ A}, \quad i_4 = \frac{v_0}{60} = 67 \text{ mA}
\]

Chapter 3, Solution 4

At node 1,

\[
4 + 2 = v_1/(5) + v_1/(10) \quad \Rightarrow \quad v_1 = 20
\]

At node 2,

\[
5 - 2 = v_2/(10) + v_2/(5) \quad \Rightarrow \quad v_2 = 10
\]

\[
i_1 = v_1/(5) = 4 \text{ A}, \quad i_2 = v_1/(10) = 2 \text{ A}, \quad i_3 = v_2/(10) = 1 \text{ A}, \quad i_4 = v_2/(5) = 2 \text{ A}
\]

Chapter 3, Solution 5

Apply KCL to the top node.

\[
\frac{30 - v_0}{2k} + \frac{20 - v_0}{6k} = \frac{v_0}{4k} \quad \Rightarrow \quad v_0 = 20 \text{ V}
\]
Chapter 3, Solution 6

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

or \[ v_0 = 8.727 \text{ V} \]

Chapter 3, Solution 7

At node a,
\[ \frac{10 - V_a}{30} = \frac{V_a}{15} + \frac{V_a - V_b}{10} \quad \rightarrow \quad 10 = 6V_a - 3V_b \quad (1) \]

At node b,
\[ \frac{V_a - V_b}{10} + \frac{12 - V_b}{20} + \frac{-9 - V_b}{5} = 0 \quad \rightarrow \quad 24 = 2V_a - 7V_b \quad (2) \]

Solving (1) and (2) leads to
\[ V_a = -0.556 \text{ V}, \quad V_b = -3.444 \text{ V} \]

Chapter 3, Solution 8

\[ i_1 + i_2 + i_3 = 0 \quad \frac{v_1}{5} + \frac{v_1 - 3}{1} + \frac{v_1 - 4v_0}{5} = 0 \]

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

or \[ v_1 = 15x5/(27) = 2.778 \text{ V} \], therefore \[ v_o = 2v_1/5 = 1.1111 \text{ V} \]
Chapter 3, Solution 9

At the non-reference node,

\[
\frac{12 - v_1}{3} = \frac{v_1}{8} + \frac{v_1 - 2v_0}{6} \quad (1)
\]

But

\[-12 + v_0 + v_1 = 0 \quad \rightarrow \quad v_0 = 12 - v_1 \quad (2)\]

Substituting (2) into (1),

\[
\frac{12 - v_1}{3} = \frac{v_1}{8} + \frac{3v_1 - 24}{6} \quad \rightarrow \quad v_0 = 3.652 \text{ V}
\]

Chapter 3, Solution 10

At node 1,

\[
\frac{v_2 - v_1}{1} = 4 + \frac{v_1}{8} \quad \rightarrow \quad 32 = -v_1 + 8v_2 - 8v_0 \quad (1)
\]
At node 0,
\[ 4 = \frac{v_0}{2} + 2i_0 \quad \text{and} \quad I_0 = \frac{v_1}{8} \quad \implies \quad 16 = 2v_0 + v_1 \] (2)

At node 2,
\[ 2I_0 = \frac{v_2 - v_1}{1} + \frac{v_2}{4} \quad \text{and} \quad I_0 = \frac{v_1}{8} \quad \implies v_2 = v_1 \] (3)

From (1), (2) and (3), \( v_0 = 24 \) V, but from (2) we get
\[ i_0 = \frac{4 - v_0}{2} = 2 - \frac{24}{4} = 2 - 6 = -4 \text{ A} \]

Chapter 3, Solution 11

Note that \( i_2 = -5 \) A. At the non-reference node
\[ \frac{10 - v}{4} + 5 = \frac{v}{6} \quad \implies \quad v = 18 \]
\[ i_1 = \frac{10 - v}{4} = -2 \text{ A}, \quad i_2 = -5 \text{ A} \]

Chapter 3, Solution 12
At node 1, \[ \frac{24 - v_1}{10} = \frac{v_1 - v_2}{20} + \frac{v_1 - 0}{40} \] \[ 96 = 7v_1 - 2v_2 \] (1)

At node 2, \[ 5 + \frac{v_1 - v_2}{20} = \frac{v_2}{50} \] \[ 500 = -5v_1 + 7v_2 \] (2)

Solving (1) and (2) gives,

\[ v_1 = 42.87 \text{ V}, \quad v_2 = 102.05 \text{ V} \]

\[ i_1 = \frac{v_1}{40} = 1.072 \text{ A}, \quad v_2 = \frac{v_2}{50} = 2.041 \text{ A} \]

Chapter 3, Solution 13

At node number 2, \[ [(v_2 + 2) - 0]/10 + v_2/4 = 3 \] or \[ v_2 = 8 \text{ volts} \]

But, \[ I = [(v_2 + 2) - 0]/10 = (8 + 2)/10 = 1 \text{ amp} \] and \[ v_1 = 8 \times 1 = 8 \text{ volts} \]

Chapter 3, Solution 14

At node 1, \[ \frac{v_1 - v_0}{2} + 5 = \frac{40 - v_0}{1} \] \[ v_1 + v_0 = 70 \] (1)

At node 0, \[ \frac{v_1 - v_0}{2} + 5 = \frac{v_0}{4} + \frac{v_0 + 20}{8} \] \[ 4v_1 - 7v_0 = -20 \] (2)

Solving (1) and (2), \[ v_0 = 20 \text{ V} \]
Nodes 1 and 2 form a supernode so that $v_1 = v_2 + 10$ \hspace{1cm} (1)

At the supernode, $2 + 6v_1 + 5v_2 = 3(v_3 - v_2) \rightarrow 2 + 6v_1 + 8v_2 = 3v_3$ \hspace{1cm} (2)

At node 3, $2 + 4 = 3(v_3 - v_2) \rightarrow v_3 = v_2 + 2$ \hspace{1cm} (3)

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

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

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

$i_0 = 6v_1 = \mathbf{29.45 \text{ A}}$

$$P_{65} = \frac{v_1^2}{R} = v_1^2G = \left(\frac{54}{11}\right)^2 \frac{6}{1} = \mathbf{144.6 \text{ W}}$$

$$P_{55} = v_2^2G = \left(\frac{-56}{11}\right)^2 \frac{5}{1} = \mathbf{129.6 \text{ W}}$$

$$P_{35} = (v_1 - v_3)^2G = (2)^2 \frac{3}{1} = \mathbf{12 \text{ W}}$$
Chapter 3, Solution 16

At the supernode,

\[ 2 = v_1 + 2(v_1 - v_3) + 8(v_2 - v_3) + 4v_2, \]

which leads to \[ 2 = 3v_1 + 12v_2 - 10v_3 \] \hspace{1cm} (1)

But \[ v_1 = v_2 + 2v_0 \] and \[ v_0 = v_2. \]

Hence

\[ v_1 = 3v_2 \] \hspace{1cm} (2)

\[ v_3 = 13V \] \hspace{1cm} (3)

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

\[ v_1 = 18.858 \text{ V}, \ v_2 = 6.286 \text{ V}, \ v_3 = 13 \text{ V} \]

Chapter 3, Solution 17

\[ v_1 = 60 \text{ V}, \ v_2 = 3i_0, \ v_3 = 10 \text{ V}, \ v_4 = 8 \text{ V} \]
At node 1,
\[ \frac{60 - v_1}{4} + \frac{v_1 - v_2}{8} = 120 = 7v_1 - 4v_2 \]  
(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
\[ \frac{3(60 - v_1)}{4} + \frac{60 - v_2}{10} + \frac{v_1 - v_2}{2} = 0 \rightarrow 1020 = 5v_1 - 12v_2 \]  
(2)

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

Chapter 3, Solution 18

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

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

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

Solving (1) to (3), we obtain \( v_1 = 10 \text{ V}, \ v_2 = 20 \text{ V} = v_3 \)
Chapter 3, Solution 19

At node 1,

\[ 5 = 3 + \frac{V_1 - V_3}{2} + \frac{V_1 - V_2}{8} + \frac{V_1}{4} \quad \rightarrow \quad 16 = 7V_1 - V_2 - 4V_3 \quad (1) \]

At node 2,

\[ \frac{V_1 - V_2}{8} = \frac{V_2}{2} + \frac{V_2 - V_3}{4} \quad \rightarrow \quad 0 = -V_1 + 7V_2 - 2V_3 \quad (2) \]

At node 3,

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

From (1) to (3),

\[
\begin{pmatrix}
7 & -1 & -4 & \mid & V_1 \\
-1 & 7 & -2 & \mid & V_2 \\
4 & 2 & -7 & \mid & V_3
\end{pmatrix} = \begin{pmatrix} 16 \\ 0 \\ -36 \end{pmatrix} \quad \rightarrow \quad AV = B
\]

Using MATLAB,

\[
V = A^{-1}B = \begin{bmatrix} 10 \\ 4.933 \\ 12.267 \end{bmatrix} \quad \rightarrow \quad V_1 = 10 \text{ V}, \ V_2 = 4.933 \text{ V}, \ V_3 = 12.267 \text{ V}
\]

Chapter 3, Solution 20

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

\[ \frac{V_1}{4} + \frac{V_2}{1} + \frac{V_3}{4} = 0 \quad \rightarrow \quad V_1 + 4V_2 + V_3 = 0 \quad (1) \]
Between nodes 1 and 3,

\[-V_1 + 12 + V_3 = 0 \quad \rightarrow \quad V_3 = V_1 - 12 \quad \tag{2}\]

Similarly, between nodes 1 and 2,

\[V_1 = V_2 + 2i \quad \tag{3}\]

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

\[V_2 = 6 + V_1 / 2 \quad \tag{4}\]

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

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

Chapter 3, Solution 21

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

\[3 \times 10^{-3} = \frac{v_1 - v_2}{4000} + \frac{v_1 - v_3}{2000} \quad \Rightarrow \quad 12 = 3v_1 - v_2 - 2v_3 \quad \tag{1}\]

At node 2,

\[\frac{v_1 - v_2}{4} + \frac{v_1 - v_2}{2} = \frac{v_2}{1} \quad \Rightarrow \quad 3v_1 - 5v_2 - 2v_3 = 0 \quad \tag{2}\]

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

\[-v_3 - 3v_2 + v_2 = 0 \quad \Rightarrow \quad v_3 = -2v_2 \quad \tag{3}\]

From (1) to (3),

\[v_1 = 1V, \quad v_2 = 3V \]
Chapter 3, Solution 22

At node 1, \[ \frac{12 - v_0}{2} = \frac{v_1}{4} + 3 + \frac{v_1 - v_2}{8} \Rightarrow 24 = 7v_1 - v_2 \] (1)

At node 2, \[ 3 + \frac{v_1 - v_2}{8} = \frac{v_2 + 5v_2}{1} \]

But, \( v_1 = 12 - v_1 \)

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

\[ 456 = 41v_1 - 9v_2 \] (2)

Solving (1) and (2),

\( v_1 = -10.91 \text{ V}, \ v_2 = -100.36 \text{ V} \)

Chapter 3, Solution 23

At the supernode, \( 5 + 2 = \frac{v_1}{10} + \frac{v_2}{5} \Rightarrow 70 = v_1 + 2v_2 \) (1)

Considering Fig. (b), \( -v_1 - 8 + v_2 = 0 \Rightarrow v_2 = v_1 + 8 \) (2)

Solving (1) and (2),

\( v_1 = 18 \text{ V}, \ v_2 = 26 \text{ V} \)
Chapter 3, Solution 24

At node 1,
\[
\frac{30 - V_1}{1} = 6 + \frac{V_1}{4} + \frac{V_1 - V_2}{2} \quad \rightarrow \quad 96 = 7V_1 - 2V_2 \tag{1}
\]

At node 2,
\[
6 + \frac{(-15 - V_2)}{3} = \frac{V_2}{5} + \frac{V_2 - V_1}{2} \quad \rightarrow \quad 30 = -15V_1 + 31V_2 \tag{2}
\]

Solving (1) and (2) gives $V_1 = 16.24$. Hence

\[i_0 = \frac{V_1}{4} = 4.06 \text{ mA}\]

Chapter 3, Solution 25

Using nodal analysis,

\[
\frac{20 - v_0}{1} + \frac{40 - v_0}{2} + \frac{10 - v_0}{2} = \frac{v_0 - 0}{4} \quad \rightarrow \quad v_0 = 20V
\]

\[i_0 = \frac{20 - v_0}{1} = 0 \text{ A}\]
Chapter 3, Solution 26

At node 1,

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

At node 2,

\[ \frac{V_1 - V_2}{5} + \frac{4I_o - V_2}{5} = \frac{V_2 - V_3}{5} \quad (2) \]

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

\[ 0 = 7V_1 - 15V_2 + 3V_3 \quad (3) \]

At node 3,

\[ \frac{3V_1 - V_3}{10} + \frac{-10V_3}{5} + \frac{V_2 - V_3}{5} = 0 \quad \longrightarrow \quad -10 = V_1 + 2V_2 - 5V_3 \quad (4) \]

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

\[
\begin{pmatrix}
7 & -4 & -2 \\
7 & -15 & 3 \\
1 & 2 & -5
\end{pmatrix}
\begin{pmatrix}
V_1 \\
V_2 \\
V_3
\end{pmatrix}
=
\begin{pmatrix}
-45 \\
0 \\
-10
\end{pmatrix}
\longrightarrow
AV = B
\]

Using MATLAB leads to

\[ V = A^{-1}B = \begin{pmatrix} -9.835 \\ -4.982 \\ -1.96 \end{pmatrix} \]

Thus,

\[ V_1 = -9.835 \text{ V}, \quad V_2 = -4.982 \text{ V}, \quad V_3 = -1.95 \text{ V} \]

Chapter 3, Solution 27

At node 1,

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

\[ 2 = 7v_1 + 11v_2 - 4v_3 \quad (1) \]

At node 2,

\[ v_1 - v_2 = 4v_2 + v_2 - v_3 \quad \longrightarrow \quad 0 = -v_1 + 6v_2 - v_3 \quad (2) \]

At node 3,

\[ 2v_3 = 4 + v_2 - v_3 + 12v_2 + 4(v_1 - v_3) \]
or 
\[-4 = 4v_1 + 13v_2 - 7v_3 \quad (3)\]

In matrix form,

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

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

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

\[
\begin{align*}
v_1 &= \frac{\Delta_1}{\Delta} = \frac{110}{176} = 0.625V, \quad v_2 &= \frac{\Delta_2}{\Delta} = \frac{66}{176} = 0.375V \\
v_3 &= \frac{\Delta_3}{\Delta} = \frac{286}{176} = 1.625V
\end{align*}
\]

\[
v_1 = 625 \text{ mV, } v_2 = 375 \text{ mV, } v_3 = 1.625 \text{ V.}
\]

**Chapter 3, Solution 28**

At node c,
\[
\frac{V_d - V_c}{10} = \frac{V_c - V_b}{4} + \frac{V_c}{5} \quad \rightarrow \quad 0 = -5V_b + 11V_c - 2V_d \quad (1)
\]

At node b,
\[
\frac{V_a + 45 - V_b}{8} + \frac{V_c - V_b}{4} = \frac{V_b}{8} \quad \rightarrow \quad -45 = V_a - 4V_b + 2V_c \quad (2)
\]

At node a,
\[
\frac{V_a - 30 - V_d}{4} + \frac{V_a}{16} + \frac{V_a + 45 - V_b}{8} = 0 \quad \rightarrow \quad 30 = 7V_a - 2V_b - 4V_d \quad (3)
\]

At node d,
\[
\frac{V_a - 30 - V_d}{4} = \frac{V_d}{20} + \frac{V_d - V_c}{10} \quad \rightarrow \quad 150 = 5V_a + 2V_c - 7V_d \quad (4)
\]

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

\[ V_a = -10.14 \text{ V}, \quad V_b = 7.847 \text{ V}, \quad V_c = -1.736 \text{ V}, \quad V_d = -29.17 \text{ V} \]

**Chapter 3, Solution 29**

At node 1,

\[
5 + V_1 - V_4 + 2V_1 + V_1 - V_2 = 0 \quad \longrightarrow \quad -5 = 4V_1 - V_2 - V_4
\]

At node 2,

\[
V_1 - V_2 = 2V_2 + 4(V_2 - V_3) = 0 \quad \longrightarrow \quad 0 = -V_1 + 7V_2 - 4V_3
\]

At node 3,

\[
6 + 4(V_2 - V_3) = V_3 - V_4 \quad \longrightarrow \quad 6 = -4V_2 + 5V_3 - V_4
\]

At node 4,

\[
2 + V_3 - V_4 + V_1 - V_4 = 3V_4 \quad \longrightarrow \quad 2 = -V_1 - V_3 + 5V_4
\]

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.

\[ V_1 = -0.7708 \text{ V}, \quad V_2 = 1.209 \text{ V}, \quad V_3 = 2.309 \text{ V}, \quad V_4 = 0.7076 \text{ V} \]
Chapter 3, Solution 30

At node 1,

\[
\frac{v_1 - v_2}{40} = \frac{100 - v_1}{10} + \frac{4v_o - v_1}{20}
\]  

(1)

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

\[7v_1 - 9v_o = 280\]  

(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

\[6v_1 - 7v_o = -720\]  

(3)

from (2) and (3),

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

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

\[\Delta_1 = \begin{vmatrix}
280 & -9 \\
-720 & -7
\end{vmatrix} = -8440, \quad \Delta_2 = \begin{vmatrix}
7 & 280 \\
6 & -720
\end{vmatrix} = -6720\]
\[ v_1 = \frac{\Delta_1}{\Delta} = \frac{-8440}{5} = -1688, \quad v_0 = \frac{\Delta_2}{\Delta} = \frac{-6720}{5} = -1344 \text{V} \]

\[ I_0 = -5.6 \text{ A} \]

**Chapter 3, Solution 31**

At the supernode,

\[ 1 + 2v_0 = \frac{v_1}{4} + \frac{v_2}{1} + \frac{v_1 - v_3}{1} \quad (1) \]

But \( v_0 = v_1 - v_3 \). Hence (1) becomes,

\[ 4 = -3v_1 + 4v_2 + 4v_3 \quad (2) \]

At node 3,

\[ 2v_0 + \frac{v_2}{4} = v_1 - v_3 + \frac{10 - v_3}{2} \]

or

\[ 20 = 4v_1 + v_2 - 2v_3 \quad (3) \]

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

\[ v_2 = v_1 + v_3 \quad (4) \]

Solving (2) to (4) leads to,

\[ v_1 = 4 \text{V}, \quad v_2 = 4 \text{V}, \quad v_3 = 0 \text{V}. \]
Chapter 3, Solution 32

We have a supernode as shown in figure (a). It is evident that $v_2 = 12 \text{ V}$, Applying KVL to loops 1 and 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, $v_1 = 2 \text{ V}, \ v_2 = 12 \text{ V}, \ v_3 = -8 \text{ V}.$

Chapter 3, Solution 33

(a) This is a **non-planar** circuit because there is no way of redrawing the circuit with no crossing branches.

(b) This is a **planar** circuit. It can be redrawn as shown below.
Chapter 3, Solution 34

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

![Planar Circuit Diagram](image)

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

Chapter 3, Solution 35

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

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

For mesh 2,

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

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

$v_0 = 4i_2 = 20 \text{ volts}$.
Chapter 3, Solution 36

![Image of circuit](image)

Applying mesh analysis gives,

\[ 12 = 10I_1 - 6I_2 \]

\[ -10 = -6I_1 + 8I_2 \]

or

\[
\begin{bmatrix}
6 \\
-5
\end{bmatrix} = \begin{bmatrix}
5 & -3 \\
-3 & 4
\end{bmatrix} \begin{bmatrix}
I_1 \\
I_2
\end{bmatrix}
\]

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

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

\[
i_1 = -I_1 = -\frac{9}{11} = -0.8181 \text{ A}, \quad i_2 = I_1 - I_2 = \frac{10}{11} = 1.4545 \text{ A}.
\]

\[
v_0 = 6i_2 = 6 \times 1.4545 = 8.727 \text{ V}.
\]

Chapter 3, Solution 37

![Image of circuit](image)
Applying mesh analysis to loops 1 and 2, we get,

\[ 6i_1 - 1i_2 + 3 = 0 \] which leads to \[ i_2 = 6i_1 + 3 \quad (1) \]

\[ -1i_1 + 6i_2 - 3 + 4v_0 = 0 \quad (2) \]

But, \[ v_0 = -2i_1 \quad (3) \]

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

Therefore, we get \[ v_0 = -2i_1 = -2(-5/9) = 1.111 \text{ volts} \]

Chapter 3, Solution 38

![Diagram](image)

We apply mesh analysis.

\[ 12 = 3i_1 + 8(i_1 - i_2) \] which leads to \[ 12 = 11i_1 - 8i_2 \quad (1) \]

\[ -2v_0 = 6i_2 + 8(i_2 - i_1) \] and \[ v_0 = 3i_1 \text{ or } i_1 = 7i_2 \quad (2) \]

From (1) and (2), \( i_1 = 84/69 \) and \( v_0 = 3i_1 = 3x89/69 \)

\[ v_0 = 3.652 \text{ volts} \]

Chapter 3, Solution 39

For mesh 1,

\[ -10 - 2I_x + 10I_1 - 6I_2 = 0 \]

But \( I_x = I_1 - I_2 \). Hence,

\[ 10 = -12I_1 + 12I_2 + 10I_1 - 6I_2 \quad \rightarrow \quad 5 = 4I_1 - 2I_2 \quad (1) \]

For mesh 2,

\[ 12 + 8I_2 - 6I_1 = 0 \quad \rightarrow \quad 6 = 3I_1 - 4I_2 \quad (2) \]

Solving (1) and (2) leads to \( I_1 = 0.8 \text{ A, } I_2 = -0.9 \text{ A} \)
Chapter 3, Solution 40

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

\[ 30 = 12i_1 - 6i_2 - 4i_3 \rightarrow 15 = 6i_1 - 3i_2 - 2i_3 \]  \hspace{1cm} (1)

for mesh 2,

\[ 0 = -6i_1 + 14i_2 - 2i_3 \rightarrow 0 = -3i_1 + 7i_2 - i_3 \] \hspace{1cm} (2)

for mesh 3,

\[ 0 = -4i_1 - 2i_2 + 10i_3 \rightarrow 0 = -2i_1 - i_2 + 5i_3 \] \hspace{1cm} (3)

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

\[ i_0 = i_1 = 4.286 \text{ mA}. \]

Chapter 3, Solution 41
For loop 1,

\[ 6 = 12i_1 - 2i_2 \quad \rightarrow \quad 3 = 6i_1 - i_2 \quad (1) \]

For loop 2,

\[ -8 = 7i_2 - 2i_1 - i_3 \quad (2) \]

For loop 3,

\[ -8 + 6 + 6i_3 - i_2 = 0 \quad \rightarrow \quad 2 = 6i_3 - i_2 \quad (3) \]

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

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

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

\[ \Delta_3 = \begin{bmatrix} 6 & -1 & 3 \\ 2 & -7 & 8 \\ 0 & -1 & 2 \end{bmatrix} = -38 \]

At node 0, \( i + i_2 = i_3 \) or \( i = i_3 - i_2 \) = \( \frac{\Delta_3 - \Delta_2}{\Delta} = \frac{-38 - 240}{-234} = 1.188 \text{ A} \)
Chapter 3, Solution 42

For mesh 1,
\[ -12 + 50I_1 - 30I_2 = 0 \quad \rightarrow \quad 12 = 50I_1 - 30I_2 \] (1)

For mesh 2,
\[ -8 + 100I_2 - 30I_1 - 40I_3 = 0 \quad \rightarrow \quad 8 = -30I_1 + 100I_2 - 40I_3 \] (2)

For mesh 3,
\[ -6 + 50I_3 - 40I_2 = 0 \quad \rightarrow \quad 6 = -40I_2 + 50I_3 \] (3)

Putting eqs. (1) to (3) in matrix form, we get
\[
\begin{bmatrix}
50 & -30 & 0 \\
-30 & 100 & -40 \\
0 & -40 & 50 \\
\end{bmatrix}
\begin{bmatrix}
I_1 \\
I_2 \\
I_3 \\
\end{bmatrix}
=
\begin{bmatrix}
12 \\
8 \\
6 \\
\end{bmatrix}
\rightarrow
AI = B
\]

Using Matlab,
\[
I = A^{-1}B = \begin{bmatrix}
0.48 \\
0.40 \\
0.44 \\
\end{bmatrix}
\]

i.e. \( I_1 = 0.48 \) A, \( I_2 = 0.4 \) A, \( I_3 = 0.44 \) A

Chapter 3, Solution 43

For loop 1,
\[ 80 = 70i_1 - 20i_2 - 30i_3 \quad \rightarrow \quad 8 = 7i_1 - 2i_2 - 3i_3 \] (1)
For loop 2,
\[ 80 = 70i_2 - 20i_1 - 30i_3 \quad \rightarrow \quad 8 = -2i_1 + 7i_2 - 3i_3 \quad (2) \]

For loop 3,
\[ 0 = -30i_1 - 30i_2 + 90i_3 \quad \rightarrow \quad 0 = i_1 + i_2 - 3i_3 \quad (3) \]

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

\[ I_o = i_3 = 16/9 = \mathbf{1.778 \ A} \]

\[ V_{ab} = 30i_3 = \mathbf{53.33 \ V}. \]

**Chapter 3, Solution 44**

![Diagram](image)

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), \( i_1 = -3.067, i_3 = -1.3333; \ i_o = i_1 - i_3 = \mathbf{-1.7333 \ A} \)
Chapter 3, Solution 45

For loop 1, \[ 30 = 5i_1 - 3i_2 - 2i_3 \] (1)

For loop 2, \[ 10i_2 - 3i_1 - 6i_4 = 0 \] (2)

For the supermesh, \[ 6i_3 + 14i_4 - 2i_1 - 6i_2 = 0 \] (3)

But \[ i_4 - i_3 = 4 \] which leads to \[ i_4 = i_3 + 4 \] (4)

Solving (1) to (4) by elimination gives \[ i = i_1 = 8.561 \text{ A}. \]

Chapter 3, Solution 46

For loop 1, \[ -12 + 11i_1 - 8i_2 = 0 \quad \rightarrow \quad 11i_1 - 8i_2 = 12 \] (1)

For loop 2, \[ -8i_1 + 14i_2 + 2v_o = 0 \]

But \[ v_o = 3i_1, \]

\[ -8i_1 + 14i_2 + 6i_1 = 0 \quad \rightarrow \quad i_1 = 7i_2 \] (2)

Substituting (2) into (1), \[ 77i_2 - 8i_2 = 12 \quad \rightarrow \quad i_2 = 0.1739 \text{ A and } i_1 = 7i_2 = 1.217 \text{ A} \]
Chapter 3, Solution 47

First, transform the current sources as shown below.

For mesh 1,
\[-20 + 14I_1 - 2I_2 - 8I_3 = 0 \quad \rightarrow \quad 10 = 7I_1 - I_2 - 4I_3 \quad (1)\]
For mesh 2,
\[12 + 14I_2 - 2I_1 - 4I_3 = 0 \quad \rightarrow \quad -6 = -I_1 + 7I_2 - 2I_3 \quad (2)\]
For mesh 3,
\[-6 + 14I_3 - 4I_2 - 8I_1 = 0 \quad \rightarrow \quad 3 = -4I_1 - 2I_2 + 7I_3 \quad (3)\]

Putting (1) to (3) in matrix form, we obtain
\[
\begin{pmatrix}
7 & -1 & -4 \\
-1 & 7 & -2 \\
-4 & -2 & 7
\end{pmatrix}
\begin{pmatrix}
I_1 \\
I_2 \\
I_3
\end{pmatrix}
=\begin{pmatrix}
10 \\
-6 \\
3
\end{pmatrix}
\quad \rightarrow \quad AI = B
\]

Using MATLAB,
\[
I = A^{-1}B = \begin{pmatrix} 2 \\ 0.0333 \\ 1.8667 \end{pmatrix}
\quad \rightarrow \quad I_1 = 2.5, \ I_2 = 0.0333, I_3 = 1.8667
\]

But
\[
I_1 = \frac{20 - V}{4} \quad \rightarrow \quad V_1 = 20 - 4I_1 = 10 \ \text{V}
\]
\[
V_2 = 2(I_1 - I_2) = 4.933 \ \text{V}
\]
Also,
\[
I_2 = \frac{V_3 - 12}{8} \quad \rightarrow \quad V_3 = 12 + 8I_2 = 12.267 \ \text{V}
\]
Chapter 3, Solution 48

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

For mesh 1,
\[-12 + 8 + 5I_1 - I_2 - 4I_4 = 0 \quad \rightarrow \quad 4 = 5I_1 - I_2 - 4I_4 \quad (1)\]

For mesh 2,
\[-8 + 13I_2 - I_1 - 10I_3 - 2I_4 = 0 \quad \rightarrow \quad 8 = -I_1 + 13I_2 - 10I_3 - 2I_4 \quad (2)\]

For mesh 3,
\[-6 + 15I_3 - 10I_2 - 5I_4 = 0 \quad \rightarrow \quad 6 = -10I_2 + 15I_3 - 5I_4 \quad (3)\]

For mesh 4,
\[-4I_1 - 2I_2 - 5I_3 + 14I_4 = 0 \quad (4)\]

Putting (1) to (4) in matrix form gives
\[
\begin{pmatrix}
5 & -1 & 0 & -4 \\
-1 & 13 & -10 & -2 \\
0 & -10 & 15 & -5 \\
-4 & -2 & -5 & 14
\end{pmatrix}
\begin{pmatrix}
I_1 \\
I_2 \\
I_3 \\
I_4
\end{pmatrix}
=
\begin{pmatrix}
4 \\
8 \\
6 \\
0
\end{pmatrix}
\quad \rightarrow \quad AI = B
\]

Using MATLAB,
\[
I = A^{-1}B = \begin{pmatrix} 7.217 \\ 8.087 \\ 7.791 \\ 6 \end{pmatrix}
\]

The current through the 10kΩ resistor is \( I_o = I_2 - I_3 = 0.2957 \text{ mA} \).
For the supermesh in figure (a),

\[ 3i_1 + 2i_2 - 3i_3 + 16 = 0 \]  \hspace{1cm} (1)

At node 0, \( i_2 - i_1 = 2i_0 \) and \( i_0 = -i_1 \) which leads to \( i_2 = -i_1 \)  \hspace{1cm} (2)

For loop 3, \( -i_1 - 2i_2 + 6i_3 = 0 \) which leads to \( 6i_3 = -i_1 \)  \hspace{1cm} (3)

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

\( i_0 = -i_1 = \textbf{10.667\,A}, \) from fig. (b), \( v_0 = i_3 - 3i_1 = (16/9) + 32 = \textbf{33.78\,V} \).
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 \( i_0 = i_1 = \mathbf{1.731 A} \)

Chapter 3, Solution 51
For loop 1, \( i_1 = 5 \text{A} \)  \hspace{1cm} (1)

For loop 2, \(-40 + 7i_2 - 2i_1 - 4i_3 = 0\) which leads to \( 50 = 7i_2 - 4i_3 \) \hspace{1cm} (2)

For loop 3, \(-20 + 12i_3 - 4i_2 = 0\) which leads to \( 5 = -i_2 + 3i_3 \) \hspace{1cm} (3)

Solving with (2) and (3), \( i_2 = 10 \text{A}, \ i_3 = 5 \text{A} \)

And, \( v_0 = 4(i_2 - i_3) = 4(10 - 5) = 20 \text{V} \).

Chapter 3, Solution 52

For mesh 1,
\[ 2(i_1 - i_2) + 4(i_1 - i_3) - 12 = 0 \] which leads to \( 3i_1 - i_2 - 2i_3 = 6 \) \hspace{1cm} (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 \( -i_1 + 3i_2 + 2i_3 = 0 \) \hspace{1cm} (2)

For the independent current source, \( i_3 = 3 + i_2 \) \hspace{1cm} (3)

Solving (1), (2), and (3), we obtain,
\[ i_1 = 3.5 \text{A}, \ i_2 = -0.5 \text{A}, \ i_3 = 2.5 \text{A}. \]
For mesh 1,

\[ 2(i_1 - i_2) + 4(i_1 - i_3) - 12 = 0 \] which leads to \[ 3i_1 - i_2 - 2i_3 = 6 \] (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,

\[ i_1 = 3.5 \text{ A}, \quad i_2 = -0.5 \text{ A}, \quad i_3 = 2.5 \text{ A}. \]
Chapter 3, Solution 54

Let the mesh currents be in mA. For mesh 1,
\[ -12 + 10 + 2I_1 - I_2 = 0 \quad \rightarrow \quad 2 = 2I_1 - I_2 \quad (1) \]
For mesh 2,
\[ -10 + 3I_2 - I_1 - I_3 = 0 \quad \rightarrow \quad 10 = -I_1 + 3I_2 - I_3 \quad (2) \]
For mesh 3,
\[ -12 + 2I_3 - I_2 = 0 \quad \rightarrow \quad 12 = -I_2 + 2I_3 \quad (3) \]
Putting (1) to (3) in matrix form leads to
\[
\begin{bmatrix}
2 & -1 & 0 \\
-1 & 3 & -1 \\
0 & -1 & 2
\end{bmatrix}
\begin{bmatrix}
I_1 \\
I_2 \\
I_3
\end{bmatrix}
= \begin{bmatrix}
2 \\
10 \\
12
\end{bmatrix}
\quad \rightarrow \quad AI = B
\]
Using MATLAB,
\[
I = A^{-1}B = \begin{bmatrix}
5.25 \\
8.5 \\
10.25
\end{bmatrix}
\quad \rightarrow \quad I_1 = 5.25 \text{ mA, } I_2 = 8.5 \text{ mA, } I_3 = 10.25 \text{ mA}
\]

Chapter 3, Solution 55

![Diagram of an electrical circuit with currents and voltages]
It is evident that \( I_1 = 4 \) \hfill (1) 

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

For the supermesh \( 6(I_2 - I_1) + 10 + 2I_3 + 4(I_3 - I_4) = 0 \) 

or \(-3I_1 + 3I_2 + 3I_3 - 2I_4 = -5 \) \hfill (3) 

At node c, \( I_2 = I_3 + 1 \) \hfill (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, Solution 56 

For loop 1, \( 12 = 4i_1 - 2i_2 - 2i_3 \) \hfill (1) 

For loop 2, \( 0 = 6i_2 - 2i_1 - 2i_3 \) \hfill (2) 

For loop 3, \( 0 = 6i_3 - 2i_1 - 2i_2 \) \hfill (3)
In matrix form (1), (2), and (3) become,

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

\[
\Delta = \begin{bmatrix}
2 & -1 & -1 \\
-1 & 3 & -1 \\
-1 & -1 & 3
\end{bmatrix}
, \quad
\Delta_2 = \begin{bmatrix}
2 & 6 & -1 \\
-1 & 3 & -1 \\
-1 & 0 & 3
\end{bmatrix}
= 24,
\]

\[
\Delta_3 = \begin{bmatrix}
2 & -1 & 6 \\
-1 & 3 & 0 \\
-1 & -1 & 0
\end{bmatrix}
= 24,
\]

therefore \( i_2 = i_3 = 24/8 = 3 \text{A}, \)

\( v_1 = 2i_2 = \textbf{6 volts}, \ v = 2i_3 = \textbf{6 volts} \)

**Chapter 3, Solution 57**

Assume \( R \) is in kilo-ohms.

\( V_2 = 4k\Omega \times 18mA = 72V, \quad V_1 = 100 - V_2 = 100 - 72 = 28V \)

Current through \( R \) is

\[ i_R = \frac{3}{3 + R} i_o, \quad V_1 = i_R R \quad \rightarrow \quad 28 = \frac{3}{3 + R} (18)R \]

This leads to \( R = 84/26 = 3.23 \text{ k}\Omega \)

**Chapter 3, Solution 58**

[Diagram of electrical circuit with currents and resistances]
For loop 1, \( 120 + 40i_1 - 10i_2 = 0 \), which leads to \(-12 = 4i_1 - i_2\) \hspace{1cm} (1)

For loop 2, \( 50i_2 - 10i_1 - 10i_3 = 0 \), which leads to \(-i_1 + 5i_2 - i_3 = 0\) \hspace{1cm} (2)

For loop 3, \(-120 - 10i_2 + 40i_3 = 0\), which leads to \(12 = -i_2 + 4i_3\) \hspace{1cm} (3)

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

Chapter 3, Solution 59

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

or \(5 = 1.5i_1 - i_2 + 16i_3\) \hspace{1cm} (1)

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

or \(6 = -i_1 + 3i_2 - 12i_3\) \hspace{1cm} (2)

Also, \(2I_0 = i_3 - i_2\) and \(I_0 = i_2\), hence, \(3i_2 = i_3\) \hspace{1cm} (3)

From (1), (2), and (3),

\[
\begin{bmatrix}
3 & -2 & 32 \\
-1 & 3 & -12 \\
0 & 3 & -1
\end{bmatrix}
\begin{bmatrix}
i_1 \\
i_2 \\
i_3
\end{bmatrix}
=
\begin{bmatrix}
10 \\
6 \\
0
\end{bmatrix}
\]

\[
\Delta = \begin{bmatrix}
3 & -2 & 32 \\
-1 & 3 & -12 \\
0 & 3 & -1
\end{bmatrix} = 5, \quad \Delta_2 = \begin{bmatrix}
3 & 10 & 32 \\
-1 & 6 & -12 \\
0 & 0 & -1
\end{bmatrix} = -28, \quad \Delta_3 = \begin{bmatrix}
3 & -2 & 10 \\
-1 & 3 & 6 \\
0 & 3 & 0
\end{bmatrix} = -84
\]

\(I_0 = i_2 = \Delta_2/\Delta = -28/5 = -5.6\ A\)

\(v_0 = 8i_3 = (-84/5)80 = -1344\ volts\)
Chapter 3, Solution 60

\[ (v_1/1) + (0.5v_1/1) = (10 - v_1)/4, \text{ which leads to } v_1 = 10/7 \]

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

\[ P_{1\Omega} = (v_1)^2/1 = 2.041 \text{ watts}, \quad P_{2\Omega} = (v_2)^2/2 = 4.939 \text{ watts} \]

\[ P_{4\Omega} = (10 - v_1)^2/4 = 18.38 \text{ watts}, \quad P_{8\Omega} = (10 - v_2)^2/8 = 5.88 \text{ watts} \]

Chapter 3, Solution 61

\[ i_s = (v_1/30) + ((v_1 - v_2)/20) \text{ which leads to } 60i_s = 5v_1 - 3v_2 \quad (1) \]

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 \( v_1 = 3i_s, \ v_2 = -15i_s \)

\[ i_0 = v_2/50 = -15i_s/50 \text{ which leads to } i_0/i_s = -15/50 = -0.3 \]
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 \(30 = 2i_1 + 4i_2 + i_3\) \hspace{1cm} (1)

At node A, \(i_1 + 4 = i_2\) \hspace{1cm} (2)

At node B, \(i_2 = 2i_1 + i_3\) \hspace{1cm} (3)

Solving (1), (2), and (3), we get \(i_1 = 2 \text{ mA}\), \(i_2 = 6 \text{ mA}\), and \(i_3 = 2 \text{ mA}\).

Chapter 3, Solution 63

For the supermesh, \(-50 + 10i_1 + 5i_2 + 4i_x = 0\), but \(i_x = i_1\). Hence, \(50 = 14i_1 + 5i_2\) \hspace{1cm} (1)

At node A, \(i_1 + 3 + (v_x/4) = i_2\), but \(v_x = 2(i_1 - i_2)\), hence, \(i_1 + 2 = i_2\) \hspace{1cm} (2)

Solving (1) and (2) gives \(i_1 = 2.105 \text{ A}\) and \(i_2 = 4.105 \text{ A}\)

\(v_x = 2(i_1 - i_2) = -4 \text{ volts}\) and \(i_x = i_2 - 2 = 4.105 \text{ amp}\)
For mesh 2, \(20i_2 - 10i_1 + 4i_0 = 0\)  \(\text{(1)}\)

But at node A, \(i_0 = i_1 - i_2\) so that (1) becomes \(i_1 = \frac{7}{12}i_2\)  \(\text{(2)}\)

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

or \(50 = 28i_1 - 3i_2 + 20i_3\)  \(\text{(3)}\)

At node B, \(i_3 + 0.2v_0 = 2 + i_1\)  \(\text{(4)}\)

But, 
\(v_0 = 10i_2\) so that (4) becomes \(i_3 = 2 - \frac{17}{12}i_2\)  \(\text{(5)}\)

Solving (1) to (5), \(i_2 = -0.674\),

\(v_0 = 10i_2 = -6.74\ \text{volts}, \quad i_0 = i_1 - i_2 = -\frac{5}{12}i_2 = 0.281\ \text{amps}\)
Casting (1) to (5) in matrix form gives
\[
\begin{pmatrix}
12 & -6 & 0 & 1 & 0 \\
-6 & 16 & -8 & -1 & -1 \\
0 & -8 & 15 & 0 & -1 \\
-1 & -1 & 0 & 5 & -2 \\
0 & -1 & -1 & 2 & 8
\end{pmatrix}
\begin{pmatrix}
I_1 \\
I_2 \\
I_3 \\
I_4 \\
I_5
\end{pmatrix}
= \begin{pmatrix} 12 \\ 0 \\ 9 \\ 6 \\ 10 \end{pmatrix}
\rightarrow \quad AI = B
\]

Using MATLAB leads to
\[
I = A^{-1}B = \begin{pmatrix}
1.673 \\
1.824 \\
1.733 \\
2.864 \\
2.411
\end{pmatrix}
\]

Thus,
\[
I_1 = 1.673 \text{ A}, \quad I_2 = 1.824 \text{ A}, \quad I_3 = 1.733 \text{ A}, \quad I_4 = 1.864 \text{ A}, \quad I_5 = 2.411 \text{ A}
\]

Chapter 3, Solution 66

Consider the circuit below.

We use mesh analysis. Let the mesh currents be in mA.
For mesh 1,
\[
20 = 4I_1 - I_2 - I_3
\]  
(1)
For mesh 2,
\[
-10 = -I_1 + 4I_2 - I_4
\]  
(2)
For mesh 3,
\[
12 = -I_1 + 4I_3 - I_4
\]  
(3)
For mesh 4,
\[
-12 = -I_2 - I_3 + 4I_4
\]  
(4)
In matrix form, (1) to (4) become
\[
\begin{bmatrix}
4 & -1 & -1 & 0 \\
-1 & 4 & 0 & -1 \\
-1 & 0 & 4 & -1 \\
0 & -1 & -1 & 4
\end{bmatrix}
\begin{bmatrix}
I_1 \\
I_2 \\
I_3 \\
I_4
\end{bmatrix}
= \begin{bmatrix}
20 \\
-10 \\
12 \\
-12
\end{bmatrix}
\rightarrow AI = B
\]
Using MATLAB,
\[
I = A^{-1} B = \begin{bmatrix}
5.5 \\
-1.75 \\
3.75 \\
-2.5
\end{bmatrix}
\]
Thus,
\[
I_a = -I_3 = -3.75 \text{ mA}
\]

Chapter 3, Solution 67

\[G_{11} = (1/1) + (1/4) = 1.25, \ G_{22} = (1/1) + (1/2) = 1.5\]

\[G_{12} = -1 = G_{21}, \ i_1 = 6 - 3 = 3, \ i_2 = 5 - 6 = -1\]

Hence, we have,
\[
\begin{bmatrix}
1.25 & -1 \\
-1 & 1.5
\end{bmatrix}
\begin{bmatrix}
v_1 \\
v_2
\end{bmatrix}
= \begin{bmatrix}
3 \\
-1
\end{bmatrix}
\]

\[
\begin{bmatrix}
1.25 & -1 \\
-1 & 1.5
\end{bmatrix}^{-1}
= \frac{1}{\Delta}
\begin{bmatrix}
1.5 & 1 \\
1 & 1.25
\end{bmatrix}, \text{ where } \Delta = [(1.25)(1.5) - (-1)(-1)] = 0.875
\]

\[
\begin{bmatrix}
v_1 \\
v_2
\end{bmatrix}
= \begin{bmatrix}
1.7143 & 1.1429 \\
1.1429 & 1.4286
\end{bmatrix}
\begin{bmatrix}
3 \\
-1
\end{bmatrix}
= \begin{bmatrix}
3(1.7143) - 1(1.1429) \\
3(1.1429) - 1(1.4286)
\end{bmatrix}
= \begin{bmatrix}
4 \\
2
\end{bmatrix}
\]

Clearly \(v_1 = 4 \text{ volts}\) and \(v_2 = 2 \text{ volts}\)
Chapter 3, Solution 68

By inspection, \( G_{11} = 1 + 3 + 5 = 8S \), \( G_{22} = 1 + 2 = 3S \), \( G_{33} = 2 + 5 = 7S \)

\( G_{12} = -1 \), \( G_{13} = -5 \), \( G_{21} = -1 \), \( G_{23} = -2 \), \( G_{31} = -5 \), \( G_{32} = -2 \)

\( i_1 = 4 \), \( i_2 = 2 \), \( i_3 = -1 \)

We can either use matrix inverse as we did in Problem 3.51 or use Cramer’s Rule. Let us use Cramer’s rule for this problem.

First, we develop the matrix relationships.

\[
\begin{bmatrix}
8 & -1 & -5 \\
-1 & 3 & -2 \\
-5 & -2 & 7 \\
\end{bmatrix}
\begin{bmatrix}
v_1 \\
v_2 \\
v_3 \\
\end{bmatrix}
= 
\begin{bmatrix}
4 \\
2 \\
-1 \\
\end{bmatrix}
\]

\[
\Delta = \begin{vmatrix}
8 & -1 & -5 \\
-1 & 3 & -2 \\
-5 & -2 & 7 \\
\end{vmatrix} = 34, \Delta_1 = \begin{vmatrix}
4 & -1 & -5 \\
2 & 3 & -2 \\
-1 & -2 & 7 \\
\end{vmatrix} = 85
\]

\[
\Delta_2 = \begin{vmatrix}
8 & 4 & -5 \\
-1 & 2 & -2 \\
-5 & -1 & 7 \\
\end{vmatrix} = 109, \Delta_3 = \begin{vmatrix}
8 & -1 & 4 \\
-1 & 3 & 2 \\
-5 & -2 & -1 \\
\end{vmatrix} = 87
\]

\( v_1 = \Delta_1/\Delta = 85/34 = \textbf{3.5 volts} \), \( v_2 = \Delta_2/\Delta = 109/34 = \textbf{3.206 volts} \)

\( v_3 = \Delta_3/\Delta = 87/34 = \textbf{2.56 volts} \)
Chapter 3, Solution 69

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

\[ G_{11} = (1/2) + (1/4) + (1/1) = 1.75, \quad G_{22} = (1/4) + (1/4) + (1/2) = 1, \]
\[ G_{33} = (1/1) + (1/4) = 1.25, \quad G_{12} = -1/4 = -0.25, \quad G_{13} = -1/1 = -1, \]
\[ G_{21} = -0.25, \quad G_{23} = -1/4 = -0.25, \quad G_{31} = -1, \quad G_{32} = -0.25 \]
\[ i_1 = 20, \quad i_2 = 5, \quad \text{and} \quad i_3 = 10 - 5 = 5 \]

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, Solution 70

\[ G_{11} = G_1 + G_2 + G_4, \quad G_{12} = -G_2, \quad G_{13} = 0, \]
\[ G_{22} = G_2 + G_3, \quad G_{21} = -G_2, \quad G_{23} = -G_3, \]
\[ G_{33} = G_1 + G_3 + G_5, \quad G_{31} = 0, \quad G_{32} = -G_3 \]
\[ i_1 = -I_1, \quad i_2 = I_2, \quad \text{and} \quad i_3 = I_1 \]

Then, the node-voltage equations are:

\[
\begin{bmatrix}
G_1 + G_2 + G_4 & -G_2 & 0 \\
-G_2 & G_1 + G_2 & -G_3 \\
0 & -G_3 & G_1 + G_3 + G_5
\end{bmatrix}
\begin{bmatrix}
v_1 \\
v_2 \\
v_3
\end{bmatrix}
= 
\begin{bmatrix}
-I_1 \\
I_2 \\
I_1
\end{bmatrix}
\]
Chapter 3, Solution 71

\[ R_{11} = 4 + 2 = 6, \ R_{22} = 2 + 8 + 2 = 12, \ R_{33} = 2 + 5 = 7, \]
\[ R_{12} = -2, \ R_{13} = 0, \ R_{21} = -2, \ R_{23} = -2, \ R_{31} = 0, \ R_{32} = -2 \]

\[ v_1 = 12, \ v_2 = -8, \text{ and } v_3 = -20 \]

Now we can write the matrix relationships for the mesh-current equations.

\[
\begin{bmatrix}
6 & -2 & 0 \\
-2 & 12 & -2 \\
0 & -2 & 7 \\
\end{bmatrix}
\begin{bmatrix}
i_1 \\
i_2 \\
i_3 \\
\end{bmatrix}
= 
\begin{bmatrix}
12 \\
-8 \\
-20 \\
\end{bmatrix}
\]

Now we can solve for \( i_2 \) using Cramer’s Rule.

\[
\Delta = \begin{vmatrix}
6 & -2 & 0 \\
-2 & 12 & -2 \\
0 & -2 & 7 \\
\end{vmatrix} = 452, \quad \Delta_2 = \begin{vmatrix}
6 & 12 & 0 \\
-2 & -8 & -2 \\
0 & -20 & 7 \\
\end{vmatrix} = -408
\]

\[ i_2 = \frac{\Delta_2}{\Delta} = -0.9026, \quad p = (i_2)^2R = 6.52 \text{ watts} \]

Chapter 3, Solution 72

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

\[ v_1 = 8, \ v_2 = 4, \ v_3 = -10, \text{ and } v_4 = -4 \]

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, Solution 73

\[ R_{11} = 2 + 3 + 4 = 9, \quad R_{22} = 3 + 5 = 8, \quad R_{33} = 1 + 4 = 5, \quad R_{44} = 1 + 1 = 2, \]
\[ R_{12} = -3, \quad R_{13} = -4, \quad R_{14} = 0, \quad R_{23} = 0, \quad R_{24} = 0, \quad R_{34} = -1 \]
\[ v_1 = 6, \quad v_2 = 4, \quad v_3 = 2, \quad \text{and} \quad v_4 = -3 \]

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, Solution 74

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

The input voltage vector is

\[
\begin{bmatrix}
V_1 \\
- V_2 \\
V_3 \\
- V_4
\end{bmatrix}
\]

\[
\begin{bmatrix}
R_1 + R_4 + R_6 & -R_4 & -R_6 & 0 \\
-R_4 & R_2 + R_4 + R_5 & 0 & -R_5 \\
-R_6 & 0 & R_6 + R_7 + R_8 & -R_8 \\
0 & -R_5 & -R_8 & R_3 + R_5 + R_8
\end{bmatrix}
\begin{bmatrix}
i_1 \\
i_2 \\
i_3 \\
i_4
\end{bmatrix}
= 
\begin{bmatrix}
V_1 \\
- V_2 \\
V_3 \\
- V_4
\end{bmatrix}
\]
Clearly, $i_1 = -3 \text{ amps}$, $i_2 = 0 \text{ amps}$, and $i_3 = 3 \text{ amps}$, which agrees with the answers in Problem 3.44.
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, $v_1 = \textbf{625 mVolts}$, $v_2 = \textbf{375 mVolts}$, and $v_3 = \textbf{1.625 volts}$, which agrees with the solution obtained in Problem 3.27.
Chapter 3, Solution 77

* Schematics Netlist *

R_R2        0 $N_0001  4  
I_I1        $N_0001 0 DC 3A  
I_I3        $N_0002 $N_0001 DC 6A  
R_R3        0 $N_0002  2  
R_R1        $N_0001 $N_0002  1  
I_I2        0 $N_0002 DC 5A  

Clearly, $v_1 = 4$ volts and $v_2 = 2$ volts, which agrees with the answer obtained in Problem 3.51.
The schematic is shown below. When the circuit is saved and simulated the node voltages are displaced on the pseudocomponents as shown. Thus,

\[ V_1 = -3\text{V}, \quad V_2 = 4.5\text{V}, V_3 = -15\text{V}, \]
Chapter 3, Solution 79

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

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

---

Chapter 3, 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, $v_1 = 84 \text{ volts}$, $v_2 = 4 \text{ volts}$, $v_3 = 20 \text{ volts}$, and $v_4 = -5.333 \text{ volts}$.

Chapter 3, Solution 81

Clearly, $v_1 = 26.67 \text{ volts}$, $v_2 = 6.667 \text{ volts}$, $v_3 = 173.33 \text{ volts}$, and $v_4 = -46.67 \text{ volts}$ 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, Solution 82

![Circuit Diagram]

This network corresponds to the Netlist.
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, Solution 84

From the output loop, \( v_0 = 500i_0 \times 20 \times 10^3 = 10^6i_0 \) \( \text{(1)} \)

From the input loop, \( 3 \times 10^{-3} + 4000i_0 - v_0/100 = 0 \) \( \text{(2)} \)

From (1) and (2) we get, \( i_0 = 0.5 \mu \text{A} \) and \( v_0 = 0.5 \text{ volt} \).

Chapter 3, Solution 85

The amplifier acts as a source.

For maximum power transfer,

\[ R_t = R_s = 9 \Omega \]
Chapter 3, Solution 86

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

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

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

Combining (1) and (2) yields,

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

$v_0 = -5000 \times 400 \times 37.4 \times 10^{-9} = \mathbf{-74.8 \text{ mvolts}}$

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

Chapter 3, Solution 88

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

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

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

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

Substituting (2) into (1) gives,

$$\left(v_s + 0.004v_1/2 = -0.004v_0 + (-0.004v_1 - 0.001v_0)/20 \right)$$

This leads to $0.125v_0 = 10v_s$ or $(v_0/v_s) = 10/0.125 = \mathbf{-80}$
Chapter 3, Solution 89

\[ v_i = V_{BE} + 40k \, I_B \]  
\[ 5 = V_{CE} + 2k \, I_C \]

If \( I_C = \beta I_B = 75I_B \) and \( V_{CE} = 2 \) volts, then (2) becomes \( 5 = 2 + 2k(75I_B) \) which leads to \( I_B = 20 \, \mu A \).

Substituting this into (1) produces, \( v_i = 0.7 + 0.8 = 1.5 \text{ volts} \).

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, \( v_0 = 500I_E = 500 \times 151I_B = 4 \) which leads to \( I_B = 5.298 \times 10^{-5} \)

Therefore, \( v_s = 0.7 + 85,500I_B = 5.23 \text{ volts} \)
Chapter 3, Solution 91

We first determine the Thevenin equivalent for the input circuit.

\[ R_{Th} = 6\|2 = 6 \times 2 / 8 = 1.5 \, \text{k}\Omega \] and 
\[ V_{Th} = 2(3)/(2+6) = 0.75 \, \text{volts} \]

\[ \begin{align*}
0.75 \, \text{V} & \quad 1.5 \, \text{k}\Omega \\
400 \, \Omega & \quad I_E \\
+ & \quad - \\
& \quad V_{BE} \\
& \quad + \\
& \quad V_{CE} \\
& \quad - \\
& \quad 9 \, \text{V} \\
& \quad + \\
& \quad - \\
& \quad 400 \, \Omega \\
& \quad + \\
& \quad I_C \\
& \quad 5 \, \text{k}\Omega \\
& \quad + \\
& \quad - \\
& \quad 12 \, \text{V} \\
& \quad + \\
& \quad - \\
& \quad 5 \, \text{k}\Omega \\
& \quad + \\
& \quad - \\
& \quad 4 \, \text{k}\Omega \\
& \quad + \\
& \quad - \\
& \quad 10 \, \text{k}\Omega \\
& \quad + \\
& \quad - \\
& \quad I_B \\
& \quad + \\
& \quad - \\
& \quad V_{BE} \\
& \quad + \\
& \quad - \\
& \quad V_{CE} \\
& \quad + \\
& \quad - \\
& \quad V_0 \\
& \quad + \\
& \quad - \\
& \quad V_C \\
& \quad + \\
& \quad - \\
& \quad I_I \\
\end{align*} \]

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

\[ I_B = 0.05/81,900 = \frac{0.61}{\mu\text{A}} \]

\[ V_0 = 400I_E = 400(1 + \beta)I_B = 49 \, \text{mV} \]

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

\[ V_{CE} = 9 - 5k\beta I_B - 400(1 + \beta)I_B = 9 - 0.659 = 8.641 \, \text{volts} \]

Chapter 3, Solution 92
\[ I_1 = I_B + I_C = (1 + \beta)I_B \quad \text{and} \quad I_E = I_B + I_C = I_1 \]

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 \[ V_C = 12 - 5k(101)I_B = 5.791 \text{ volts} \]

Chapter 3, Solution 93

From (b), \[-v_1 + 2i - 3v_0 + v_2 = 0 \quad \text{which leads to} \quad i = (v_1 + 3v_0 - v_2)/2 \]

At node 1 in (a), \[((24 - v_1)/4) = (v_1/2) + ((v_1 +3v_0 - v_2)/2) + ((v_1 - v_2)/1), \text{ where } v_0 = v_2\]

or \[ 24 = 9v_1 \] which leads to \[ v_1 = 2.667 \text{ volts} \]

At node 2, \[((v_1 - v_2)/1) + ((v_1 + 3v_0 - v_2)/2) = (v_2/8) + v_2/4, \text{ where } v_0 = v_2\]

\[ v_2 = 4v_1 = 10.66 \text{ volts} \]

Now we can solve for the currents, \( i_1 = v_1/2 = 1.333 \text{ A} \), \( i_2 = 1.333 \text{ A} \), and \( i_3 = 2.667 \text{ A} \).