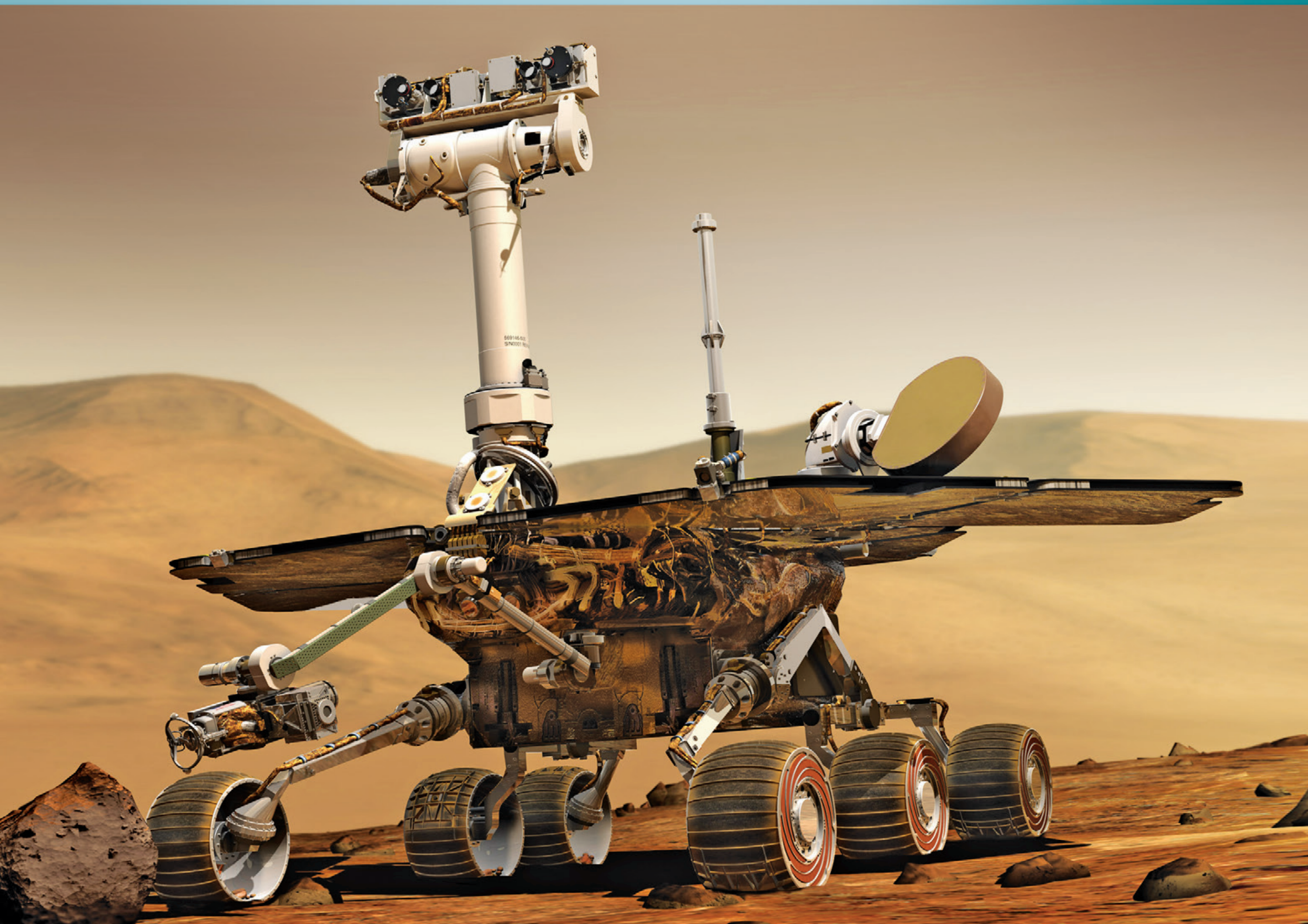
FIFTH EDITION

Fundamentals of Electric Circuits



Charles K. Alexander | Matthew N. O. Sadiku

3.7 In the circuit of Fig. 3.49, current i_1 is:

(a) 4 A (b) 3 A (c) 2 A (d) 1 A

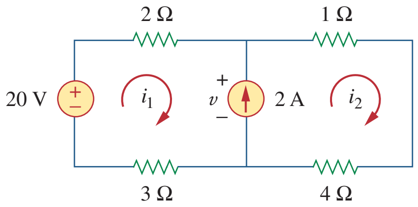


Figure 3.49
For Review Questions 3.7 and 3.8.

3.8 The voltage v across the current source in the circuit of Fig. 3.49 is:

(a) 20 V (b) 15 V (c) 10 V (d) 5 V

3.9 The *PSpice* part name for a current-controlled voltage source is:

(a) EX (b) FX (c) HX (d) GX

3.10 Which of the following statements are not true of the pseudocomponent IPROBE:

(a) It must be connected in series.
(b) It plots the branch current.
(c) It displays the current through the branch in which it is connected.
(d) It can be used to display voltage by connecting it in parallel.
(e) It is used only for dc analysis.
(f) It does not correspond to a particular circuit element.

Answers: 3.1a, 3.2c, 3.3a, 3.4c, 3.5c, 3.6a, 3.7d, 3.8b, 3.9c, 3.10b,d.

Problems

Sections 3.2 and 3.3 Nodal Analysis

3.1 Using Fig. 3.50, design a problem to help other students better understand nodal analysis.

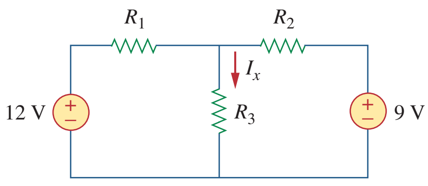


Figure 3.50
For Prob. 3.1 and Prob. 3.39.

3.2 For the circuit in Fig. 3.51, obtain v_1 and v_2.

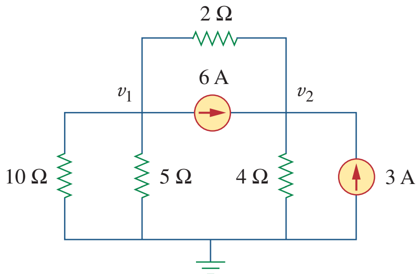


Figure 3.51
For Prob. 3.2.

3.3 Find the currents I_1 through I_4 and the voltage v_o in the circuit of Fig. 3.52.

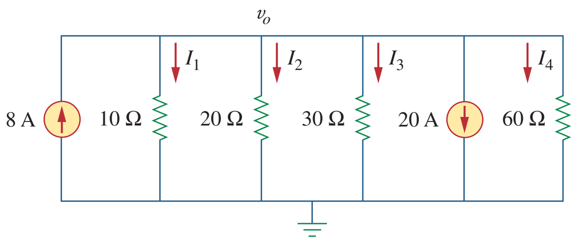


Figure 3.52
For Prob. 3.3.

3.4 Given the circuit in Fig. 3.53, calculate the currents i_1 through i_4.

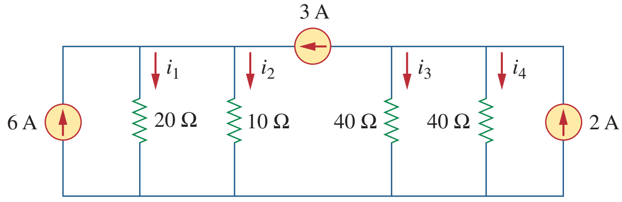


Figure 3.53
For Prob. 3.4.

3.5 Obtain v_o in the circuit of Fig. 3.54.

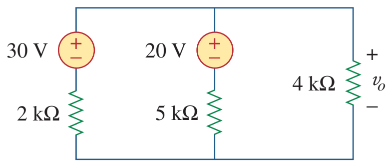


Figure 3.54
For Prob. 3.5.

3.6 Solve for V_1 in the circuit of Fig. 3.55 using nodal analysis.

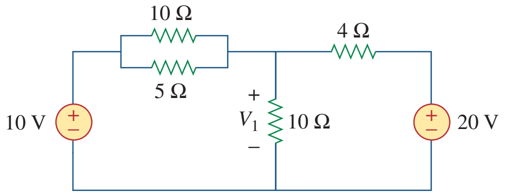


Figure 3.55
For Prob. 3.6.

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

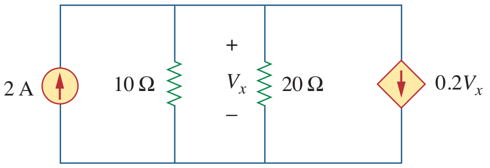


Figure 3.56
For Prob. 3.7.

3.8 Using nodal analysis, find v_o in the circuit of Fig. 3.57.

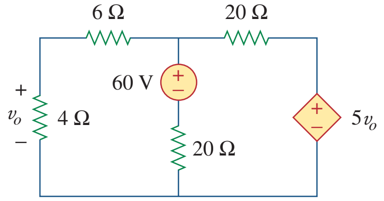


Figure 3.57
For Prob. 3.8 and Prob. 3.37.

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

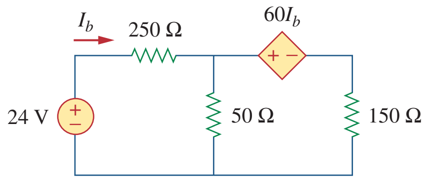


Figure 3.58
For Prob. 3.9.

3.10 Find I_o in the circuit of Fig. 3.59.

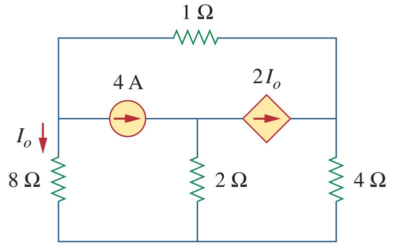


Figure 3.59
For Prob. 3.10.

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

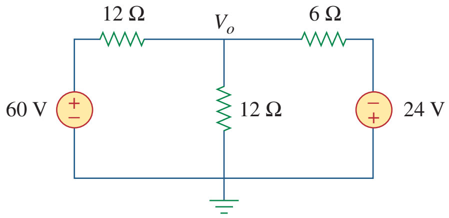


Figure 3.60
For Prob. 3.11.

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

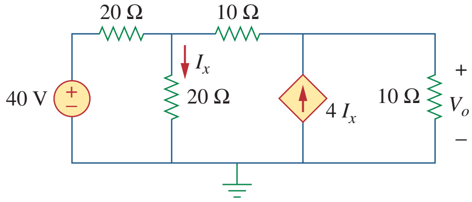


Figure 3.61
For Prob. 3.12.

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

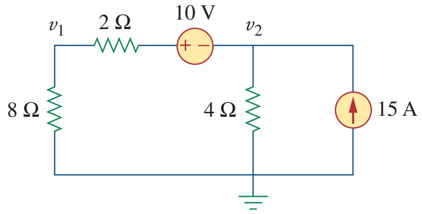


Figure 3.62
For Prob. 3.13.

3.14 Using nodal analysis, find v_o in the circuit of Fig. 3.63.

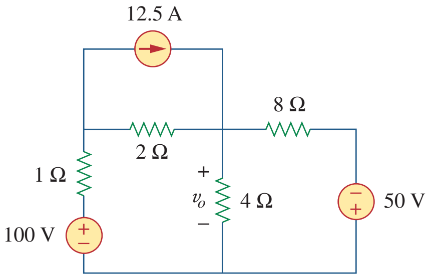


Figure 3.63
For Prob. 3.14.

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

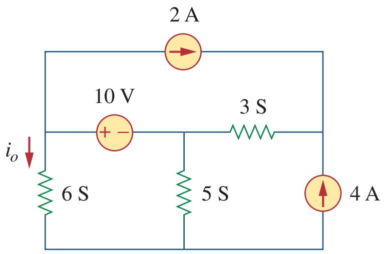


Figure 3.64
For Prob. 3.15.

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

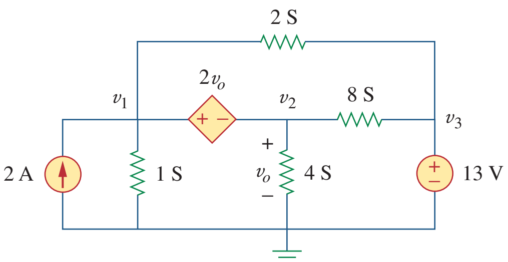


Figure 3.65
For Prob. 3.16.

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

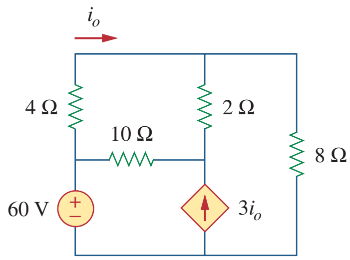


Figure 3.66
For Prob. 3.17.

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

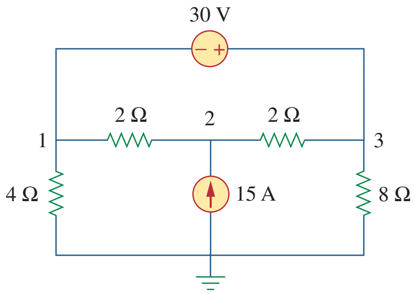


Figure 3.67
For Prob. 3.18.

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

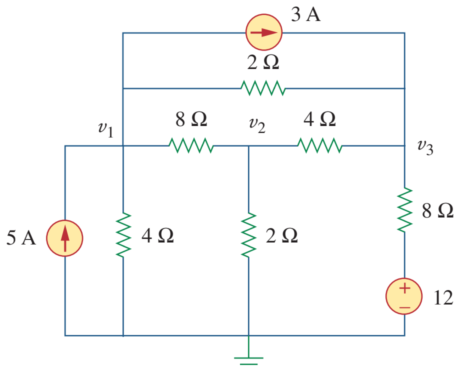


Figure 3.68
For Prob. 3.19.

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

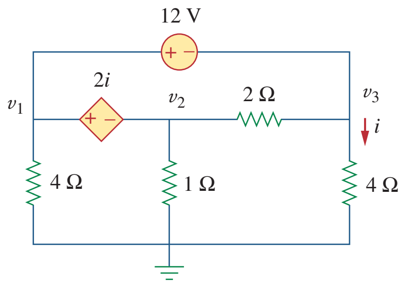


Figure 3.69
For Prob. 3.20.

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

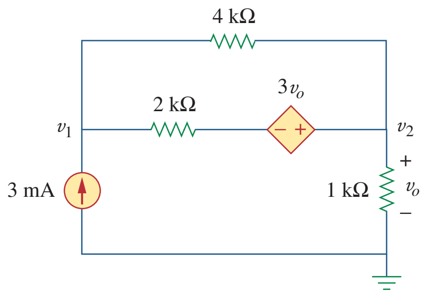


Figure 3.70
For Prob. 3.21.

3.22 Determine v_1 and v_2 in the circuit of Fig. 3.71.

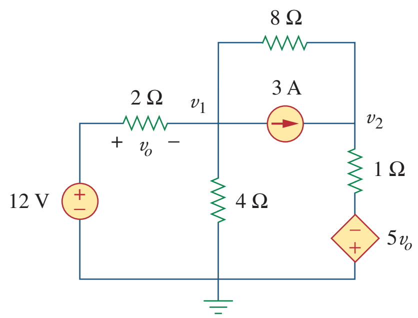


Figure 3.71
For Prob. 3.22.

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

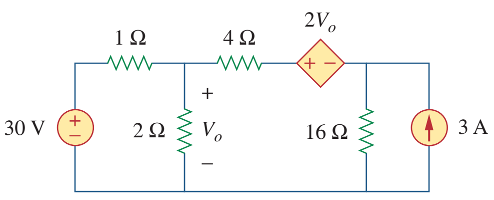


Figure 3.72
For Prob. 3.23.

3.24 Use nodal analysis and *MATLAB* to find V_o in the circuit of Fig. 3.73.

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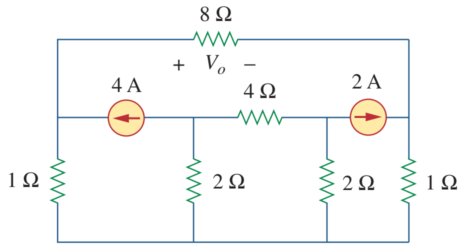

Figure 3.73
For Prob. 3.24.

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

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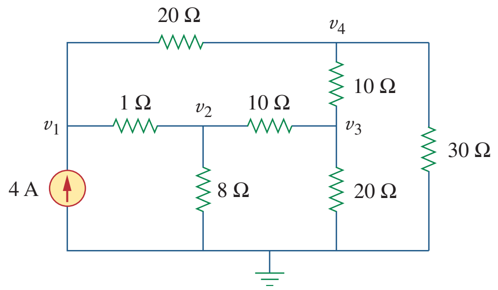

Figure 3.74
For Prob. 3.25.

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

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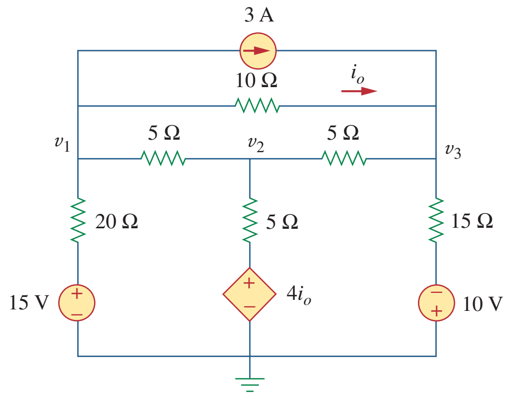


Figure 3.75
For Prob. 3.26.

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

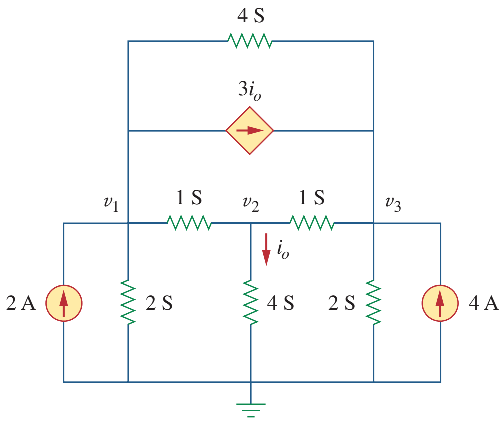


Figure 3.76
For Prob. 3.27.

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

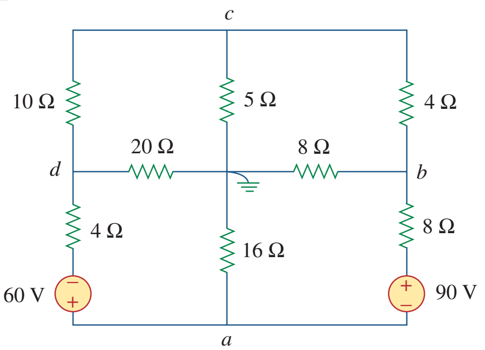


Figure 3.77
For Prob. 3.28.

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

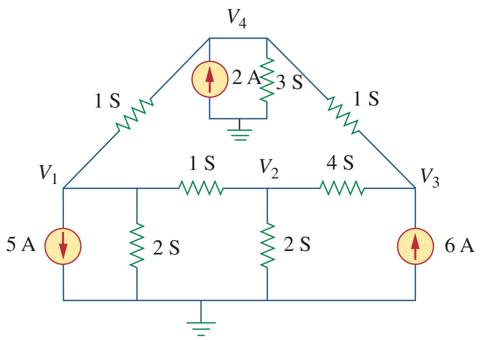


Figure 3.78
For Prob. 3.29.

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

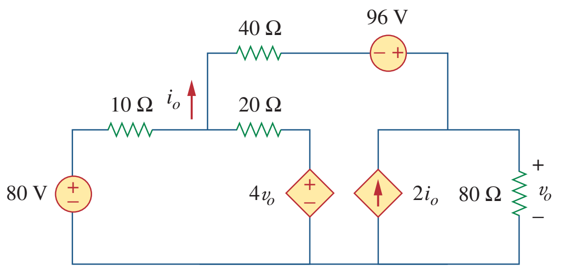


Figure 3.79
For Prob. 3.30.

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

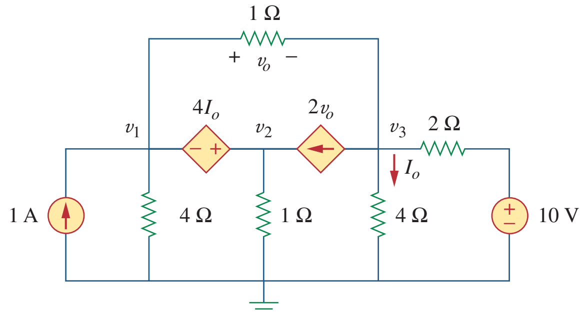


Figure 3.80
For Prob. 3.31.

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

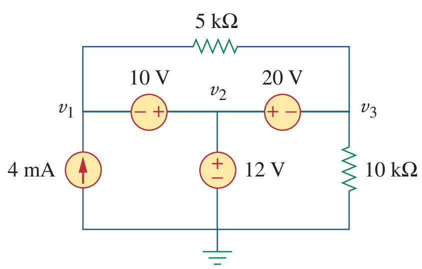
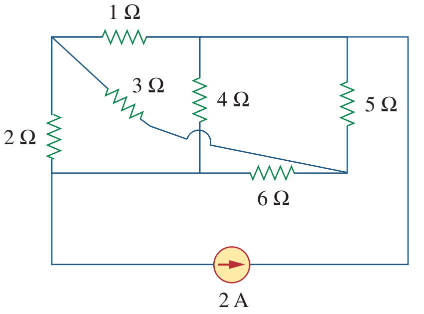


Figure 3.81
For Prob. 3.32.

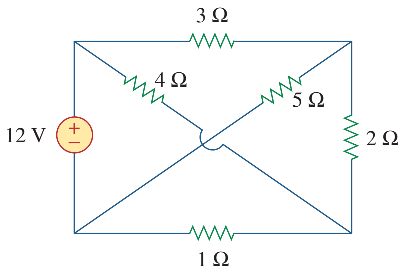
* An asterisk indicates a challenging problem.

Sections 3.4 and 3.5 Mesh Analysis

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



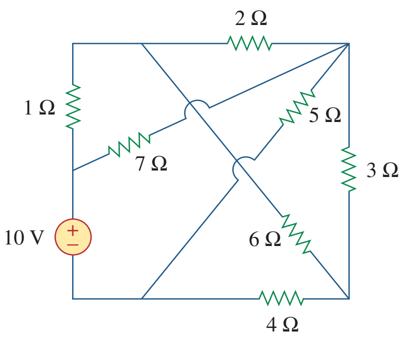
(a)



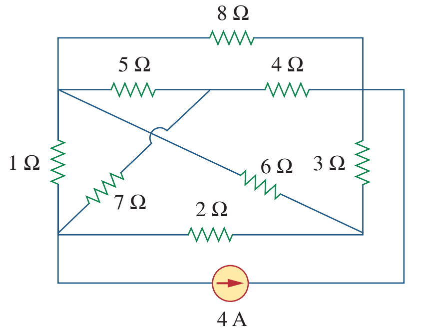
(b)

Figure 3.82
For Prob. 3.33.

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



(a)



(b)

Figure 3.83
For Prob. 3.34.

3.35 Rework Prob. 3.5 using mesh analysis.

3.36 Use mesh analysis to obtain i_1, i_2, and i_3 in the circuit in Fig. 3.84.

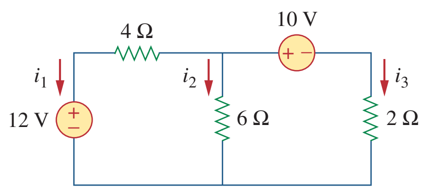


Figure 3.84
For Prob. 3.36.

3.37 Solve Prob. 3.8 using mesh analysis.

3.38 Apply mesh analysis to the circuit in Fig. 3.85 and obtain I_o.

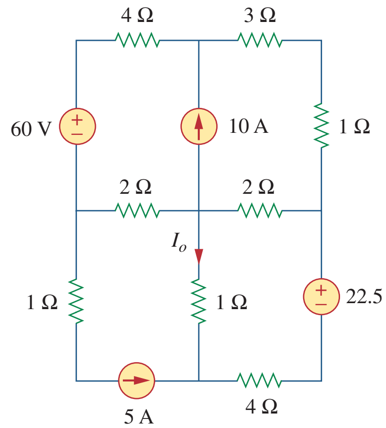


Figure 3.85
For Prob. 3.38.

3.39 Using Fig. 3.50 from Prob. 3.1, design a problem to help other students better understand mesh analysis.

3.40 For the bridge network in Fig. 3.86, find i_o using mesh analysis.

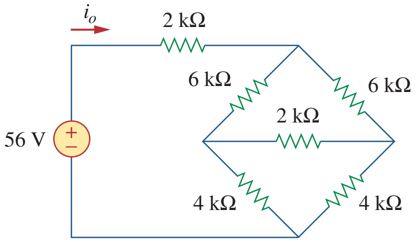


Figure 3.86
For Prob. 3.40.

3.41 Apply mesh analysis to find i in Fig. 3.87.

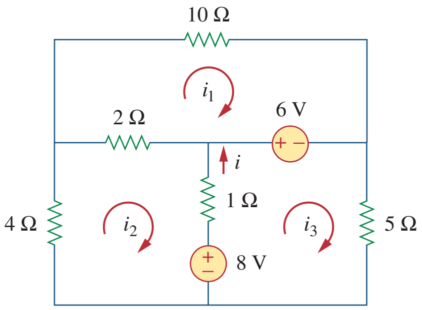


Figure 3.87
For Prob. 3.41.

3.42 Using Fig. 3.88, design a problem to help students better understand mesh analysis using matrices.

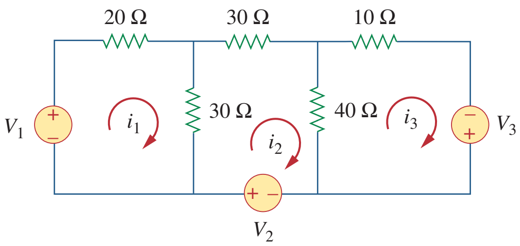


Figure 3.88
For Prob. 3.42.

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

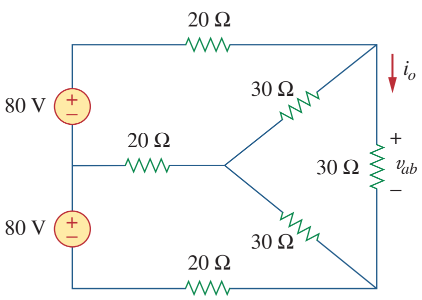


Figure 3.89
For Prob. 3.43.

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

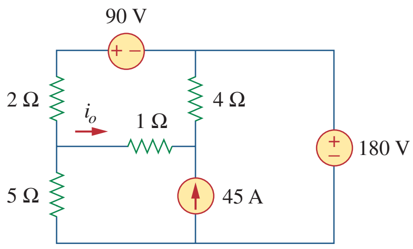


Figure 3.90
For Prob. 3.44.

3.45 Find current i in the circuit of Fig. 3.91.

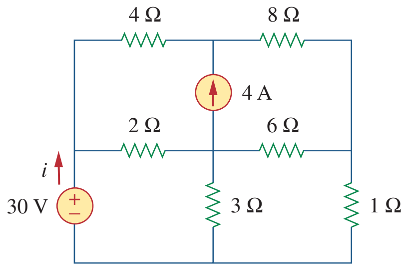


Figure 3.91
For Prob. 3.45.

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

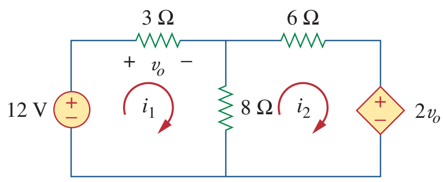


Figure 3.92
For Prob. 3.46.

3.47 Rework Prob. 3.19 using mesh analysis.

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

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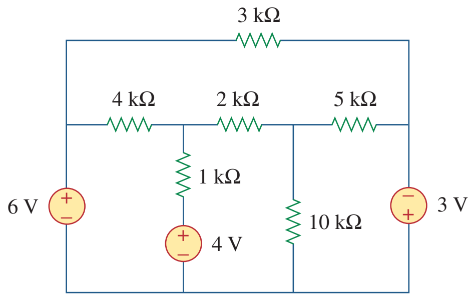

Figure 3.93
For Prob. 3.48.

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

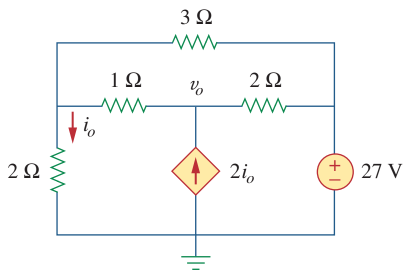

Figure 3.94
For Prob. 3.49.

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

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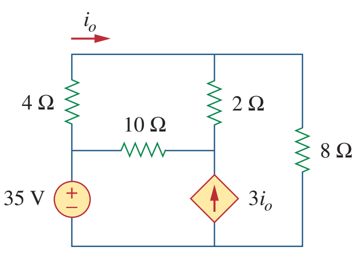

Figure 3.95
For Prob. 3.50.

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

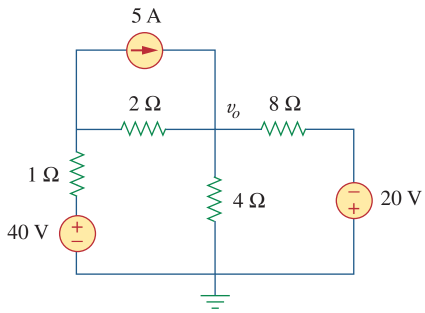

Figure 3.96
For Prob. 3.51.

3.52 Use mesh analysis to find i_1, i_2, and i_3 in the circuit of Fig. 3.97.

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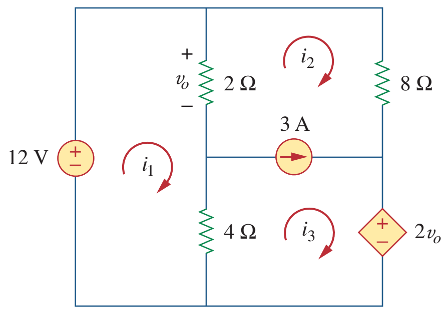

Figure 3.97
For Prob. 3.52.

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

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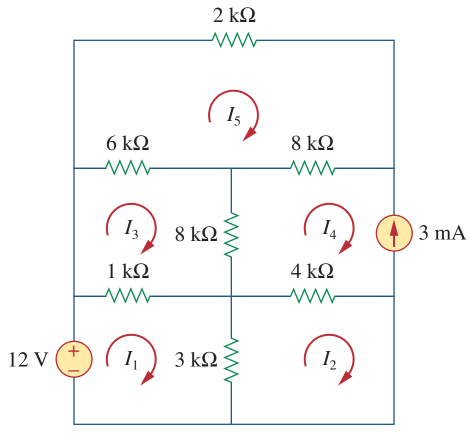

Figure 3.98
For Prob. 3.53.

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

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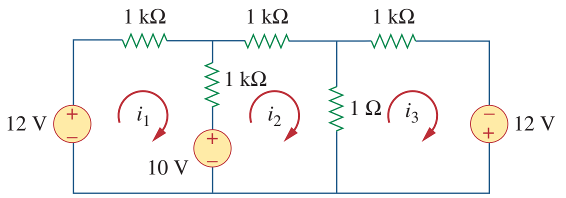


Figure 3.99
For Prob. 3.54.

***3.55** In the circuit of Fig. 3.100, solve for I_1, I_2, and I_3.

ML

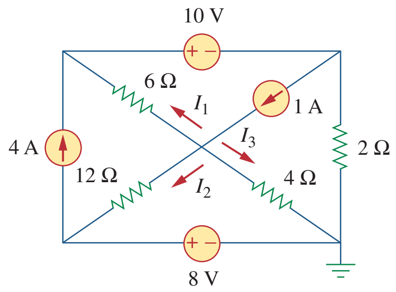


Figure 3.100
For Prob. 3.55.

3.56 Determine v_1 and v_2 in the circuit of Fig. 3.101.

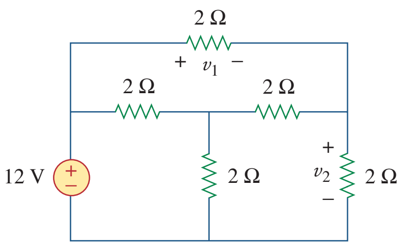


Figure 3.101
For Prob. 3.56.

3.57 In the circuit of Fig. 3.102, find the values of R, V_1, and V_2 given that $i_o = 15$ mA.

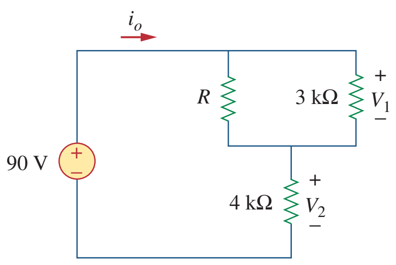


Figure 3.102
For Prob. 3.57.

3.58 Find i_1, i_2, and i_3 in the circuit of Fig. 3.103.

ML

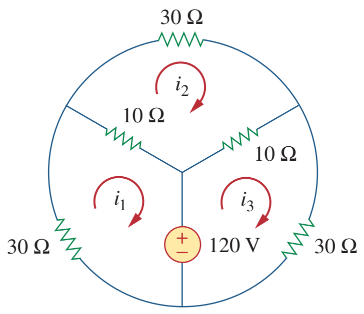


Figure 3.103
For Prob. 3.58.

3.59 Rework Prob. 3.30 using mesh analysis.

ML

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

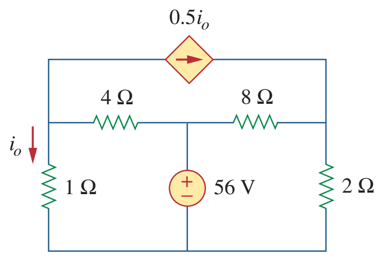


Figure 3.104
For Prob. 3.60.

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

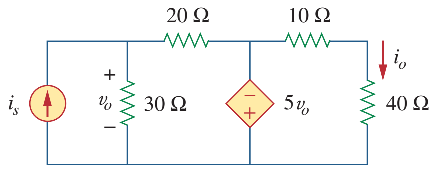


Figure 3.105
For Prob. 3.61.

3.62 Find the mesh currents i_1, i_2, and i_3 in the network of Fig. 3.106.

ML

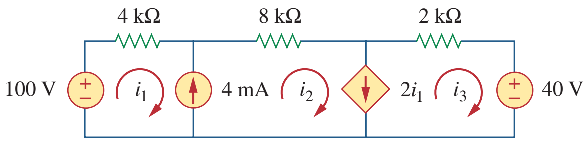


Figure 3.106
For Prob. 3.62.

Chapter 3, Problem 1.

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

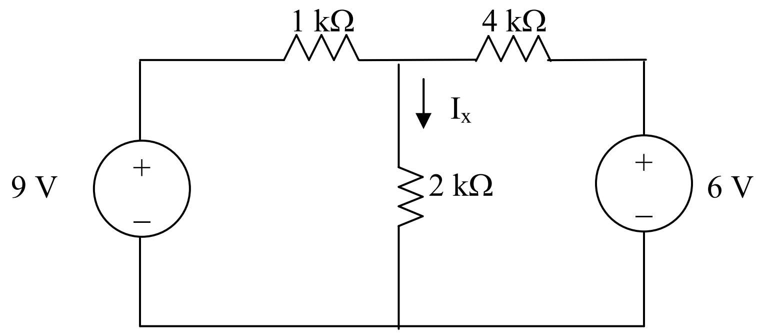


Figure 3.50 For Prob. 3.1.

Chapter 3, Solution 1

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

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

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

Chapter 3, Problem 2.

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

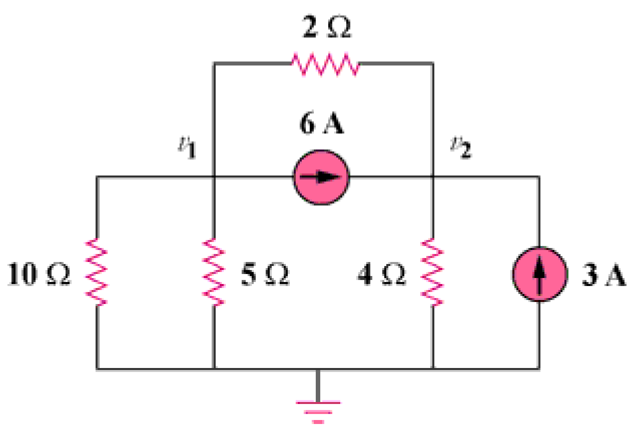


Figure 3.51

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 = **0 V**, v_2 = **12 V**

Chapter 3, Problem 3.

Find the currents i_1 through i_4 and the voltage v_o in the circuit in Fig. 3.52.

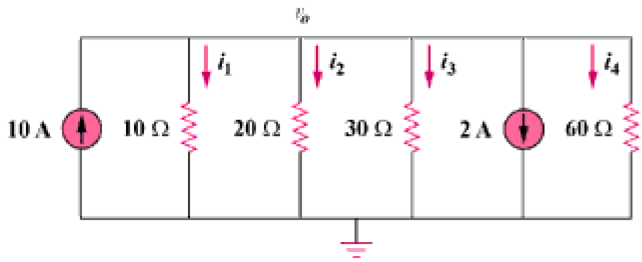


Figure 3.52

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 $\boldsymbol{i_4}$.

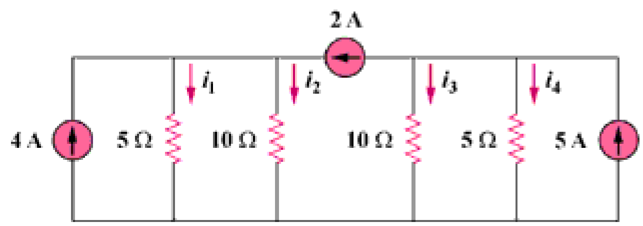
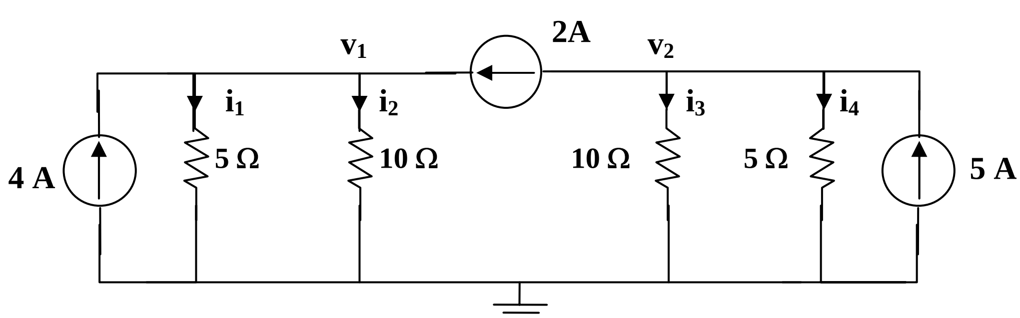


Figure 3.53

Chapter 3, Solution 4



At node 1,

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

At node 2,

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

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

Chapter 3, Problem 5.

Obtain v_0 in the circuit of Fig. 3.54.

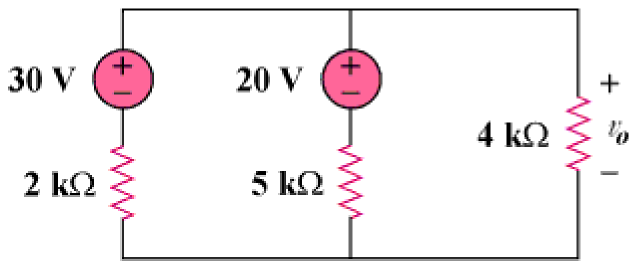


Figure 3.54

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.

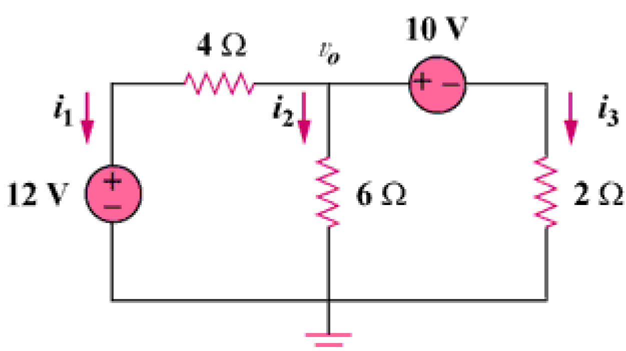


Figure 3.55

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.

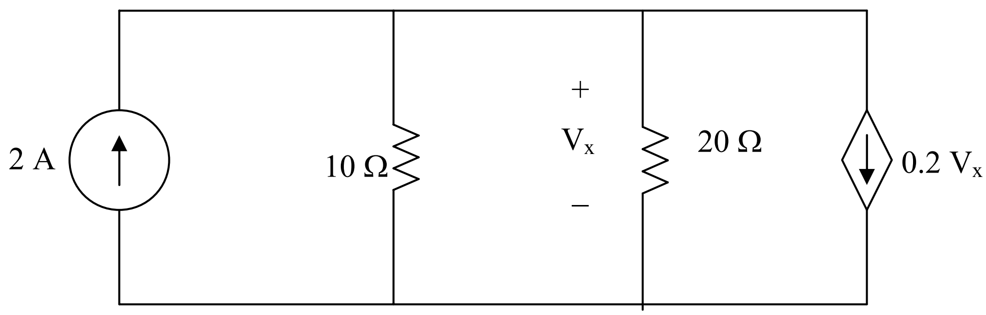


Figure 3.56 For Prob. 3.7.

Chapter 3, Solution 7

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

$0.35V_x = 2$ or $V_x =$ **<u>5.714 V</u>**.

Substituting into the original equation for a check we get,

0.5714 + 0.2857 + 1.1428 = 1.9999 checks!

Chapter 3, Problem 8.

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

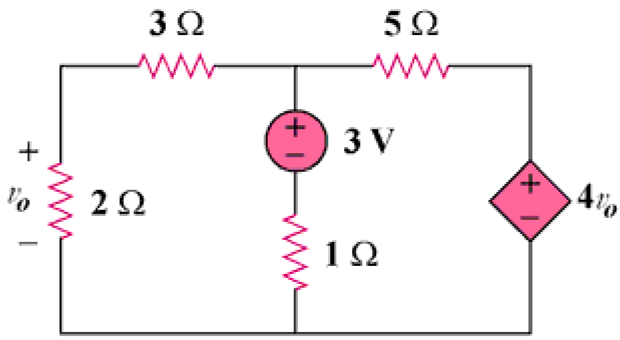
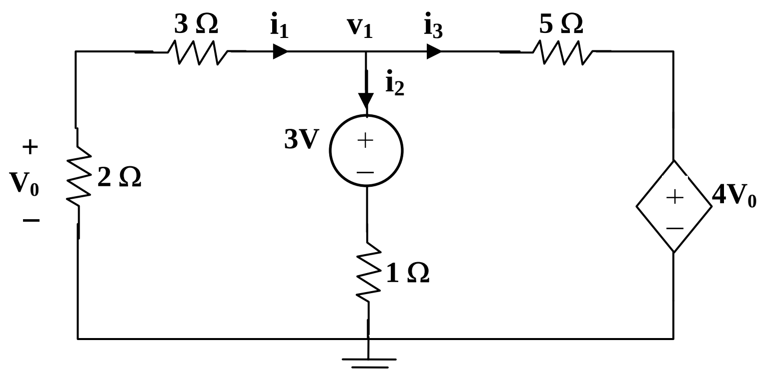


Figure 3.57

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

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

Chapter 3, Problem 9.

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

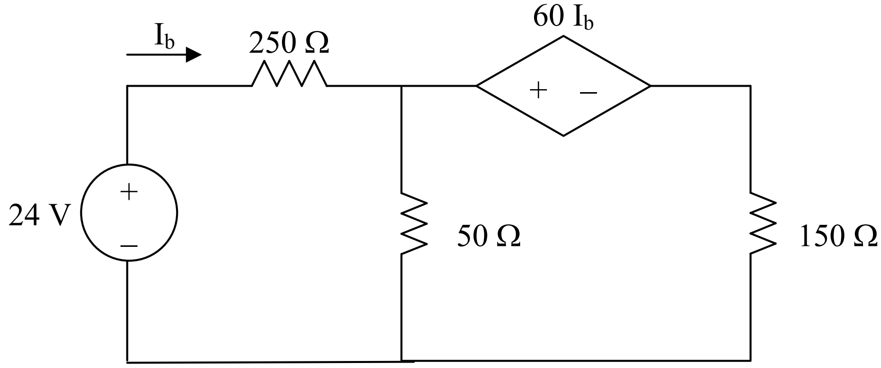


Figure 3.58 For Prob. 3.9.

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.

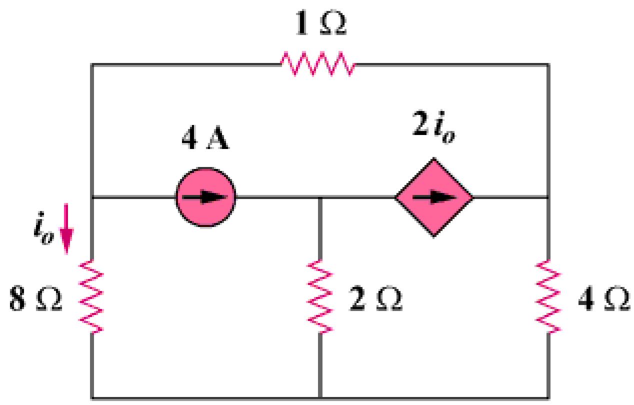
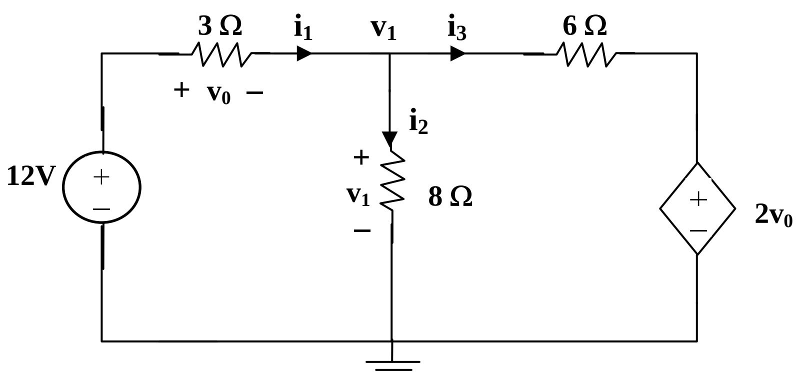


Figure 3.59

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.

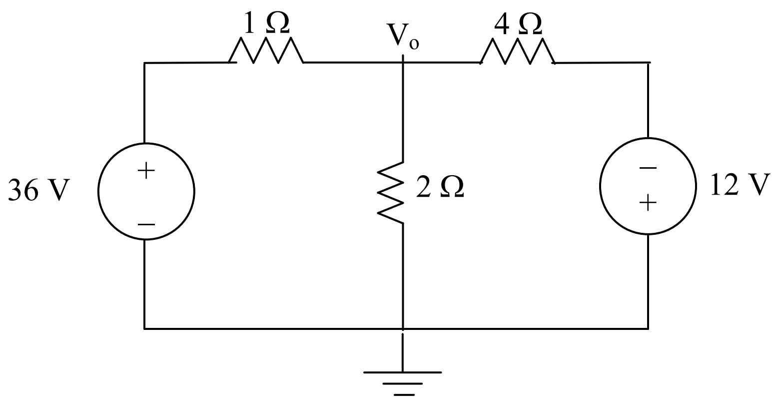


Figure 3.60 For Prob. 3.11.

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 $V_o = 18.857V$

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

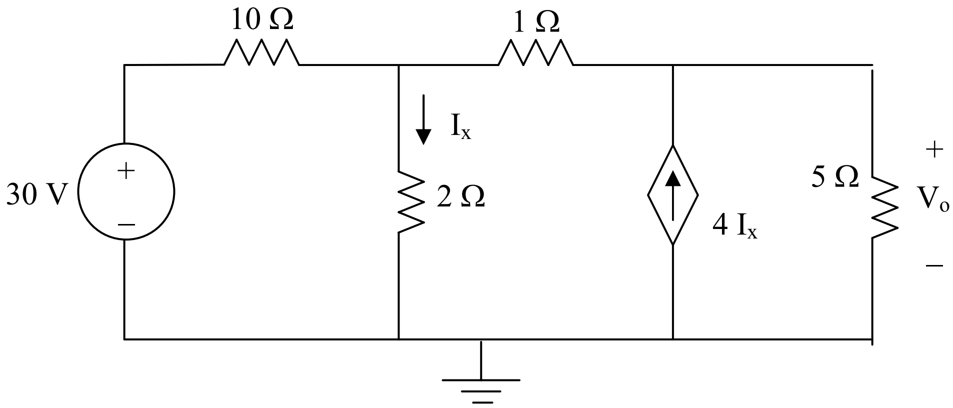
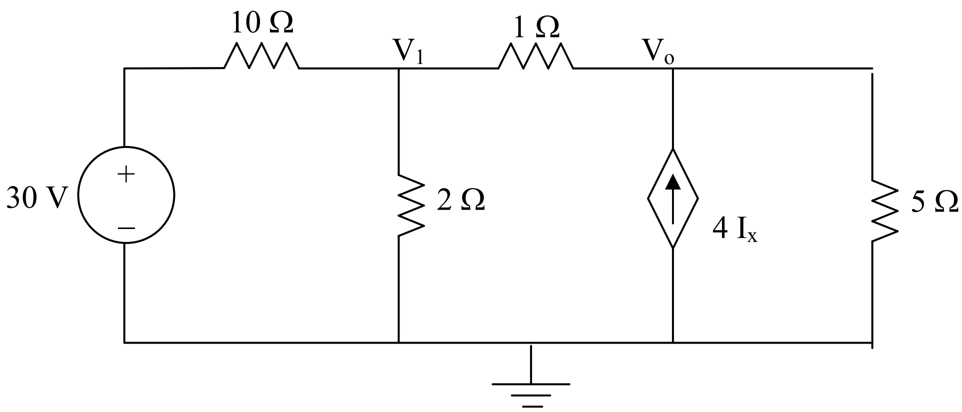


Figure 3.61 For Prob. 3.12.

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

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

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.

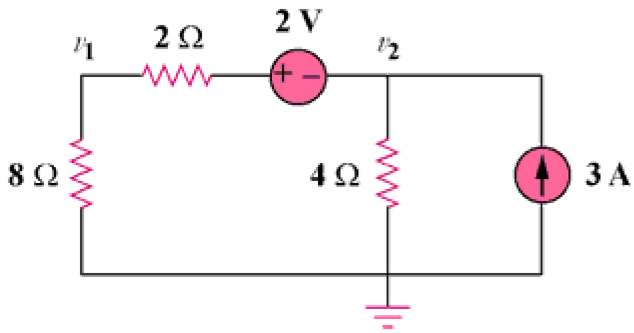


Figure 3.62

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, Problem 14.

Using nodal analysis, find v_o in the circuit of Fig. 3.63.

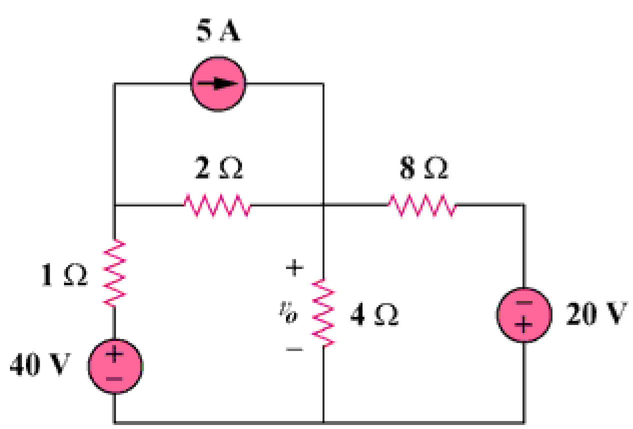
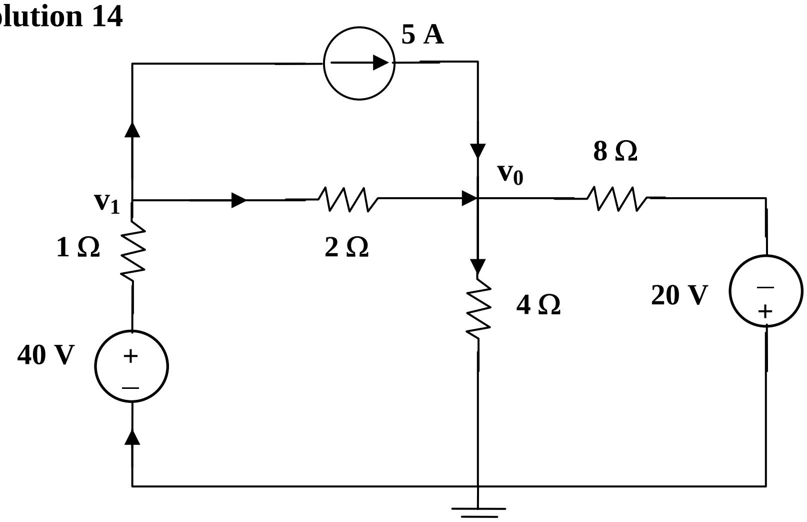


Figure 3.63

Chapter 3, Solution 14



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

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

Solving (1) and (2), $v_0 =$ **27.27 V**

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.

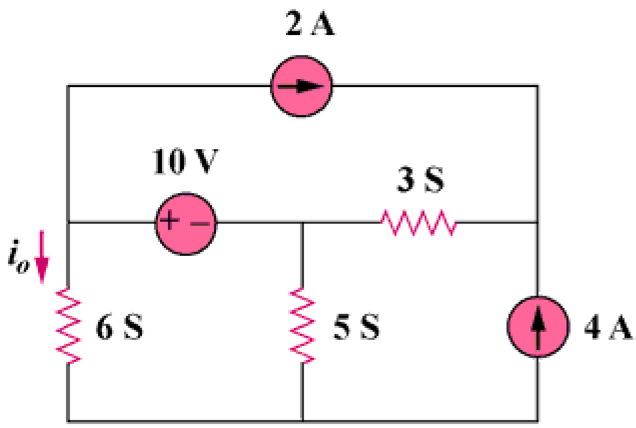
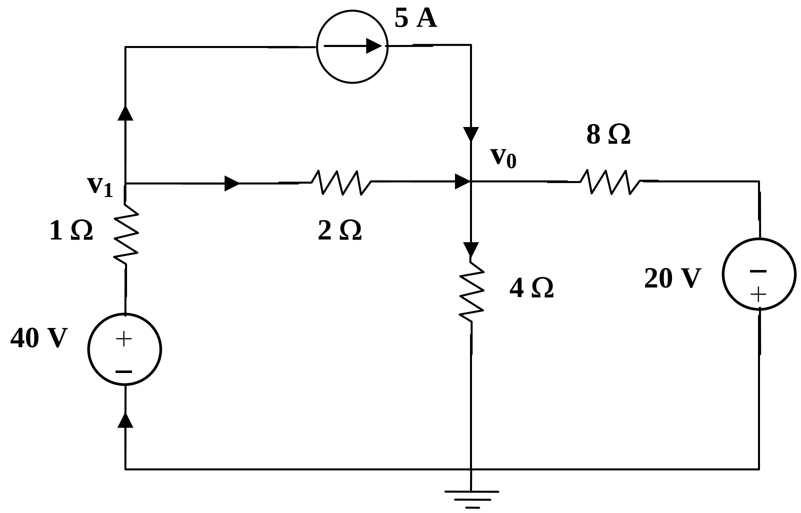


Figure 3.64

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.

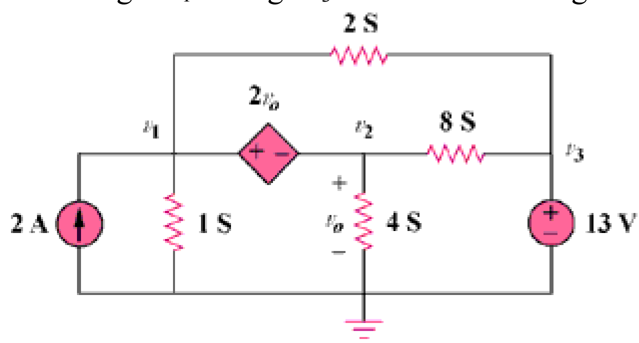
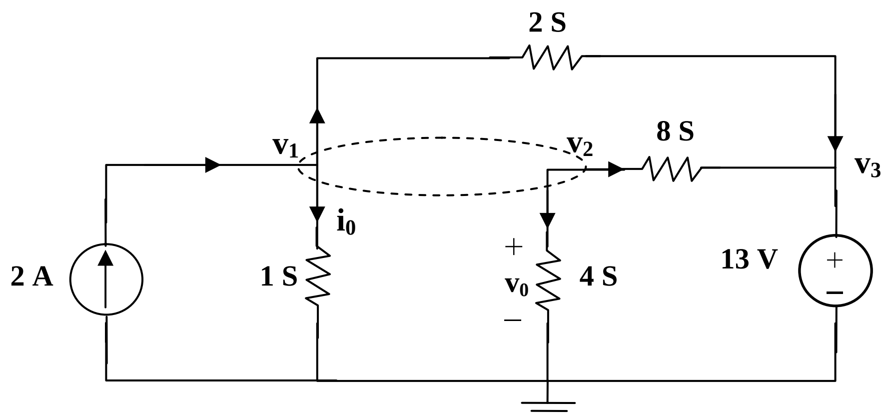


Figure 3.65

Chapter 3, Solution 16



At the supernode,

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

But

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

Hence

$v_1 = 3v_2$ (2)

$v_3 = 13V$ (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.

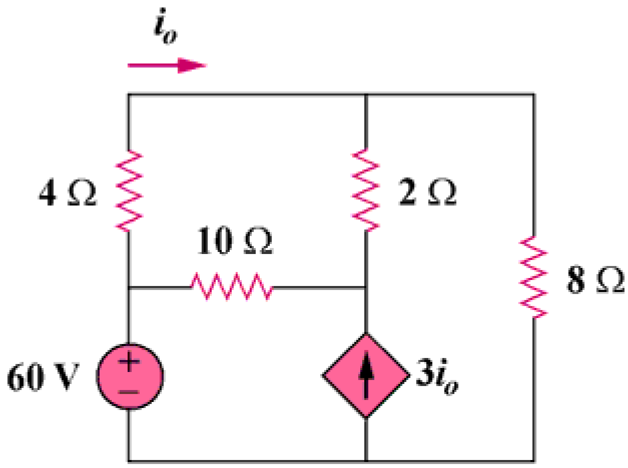
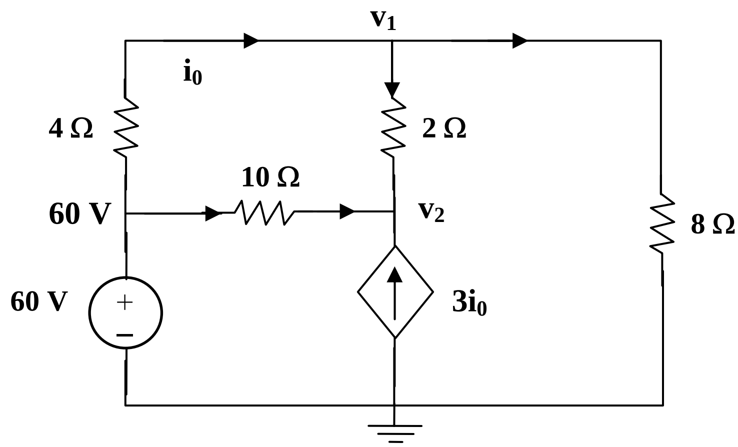


Figure 3.66

Chapter 3, Solution 17



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

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>**

Chapter 3, Problem 18.

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

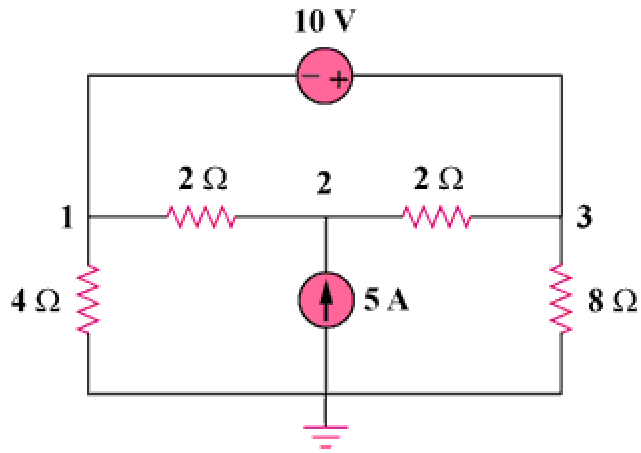
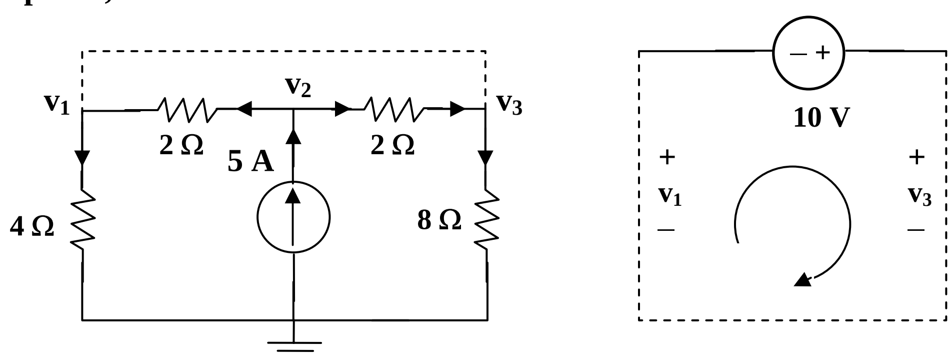


Figure 3.67

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.

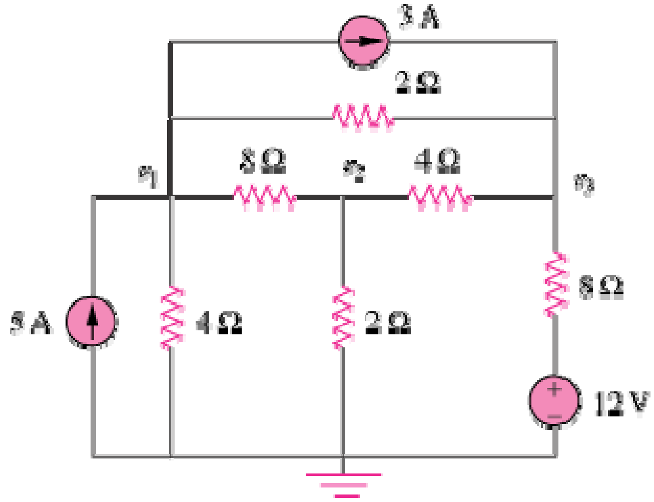


Figure 3.68

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.

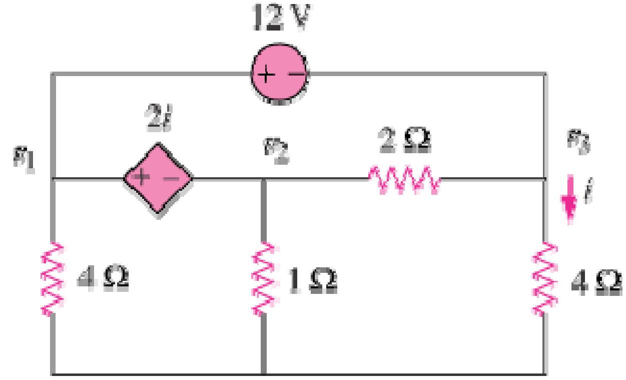
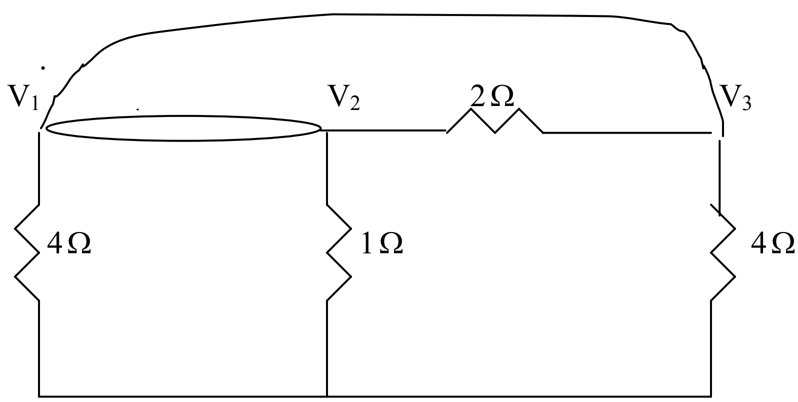


Figure 3.69

Chapter 3, Solution 20

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

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



Between nodes 1 and 3,

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

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.

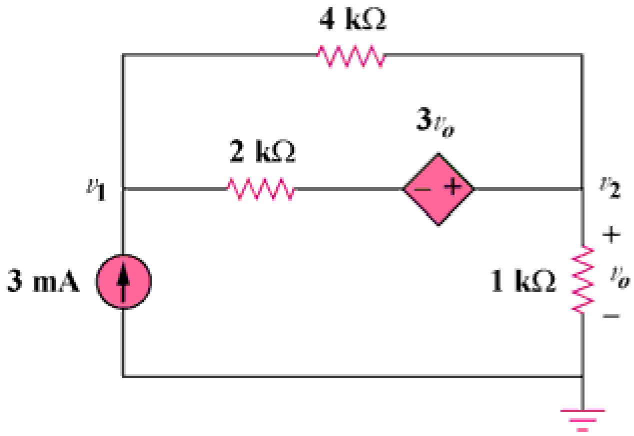
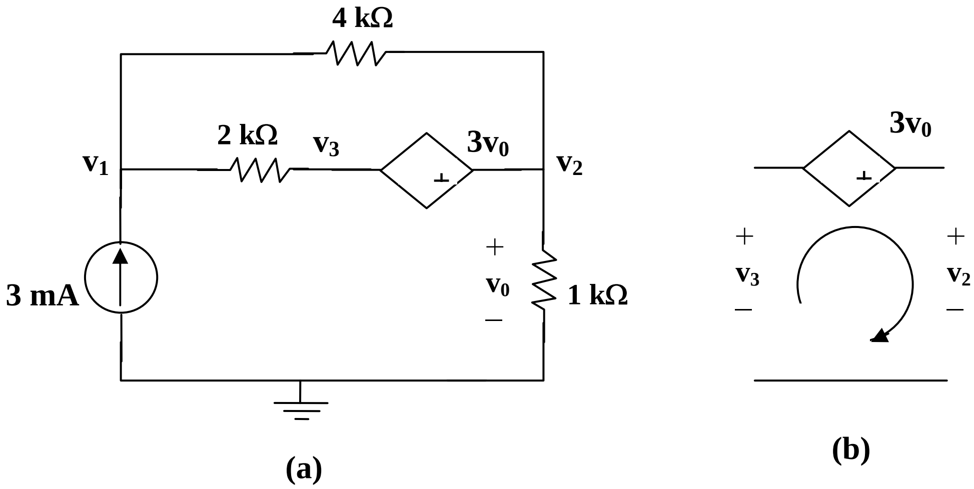


Figure 3.70

Chapter 3, Solution 21



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

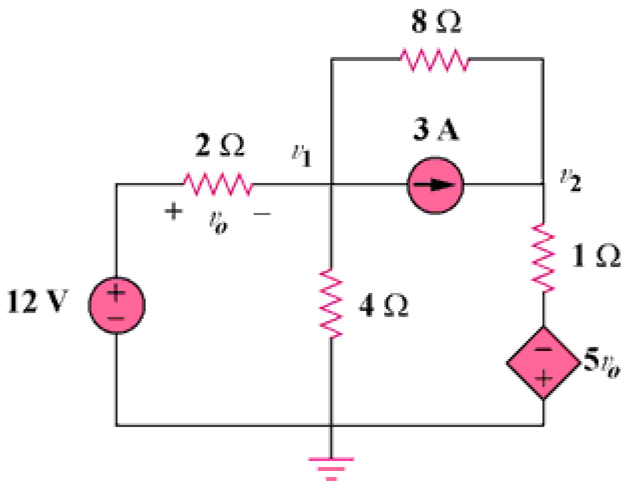


Figure 3.71

Chapter 3, Solution 22

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

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

But, $v_1 = 12 - v_1$

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

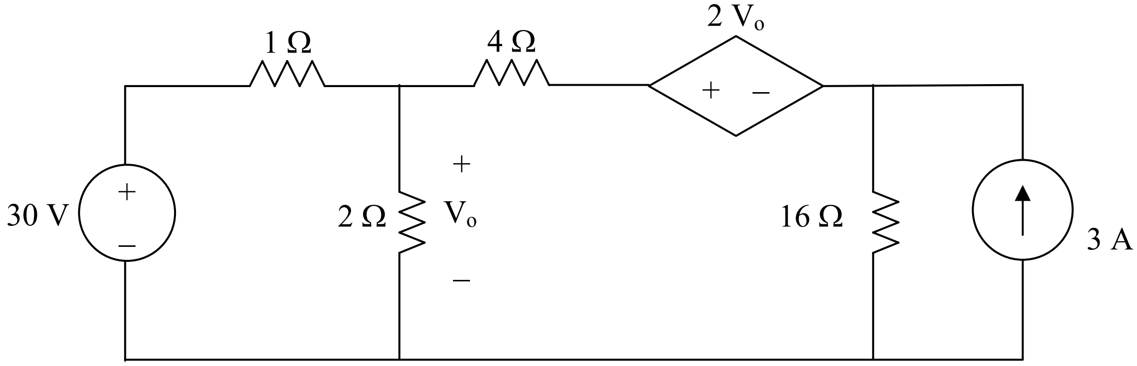
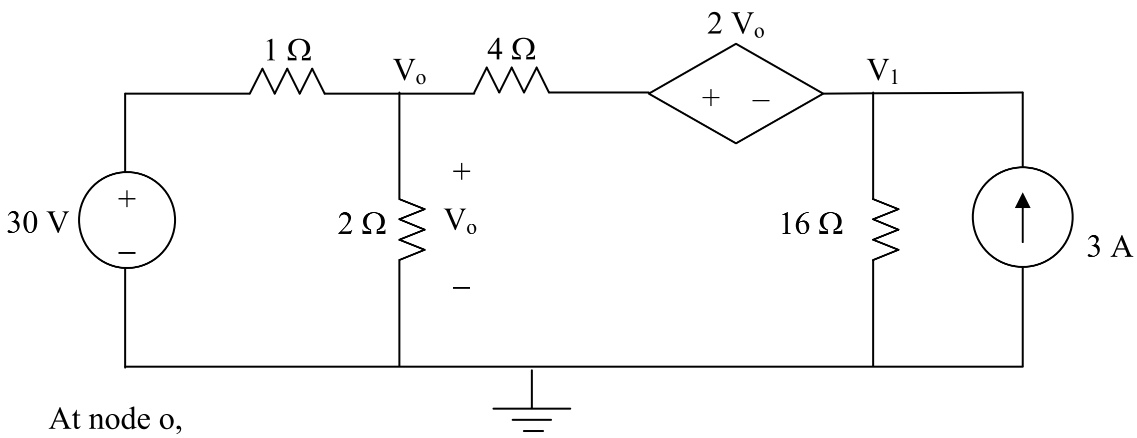


Figure 3.72 For Prob. 3.23.

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.

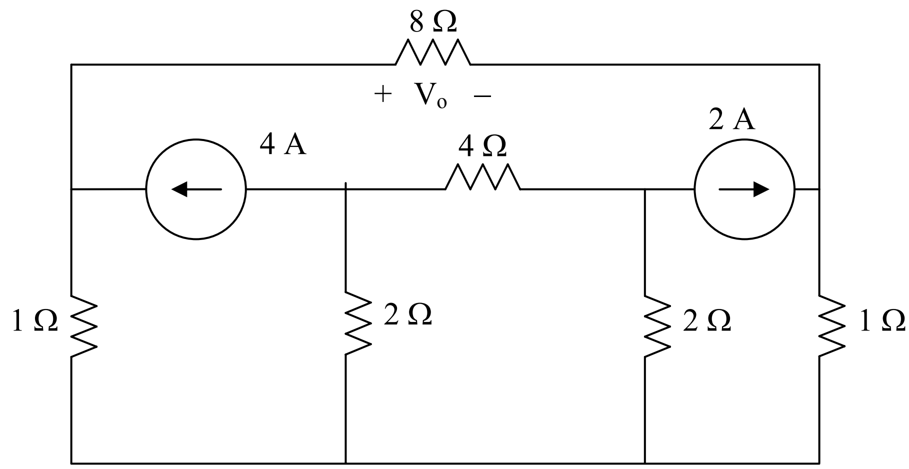
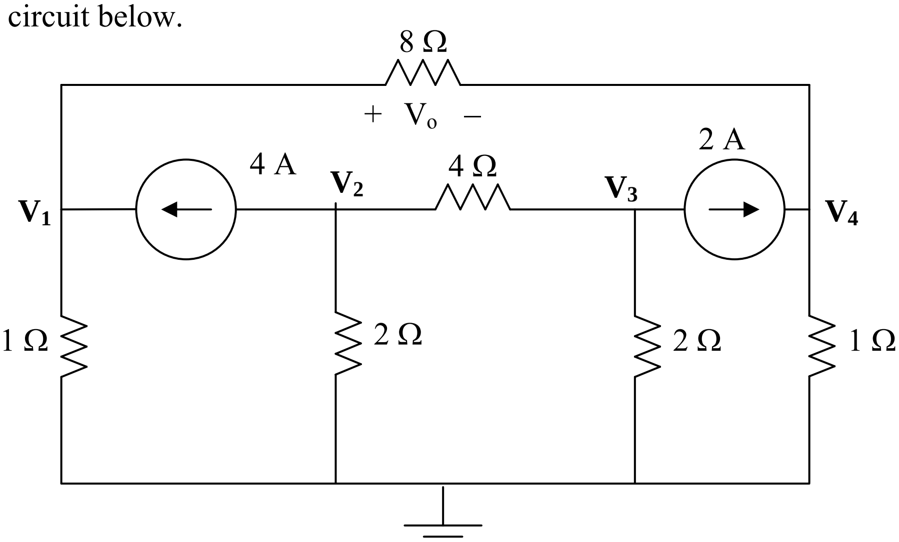


Figure 3.73 For Prob. 3.24.

Chapter 3, Solution 24

Consider the circuit below.



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

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

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

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

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

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
```

$V_o = V_1 - V_4 = 3.8 - 2.2 =$ **1.6 V**.

Chapter 3, Problem 25.

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

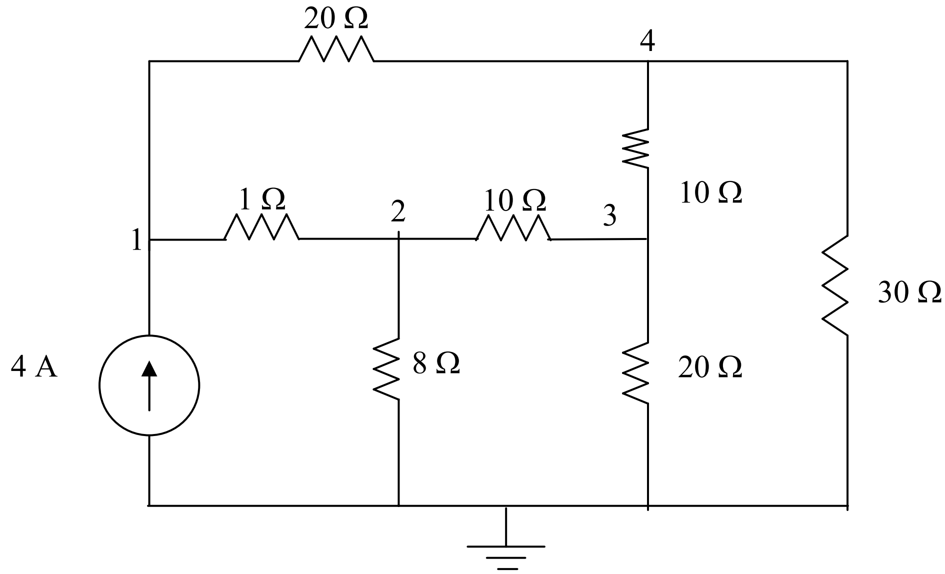
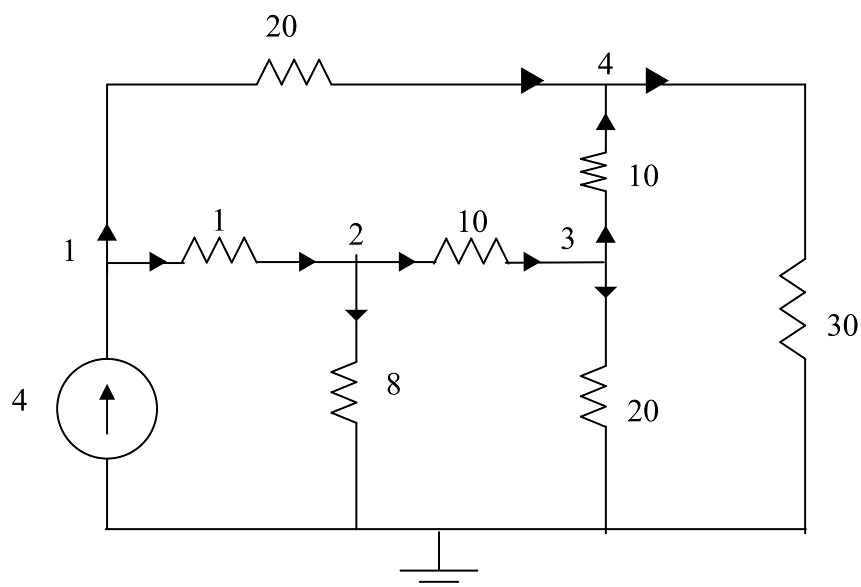


Figure 3.74 For Prob. 3.25.

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.

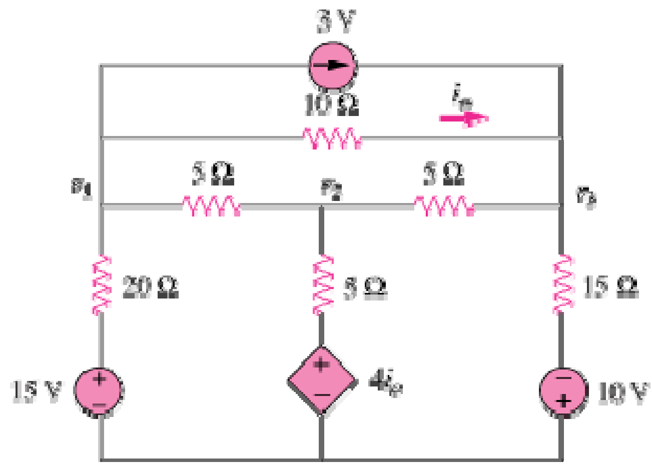


Figure 3.75

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 = **–7.19V**; V_2 = **–2.78V**; V_3 = **2.89V**.

Chapter 3, Problem 27.

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

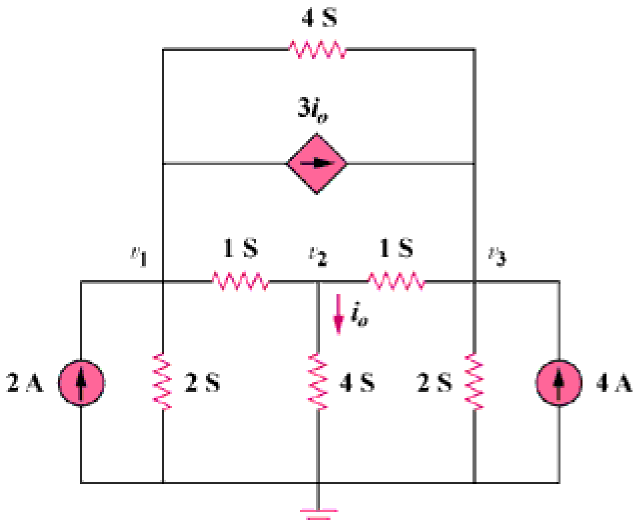


Figure 3.76

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.

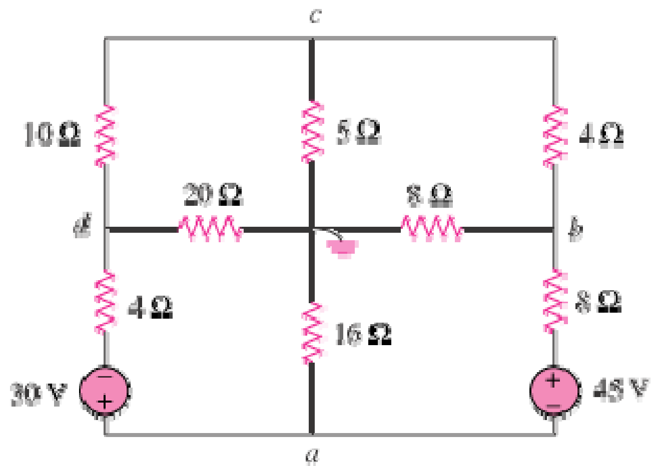


Figure 3.77

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.

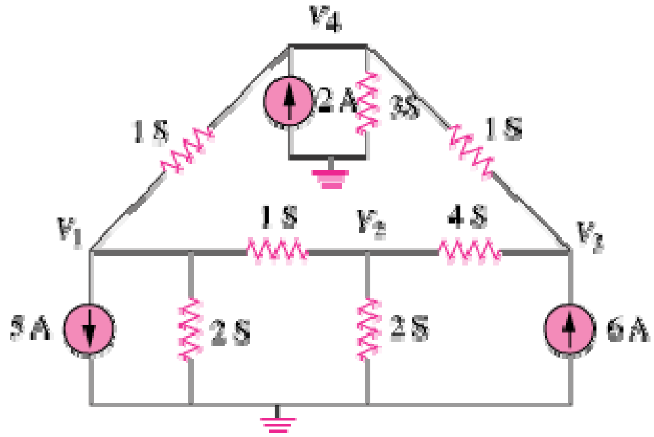


Figure 3.78

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 $\boldsymbol{v_o}$ and $\boldsymbol{i_o}$ in the circuit of Fig. 3.79.

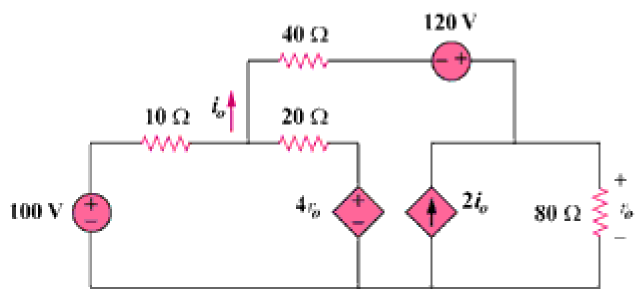
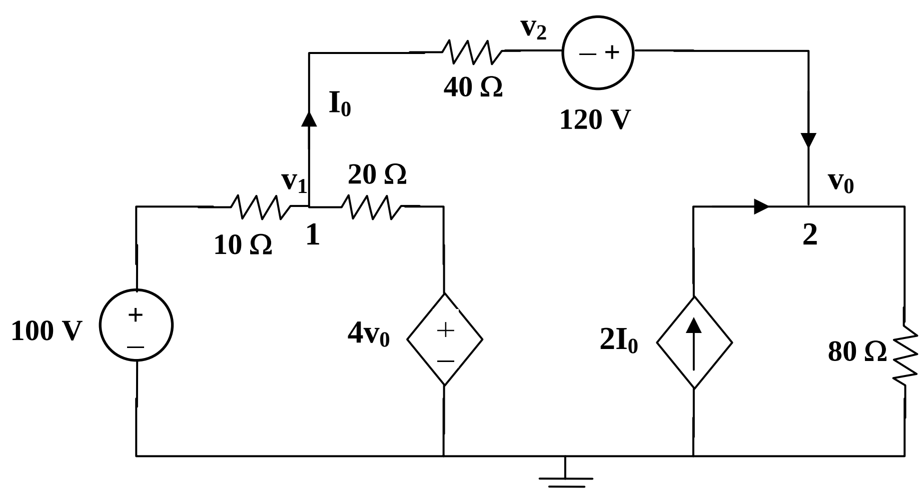


Figure 3.79

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),

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

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

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

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

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

Chapter 3, Problem 31.

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

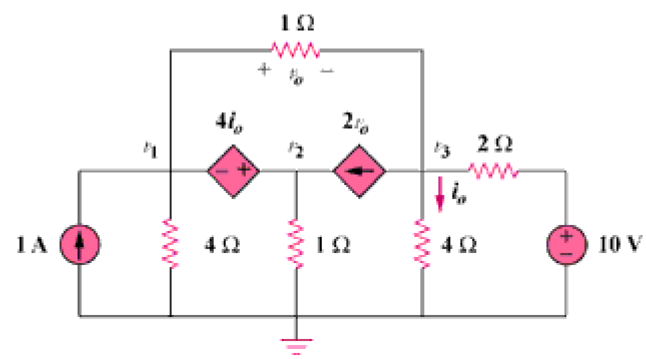
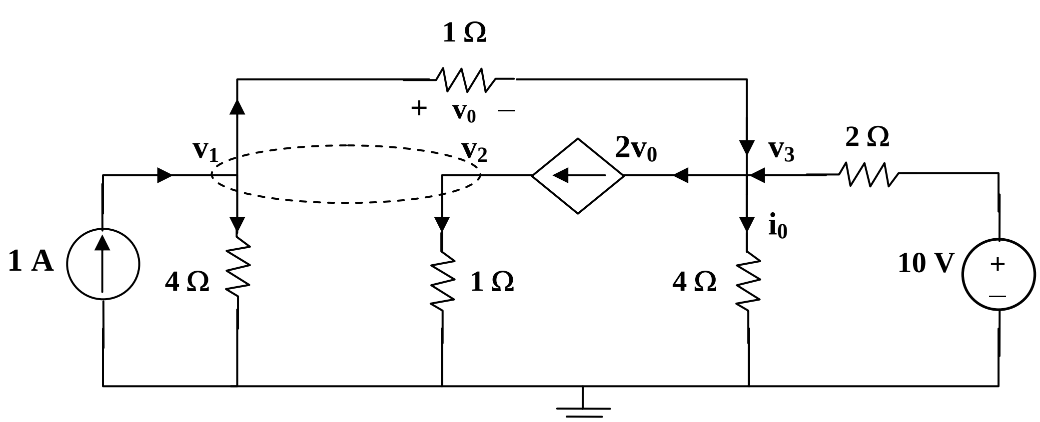


Figure 3.80

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,

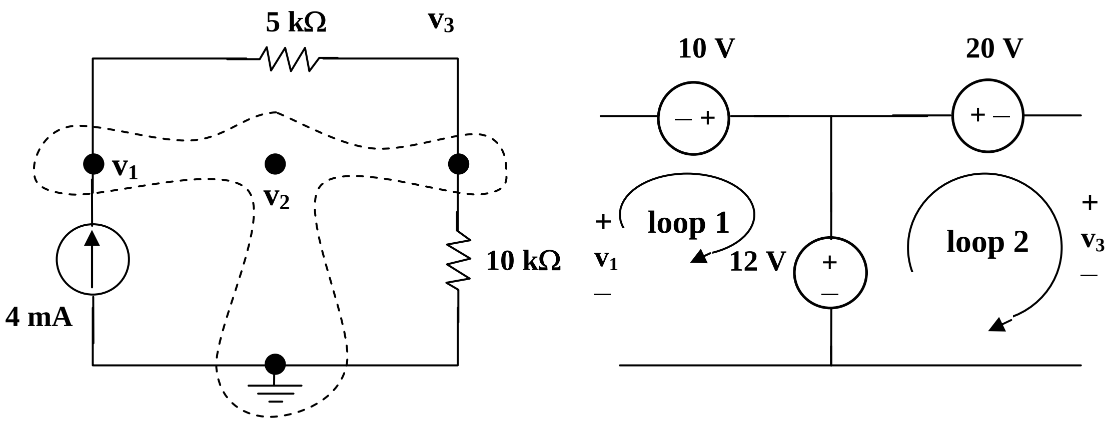
$v_1 =$ **<u>4.97V</u>**, $v_2 =$ **<u>4.85V</u>**, $v_3 =$ **<u>–0.12V</u>**.

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



(a) (b)

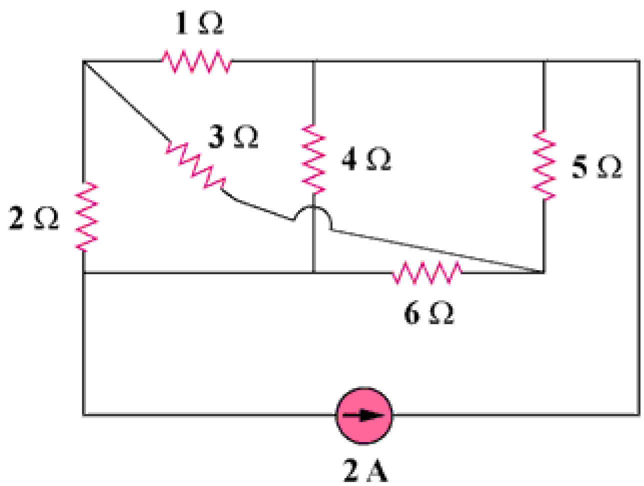
We have a supernode as shown in figure (a). It is evident that $v_2 = 12$ V, Applying KVL to loops 1and 2 in figure (b), we obtain,

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

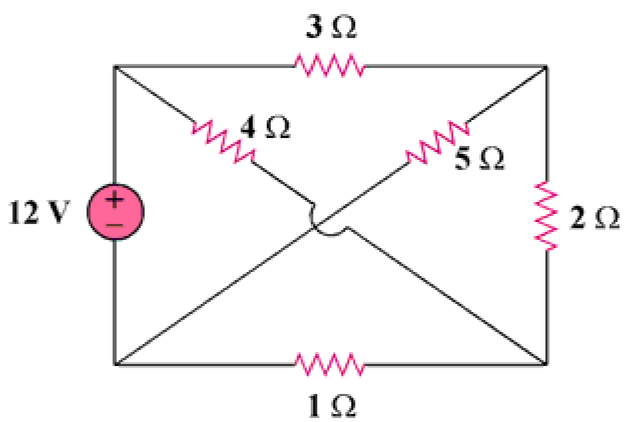
Thus, $v_1 = \underline{\mathbf{2\ V}}$, $v_2 = \underline{\mathbf{12\ V}}$, $v_3 = \underline{\mathbf{-8V}}$.

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)

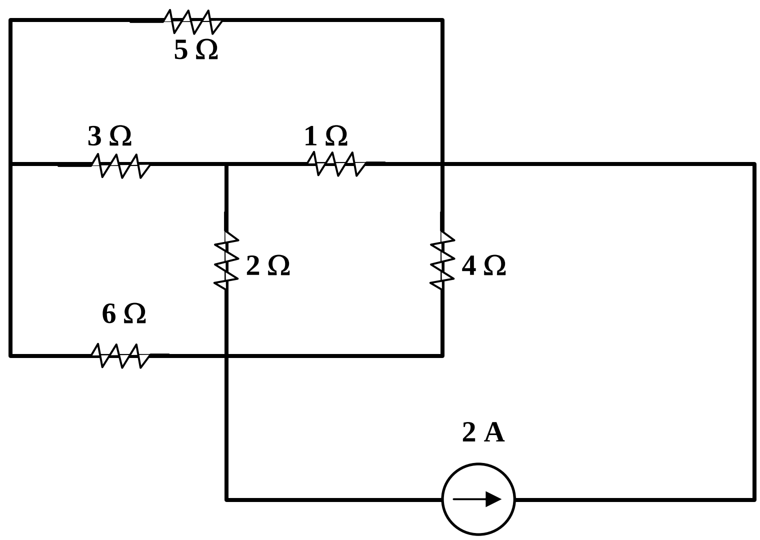


(b)

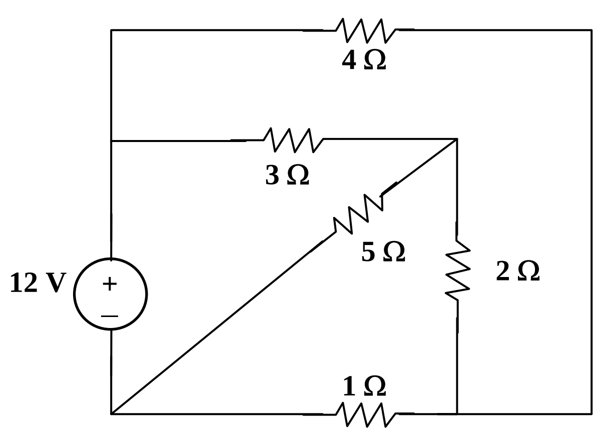
Figure 3.82

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.

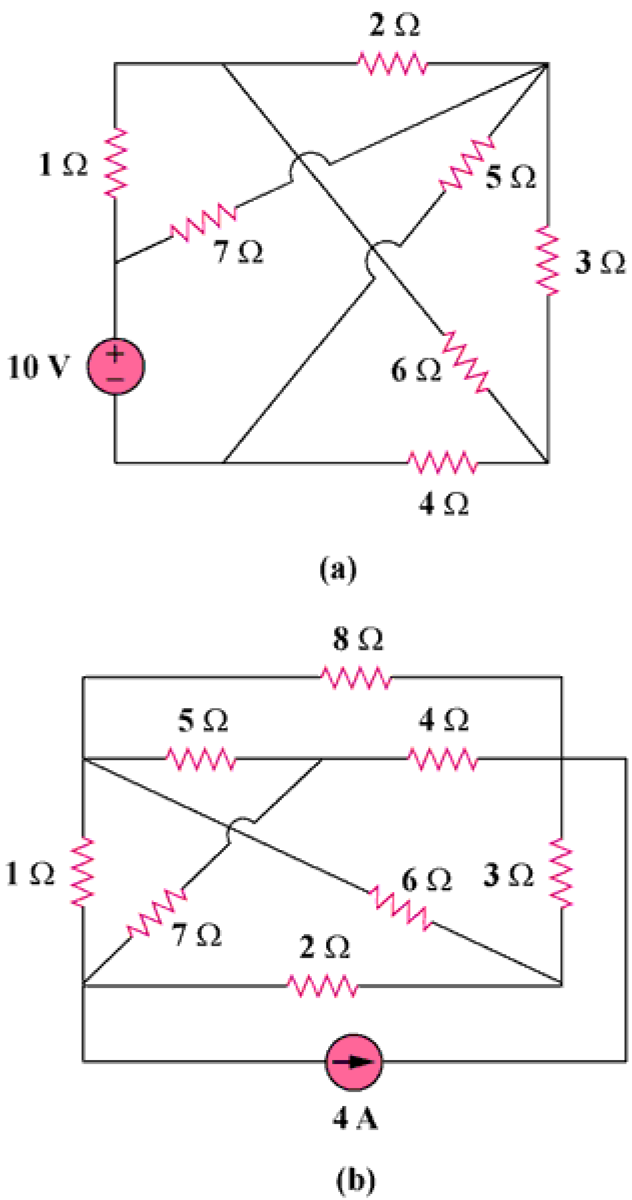
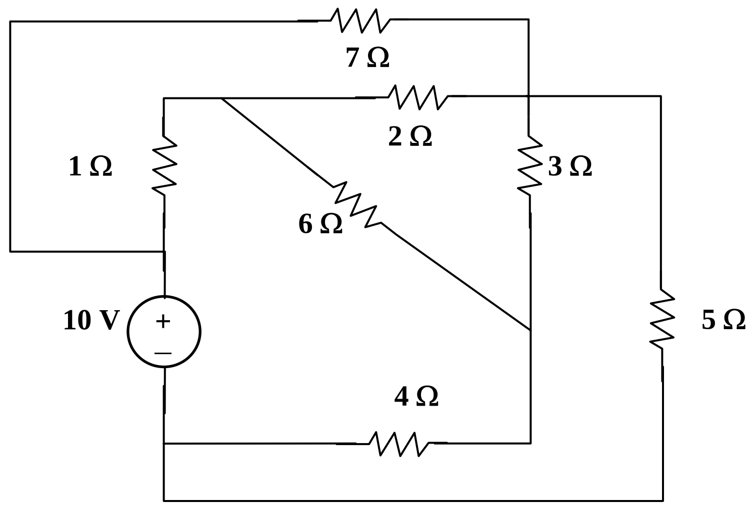


Figure 3.83

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.

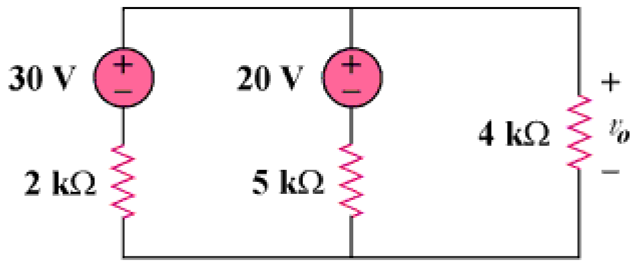
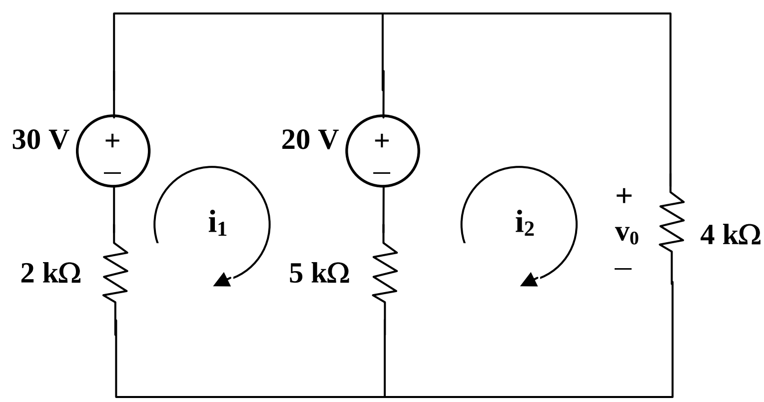


Figure 3.54

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.

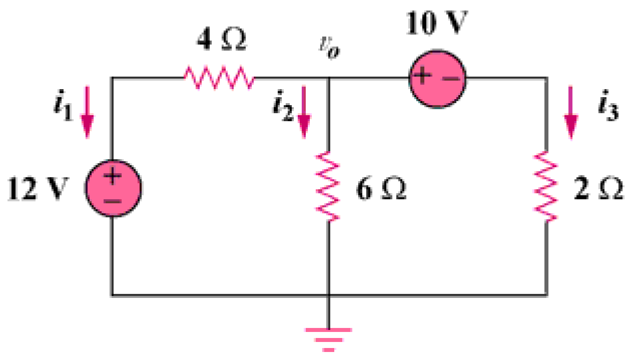
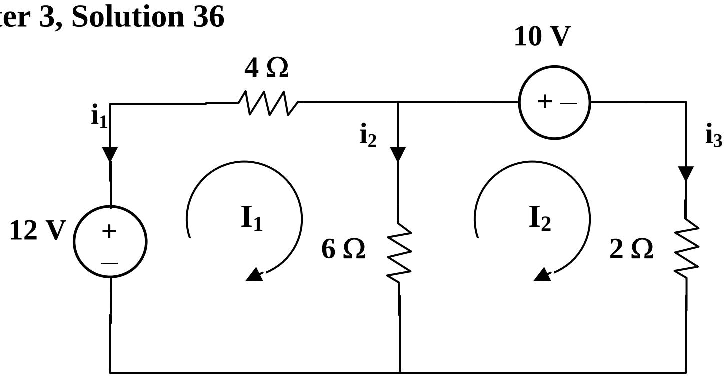


Figure 3.55

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.

$v_o = 6i_2 = 6x1.4545 =$ **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.

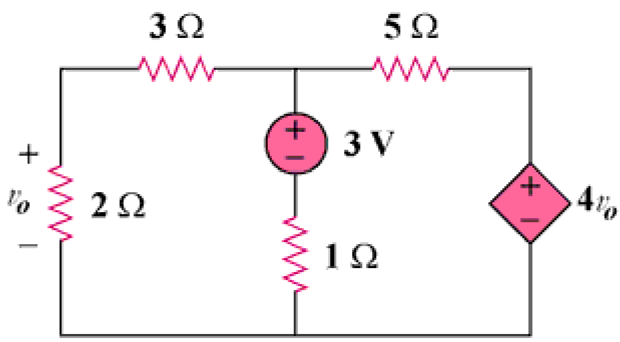
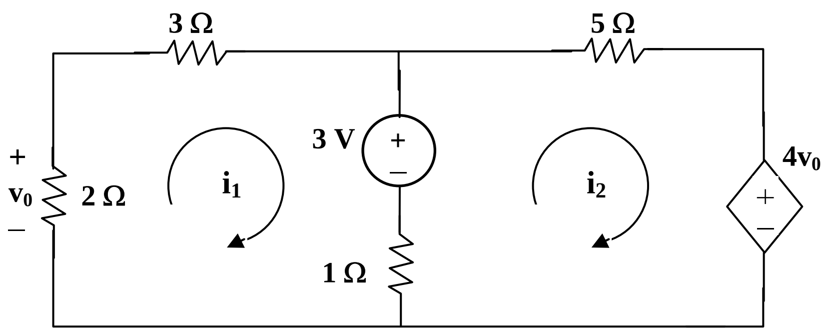


Figure 3.57

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)

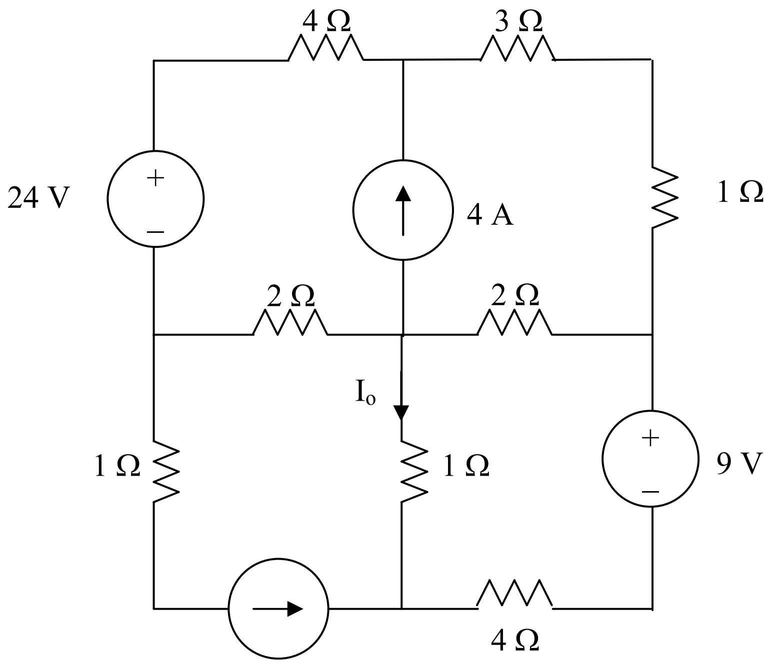
$-1i_1 + 6i_2 - 3 + 4v_0 = 0$ (2)

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**

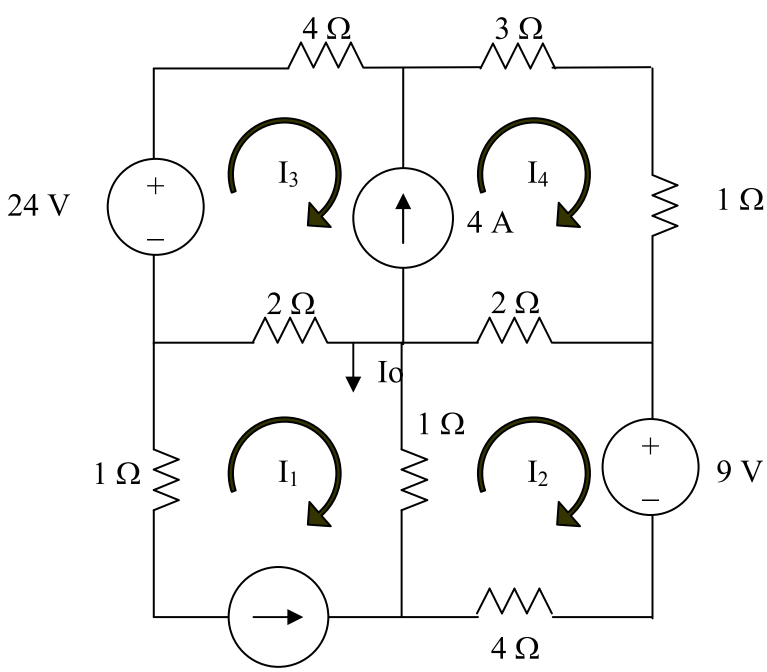
Chapter 3, Problem 38.
Apply mesh analysis to the circuit in Fig. 3.84 and obtain I_o.



2A

Figure 3.84 For Prob. 3.38.

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



2 A

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.

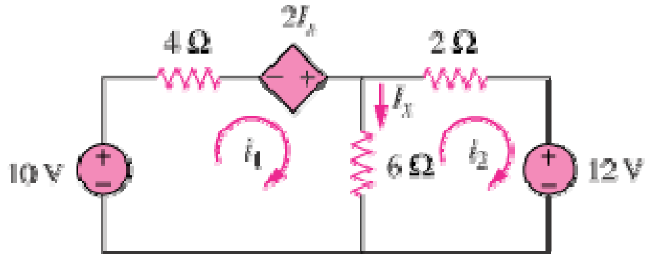


Figure 3.85

Chapter 3, Solution 39

For mesh 1,

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

But $I_x = I_1 - I_2$. Hence,

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

For mesh 2,

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

Solving (1) and (2) leads to

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

Chapter 3, Problem 40.

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

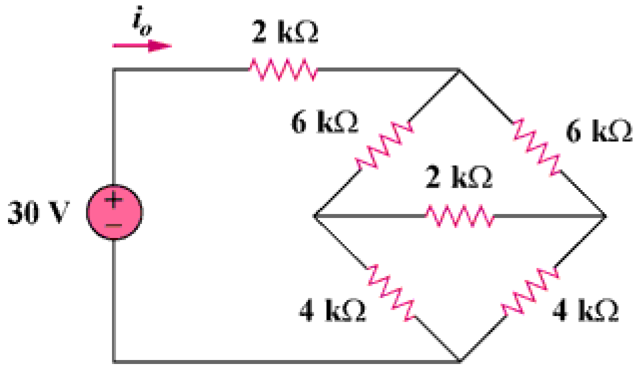
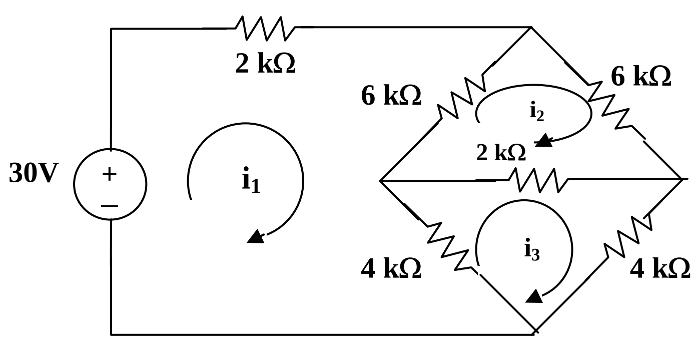


Figure 3.86

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 i_o in Fig. 3.87.

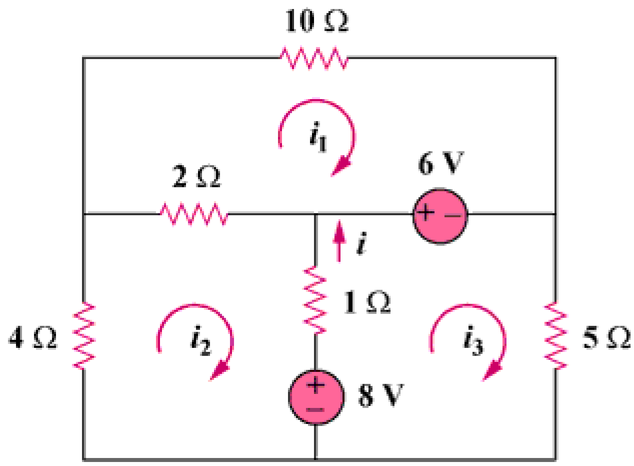
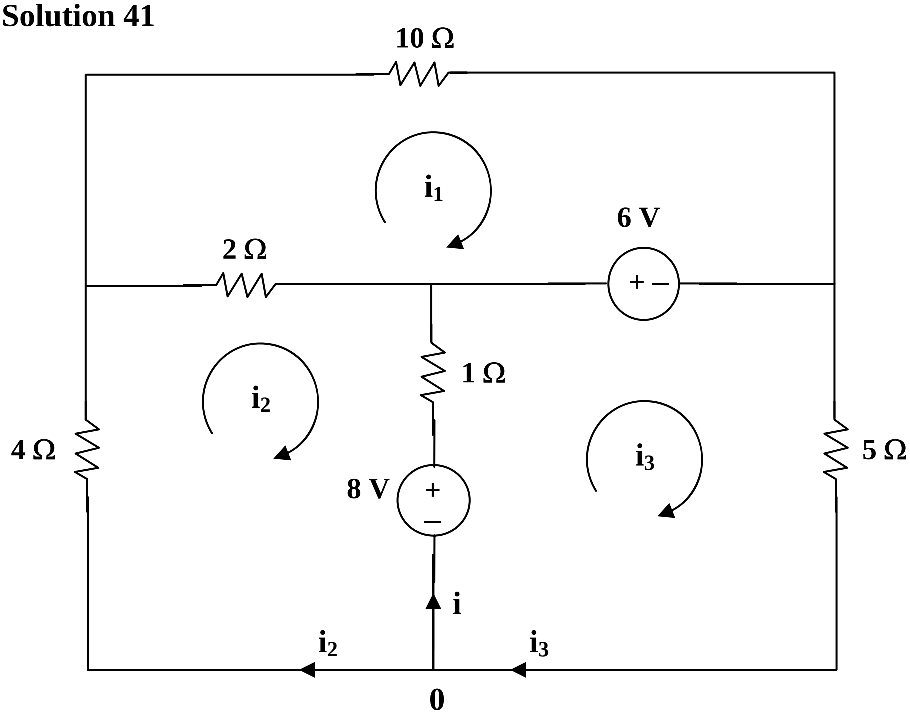


Figure 3.87

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.

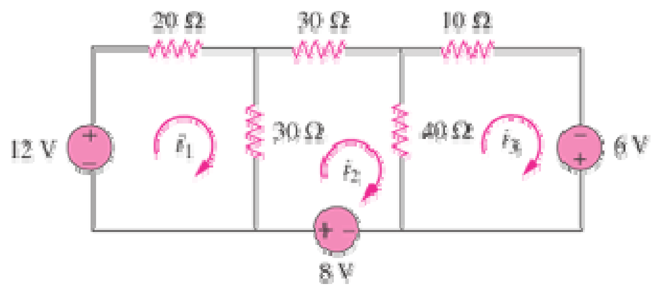


Figure 3.88

Chapter 3, Solution 42

For mesh 1,

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

For mesh 2,

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

For mesh 3,

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

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.

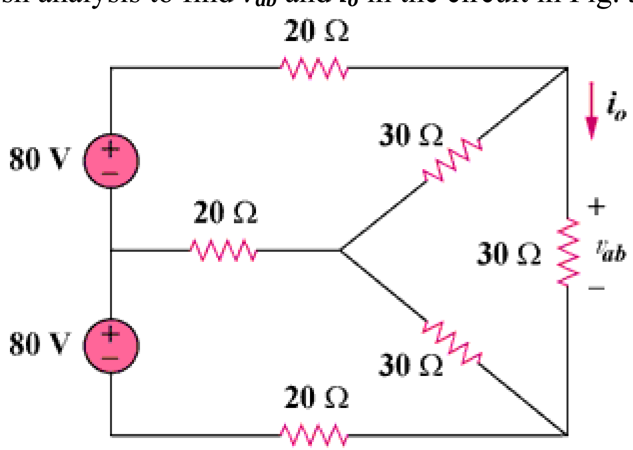
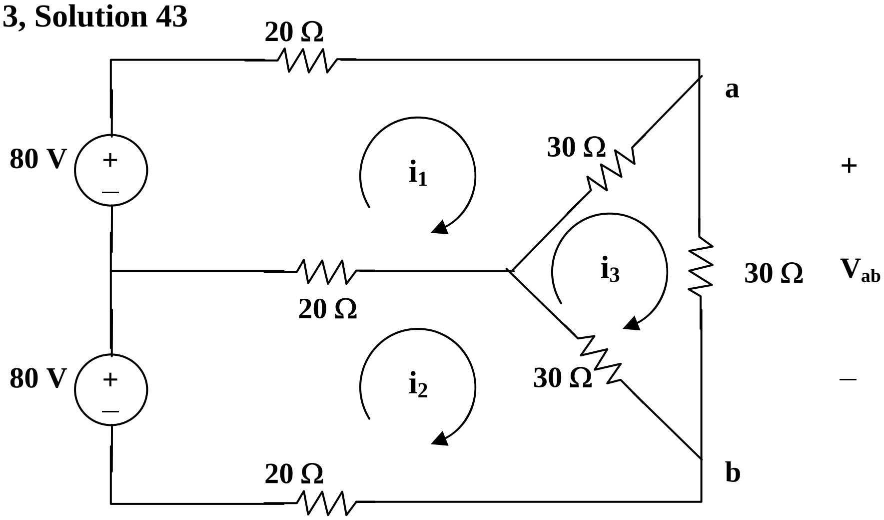


Figure 3.89

Chapter 3, Solution 43



For loop 1,

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

For loop 2,

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

For loop 3,

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

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

$I_o = i_3 = 16/9 =$ **1.7778 A**

$V_{ab} = 30i_3 =$ **53.33 V**.

Chapter 3, Problem 44.

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

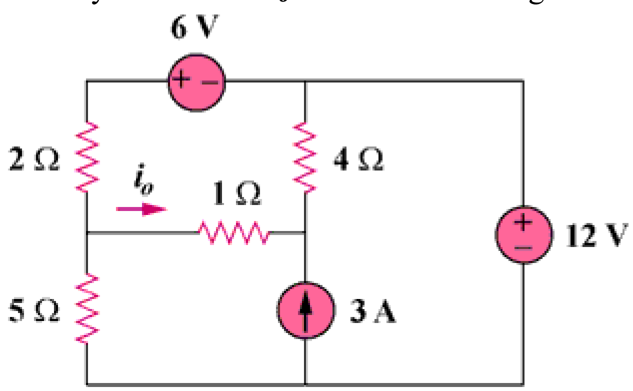
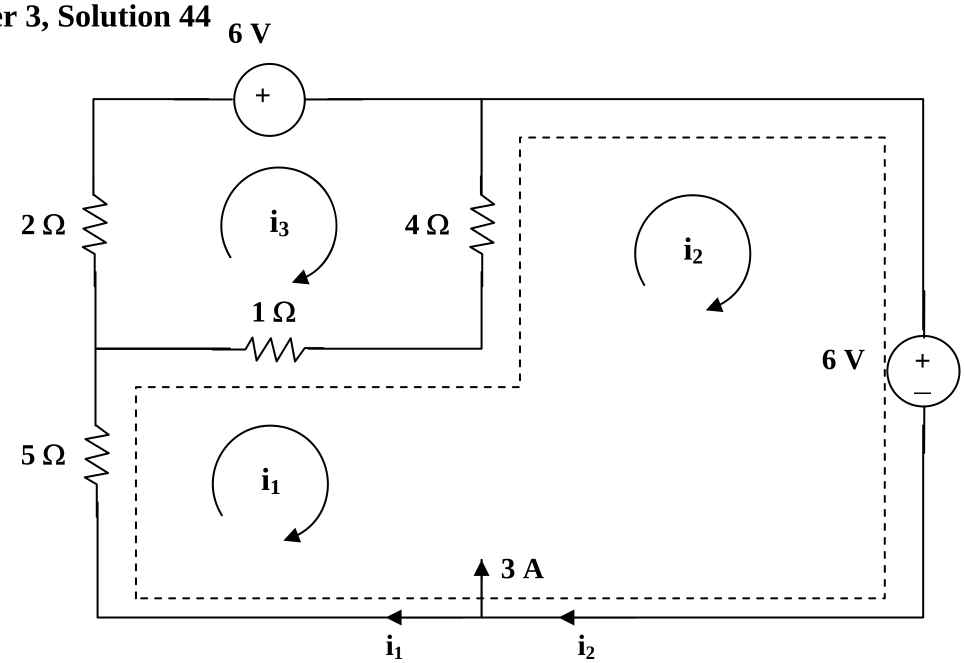


Figure 3.90

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), $i_1 = -3.067$, $i_3 = -1.3333$; $i_o = i_1 - i_3 =$ **-1.7333 A**

Chapter 3, Problem 45.

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

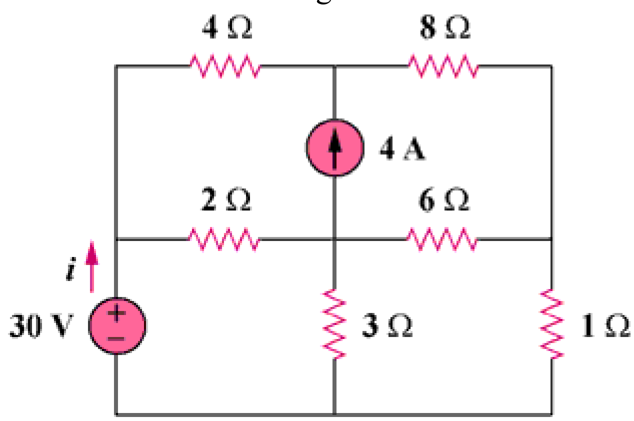
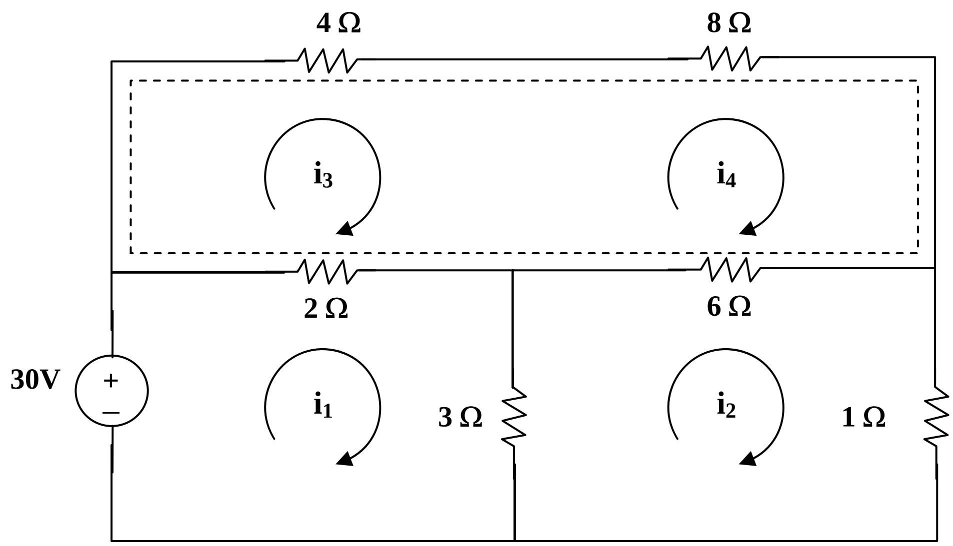


Figure 3.91

Chapter 3, Solution 45



For loop 1, $30 = 5i_1 - 3i_2 - 2i_3$ (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 $i = i_1 =$ **<u>8.561 A</u>**.

Chapter 3, Problem 46.

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

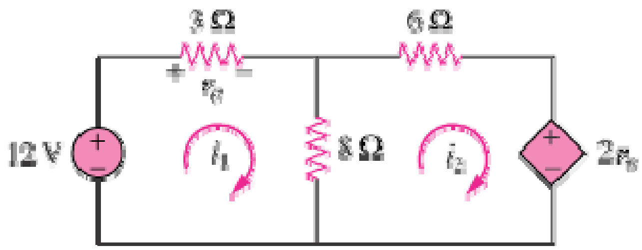


Figure 3.92

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.

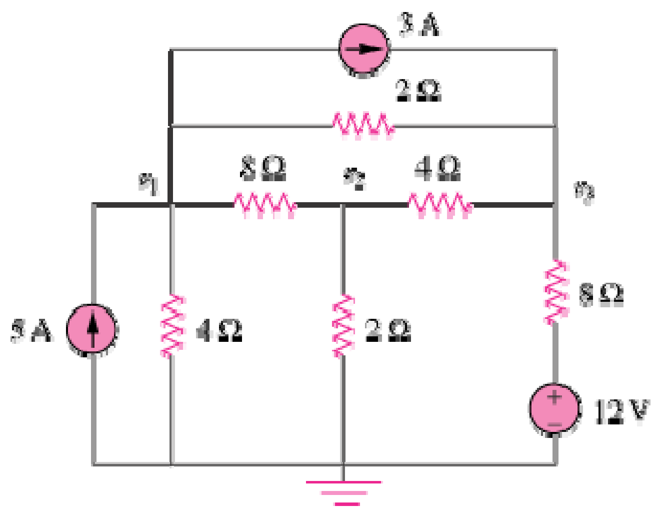
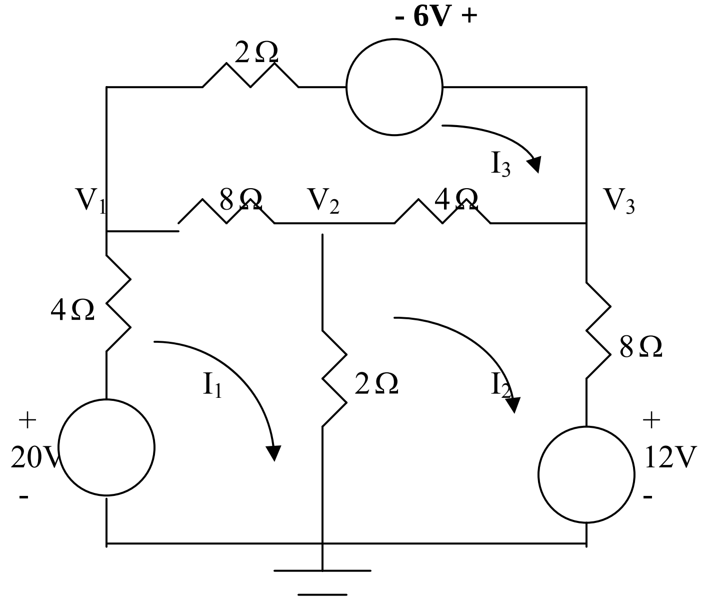


Figure 3.68

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,

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

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.

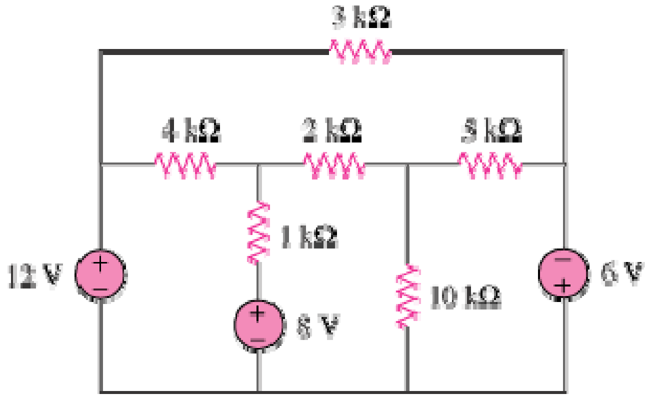
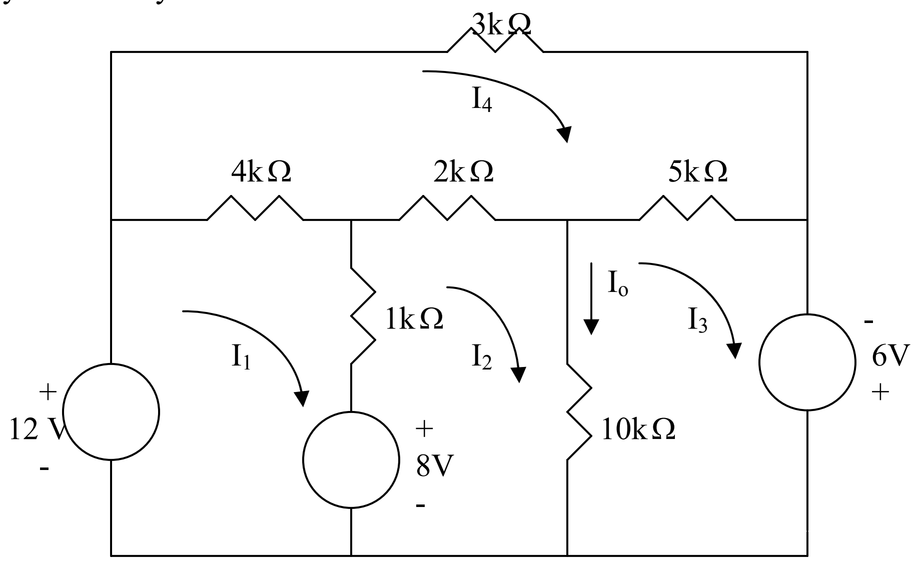


Figure 3.93

Chapter 3, Solution 48

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



For mesh 1,

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

For mesh 2,

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

For mesh 3,

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

For mesh 4,

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

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

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

Using MATLAB,

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

The current through the 10kΩ 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.

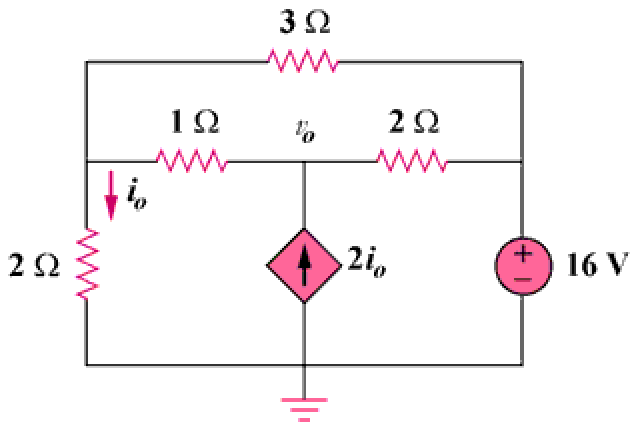
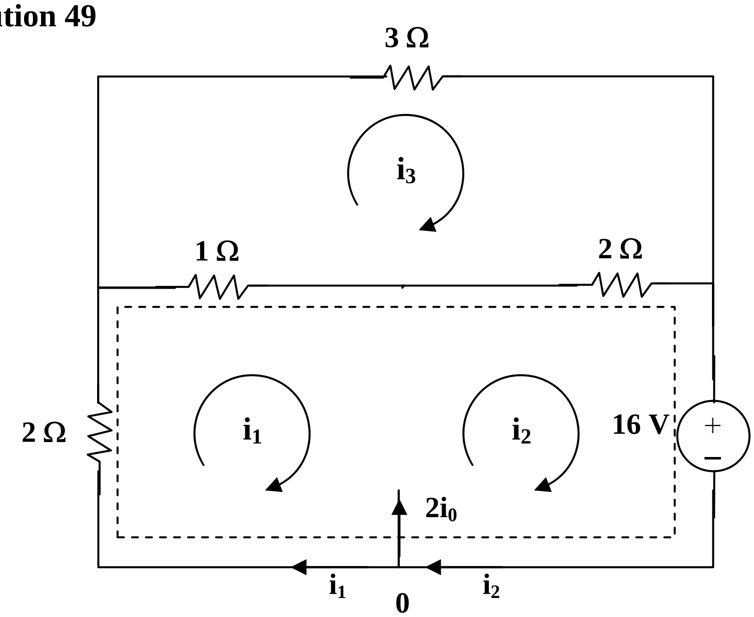
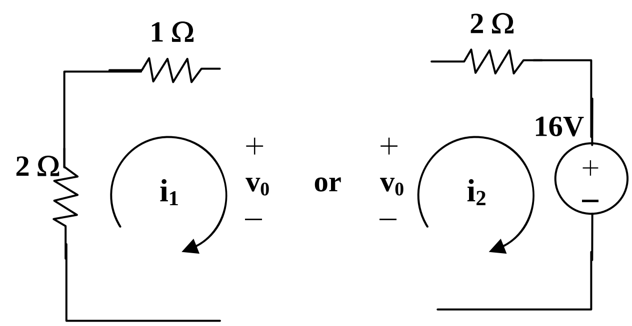


Figure 3.94

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, $i_2 - i_1 = 2i_0$ and $i_0 = -i_1$ which leads to $i_2 = -i_1$ (2)

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

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

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

Chapter 3, Problem 50.

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

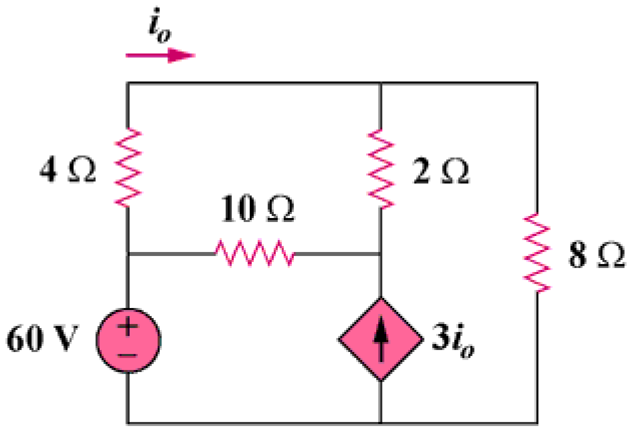
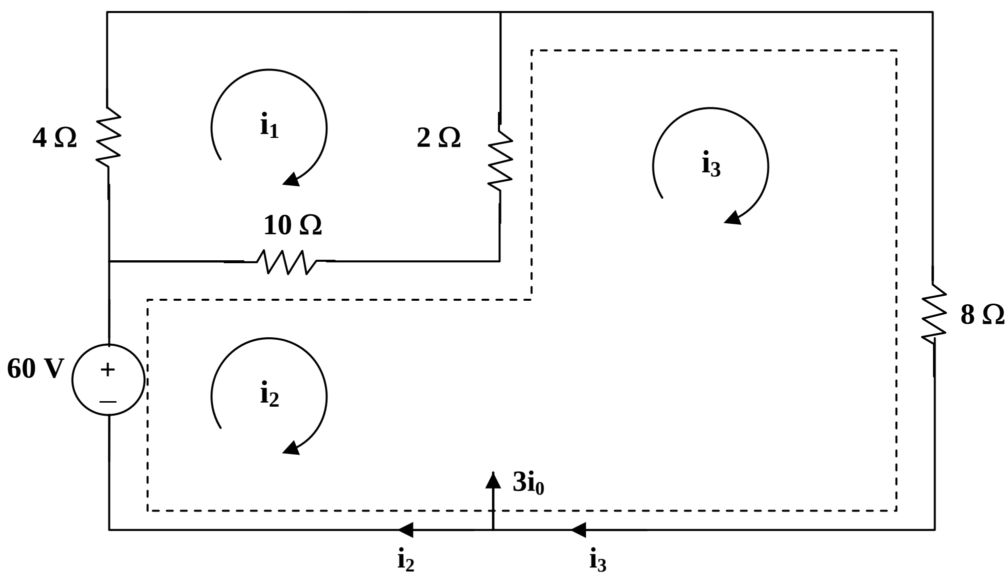


Figure 3.95

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.

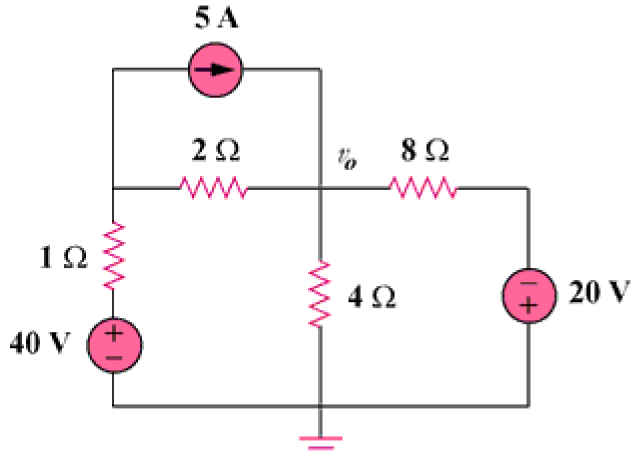
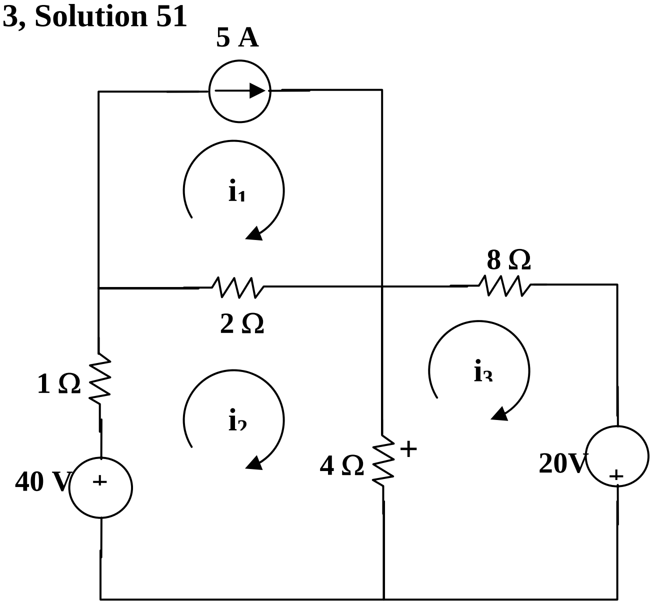


Figure 3.96

Chapter 3, Solution 51



For loop 1, $i_1 = 5A$ (1)

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

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

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

And, $v_0 = 4(i_2 - i_3) = 4(10 - 5) =$ **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.

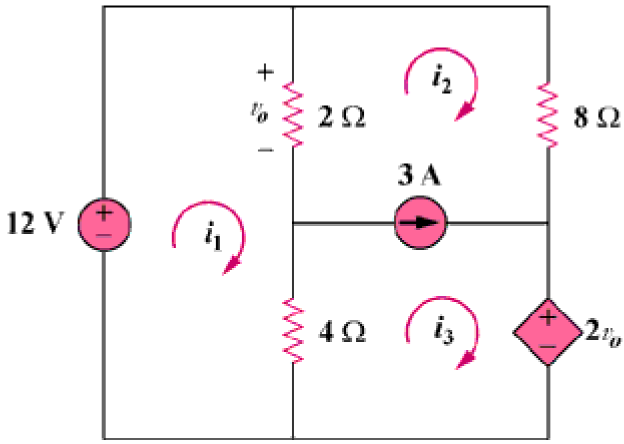
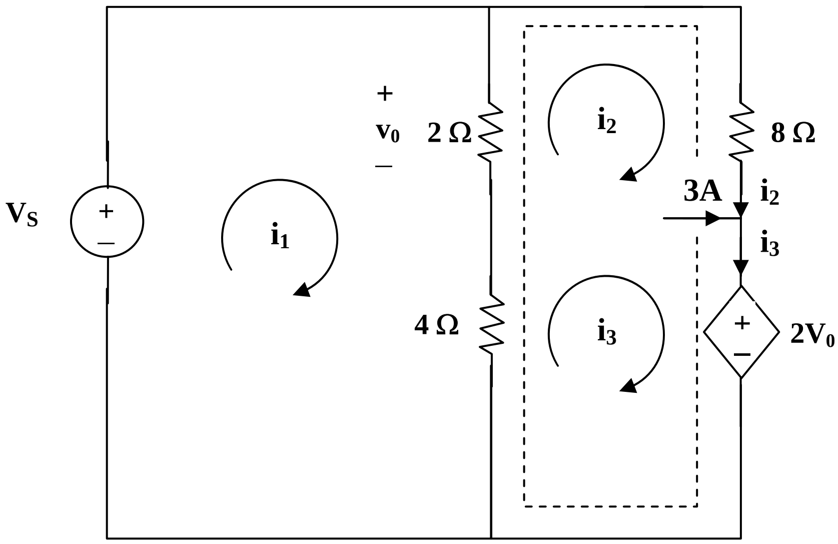


Figure 3.97

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 = **<u>3.5 A</u>**, i_2 = **<u>-0.5 A</u>**, i_3 = **<u>2.5 A</u>**.

Chapter 3, Problem 53.

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

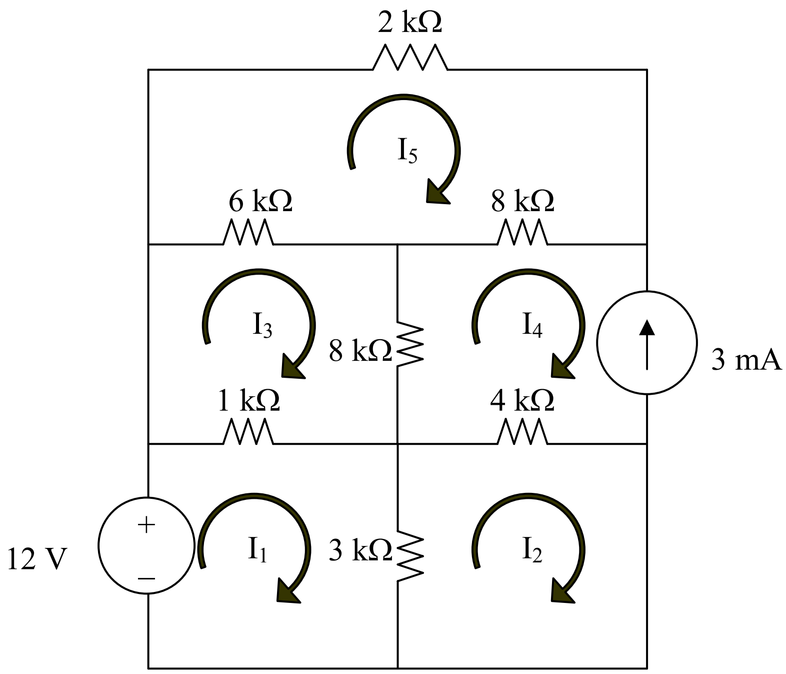


Figure 3.98 For Prob. 3.53.

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 =
```

1.6196 mA
–1.0202 mA
–2.461 mA
3 mA
–2.423 mA

Chapter 3, Problem 54.

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

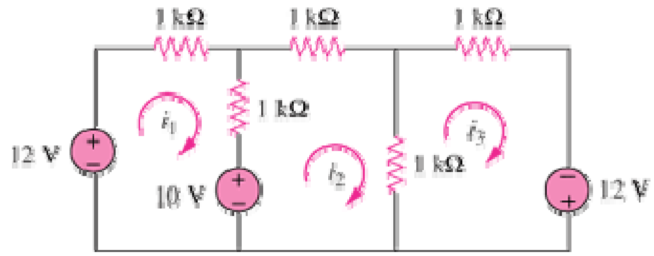


Figure 3.99

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 i_1, i_2, and i_3.

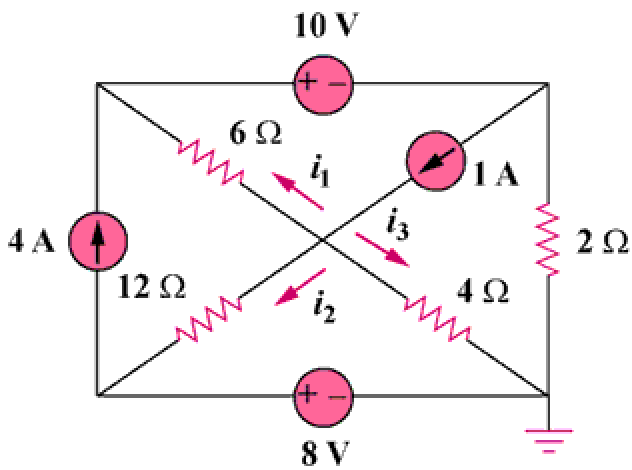
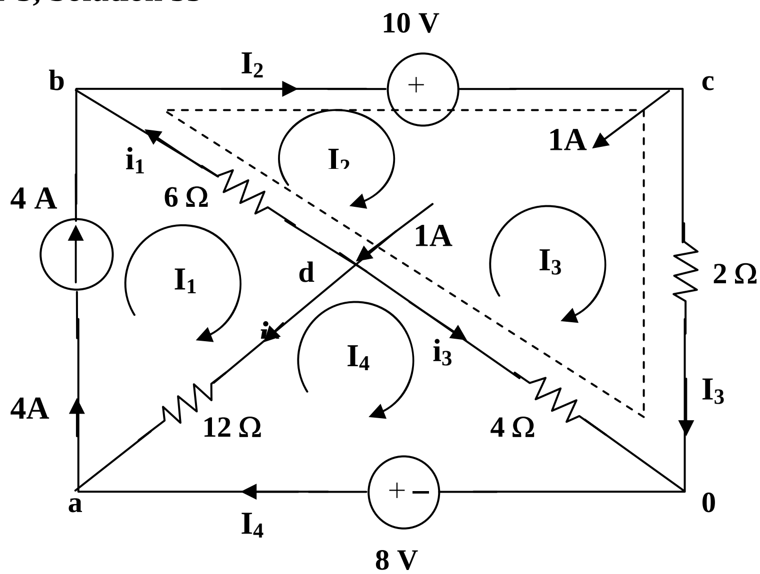


Figure 3.100

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 v_1 and v_2 in the circuit of Fig. 3.101.

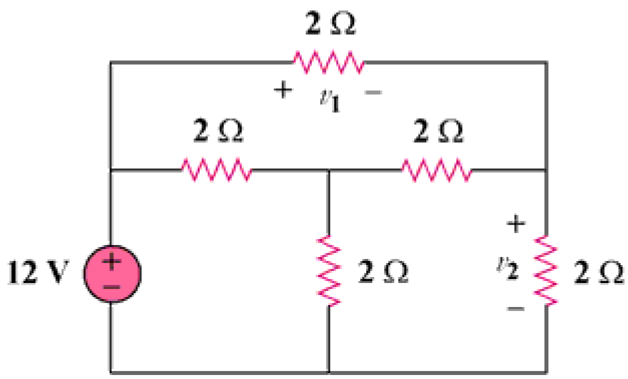
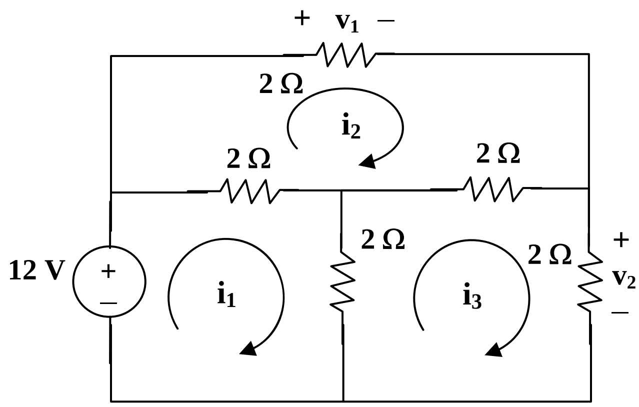


Figure 3.101

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

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

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

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

$v_1 = 2i_2 =$ **<u>6 volts</u>**, $v = 2i_3 =$ **<u>6 volts</u>**

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.

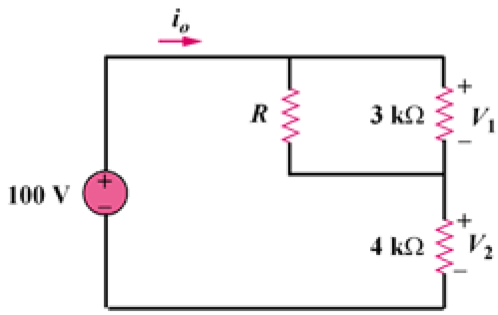


Figure 3.102

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

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

This leads to R = 84/26 = **3.23 kΩ**

Chapter 3, Problem 58.

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

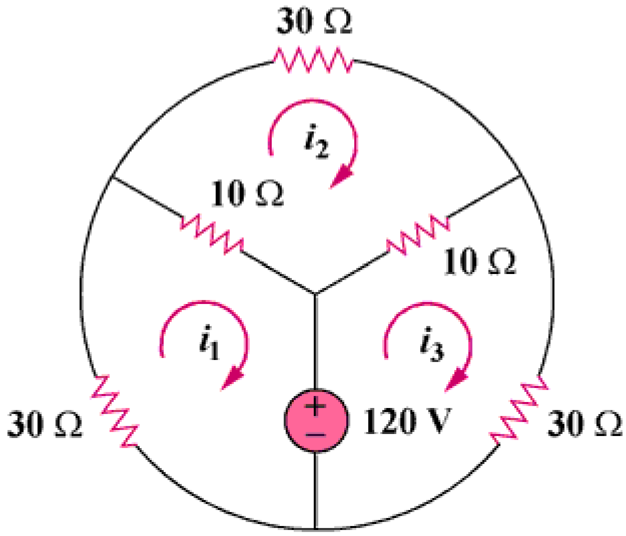
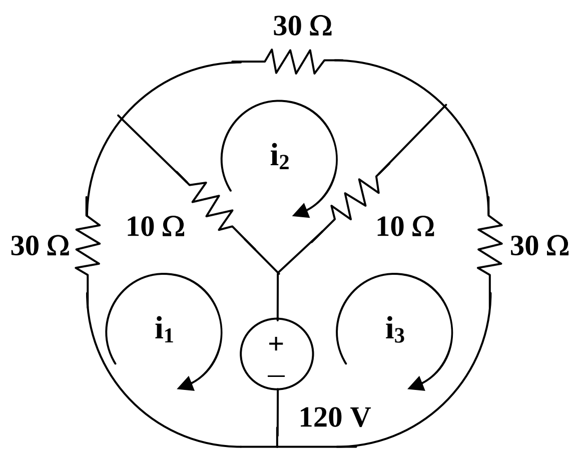


Figure 3.103

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 = **<u>-3A</u>**, i_2 = **<u>0</u>**, and i_3 = **<u>3A</u>**

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.

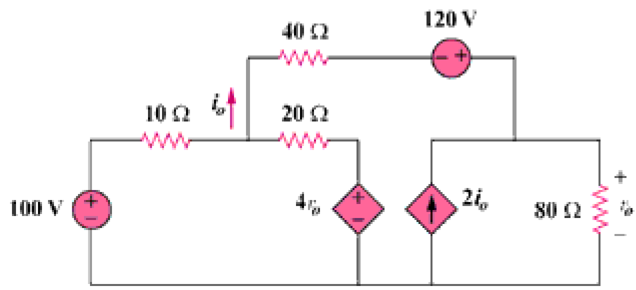
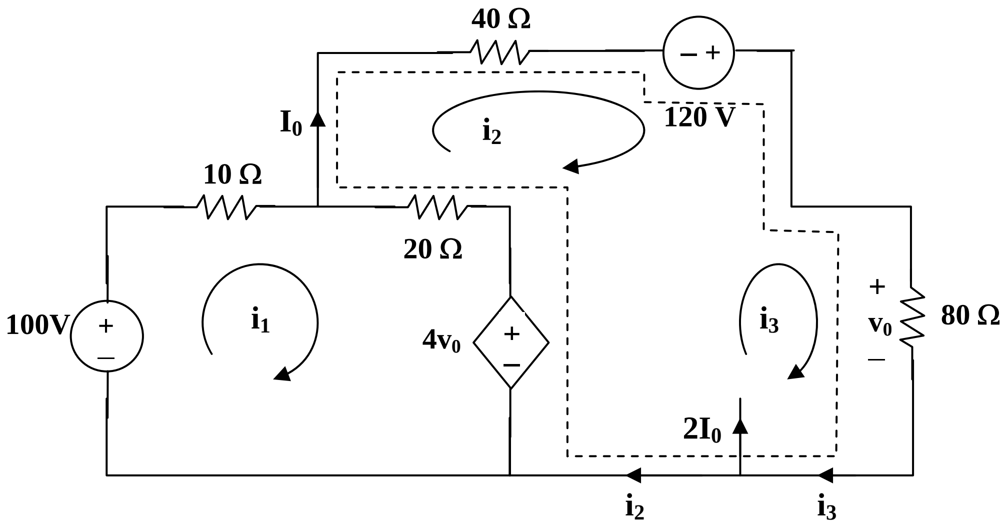


Figure 3.79

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

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

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

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

Chapter 3, Problem 60.

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

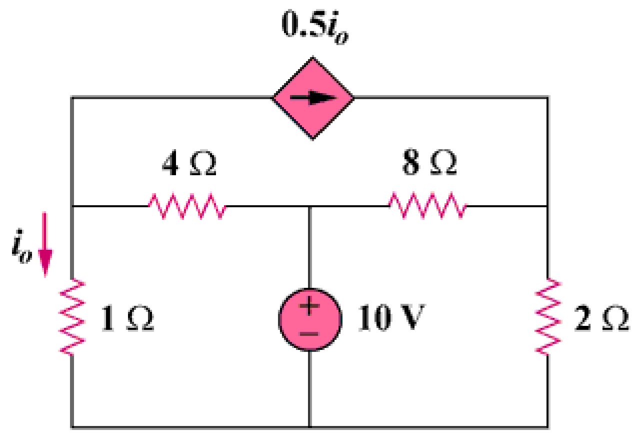
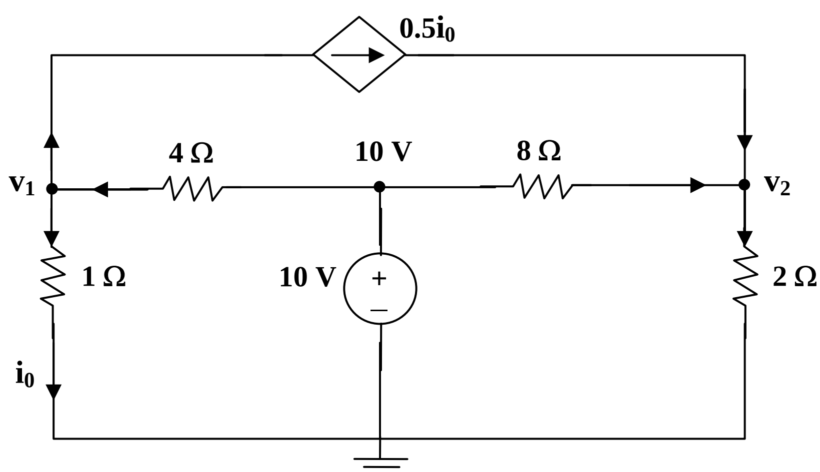


Figure 3.104

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.

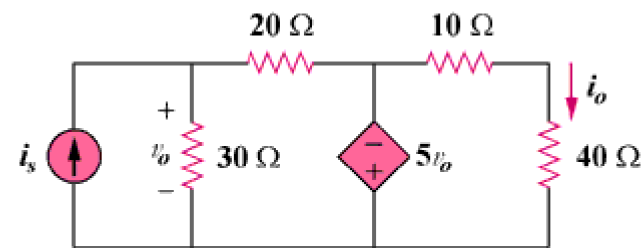
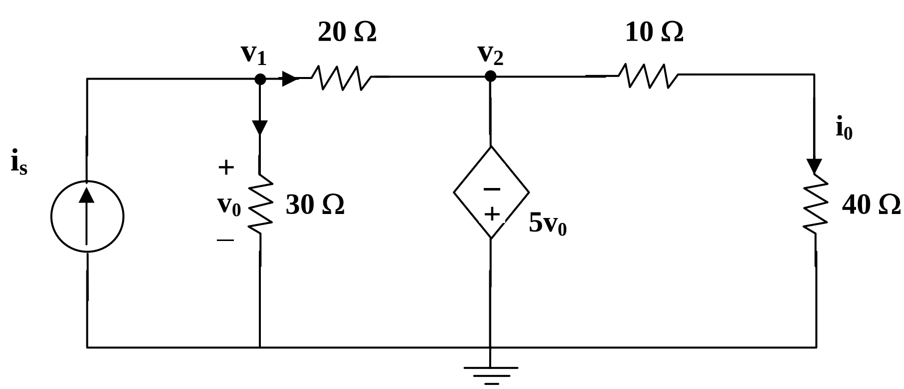


Figure 3.105

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 $i_0/i_s = -15/50 =$ **−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.

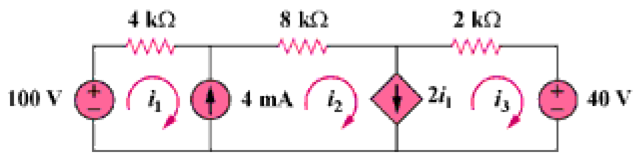
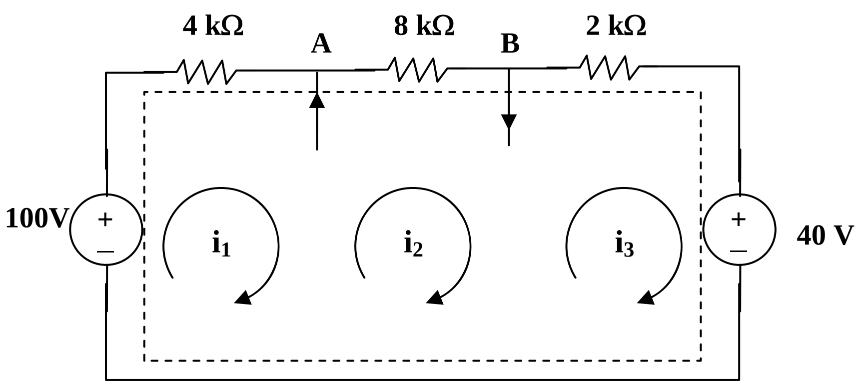


Figure 3.106

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 v_x, and i_x in the circuit shown in Fig. 3.107.

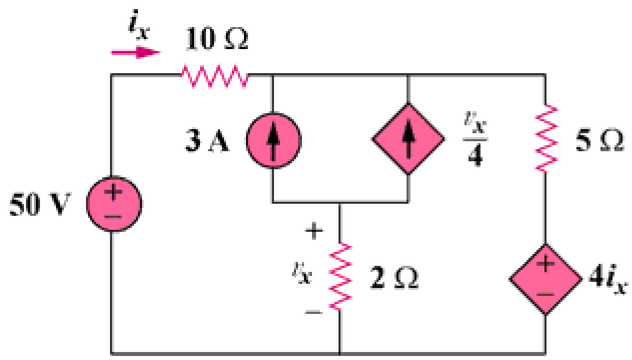
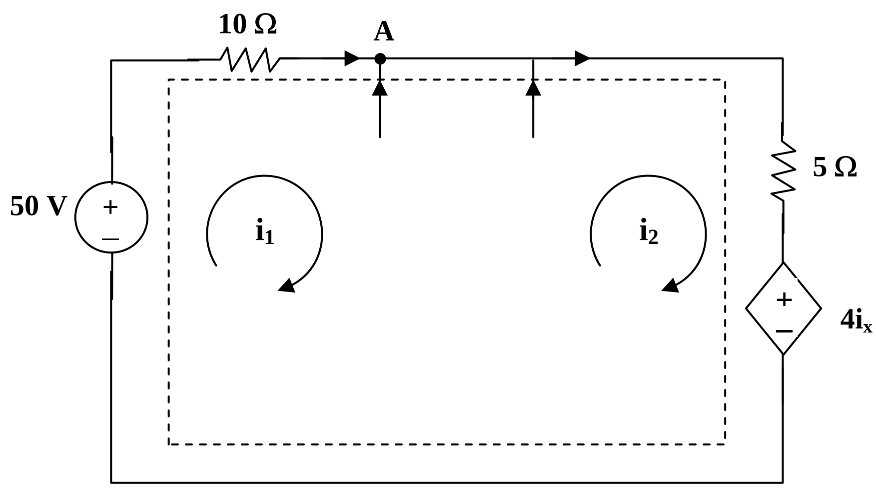


Figure 3.107

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

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

Chapter 3, Problem 64.

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

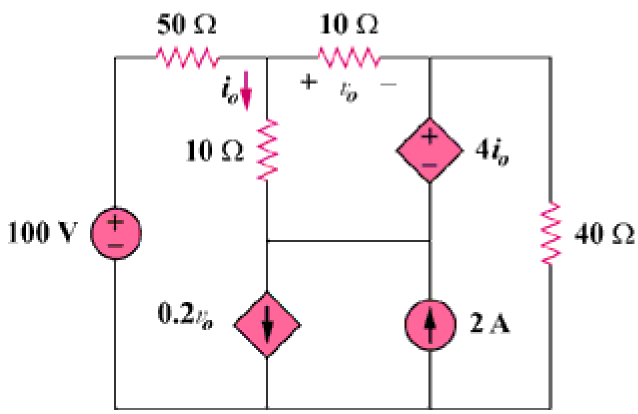
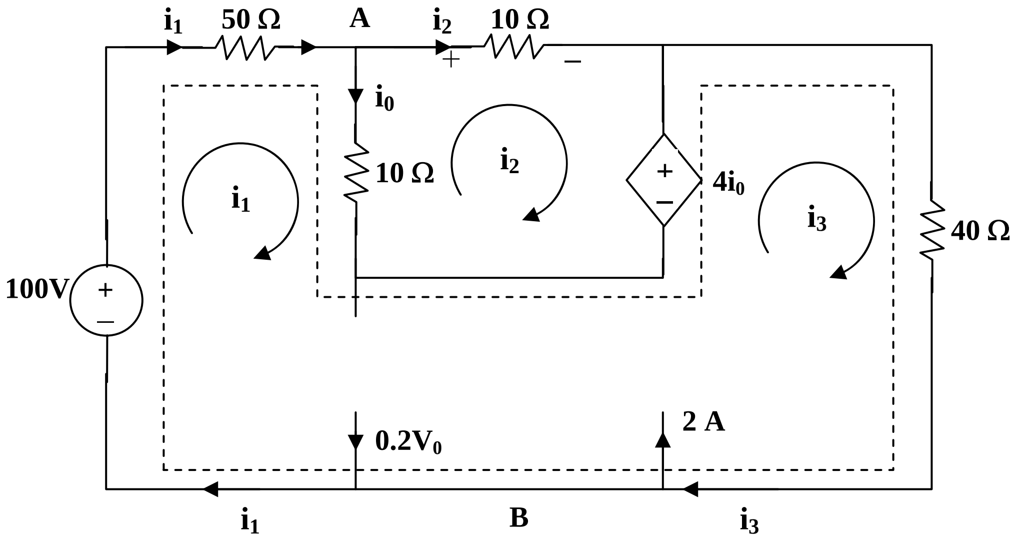


Figure 3.108

Chapter 3, Solution 64



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

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

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

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

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

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

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

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

Chapter 3, Problem 65.

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

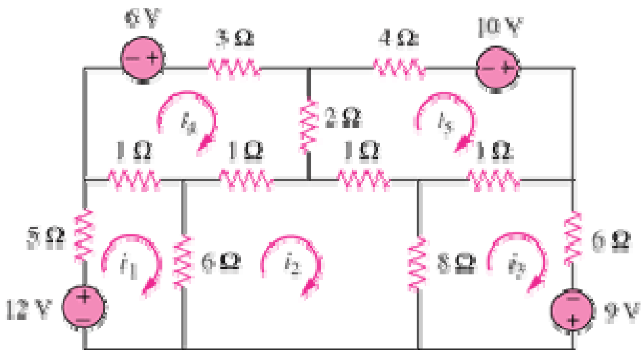


Figure 3.109

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

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

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**.