Solution (Tutorial 10: Nodal and Mesh Analysis)

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

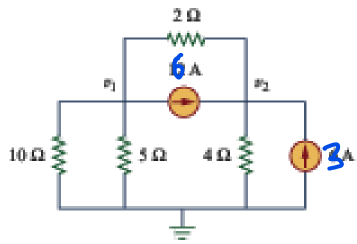


Figure 3.51
For Prob. 3.2.

Chapter 3, Solution 2

At node 1,

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

At node 2,

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

Solving (1) and (2),

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

3.6 Use nodal analysis to obtain v_o in the circuit of Fig. 3.55.

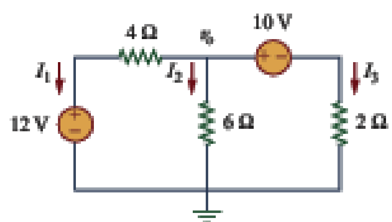


Figure 3.55
For Prob. 3.6.

Chapter 3, Solution 6

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

or v_0 = **<u>8.727 V</u>**

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

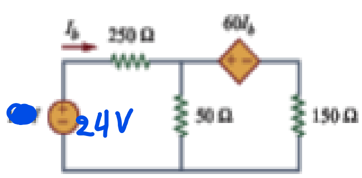


Figure 3.58
For Prob. 3.9.

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, $\quad I_b$ = (24 – 4.165)/250 = **<u>79.34 mA</u>**.

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

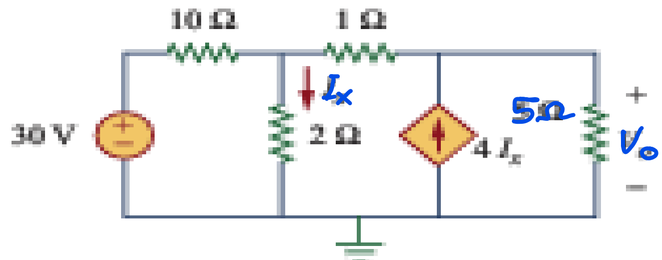
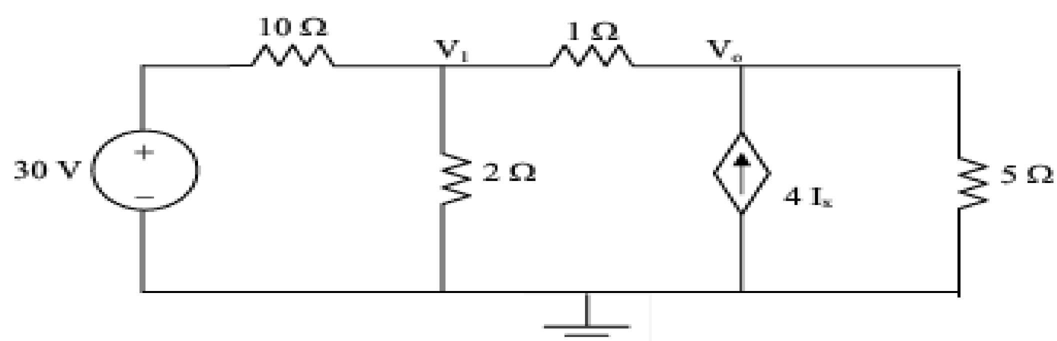


Figure 3.61
For Prob. 3.12.

Chapter 3, Solution 12

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



At node 1,

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

$$16V_1 - 10V_o = 30$$

At node o,

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

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

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

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

Substituting (3) into 1,

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

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

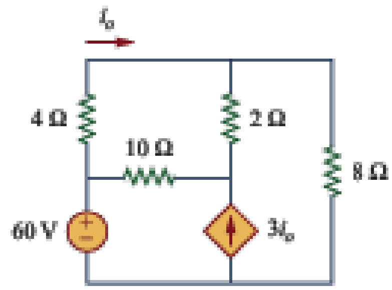
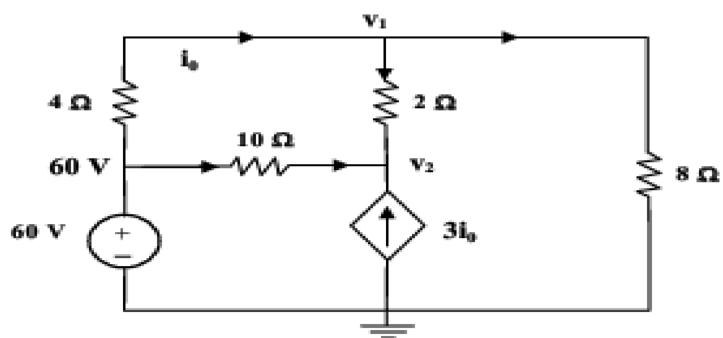


Figure 3.66
For Prob. 3.17.



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

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

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 $i_o = \frac{60 - v_1}{4} = \underline{\mathbf{1.73\ A}}$

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

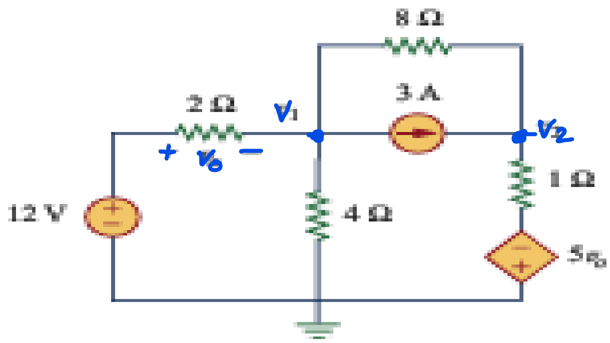


Figure 3.71
For Prob. 3.22.

Chapter 3, Solution 22

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

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

But, $v_o = 12 - v_1$

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

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

Solving (1) and (2),

$v_1 = \underline{\mathbf{-\ 10.91\ V}}$, $v_2 = \underline{\mathbf{-\ 100.36\ V}}$

3.49 Find V_o and I_o in the circuit of Fig. 3.94.

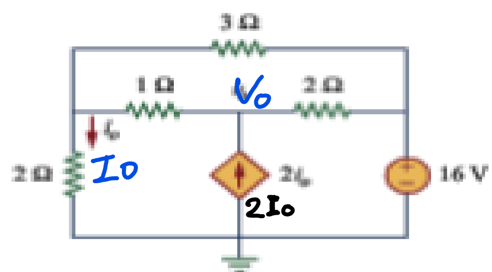
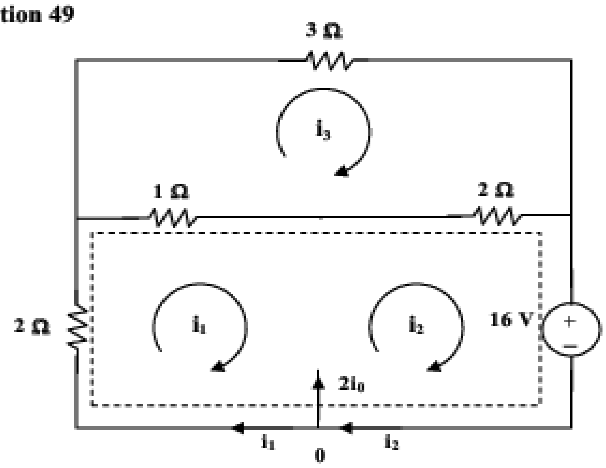
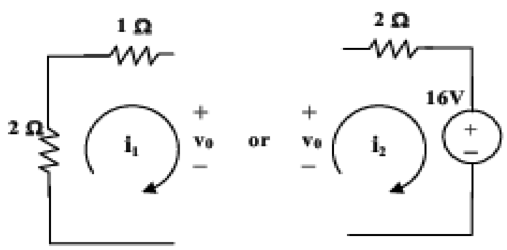


Figure 3.94
For Prob. 3.49.

Chapter 3, Solution 49



(a)



(b)

For the supermesh in figure (a),

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

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

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

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

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

v_o

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

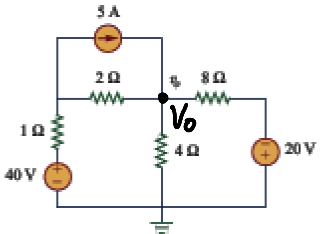
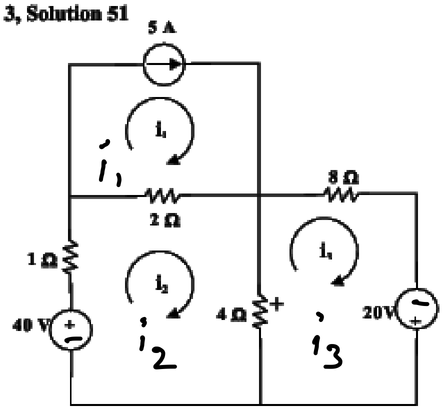


Figure 3.96
For Prob. 3.51.

Chapter 3, Solution 51



For loop 1, $i_1 = 5\text{A}$ (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), $i_2 = 10\text{ A},\ i_3 = 5\text{ A}$

And, $v_o = 4(i_2 - i_3) = 4(10 - 5) = \underline{\mathbf{20\ V}}$.

i_o

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

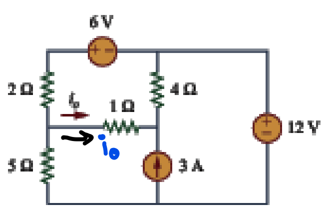
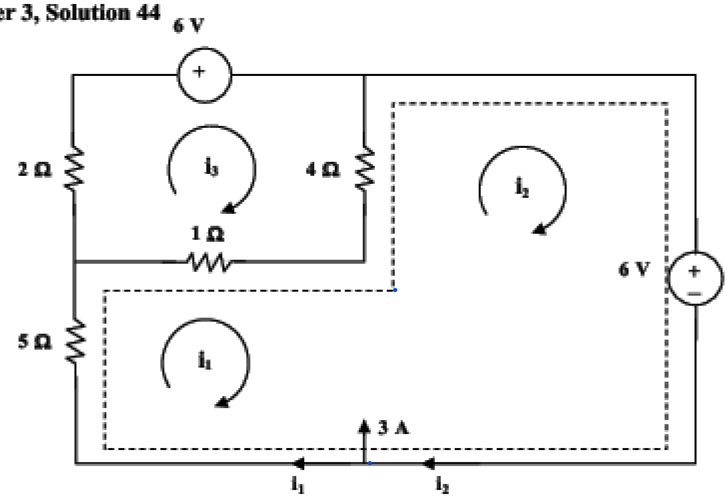
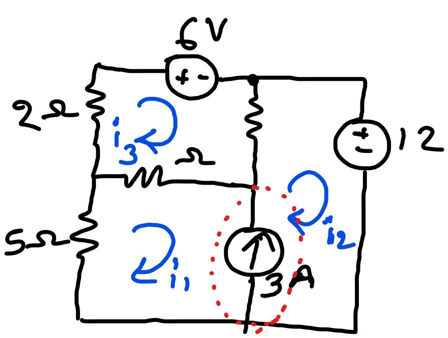


Figure 3.90
For Prob. 3.44.

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

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

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

$i_2 - i_1 = 3\,A$

$i_2 = i_1 + 3A$