Problem 3.2 Apply nodal analysis to determine V_x in the circuit of Fig. P3.2.

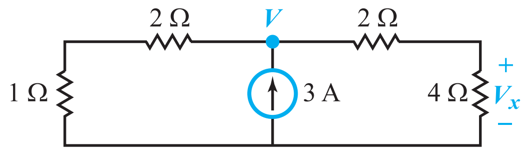

Figure P3.2: Circuit for Problem 3.2.

Solution: At node V, application of KCL gives

$$\frac{V}{2+1} - 3 + \frac{V}{2+4} = 0,$$

which leads to

$$V = 6 \text{ V}.$$

By voltage division,

$$V_x = \frac{V \times 4}{2+4} = \frac{6 \times 4}{6} = 4 \text{ V}.$$

Problem 3.3 Use nodal analysis to determine the current I_x and amount of power supplied by the voltage source in the circuit of Fig. P3.3.

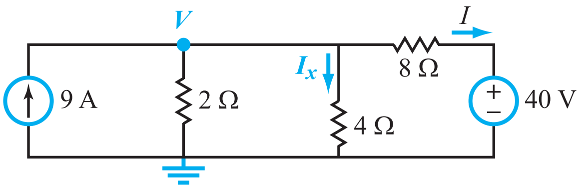

Figure P3.3: Circuit for Problem 3.3.

Solution: At node V, application of KCL gives

$$-9 + \frac{V}{2} + \frac{V}{4} + \frac{V-40}{8} = 0$$
$$V\left(\frac{1}{2} + \frac{1}{4} + \frac{1}{8}\right) = 9 + \frac{40}{8}$$
$$\frac{7V}{8} = 9 + 5$$
$$V = 16 \text{ V}.$$

The current I_x is then given by

$$I_x = \frac{V}{4} = \frac{16}{4} = 4 \text{ A}.$$

To find the power supplied by the 40-V source, we need to first find the current I flowing into its positive terminal,

$$I = \frac{V-40}{8} = \frac{16-40}{8} = -3 \text{ A}.$$

Hence,

$$P = VI = 40 \times (-3) = -120 \text{ W}$$

(The minus sign confirms that the voltage source is a supplier of power.)

Problem 3.4 For the circuit in Fig. P3.4:

(a) Apply nodal analysis to find node voltages V_1 and V_2.

(b) Determine the voltage V_R and current I.

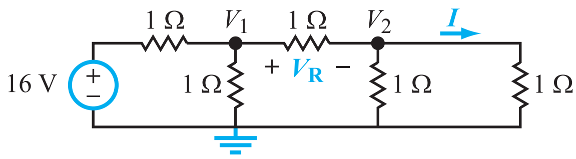

Figure P3.4: Circuit for Problem 3.4.

Solution: (a) At nodes V_1 and V_2,

$$\text{Node 1:} \quad \frac{V_1 - 16}{1} + \frac{V_1}{1} + \frac{V_1 - V_2}{1} = 0 \tag{1}$$

$$\text{Node 2:} \quad \frac{V_2 - V_1}{1} + \frac{V_2}{1} + \frac{V_2}{1} = 0 \tag{2}$$

Simplifying Eqs. (1) and (2) gives:

$$3V_1 - V_2 = 16 \tag{3}$$

$$-V_1 + 3V_2 = 0. \tag{4}$$

Simultaneous solution of Eqs. (3) and (4) leads to:

$$V_1 = 6 \text{ V}, \qquad V_2 = 2 \text{ V}.$$

(b)

$$V_R = V_1 - V_2 = 6 - 2 = 4 \text{ V}$$

$$I = \frac{V_2}{1} = \frac{2}{1} = 2 \text{ A}.$$

Problem 3.10 The circuit in Fig. P3.10 contains a dependent current source. Determine the voltage V_x.

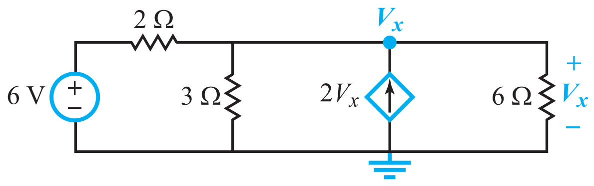

Figure P3.10: Circuit for Problem 3.10.

Solution: In terms of the node voltage V_x, KCL gives

$$\frac{V_x - 6}{2} + \frac{V_x}{3} - 2V_x + \frac{V_x}{6} = 0,$$

whose solution leads to

$$V_x = -3 \text{ V}.$$

Problem 3.14 Apply nodal analysis to find the current I_x in the circuit of Fig. P3.14.

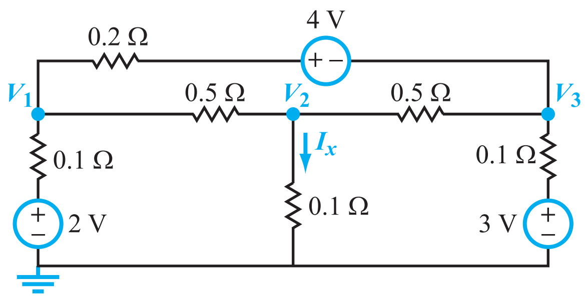

Figure P3.14: Circuit for Problem 3.14.

Solution: Application of KCL to the designated node voltages V_1, V_2, and V_3 gives

$$\frac{V_1 - 2}{0.1} + \frac{V_1 - V_2}{0.5} + \frac{V_1 - V_3 - 4}{0.2} = 0 \tag{1}$$

$$\frac{V_2 - V_1}{0.5} + \frac{V_2}{0.1} + \frac{V_2 - V_3}{0.5} = 0 \tag{2}$$

$$\frac{V_3 - V_1 + 4}{0.2} + \frac{V_3 - V_2}{0.5} + \frac{V_3 - 3}{0.1} = 0 \tag{3}$$

Simplification, followed with simultaneous solution, leads to

$$V_1 = 2.865 \text{ V}, \qquad V_2 = 0.625 \text{ V}, \qquad V_3 = 1.51 \text{ V},$$

and

$$I_x = \frac{V_2}{0.1} = \frac{0.625}{0.1} = 6.25 \text{ A}.$$

Problem 3.26 Apply mesh analysis to find the mesh currents in the circuit of Fig. P3.26. Use the information to determine the voltage V.

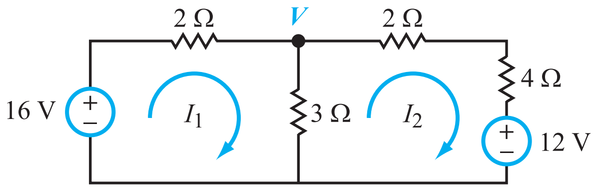

Figure P3.26: Circuit for Problem 3.26.

Solution: Application of KVL to the two loops gives:

$$\text{Mesh 1:} \quad -16 + 2I_1 + 3(I_1 - I_2) = 0,$$
$$\text{Mesh 2:} \quad 3(I_2 - I_1) + (2+4)I_2 + 12 = 0,$$

which can be simplified to

$$5I_1 - 3I_2 = 16 \qquad (1)$$
$$-3I_1 + 9I_2 = -12. \qquad (2)$$

Simultaneous solution of (1) and (2) leads to

$$I_1 = 3 \text{ A}, \qquad I_2 = -\frac{1}{3} \text{ A}.$$

Hence,

$$V = 3(I_1 - I_2) = 3\left(3 + \frac{1}{3}\right) = 10 \text{ V}.$$

Problem 3.31 Apply mesh analysis to determine the amount of power supplied by the voltage source in Fig. P3.31.

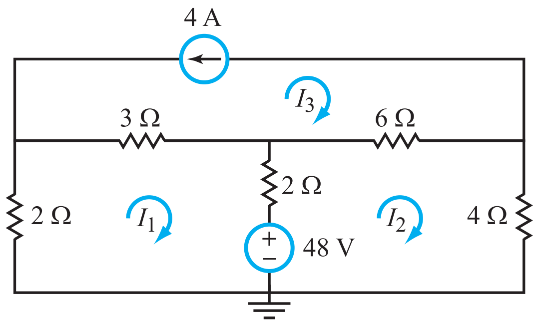

Figure P3.31: Circuit for Problem 3.31.

Solution:

$$\begin{aligned}
&\text{Mesh 1:} \quad && 2I_1 + 3(I_1 - I_3) + 2(I_1 - I_2) + 48 = 0 \\
&\text{Mesh 2:} \quad && -48 + 2(I_2 - I_1) + 6(I_2 - I_3) + 4I_2 = 0 \\
&\text{Mesh 3:} \quad && I_3 = -4 \text{ A}.
\end{aligned}$$

Solution is:

$$I_1 = -8.4 \text{ A}, \qquad I_2 = 0.6 \text{ A}, \qquad I_3 = -4 \text{ A}.$$

Current entering "+" terminal of voltage source is:

$$I = I_1 - I_2 = -8.4 - 0.6 = -9 \text{ A}.$$

Hence,

$$P = VI = 48 \times (-9) = -432 \text{ W}.$$

Problem 3.34 Apply mesh analysis to the circuit in Fig. P3.34 to determine V_x.

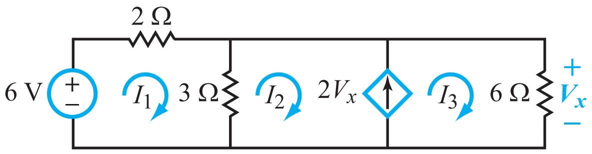

Figure P3.34: Circuit for Problem 3.34.

Solution:

$$\begin{aligned}
&\text{Mesh 1:} && -6+2I_1+3(I_1-I_2)=0\\
&\text{Supermesh:} && 3(I_2-I_1)+6I_3=0\\
&\text{Auxiliary 1:} && I_3-I_2=2V_x\\
&\text{Auxiliary 2:} && V_x=6I_3
\end{aligned}$$

Solution is:

$$I_1=4.5 \text{ A}, \qquad I_2=5.5 \text{ A}, \qquad I_3=-0.5 \text{ A}.$$
$$V_x=6I_3=6\times(-0.5)=-3 \text{ V}.$$