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

![Circuit for Problem 3.2.](image)

**Solution:** At node $V$, application of KCL gives

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

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.

![Circuit for Problem 3.3.](image)

Solution: At node $V$, application of KCL gives

$$-9 + V \frac{1}{2} + V \frac{1}{4} + \frac{V - 40}{8} = 0$$

$$V \left( \frac{1}{2} + \frac{1}{4} + \frac{1}{8} \right) = 9 + \frac{40}{8}$$

$$\frac{7V}{8} = 9 + 5$$

$$V = 16 \text{ V}.$$  

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.](image)

Solution: (a) At nodes $V_1$ and $V_2$,

Node 1: \[ \frac{V_1 - 16}{1} + \frac{V_1}{1} + \frac{V_1 - V_2}{1} = 0 \] (1)
Node 2: \[ \frac{V_2 - V_1}{1} + \frac{V_2}{1} + \frac{V_2}{1} = 0 \] (2)

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

\[ 3V_1 - V_2 = 16 \] (3)
\[ -V_1 + 3V_2 = 0. \] (4)

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

\[ V_1 = 6 \text{ V}, \quad V_2 = 2 \text{ V}. \]

(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.](image)

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.

![Circuit for Problem 3.14](image-url)

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

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

$$\frac{V_2 - V_1}{0.5} + \frac{V_2}{0.1} + \frac{V_2 - V_3}{0.5} = 0 \quad (2)$$

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

Simplification, followed with simultaneous solution, leads to

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

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 $V$.

![Circuit for Problem 3.26](image)

**Solution:** Application of KVL to the two loops gives:

Mesh 1: $\quad -16 + 2I_1 + 3(I_1 - I_2) = 0$,

Mesh 2: $\quad 3(I_2 - I_1) + (2 + 4)I_2 + 12 = 0$,

which can be simplified to

$$5I_1 - 3I_2 = 16 \quad (1)$$

$$-3I_1 + 9I_2 = -12 \quad (2)$$

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

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

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.](image_url)

**Solution:**

Mesh 1: \[2I_1 + 3(I_1 - I_3) + 2(I_1 - I_2) + 48 = 0\]

Mesh 2: \[-48 + 2(I_2 - I_1) + 6(I_2 - I_3) + 4I_2 = 0\]

Mesh 3: \[I_3 = -4 \text{ A.}\]

Solution is:

\[I_1 = -8.4 \text{ A}, \quad I_2 = 0.6 \text{ A}, \quad I_3 = -4 \text{ A.}\]

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 $V_x$.

![Circuit for Problem 3.34](image)

**Solution:**

Mesh 1:  $-6 + 2I_1 + 3(I_1 - I_2) = 0$

Supermesh:  $3(I_2 - I_1) + 6I_3 = 0$

Auxiliary 1:  $I_3 - I_2 = 2V_x$

Auxiliary 2:  $V_x = 6I_3$

Solution is:

$I_1 = 4.5$ A,  $I_2 = 5.5$ A,  $I_3 = -0.5$ A.

$V_x = 6I_3 = 6 \times (-0.5) = -3$ V.