Problem 3.5  Apply nodal analysis to determine the voltage $V_R$ in the circuit of Fig. P3.5.

![Circuit for Problem 3.5](image)

**Solution:** At node $V$:

$$\frac{V - 12}{4} + \frac{V}{2} + \frac{V - 8}{4} = 0,$$

which leads to

$$V = 5 \text{ V}.$$

Hence,

$$V_R = 12 - V = 12 - 5 = 7 \text{ V}.$$
**Problem 3.6** Use the nodal-analysis method to find \( V_1 \) and \( V_2 \) in the circuit of Fig. P3.6 and then apply that to determine \( I_x \).

![Circuit for Problem 3.6](image)

**Figure P3.6:** Circuit for Problem 3.6.

**Solution:** At nodes \( V_1 \) and \( V_2 \):

Node 1:  
\[-2 + \frac{V_1}{6} + \frac{V_1 - V_2}{12} - 4 = 0\]  \hspace{1cm} (1)

Node 2:  
\[4 + \frac{V_2}{6} + \frac{V_2 - V_1}{12} - 3 = 0\]  \hspace{1cm} (2)

Simplifying Eq. (1):

\[V_1 \left(1 + \frac{1}{12}\right) - \frac{V_2}{12} = 6\]  \hspace{1cm} (1)

\[3V_1 - V_2 = 72\]  \hspace{1cm} (3)

Simplifying Eq. (2):

\[-\frac{V_1}{12} + \frac{V_2}{6} \left(1 + \frac{1}{12}\right) = -1\]  \hspace{1cm} (2)

\[-V_1 + 3V_2 = -12\]  \hspace{1cm} (4)

Solution of (3) and (4) simultaneously leads to:

\[V_1 = 25.5 \text{ V}, \quad V_2 = 4.5 \text{ V}.\]

The current \( I_x \) is given by

\[I_x = \frac{V_2 - V_1}{12} = \frac{4.5 - 25.5}{12} = \frac{-21}{12} = -1.75 \text{ A.}\]
Problem 3.27  Use mesh analysis to determine the amount of power supplied by the voltage source in the circuit of Fig. P3.27.

Solution:

Mesh 1: \( I_1 = 9 \text{ A} \)

Mesh 2: \( 2(I_2 - I_1) + 4(I_2 - I_3) = 0 \)

Mesh 3: \( 4(I_3 - I_2) + 8I_3 + 40 = 0 \)

Simplification leads to:

\[
6I_2 - 4I_3 = 18 \\
-4I_2 + 12I_3 = -40
\]

Solution is:

\( I_2 = 1 \text{ A}, \quad I_3 = -3 \text{ A.} \)

Power supplied by voltage source:

\[ P = VI = 40 \times (-3) = -120 \text{ W.} \]
Problem 3.43  Apply mesh analysis to the circuit of Fig. P3.43 to find $I_x$.

**Solution:**

Mesh 1:  
$$-4 + I_1 + 0.1(I_1 - I_2) + 0.2(I_1 - I_3) = 0$$

Mesh 2:  
$$0.1(I_2 - I_1) + 0.2I_2 + (I_2 - I_3) = 0$$

Mesh 3:  
$$0.2(I_3 - I_1) + (I_3 - I_2) + 0.1I_3 = 0$$

$$I_1 = 3.48 \text{ A}, \quad I_2 = 1.67 \text{ A}, \quad I_3 = 1.82 \text{ A}$$

$$I_x = I_3 - I_2 = 1.82 - 1.67 = 0.15 \text{ A}.$$
**Problem 3.54**  Develop a mesh-current matrix equation for the circuit in Fig. P3.54 by applying the by-inspection method. Solve for \(I_1\) to \(I_3\).

![Circuit for Problem 3.54.](image)

**Solution:**

\[
R_{11} = 5 + 10 = 15
\]

\[
R_{12} = R_{21} = -10
\]

\[
R_{13} = R_{31} = 0
\]

\[
R_{22} = 10 + 5 + 10 = 25
\]

\[
R_{23} = R_{32} = -10
\]

\[
R_{33} = 10 + 5 = 15
\]

\[
V_{t1} = 21
\]

\[
V_{t2} = 0
\]

\[
V_{t3} = 4.2
\]

Application of Eq. (3.29) gives:

\[
\begin{bmatrix}
15 & -10 & 0 \\
-10 & 25 & -10 \\
0 & -10 & 15
\end{bmatrix}
\begin{bmatrix}
I_1 \\
I_2 \\
I_3
\end{bmatrix}
= 
\begin{bmatrix}
21 \\
0 \\
4.2
\end{bmatrix}
\]

Matrix inversion gives:

\[
I_1 = 2.36 \text{ A}, \quad I_2 = 1.44 \text{ A}, \quad I_3 = 1.24 \text{ A}.
\]
Problem 3.65  Find the Thévenin equivalent circuit at terminals $(a,b)$ for the circuit in Fig. P3.65.

![Circuit Diagram](image)

**Figure P3.65:** Circuit for Problem 3.65.

**Solution:**

\[
\frac{V}{4} + \frac{V}{6} + \frac{V - 2}{3} = 4
\]

Hence, \( V = \frac{56}{9} \) V.

\[ V_{Th} = V_{oc} = V - 2 = \frac{56}{9} - 2 = 4.22 \text{ V} \]

Suppressing the sources:

Thévenin equivalent circuit:

\[ R_{Th} = \frac{4}{3} + 2.5 = 3.83 \Omega \]

\[ 4.22 \text{ V} \]

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