We name currents $I_1$, $I_2$, and $I_3$ as shown.

From Kirchhoff's current rule, $I_3 = I_1 + I_2$.

Applying Kirchhoff's voltage rule to the loop containing $I_2$ and $I_3$,

\[ 12.0 \text{ V} - (4.00) I_3 - (6.00) I_2 - 4.00 \text{ V} = 0 \]

\[ 8.00 = (4.00) I_3 + (6.00) I_2 \]

Applying Kirchhoff's voltage rule to the loop containing $I_1$ and $I_2$,

\[ -(6.00) I_2 - 4.00 \text{ V} + (8.00) I_1 = 0 \quad (8.00) I_2 = 4.00 + (6.00) I_2 \]

Solving the above linear system, we proceed to the pair of simultaneous equations:

\[ \begin{cases} 8 = 4 I_1 + 4 I_2 + 6 I_3 \\ 8 = 4 I_4 + 10 I_2 \end{cases} \quad \text{or} \quad \begin{cases} 8 = 4 I_4 + 10 I_2 \\ I_2 = 1.33 I_4 - 0.667 \end{cases} \]

and to the single equation $8 = 4 I_4 + 13.3 I_4 - 6.67$

\[ I_4 = \frac{14.7 \text{ V}}{17.3 \Omega} = 0.846 \text{ A} \quad \text{Then} \quad I_2 = 1.33(0.846 \text{ A}) - 0.667 \]

and $I_3 = I_1 + I_2$ give $I_1 = 546 \text{ m A}, I_2 = 462 \text{ m A}, I_3 = 1.31 \text{ A}$.

All currents are in the directions indicated by the arrows in the circuit diagram.

Label the currents in the branches as shown in the first figure. Reduce the circuit by combining the two parallel resistors as shown in the second figure.

Apply Kirchhoff's loop rule to both loops in Figure (b) to obtain:

\[ (2.71 R) I_1 + (1.71 R) I_2 = 250 \]

and

\[ (1.71 R) I_1 + (3.71 R) I_2 = 500 \]

With $R = 1000 \Omega$, simultaneous solution of these equations yields:

\[ I_1 = 10.0 \text{ mA} \]

and

\[ I_2 = 130.0 \text{ mA} \]

From Figure (b),

\[ V_c - V_a = (I_1 + I_2)(1.71 R) = 240 \text{ V} \]

Thus, from Figure (a),

\[ I_4 = \frac{V_c - V_a}{4R} = \frac{240 \text{ V}}{4 \times 1000 \Omega} = 60.0 \text{ mA} \]

Finally, applying Kirchhoff’s point rule at point $a$ in Figure (a) gives:

\[ I = I_4 - I_1 = 60.0 \text{ mA} - 10.0 \text{ mA} = 50.0 \text{ mA} \]

or

\[ I = 50.0 \text{ mA from point to point} \]
P28.26 Name the currents as shown in the figure to the right. Then \( w + x + z = y \). Loop equations are

\[
\begin{align*}
-200w - 40.0x + 80.0x &= 0 \\
-80.0x + 40.0y + 360 - 20.0y &= 0 \\
+360 - 20.0y - 70.0z + 80.0 &= 0
\end{align*}
\]

Eliminate \( y \) by substitution.

\[
\begin{align*}
x = 2.50w + 0.500 \\
400 - 100x = 20.0y + 20.0z = 0 \\
440 - 20.0w - 20.0x - 90.0z = 0
\end{align*}
\]

Eliminate \( x \).

\[
\begin{align*}
350 - 270w - 20.0z &= 0 \\
430 - 70.0w - 90.0z &= 0
\end{align*}
\]

Eliminate \( z = 17.5 - 13.5w \) to obtain

\[
430 - 70.0w - 1.575 + 1.215w = 0
\]

\[
w = \frac{70.0}{70.0} = \frac{1.00 \text{ A upw and in 200 } \Omega}{70.0}
\]

Now

\[
z = \frac{4.00 \text{ A upw and in 70.0 } \Omega}{70.0}
\]

\[
x = \frac{3.00 \text{ A upw and in 80.0 } \Omega}{70.0}
\]

\[
y = \frac{8.00 \text{ A downw and in 20.0 } \Omega}{70.0}
\]

and for the 200 \( \Omega \),

\[
\Delta V = \vec{R} = (1.00 \text{ A})(200 \Omega) = 200 \text{ V}
\]

P28.27 Using Kirchhoff's rules,

\[
12.0 - (0.010 \Omega) I_1 - (0.060 \Omega) I_3 = 0
\]

\[10.0 + (1.00 \Omega) I_2 - (0.060 \Omega) I_3 = 0\]

and

\[
I_1 = I_2 + I_3
\]

\[
12.0 - (0.010 \Omega) I_2 - (0.070 \Omega) I_3 = 0
\]

\[10.0 + (1.00 \Omega) I_2 - (0.060 \Omega) I_3 = 0\]

Solving simultaneously,

\[
I_2 = \frac{0.283 \text{ A downw and in the dead battery}}{0.060 \Omega}
\]

and

\[
I_3 = \frac{171 \text{ A downw and in the starter}}{1.00 \Omega}
\]

The currents are forward in the live battery and in the starter, relative to normal starting operation. The current is backward in the dead battery, tending to charge it up.

P28.27 Using Kirchhoff's rules,

\[
12.0 - (0.010 \Omega) I_1 - (0.060 \Omega) I_3 = 0
\]

\[10.0 + (1.00 \Omega) I_2 - (0.060 \Omega) I_3 = 0\]

and

\[
I_1 = I_2 + I_3
\]

\[
12.0 - (0.010 \Omega) I_2 - (0.070 \Omega) I_3 = 0
\]

\[10.0 + (1.00 \Omega) I_2 - (0.060 \Omega) I_3 = 0\]

Solving simultaneously,
\[ I_2 = 0.283 \text{ A} \text{ dow nw arl} \text{ in the dead battery} \]

and \[ I_3 = 171 \text{ A} \text{ dow nw arl} \text{ in the starter}. \]

The currents are forward in the live battery and in the starter, relative to normal starting operation. The current is backward in the dead battery, tending to charge it up.