P1.25 (a) \( p(t) = v_i i = 50 \sin(200\pi t) \) W

(b) \( w = \int_0^{0.005} p(t)dt = \int_0^{0.005} 50 \sin(200\pi t)dt = (50 / 200\pi) \cos(200\pi t)|_0^{0.005} = 0.1592 \) J

(c) \( w = \int_0^{0.01} p(t)dt = \int_0^{0.01} 50 \sin(200\pi t)dt = (50 / 200\pi) \cos(200\pi t)|_0^{0.01} = 0 \) J

P1.26* Energy = \( \frac{\text{Cost}}{\text{Rate}} = \frac{\$60}{0.12 \$/\text{kWh}} = 500 \text{ kWh} \)

\[ P = \frac{\text{Energy}}{\text{Time}} = \frac{500 \text{ kWh}}{30 \times 24 \text{ h}} = 694.4 \text{ W} \]

\[ I = \frac{P}{V} = \frac{694.4}{120} = 5.787 \text{ A} \]

Reduction = \( \frac{60}{694.4} \times 100\% = 8.64\% \)

P1.27 (a) \( P = 60 \text{ W delivered to element } A \).
(b) \( P = 60 \text{ W taken from element } A \).
(c) \( P = 60 \text{ W delivered to element } A \).

P1.28* (a) \( P = 60 \text{ W taken from element } A \).
(b) \( P = 60 \text{ W delivered to element } A \).
(c) \( P = 60 \text{ W taken from element } A \).

P1.29 The power that can be delivered by the cell is \( P = vi = 0.12 \) W. In 75 hours, the energy delivered is \( W = PT = 9 \text{ Whr} = 0.009 \text{ kWhr} \). Thus the unit cost of the energy is \( Cost = (0.50)/(0.009) = 55.56 \$/\text{kWhr} \) which is 463 times the typical cost of energy from electric utilities.
(a) Elements $C$ and $D$ are in series.
(b) Because elements $C$ and $D$ are in series, the currents are equal in magnitude. However, because the reference directions are opposite, the algebraic signs of the current values are opposite. Thus, we have $i_c = -i_d$.
(c) At the node joining elements $A$, $B$, and $C$, we can write the KCL equation $i_b = i_a + i_c = 3 + 1 = 4$ A. Also we found earlier that $i_d = -i_c = -1$ A.

**P1.37** At the node joining elements $A$ and $B$, we have $i_a + i_b = 0$. Thus, $i_a = -2$ A. For the node at the top end of element $C$, we have $i_b + i_c = 3$. Thus, $i_c = 1$ A. Finally, at the top right-hand corner node, we have $3 + i_e = i_d$. Thus, $i_d = 4$ A. Elements $A$ and $B$ are in series.

**P1.38** We are given $i_a = 2$ A, $i_b = 3$ A, $i_d = -5$ A, and $i_h = 4$ A. Applying KCL, we find

\[i_c = i_b - i_a = 1 \text{ A} \quad i_e = i_e + i_h = 5 \text{ A}\]
\[i_f = i_a + i_d = -3 \text{ A} \quad i_g = i_f - i_h = -7 \text{ A}\]

**P1.39** We are given $i_a = -1$ A, $i_c = 3$ A, $i_g = 5$ A, and $i_h = 1$ A. Applying KCL, we find

\[i_b = i_c + i_a = 2 \text{ A} \quad i_e = i_c + i_h = 4 \text{ A}\]
\[i_d = i_f - i_a = 7 \text{ A} \quad i_f = i_g + i_h = 6 \text{ A}\]

**P1.40** If one travels around a closed path adding the voltages for which one enters the positive reference and subtracting the voltages for which one enters the negative reference, the total is zero.

**P1.41** (a) Elements $A$ and $B$ are in parallel.
(b) Because elements $A$ and $B$ are in parallel, the voltages are equal in magnitude. However because the reference polarities are opposite, the algebraic signs of the voltage values are opposite. Thus, we have $v_a = -v_b$.
(c) Writing a KVL equation while going clockwise around the loop composed of elements $A$, $C$ and $D$, we obtain $v_a - v_a - v_c = 0$. Solving for $v_c$ and substituting values, we find $v_c = 7$ V. Also we have $v_b = -v_a = -2$ V.
P1.42* Summing voltages for the lower left-hand loop, we have \(-5 + \nu_a + 10 = 0\), which yields \(\nu_a = -5\) V. Then for the top-most loop, we have \(\nu_c - 15 - \nu_a = 0\), which yields \(\nu_c = 10\) V. Finally, writing KCL around the outside loop, we have \(-5 + \nu_c + \nu_b = 0\), which yields \(\nu_b = -5\) V.

P1.43 We are given \(\nu_a = 5\) V, \(\nu_b = 7\) V, \(\nu_f = -10\) V, and \(\nu_h = 6\) V. Applying KVL, we find
\[
\begin{align*}
\nu_d &= \nu_a + \nu_b = 12\text{ V} \\
\nu_e &= -\nu_a - \nu_c + \nu_d = 8\text{ V} \\
\nu_b &= \nu_c + \nu_e = 7\text{ V}
\end{align*}
\]
\[
\begin{align*}
\nu_c &= -\nu_a - \nu_f - \nu_h = -1\text{ V} \\
\nu_g &= \nu_e - \nu_h = 2\text{ V}
\end{align*}
\]

P1.44* Applying KCL and KVL, we have
\[
\begin{align*}
i_c &= i_a - i_d = 1\text{ A} \\
i_b &= -i_a = -2\text{ A} \\
v_b &= \nu_d - \nu_a = -6\text{ V} \\
v_c &= \nu_d = 4\text{ V}
\end{align*}
\]
The power for each element is
\[
\begin{align*}
P_A &= -\nu_e i_a = -20\text{ W} \\
P_B &= \nu_b i_a = 12\text{ W} \\
P_C &= \nu_c i_c = 4\text{ W} \\
P_D &= \nu_d i_d = 4\text{ W}
\end{align*}
\]
Thus, \(P_A + P_B + P_C + P_D = 0\)

P1.45 (a) In Figure P1.28, elements \(C, D,\) and \(E\) are in parallel. (b) In Figure P1.33, no element is in parallel with another element. (c) In Figure P1.34, elements \(C\) and \(D\) are in parallel.

P1.46 The points and the voltages specified in the problem statement are:
\[
\begin{align*}
\nu_{ab} &= 5 \\
\nu_{da} &= -10 \\
\nu_{cb} &= 15
\end{align*}
\]
Applying KVL to the loop \(abca\), substituting values and solving, we obtain:
\[
\begin{align*}
\nu_{ab} - \nu_{cb} - \nu_{ac} &= 0 \\
5 - 15 - \nu_{ac} &= 0
\end{align*}
\]
\(\nu_{ac} = -10\) V
Similarly, applying KVL to the loop \( abcda \), substituting values and solving, we obtain:

\[
\begin{align*}
\nu_{ab} - \nu_{cb} + \nu_{cd} + \nu_{da} &= 0 \\
5 - 15 + \nu_{cd} - 10 &= 0 \\
\nu_{cd} &= 20 \text{ V}
\end{align*}
\]

**P1.47**

(a) The voltage between any two points of an ideal conductor is zero regardless of the current flowing.

(b) An ideal voltage source maintains a specified voltage across its terminals.

(c) An ideal current source maintains a specified current through itself.

**P1.48**

Four types of controlled sources and the units for their gain constants are:

1. Voltage-controlled voltage sources. \( V/V \) or unitless.
2. Voltage-controlled current sources. \( A/V \) or siemens.
3. Current-controlled voltage sources. \( V/A \) or ohms.
4. Current-controlled current sources. \( A/A \) or unitless.

**P1.49**

Provided that the current reference points into the positive voltage reference, the voltage across a resistance equals the current through the resistance times the resistance. On the other hand, if the current reference points into the negative voltage reference, the voltage equals the negative of the product of the current and the resistance.

**P1.50**
P2.3  (a) \( R_{eq} = 25 \Omega \)  \hspace{1cm} (b) \( R_{eq} = 24 \Omega \)

P2.4* We have \( 4 + \frac{1}{20 + 1/R_x} = 8 \) which yields \( R_x = 5 \Omega \).

P2.5 We have \( \frac{1}{120 + 1/R_x} = 48 \) which yields \( R_x = 80 \Omega \).

P2.6 We have \( R_{eq} = \frac{R(3R)}{R + 3R} = \frac{3R}{4} \). Clearly, for \( R_{eq} \) to be an integer, \( R \) must be an integer multiple of 4.

P2.7 \( R_{ab} = 6 \ \Omega \)

P2.8 Because the resistances are in parallel, the same voltage \( v \) appears across both of them. The current through \( R_1 \) is \( i_1 = v/100 \). The current through \( R_2 \) is \( i_2 = 2i_1 = 2v/100 \). Finally we have \( R_2 = v/i_2 = v/(2v/100) = 50 \ \Omega \).

P2.9 Combining the resistances shown in Figure P2.9b, we have

\[
R_{eq} = 1 + \frac{1}{1 + 1/R_{eq}} + 1 = 2 + \frac{R_{eq}}{1 + R_{eq}}
\]

\[
R_{eq} (1 + R_{eq}) = 2(1 + R_{eq}) + R_{eq}
\]

\[
(R_{eq})^2 - 2R_{eq} - 2 = 0
\]

\[
R_{eq} = 2.732 \ \Omega
\]

\( R_{eq} = -0.732 \ \Omega \) is another root, but is not physically reasonable.

P2.10* The 12-\( \Omega \) and 6-\( \Omega \) resistances are in parallel having an equivalent resistance of 4 \( \Omega \). Similarly, the 18-\( \Omega \) and 9-\( \Omega \) resistances are in parallel.
\( \frac{v_3}{20} + \frac{v_3 - v_1}{20} + \frac{v_3 - v_2}{10} = 0 \)

Solving, we find \( R_{eq} = v_1 = 13.33 \).

P2.55* First, we can write: \( i_x = \frac{v_1 - v_2}{5} \).

Then, writing KCL equations at nodes 1 and 2, we have:
\[
\frac{v_1}{10} + i_x = 1 \quad \text{and} \quad \frac{v_2}{20} + 0.5i_x - i_x = 0
\]

Substituting for \( i_x \) and simplifying, we have
\[
0.3v_1 - 0.2v_2 = 1 \\
-0.1v_1 + 0.15v_2 = 0
\]

Solving, we have \( v_1 = 6 \) and \( v_2 = 4 \).

Then, we have \( i_x = \frac{v_1 - v_2}{5} = 0.4 \text{ A} \).

P2.56 First, we can write \( i_x = \frac{v_1}{10} \). Then writing KVL, we have \( v_1 - 5i_x - v_2 = 0 \).

Writing KCL at the reference node, we have \( i_x + \frac{v_2}{20} = 8 \). Using the first equation to substitute for \( i_x \) and simplifying, we have
\[
0.5v_1 - v_2 = 0 \\
2v_1 + v_2 = 160
\]

Solving, we find \( v_1 = 64 \), \( v_2 = 32 \), and \( i_x = \frac{v_1}{10} = 6.4 \text{ A} \). Finally, the power delivered to the 16-Ω resistance is \( P = \frac{(v_1 - v_2)^2}{16} = 64 \text{ W} \).

P2.57* \( v_x = v_2 - v_1 \)

Writing KCL at nodes 1 and 2:
\[
\frac{v_1}{5} + \frac{v_1 - 2v_x}{15} + \frac{v_1 - v_2}{10} = 1
\]
\[
\frac{v_2}{5} + \frac{v_2 - 2v_x}{10} + \frac{v_2 - v_1}{10} = 2
\]
Finally, the power delivered by the source is $P = 10i_1 = 10$ W.

P2.66

\[ 4i_A + 28(i_A - i_B) = 16 \]
\[ 28(i_B - i_A) + 7i_B + 14i_B = 0 \]
Solving we find $i_A = 1$ A and $i_B = 0.5714$ A. Then we have $i_1 = i_A = 1$ A and $i_2 = i_A - i_B = 0.4286$ A.

P2.67 Mesh A: $10i_A + 5i_A + 10(i_A - i_B) = 0$
By inspection: $i_B = 2$

Solving, we find $i_A = 0.8$ A. Then we have $i_1 = i_A = 0.8$ A and $i_2 = i_B - i_A = 1.2$ A.

P2.68 First we select mesh-current variables as shown.

Then, we can write
\[(R_w + R_n + R_i)i_i - R_n i_2 - R_i i_3 = 120\]
\[-R_n i_1 + (R_w + R_n + R_i)i_1 - R_i i_3 = 120\]
\[-R_i i_1 - R_2 i_2 + (R_1 + R_2 + R_3)i_3 = 0\]

Substituting values for the resistances and solving we find
\[i_1 = i_2 = 40.58 \text{ A} \text{ and } i_3 = 28.99 \text{ A} .\] Then, the voltages across \(R_1\) and \(R_2\) are both \(10(i_1 - i_3) = 115.9 \text{ V}\) and the voltage across \(R_3\) is \(8i_3 = 231.9 \text{ V}\). The current through the neutral wire is \(i_1 - i_2 = 0\).

P2.69

![Diagram of a circuit with two loops and a 10 V source.]

Writing and simplifying the mesh equations, we obtain:
\[40i_1 - 20i_2 = 10\]
\[-20i_1 + 40i_2 = 0\]

Solving, we find \(i_1 = 0.3333\) and \(i_2 = 0.1667\).
Thus, \(V = 20(i_1 - i_2) = 3.333 \text{ V}\).

P2.70

The mesh currents and corresponding equations are:

\[i_1 = 8 \text{ A} \quad (i_2 - i_1) + 5i_2 = 0\]

Solving, we find \(i_2 = 6 \text{ A}\).
However, \(i_3\) shown in Figure P2.44 is the same as \(i_2\), so the answer is \(i_3 = 6 \text{ A}\).

P2.71*

Because of the current sources, two of the mesh currents are known.