P1.1 Four reasons that non-electrical engineering majors need to learn the fundamentals of EE are:

1. To pass the Fundamentals of Engineering Exam.
2. To be able to lead in the design of systems that contain electrical/electronic elements.
3. To be able to operate and maintain systems that contain electrical/electronic functional blocks.
4. To be able to communicate effectively with electrical engineers.

P1.5 Electrons per second = \( \frac{1 \text{ coulomb/s}}{1.60 \times 10^{-19} \text{ coulomb/electron}} = 6.25 \times 10^{18} \)

P1.8 (a) The sine function completes one cycle for each \( 2\pi \) radian increase in the angle. Because the angle is \( 200\pi \), one cycle is completed for each time interval of \( 0.01 \) s. The sketch is:

![Sketch of a sine wave]

P1.9 \( Q = \int_{0}^{\infty} i(t) \, dt = \int_{0}^{\infty} 2e^{-t} \, dt = -2e^{-t} \bigg|_{0}^{\infty} = 2 \text{ coulombs} \)
The number of electrons passing through a cross section of the wire per second is

$$N = \frac{15}{1.6 \times 10^{-19}} = 9.375 \times 10^{19} \text{ electrons/second}$$

The volume of copper containing this number of electrons is

$$\text{volume} = \frac{9.375 \times 10^{19}}{10^{29}} = 9.375 \times 10^{-10} \text{ m}^3$$

The cross sectional area of the wire is

$$A = \frac{\pi d^2}{4} = 3.301 \times 10^{-6} \text{ m}^2$$

Finally, the average velocity of the electrons is

$$u = \frac{\text{volume}}{A} = 0.2840 \text{ mm/s}$$

Q = current $\times$ time = (5 amperes) $\times$ (36,000 seconds) = $1.8 \times 10^5$ coulombs

Energy = $QV = (1.8 \times 10^5) \times (12) = 2.16 \times 10^6$ joules

The amount of energy is $W = QV = (3 \text{ C}) \times (10 \text{ V}) = 30 \text{ J}$. Because the reference polarity is positive at terminal $a$ and the voltage value is negative, terminal $b$ is actually the positive terminal. Because the charge moves from the negative terminal to the positive terminal, energy is removed from the device.

$p(t) = \nu(t)i(t) = 20e^{-t}$ W

Energy = $\int_0^\infty p(t) \, dt = -20e^{-t} \bigg|_0^\infty = 20$ joules

The element absorbs the energy.
P1.19* Energy = \frac{\text{Cost}}{\text{Rate}} = \frac{\$40}{0.1 \$/\text{kWh}} = 400 \text{ kWh}

\[ P = \frac{\text{Energy}}{\text{Time}} = \frac{400 \text{ kWh}}{30 \times 24 \text{ h}} = 555.5 \text{ W} \quad I = \frac{P}{V} = \frac{555.5}{120} = 4.630 \text{ A} \]

Reduction = \frac{40}{555.5} \times 100\% = 7.20\%

P1.26* Elements A and B are in series. Also elements E and F are in series.

P1.29* We are given \( i_a = 2 \text{ A} \), \( i_b = 3 \text{ A} \), \( i_c = -5 \text{ A} \), and \( i_h = 4 \text{ A} \). Applying KCL, we find

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

P1.30 We are given \( i_a = -1 \text{ A} \), \( i_c = 3 \text{ A} \), \( i_g = 5 \text{ A} \), and \( i_h = 1 \text{ A} \). Applying KCL, we find

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

P1.40 The resistance of the copper wire is given by \( R_{cu} = \rho_{cu} L/A \), and the resistance of the tungsten wire is \( R_w = \rho_w L/A \). Taking the ratios of the respective sides of these equations yields \( R_w/R_{cu} = \rho_w/\rho_{cu} \). Solving for \( R_w \) and substituting values, we have

\[ R_w = R_{cu} \rho_w/\rho_{cu} \]
\[ = (0.5) \times (5.44 \times 10^{-8})/(1.72 \times 10^{-8}) \]
\[ = 1.58 \Omega \]
As shown above, the 2 A current circulates clockwise through all three elements in the circuit. Applying KVL, we have
\[ \nu_c = \nu_R + 10 = 5i_R + 10 = 20 \text{ V} \]

\[ P_{\text{current-source}} = -\nu_c i_R = -40 \text{ W}. \] Thus, the current source delivers power.

\[ P_R = (i_R)^2 R = 2^2 \times 5 = 20 \text{ W}. \] The resistor absorbs power.

\[ P_{\text{voltage-source}} = 10 \times i_R = 20 \text{ W}. \] The voltage source absorbs power.

Applying Ohm’s law, we have \( \nu_2 = (5 \Omega) \times (1 \text{ A}) = 5 \text{ V} \). However, \( \nu_2 \) is the voltage across all three resistors that are in parallel. Thus,
\[ i_3 = \frac{\nu_2}{5} = 1 \text{ A}, \] and \[ i_5 = \frac{\nu_2}{10} = 0.5 \text{ A}. \] Applying KCL, we have
\[ i_1 = i_2 + i_3 + 1 = 2.5 \text{ A}. \] By Ohm’s law: \( \nu_1 = 5i_1 = 12.5 \text{ V} \). Finally using KVL, we have \( \nu_A = \nu_1 + \nu_2 = 17.5 \text{ V} \).
\[ V_x = (4 \, \Omega) \times (1 \, \text{A}) = 4 \, \text{V} \quad \text{and} \quad I_x = I_x/2 + 1 = 3 \, \text{A} \]

Applying KVL around the outside of the circuit:

\[ V_s = 3I_x + 4 + 2 = 15 \, \text{V} \]

**P1.58** \[ I_x = -30 \, \text{V}/15 \, \Omega = -2 \, \text{A} \]

Applying KCL for the node at the top end of the controlled current source:

\[ I_x = I_x/2 - I_x = -I_x/2 = 1 \, \text{A} \]

The source labeled \( I_x \) is an independent current source. The source labeled \( I_x/2 \) is a current-controlled current source.