P 1.8 First we use Eq. (1.2) to relate current and charge:

$$i = \frac{dq}{dt} = 20\cos 5000t$$

Therefore, $dq = 20\cos 5000t\, dt$

To find the charge, we can integrate both sides of the last equation. Note that we substitute x for q on the left side of the integral, and y for t on the right side of the integral:

$$\int_{q(0)}^{q(t)} dx = 20\int_0^t \cos 5000y\, dy$$

We solve the integral and make the substitutions for the limits of the integral, remembering that $\sin 0 = 0$:

$$q(t) - q(0) = 20\frac{\sin 5000y}{5000}\Big|_0^t = \frac{20}{5000}\sin 5000t - \frac{20}{5000}\sin 5000(0) = \frac{20}{5000}\sin 5000t$$

But $q(0) = 0$ by hypothesis, i.e., the current passes through its maximum value at $t = 0$, so $q(t) = 4\times 10^{-3}\sin 5000t\ \mathrm{C} = 4\sin 5000t\ \mathrm{mC}$

P 1.9 [a] First we use Eq. (1.2) to relate current and charge:

$$i = \frac{dq}{dt} = 40te^{-500t}$$

Therefore, $dq = 40te^{-500t}\,dt$

To find the charge, we can integrate both sides of the last equation. Note that we substitute x for q on the left side of the integral, and y for t on the right side of the integral:

$$\int_{q(0)}^{q(t)} dx = 40\int_0^t ye^{-500y}\,dy$$

We solve the integral and make the substitutions for the limits of the integral:

$$q(t) - q(0) = 40\frac{e^{-500y}}{(-500)^2}(-500y - 1)\bigg|_0^t = 160\times10^{-6}e^{-500t}(-500t-1) + 160\times10^{-6}$$

$$= 160\times10^{-6}(1 - 500te^{-500t} - e^{-500t})$$

But $q(0) = 0$ by hypothesis, so

$$q(t) = 160(1 - 500te^{-500t} - e^{-500t})\,\mu\text{C}$$

[b] $q(0.001) = (160)[1 - 500(0.001)e^{-500(0.001)} - e^{-500(0.001)} = 14.4\,\mu\text{C}.$

P 1.14 Assume we are standing at box A looking toward box B. Use the passive sign convention to get $p = vi$, since the current i is flowing into the + terminal of the voltage v. Now we just substitute the values for v and i into the equation for power. Remember that if the power is positive, B is absorbing power, so the power must be flowing from A to B. If the power is negative, B is generating power so the power must be flowing from B to A.

[a] $p = (30)(6) = 180$ W   180 W from A to B

[b] $p = (-20)(-8) = 160$ W   160 W from A to B

[c] $p = (-60)(4) = -240$ W   240 W from B to A

[d] $p = (40)(-9) = -360$ W   360 W from B to A

P 1.20 [**a**] $p = vi = 0.25e^{-3200t} - 0.5e^{-2000t} + 0.25e^{-800t}$

$$p(625\,\mu\text{s}) = 42.2 \text{ mW}$$

[**b**]

$$\begin{aligned} w(t) &= \int_0^t (0.25e^{-3200t} - 0.5e^{-2000t} + 0.25e^{-800t}) \\ &= 140.625 - 78.125e^{-3200t} + 250e^{-2000t} - 312.5e^{-800t}\,\mu\text{J} \\ w(625\,\mu\text{s}) &= 12.14\,\mu\text{J} \end{aligned}$$

[**c**] $w_{\text{total}} = 140.625\,\mu\text{J}$

P 1.26 **[a]**

$$\begin{aligned} q &= \text{area under } i \text{ vs. } t \text{ plot} \\ &= \tfrac{1}{2}(8)(12{,}000) + (16)(12{,}000) + \tfrac{1}{2}(16)(4000) \\ &= 48{,}000 + 192{,}000 + 32{,}000 = 272{,}000 \text{ C} \end{aligned}$$

[b]

$$\begin{aligned} w &= \int p\,dt = \int vi\,dt \\ v &= 250 \times 10^{-6}t + 8 \qquad 0 \leq t \leq 16 \text{ ks} \end{aligned}$$

$0 \leq t \leq 12{,}000s$:

$$\begin{aligned} i &= 24 - 666.67 \times 10^{-6}t \\ p &= 192 + 666.67 \times 10^{-6}t - 166.67 \times 10^{-9}t^2 \\ w_1 &= \int_0^{12{,}000} (192 + 666.67 \times 10^{-6}t - 166.67 \times 10^{-9}t^2)\,dt \\ &= (2304 + 48 - 96)10^3 = 2256 \text{ kJ} \end{aligned}$$

$12{,}000 \text{ s} \le t \le 16{,}000 \text{ s}$:

$$
\begin{aligned}
i &= 64 - 4 \times 10^{-3}t \\
p &= 512 - 16 \times 10^{-3}t - 10^{-6}t^2 \\
w_2 &= \int_{12{,}000}^{16{,}000} (512 - 16 \times 10^{-3}t - 10^{-6}t^2)\, dt \\
&= (2048 - 896 - 789.33)10^3 = 362.667 \text{ kJ} \\
w_T &= w_1 + w_2 = 2256 + 362.667 = 2618.667 \text{ kJ}
\end{aligned}
$$

P 1.29 We use the passive sign convention to determine whether the power equation is $p = vi$ or $p = -vi$ and substitute into the power equation the values for v and i, as shown below:

$$\begin{aligned}
p_{\rm a} &= -v_{\rm a}i_{\rm a} = -(40)(-4 \times 10^{-3}) = 160 \text{ mW} \\
p_{\rm b} &= v_{\rm b}i_{\rm b} = (-24)(-4 \times 10^{-3}) = 96 \text{ mW} \\
p_{\rm c} &= -v_{\rm c}i_{\rm c} = -(-16)(4 \times 10^{-3}) = 64 \text{ mW} \\
p_{\rm d} &= -v_{\rm d}i_{\rm d} = -(-80)(-1.5 \times 10^{-3}) = -120 \text{ mW} \\
p_{\rm e} &= v_{\rm e}i_{\rm e} = (40)(2.5 \times 10^{-3}) = 100 \text{ mW} \\
p_{\rm f} &= v_{\rm f}i_{\rm f} = (120)(-2.5 \times 10^{-3}) = -300 \text{ mW}
\end{aligned}$$

Remember that if the power is positive, the circuit element is absorbing power, whereas is the power is negative, the circuit element is developing power. We can add the positive powers together and the negative powers together — if the power balances, these power sums should be equal:

$\sum P_{\rm dev} = 120 + 300 = 420$ mW;

$\sum P_{\rm abs} = 160 + 96 + 64 + 100 = 420$ mW

Thus, the power balances and the total power absorbed in the circuit is 420 mW.