CHAPTER 1

Exercises

E1.1 Charge = Current $\times$ Time = (2 *A*) $\times$ (10 s) = 20 *C*

E1.2 $i(t) = \frac{dq(t)}{dt} = \frac{d}{dt}(0.01\sin(200t) = 0.01 \times 200\cos(200t) = 2\cos(200t)$ *A*

E1.3 Because i_2 has a positive value, positive charge moves in the same direction as the reference. Thus, positive charge moves downward in element *C*.

Because i_3 has a negative value, positive charge moves in the opposite direction to the reference. Thus positive charge moves upward in element *E*.

E1.4 Energy = Charge $\times$ Voltage = (2 *C*) $\times$ (20 V) = 40 J

Because v_{ab} is positive, the positive terminal is *a* and the negative terminal is *b*. Thus the charge moves from the negative terminal to the positive terminal, and energy is removed from the circuit element.

E1.5 i_{ab} enters terminal *a*. Furthermore, v_{ab} is positive at terminal *a*. Thus the current enters the positive reference, and we have the passive reference configuration.

E1.6 (a) $p_a(t) = v_a(t)i_a(t) = 20t^2$

$$w_a = \int_0^{10} p_a(t)dt = \int_0^{10} 20t^2 dt = \left.\frac{20t^3}{3}\right|_0^{10} = \frac{20t^3}{3} = 6667 \text{ J}$$

(b) Notice that the references are opposite to the passive sign convention. Thus we have:

$$p_b(t) = -v_b(t)i_b(t) = 20t - 200$$

$$w_b = \int_0^{10} p_b(t)dt = \int_0^{10} (20t - 200)dt = 10t^2 - 200t\Big|_0^{10} = -1000 \text{ J}$$

E1.7 (a) Sum of currents leaving = Sum of currents entering

$i_a = 1 + 3 = 4$ A

(b) $2 = 1 + 3 + i_b \Rightarrow i_b = -2$ A

(c) $0 = 1 + i_c + 4 + 3 \Rightarrow i_c = -8$ A

E1.8 Elements A and B are in series. Also, elements E, F, and G are in series.

E1.9 Go clockwise around the loop consisting of elements A, B, and C:

$-3 - 5 + v_c = 0 \Rightarrow v_c = 8$ V

Then go clockwise around the loop composed of elements C, D and E:

$-v_c - (-10) + v_e = 0 \Rightarrow v_e = -2$ V

E1.10 Elements E and F are in parallel; elements A and B are in series.

E1.11 The resistance of a wire is given by $R = \dfrac{\rho L}{A}$. Using $A = \pi d^2/4$ and substituting values, we have:

$$9.6 = \frac{1.12 \times 10^{-6} \times L}{\pi(1.6 \times 10^{-3})^2/4} \quad \Rightarrow \quad L = 17.2 \text{ m}$$

E1.12 $P = V^2/R \Rightarrow R = V^2/P = 144\ \Omega \Rightarrow I = V/R = 120/144 = 0.833$ A

E1.13 $P = V^2/R \Rightarrow V = \sqrt{PR} = \sqrt{0.25 \times 1000} = 15.8$ V

$I = V/R = 15.8/1000 = 15.8$ mA

E1.14 Using KCL at the top node of the circuit, we have $i_1 = i_2$. Then, using KVL going clockwise, we have $-v_1 - v_2 = 0$; but $v_1 = 25$ V, so we have $v_2 = -25$ V. Next we have $i_1 = i_2 = v_2/R = -1$ A. Finally, we have $P_R = v_2 i_2 = (-25) \times (-1) = 25$ W and $P_s = v_1 i_1 = (25) \times (-1) = -25$ W.

E1.15 At the top node we have $i_R = i_s = 2$A. By Ohm's law we have $v_R = Ri_R = 80$ V. By KVL we have $v_s = v_R = 80$ V. Then $p_s = -v_s i_s = -160$ W (the minus sign is due to the fact that the references for v_s and i_s are opposite to the passive sign configuration). Also we have $P_R = v_R i_R = 160$ W.

Answers for Selected Problems

P1.7* Electrons are moving in the reference direction (i.e., from a to b).

$Q = 9\ C$

P1.9* $i(t) = 2 + 2t\ A$

P1.12* $Q = 2$ coulombs

P1.14* (a) $h = 17.6$ km
(b) $v = 587.9$ m/s
(c) The energy density of the battery is 172.8×10^3 J/kg which is about 0.384% of the energy density of gasoline.

P1.17* $Q = 3.6 \times 10^5$ coulombs

Energy $= 4.536 \times 10^6$ joules

P1.20* (a) 30 W absorbed
(b) 30 W absorbed
(c) 60 W supplied

P1.22* $Q = 50\ C$. Electrons move from b to a.

P1.24* Energy $= 500$ kWh

$P = 694.4$ W $\qquad I = 5.787\ A$

Reduction $= 8.64\%$

P1.27* (a) $P =$ 50 W taken from element A.
(b) $P =$ 50 W taken from element A.
(c) $P = 50$ W delivered to element A.

P1.34* Elements E and F are in series.

P1.36* $i_a = -2$ A. $i_c = 1$ A. $i_d = 4$ A. Elements A and B are in series.

P1.37*

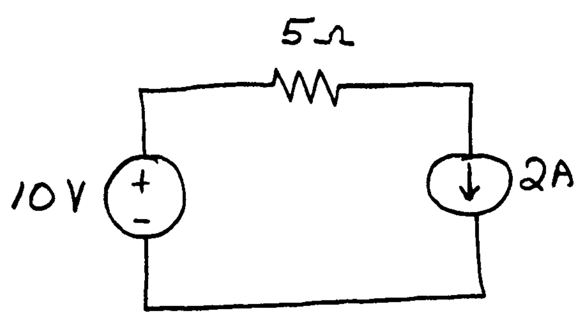
$i_c = 1\ A$	$i_e = 5\ A$
$i_f = -3\ A$	$i_g = -7\ A$

P1.41* $v_a = -5$ V. $v_c = 10$ V. $v_b = -5$ V.

P1.42*

$i_c = 1\ A$	$i_b = -2\ A$
$v_b = -6$ V	$v_c = 4$ V
$P_A = -20$ W	$P_B = 12$ W
$P_C = 4$ W	$P_D = 4$ W

P1.52*



P1.58* $R = 100\ \Omega$; 19% reduction in power

P1.62* (a) Not contradictory.
(b) A 2-A current source in series with a 3-A current source is contradictory.
(c) Not contradictory.
(d) A 2-A current source in series with an open circuit is contradictory.
(e) A 5-V voltage source in parallel with a short circuit is contradictory.

P1.63* $i_R = 2A$

$P_{current-source} = -40$ W. Thus, the current source delivers power.

$P_R = 20$ W. The resistor absorbs power.

$P_{voltage-source} = 20$ W. The voltage source absorbs power.

P1.64* $v_x = 17.5$ V

P1.69* (a) $v_x = 10/6 = 1.667$ V

(b) $i_x = 0.5556$ A

(c) $P_{voltage-source} = -10i_x = -5.556$ W. (This represents power delivered by the voltage source.)

$P_R = 3(i_x)^2 = 0.926$ W (absorbed)

$P_{controlled-source} = 5v_x i_x = 4.63$ W (absorbed)

P1.70* The circuit contains a voltage-controlled current source. $v_s = 15$ V

Practice Test

T1.1 (a) 4; (b) 7; (c) 16; (d) 18; (e) 1; (f) 2; (g) 8; (h) 3; (i) 5; (j) 15; (k) 6; (l) 11;

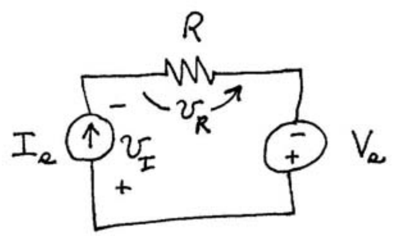
(m) 13; (n) 9; (o) 14.

T1.2 (a) The current $I_s = 3$ A circulates clockwise through the elements entering the resistance at the negative reference for v_R. Thus, we have $v_R = -I_s R = -6$ V.

(b) Because I_s enters the negative reference for V_s, we have $P_V = -V_s I_s = -30$ W. Because the result is negative, the voltage source is delivering energy.

(c) The circuit has three nodes, one on each of the top corners and one along the bottom of the circuit.

(d) First, we must find the voltage v_I across the current source. We choose the reference shown:



Then, going around the circuit counterclockwise, we have $-v_I + V_s + v_R = 0$, which yields $v_I = V_s + v_R = 10 - 6 = 4$ V. Next, the power for the current source is $P_I = I_s v_I = 12$ W. Because the result is positive, the current source is absorbing energy.

Alternatively, we could compute the power delivered to the resistor as $P_R = I_s^2 R = 18$ W. Then, because we must have a total power of zero for the entire circuit, we have $P_I = -P_V - P_R = 30 - 18 = 12$ W.

T1.3 (a) The currents flowing downward through the resistances are v_{ab}/R_1 and v_{ab}/R_2. Then, the KCL equation for node a (or node b) is

$$I_2 = I_1 + \frac{v_{ab}}{R_1} + \frac{v_{ab}}{R_2}$$

Substituting the values given in the question and solving yields $v_{ab} = -8$ V.
(b) The power for current source I_1 is $P_{I1} = v_{ab} I_1 = -8 \times 3 = -24$ W. Because the result is negative we know that energy is supplied by this current source.
The power for current source I_2 is $P_{I2} = -v_{ab} I_2 = 8 \times 1 = 8$ W. Because the result is positive, we know that energy is absorbed by this current source.
(c) The power absorbed by R_1 is $P_{R1} = v_{ab}^2 / R_1 = (-8)^2 / 12 = 5.33$ W. The power absorbed by R_2 is $P_{R2} = v_{ab}^2 / R_2 = (-8)^2 / 6 = 10.67$ W.

T1.4 (a) Applying KVL, we have $-V_s + v_1 + v_2 = 0$. Substituting values given in the problem and solving we find $v_1 = 8$ V.
(b) Then applying Ohm's law, we have $i = v_1 / R_1 = 8/4 = 2$ A.
(c) Again applying Ohm's law, we have $R_2 = v_2 / i = 4/2 = 2\ \Omega$.

T1.5 Applying KVL, we have $-V_s + v_x = 0$. Thus, $v_x = V_s = 15$ V. Next Ohm's law gives $i_x = v_x / R = 15/10 = 1.5$ A. Finally, KCL yields
$i_{sc} = i_x - av_x = 1.5 - 0.3 \times 15 = -3$ A.