Homework # 1

P1.4* The reference direction for i_{ab} points from a to b. Because i_{ab} has a negative value, the current is equivalent to positive charge moving opposite to the reference direction. Finally since electrons have negative charge, they are moving in the reference direction (i.e., from a to b).

For a constant (dc) current, charge equals current times the time interval. Thus, $Q = (5\ A) \times (3\ s) = 15\ C$.

P1.5* $i(t) = \frac{dq(t)}{dt} = \frac{d}{dt}(2 + 3t) = 3\ A$

P1.7* $Q = \int_0^\infty i(t)dt = \int_0^\infty 2e^{-t}dt = -2e^{-t} \mid_0^\infty = 2 \text{ coulombs}$

P1.10* $Q = \text{current} \times \text{time} = (5 \text{ amperes}) \times (36{,}000 \text{ seconds}) = 1.8 \times 10^5 \text{ coulombs}$

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

P1.11* (a) $P = -v_a i_a = -20$ W Energy is being supplied by the element.
(b) $P = v_b i_b = 50$ W Energy is being absorbed by the element.
(c) $P = -v_c i_c = 40$ W Energy is being absorbed by the element.

P1.16* $\text{Energy} = \frac{\text{Cost}}{\text{Rate}} = \frac{\$40}{0.1\ \$/\text{kWh}} = 400\ \text{kWh}$

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

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

P1.18* (a) $P = 60$ W taken from element A.
(b) $P = 60$ W delivered to element A.
(c) $P = 60$ W taken from element A.

P1.20* Elements A and B are in series. Also elements E and F are in series.

P1.22* 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.

P1.23* We are given $i_a = 2$ A, $i_b = 3$ A, $i_d = -5$ A, and $i_h = 4$ A. Applying KCL, we find

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

P1.26* Summing voltages for the lower left-hand loop, we have $-5 + v_a + 10 = 0$, which yields $v_a = -5$ V. Then for the top-most loop, we have $v_c - 15 - v_a = 0$, which yields $v_c = 10$ V. Finally, writing KVL around the outside loop, we have $-5 + v_c + v_b = 0$, which yields $v_b = -5$ V.

P1.28* Applying KCL and KVL, we have

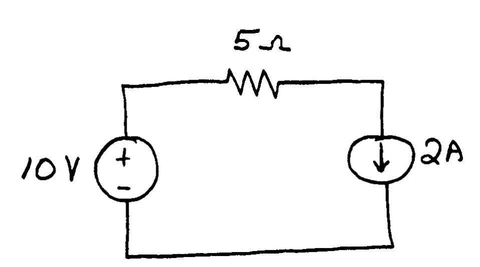
$$i_c = i_a - i_d = 1 \text{ A} \qquad i_b = -i_a = -2 \text{ A}$$
$$v_b = v_d - v_a = -6 \text{ V} \qquad v_c = v_d = 4 \text{ V}$$

The power for each element is

$$P_A = -v_a i_a = -20 \text{ W} \qquad P_B = v_b i_b = 12 \text{ W}$$
$$P_C = v_c i_c = 4 \text{ W} \qquad P_D = v_d i_d = 4 \text{ W}$$

Thus, $P_A + P_B + P_C + P_D = 0$

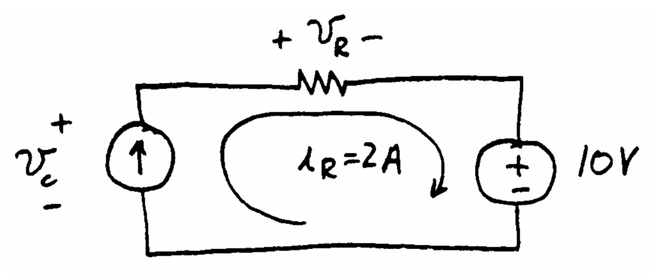
P1.30*



P1.36* $R = \dfrac{(V_1)^2}{P_1} = \dfrac{100^2}{100} = 100\ \Omega$

$P_2 = \dfrac{(V_2)^2}{R} = \dfrac{90^2}{100} = 81$ W for a 19% reduction in power

P1.39*



As shown above, the 2 A current circulates clockwise through all three elements in the circuit. Applying KVL, we have

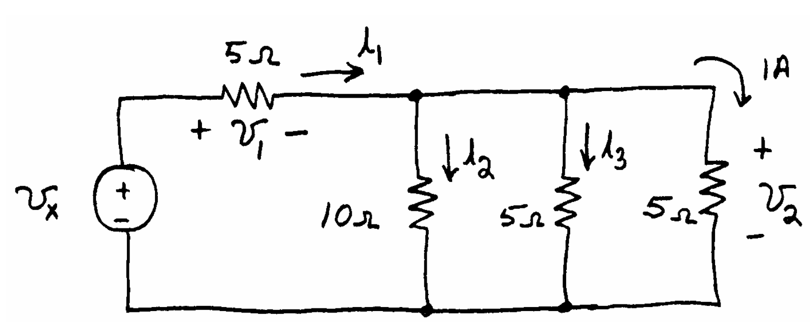
$$v_c = v_R + 10 = 5i_R + 10 = 20\ \text{V}$$

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

$P_R = (i_R)^2 R = 2^2 \times 5 = 20$ W. The resistor absorbs power.

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

P1.41*



Applying Ohm's law, we have $v_2 = (5\ \Omega) \times (1\ A) = 5$ V. However, v_2 is the voltage across all three resistors that are in parallel. Thus, $i_3 = \dfrac{v_2}{5} = 1$ A, and $i_2 = \dfrac{v_2}{10} = 0.5$ A. Applying KCL, we have $i_1 = i_2 + i_3 + 1 = 2.5$ A. By Ohm's law: $v_1 = 5i_1 = 12.5$ V. Finally using KVL, we have $v_x = v_1 + v_2 = 17.5$ V.

P1.42* (a) Applying KVL, we have $10 = v_x + 5v_x$, which yields $v_x = 10/6 = 1.667$ V

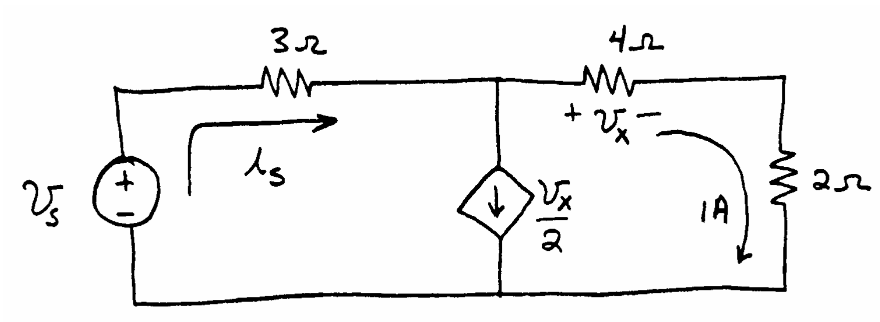
(b) $i_x = v_x / 3 = 0.5556$ A

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

$$P_R = 3(i_x)^2 = 0.926 \text{ W (absorbed)}$$

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

P1.44*



$v_x = (4\ \Omega) \times (1\ A) = 4$ V $\qquad$ $i_s = v_x / 2 + 1 = 3$ A

Applying KVL around the outside of the circuit:

$$v_s = 3i_s + 4 + 2 = 15 \text{ V}$$