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Basic Concepts

Section 1.2 Solutions

1.2.1 If the current in an electric conductor is 2.4 A, how many coulombs of charge pass any point in a 30-s interval?

Solution:

$$I = 2.4 \text{ A}, \Delta t = 30 \text{ s}$$

$$Q = I \cdot \Delta t$$

$$Q = 72 \text{ C}$$

1.2.2 Determine the time interval required for a 12-A battery charger to deliver 4800 C.

Solution:

$$I = 12 \text{ A}, Q = 4800 \text{ C}$$

$$\Delta t = \frac{Q}{I}$$

$$\Delta t = 400 \text{ s}$$

1.2.3 If a 12-V battery delivers 100 J in 5 s, find (a) the amount of charge delivered and (b) the current produced.

Solution:

$$V = 12 \text{ V}, \Delta W = 100 \text{ J in } 5 \text{ s}$$

$$\text{a. } \Delta Q = \frac{\Delta W}{V}$$

$$\Delta Q = 8.33 \text{ C}$$

$$\text{b. } I = \frac{\Delta Q}{\Delta t}, \Delta t = 5 \text{ s}$$

$$I = 1.67 \text{ A}$$

1.2.4 The current in a conductor is 1.5 A. How many coulombs of charge pass any point in a time interval of 1.5 min?

Solution:

$$I = 1.5 \text{ A}, \Delta t = 1.5 \text{ min} = 90 \text{ s}$$

$$Q = I \cdot \Delta t$$

$$Q = 135 \text{ C}$$

1.2.5 If 60 C of charge pass through an electric conductor in 30 s, determine the current in the conductor.

Solution:

$$Q = 60 \text{ C}, \Delta t = 30 \text{ s}$$

$$I = \frac{Q}{\Delta t}$$

$$I = 2 \text{ A}$$

1.2.6 Calculate the power absorbed by element A in Fig. P1.2.6.

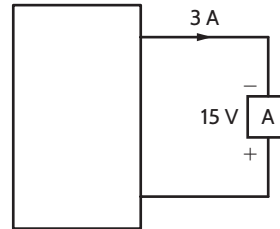
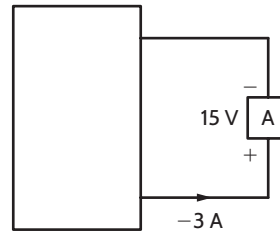


FIGURE P1.2.6

Solution:



$$P_A = (15)(-3)$$

$$P_A = -45 \text{ W absorbed}$$

1.2.7 Calculate the power supplied by element A in Fig. P1.2.7.

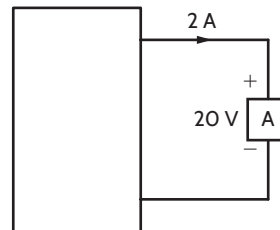
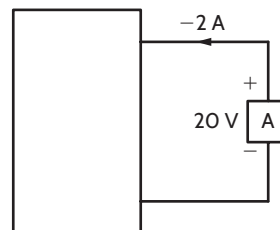


FIGURE P1.2.7

Solution:



$$P_A = (20)(-2)$$

$$P_A = -40 \text{ W supplied}$$

1.2.8 The charge entering the positive terminal of an element is given by the expression $q(t) = -12 e^{-2t}$ mC. The power delivered to the element is $p(t) = 2.4 e^{-3t}$ W. Compute the current in the element, the voltage across the element, and the energy delivered to the element in the time interval $0 < t < 100$ ms.

Solution:

$$\begin{aligned}
 q(t) &= -12 e^{-2t} \text{ mC} \\
 P(t) &= 2.4 e^{-3t} \text{ W} \\
 i(t) &= \frac{dq(t)}{dt} = -2 \cdot (-12 e^{-2t}) \\
 i(t) &= 24 e^{-2t} \text{ mA} \\
 W &= \int_{t_1}^{t_2} P(t) dt = \int_0^{100\text{m}} 2.4 e^{-3t} dt \\
 W &= \left. \frac{(2.4 e^{-3t})}{-3} \right|_0^{100\text{m}} \\
 W &= 207.35 \text{ mJ} \\
 V(t) &= \frac{P(t)}{i(t)} \\
 V(t) &= 100 e^{-t} \text{ V}
 \end{aligned}$$

1.2.9 The voltage across an element is $12 e^{-2t}$ V. The current entering the positive terminal of the element is $2 e^{-2t}$ A. Find the energy absorbed by the element in 1.5 seconds starting from $t = 0$.

Solution:

$$\begin{aligned}
 V(t) &= 12 e^{-2t} \text{ V} \\
 i(t) &= 2 e^{-2t} \text{ A} \\
 W &= \int_{t_1}^{t_2} V \cdot i dt = \int_0^{1.5} (12 e^{-2t}) \cdot (2 e^{-2t}) dt \\
 W &= \left. \frac{(24 e^{-4t})}{-4} \right|_0^{1.5} \\
 W &= 5.99 \text{ J}
 \end{aligned}$$

1.2.10 The power absorbed by the BOX in Fig. P1.2.10 is $2 e^{-2t}$ W. Calculate the amount of charge that enters the BOX between 0.1 and 0.4 seconds.

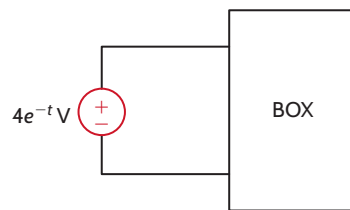


FIGURE P1.2.10

Solution:

$$\begin{aligned}
 P(t) &= 2 e^{-2t} \text{ W} \\
 V(t) &= 4 e^{-t} \text{ V} \\
 i(t) &= \frac{P(t)}{V(t)} = 0.5 e^{-t} \text{ A} \\
 \Delta q(t) &= \int_{0.1}^{0.4} i(t) dt \\
 &= (-0.5 e^{-t}) \Big|_{0.1}^{0.4} \\
 q(t) &= 117.26 \text{ mC}, \quad 0.1 \text{ s} < t < 0.4 \text{ s}
 \end{aligned}$$

1.2.11 The power absorbed by the BOX in Fig. P1.2.11 is $0.1 e^{-4t}$ W. Calculate the energy absorbed by the BOX during this same time interval.

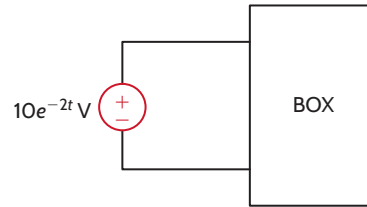


FIGURE P1.2.11

Solution:

$$P(t) = 0.1 e^{-4t} \text{ W}$$

$$W = \int P(t) dt = \int_0^{\infty} 0.1 e^{-4t} dt$$

$$W = \left. \frac{(0.1 e^{-4t})}{-4} \right|_0^{\infty}$$

$$W = 25 \text{ mJ}$$

1.2.12 Five coulombs of charge pass through the element in Fig. P1.2.12 from point A to point B. If the energy absorbed by the element is 120 J, determine the voltage across the element.

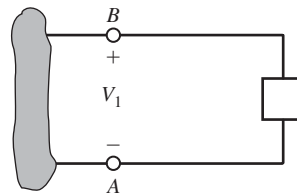


FIGURE P1.2.12

Solution:

$$W = 120 \text{ J}, Q = 5 \text{ C}$$

$$W = -V_1 \cdot Q$$

$$V_1 = -\frac{W}{Q}$$

$$V_1 = -24 \text{ V}$$

1.2.13 The current that enters an element is shown in Fig. P1.2.13. Find the charge that enters the element in the time interval $0 < t < 20$ s.

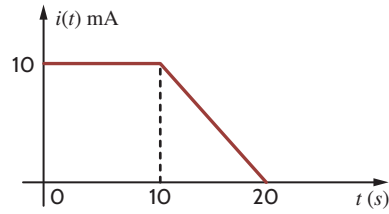


FIGURE P1.2.13

Solution:

$$i(t) = m \cdot t + b$$

$$m = \frac{10\text{m} - 0}{10 - 20} = -1\text{m}$$

$$i(t) = -1\text{m} \cdot t + b$$

$$10\text{m} = -1\text{m} \cdot (10\text{ s}) + b$$

$$b = 20\text{m}$$

$$i(t) = (-t + 20) \text{ mA}$$

$$q(t) = \int_0^{20} i(t) dt$$

$$q(t) = \int_0^{10} 10 \times 10^{-3} dt + \int_{10}^{20} \frac{20-t}{1000} dt$$

$$q(t) = 10 \times 10^{-3} \cdot t \Big|_0^{10} + \frac{1}{1000} \left(20t - \frac{t^2}{2} \right) \Big|_{10}^{20}$$

$$q(t) = 0.15 \text{ C}, \quad 0 < t < 20 \text{ s}$$

1.2.14 Element A in the diagram in Fig. P1.2.14 absorbs 30 W of power. Calculate V_x .

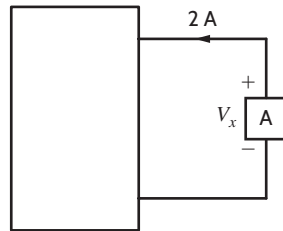
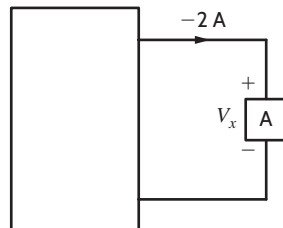


FIGURE P1.2.14

Solution:



$$30 = V_x \cdot (-2)$$

$$V_x = -15 \text{ V}$$

1.2.15 Element B in the diagram in Fig. P1.2.15 supplies 60 W of power. Calculate I_x .

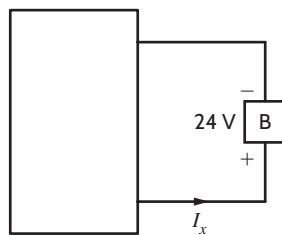
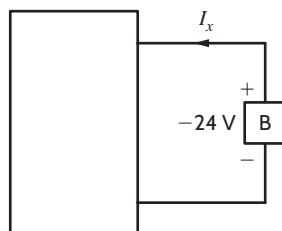


FIGURE P1.2.15

Solution:



$$60 = (-24) \cdot I_x$$

$$I_x = -2.5 \text{ A}$$

1.2.16 Element B in the diagram in Fig. P1.2.16 supplies 72 W of power. Calculate I_x .

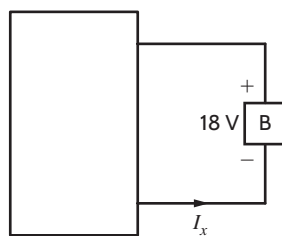


FIGURE P1.2.16

Solution:

$$72 = (18) \cdot I_x$$

$$I_x = 4 \text{ A}$$

1.2.17 Two elements are connected in series, as shown in Fig. P1.2.17. Element 1 supplies 24 W of power. Is element 2 absorbing or supplying power, and how much?

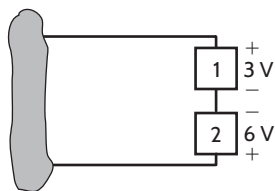
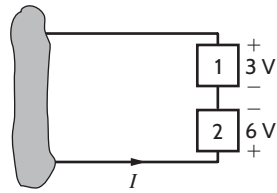


FIGURE P1.2.17

Solution:



$$P_1 = 24 = V_1 \cdot I$$

$$I = \frac{24}{3} = 8 \text{ A}$$

$$P_2 = V_2 \cdot I = (6)(8)$$

$$P_2 = 48 \text{ W absorbed}$$

1.2.18 The energy absorbed by the BOX in Fig. P1.2.18 is given below. Calculate and sketch the current flowing into the BOX. Also calculate the charge that enters the BOX between 0 and 12 s.

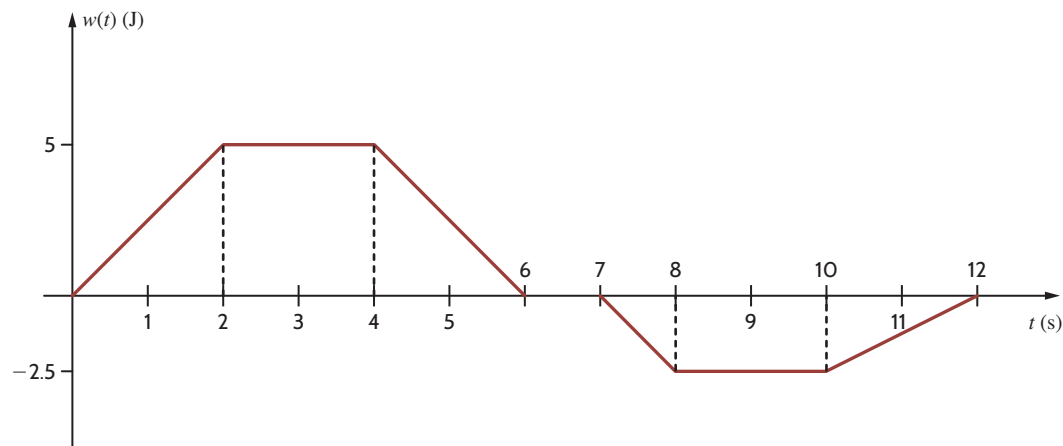
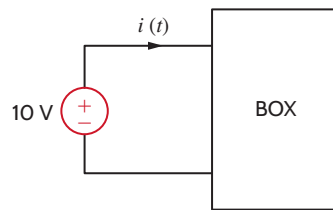
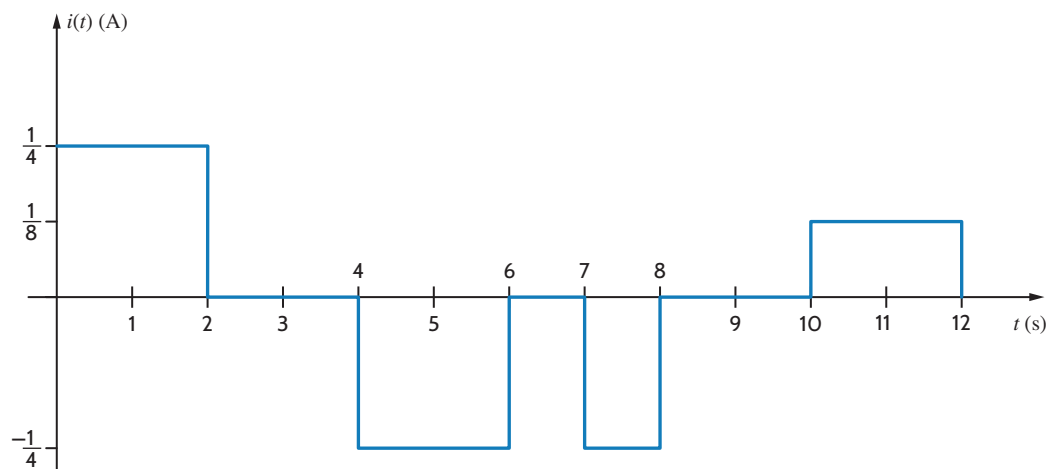


FIGURE P1.2.18

Solution:

$$P = \frac{dw}{dt}$$

$$P = V \cdot i = (10) \cdot i$$

$$0 \text{ s} \leq t \leq 2 \text{ s}$$

$$P = \frac{5 - 0}{2 - 0} = 2.5 \text{ W}, \quad i = \frac{P}{V} = \frac{2.5}{10} = \frac{1}{4} \text{ A}$$

$$2 \text{ s} \leq t \leq 4 \text{ s}$$

$$P = \frac{5 - 5}{4 - 2} = 0 \text{ W}, \quad i = 0 \text{ A}$$

$$4 \text{ s} \leq t \leq 6 \text{ s}$$

$$P = \frac{0 - 5}{6 - 4} = -2.5 \text{ W}, \quad i = \frac{P}{V} = \frac{-2.5}{10} = -\frac{1}{4} \text{ A}$$

$$6 \text{ s} \leq t \leq 7 \text{ s}$$

$$P = \frac{0 - 0}{7 - 6} = 0 \text{ W}, \quad i = 0 \text{ A}$$

$$7 \text{ s} \leq t \leq 8 \text{ s}$$

$$P = \frac{-2.5 - 0}{8 - 7} = -2.5 \text{ W}, \quad i = \frac{P}{V} = \frac{-2.5}{10} = -\frac{1}{4} \text{ A}$$

$$8 \text{ s} \leq t \leq 10 \text{ s}$$

$$P = \frac{-2.5 - (-2.5)}{10 - 8} = 0 \text{ W}, \quad i = 0 \text{ A}$$

$$10 \text{ s} \leq t \leq 12 \text{ s}$$

$$P = \frac{0 - (-2.5)}{12 - 10} = 1.25 \text{ W}, \quad i = \frac{P}{V} = \frac{1.25}{10} = \frac{1}{8} \text{ A}$$

$$q = \int i \, dt$$

$$q = \left(\frac{1}{4}\right) \cdot (2) + \left(\frac{-1}{4}\right) \cdot (2) + \left(\frac{-1}{4}\right) \cdot (1) + \left(\frac{1}{8}\right) \cdot (2)$$

$$q = 0 \text{ C}$$

1.2.19 The energy absorbed by the BOX in Fig. P1.2.19 is shown in the graph below. Calculate and sketch the current flowing into the BOX between 0 and 10 milliseconds.

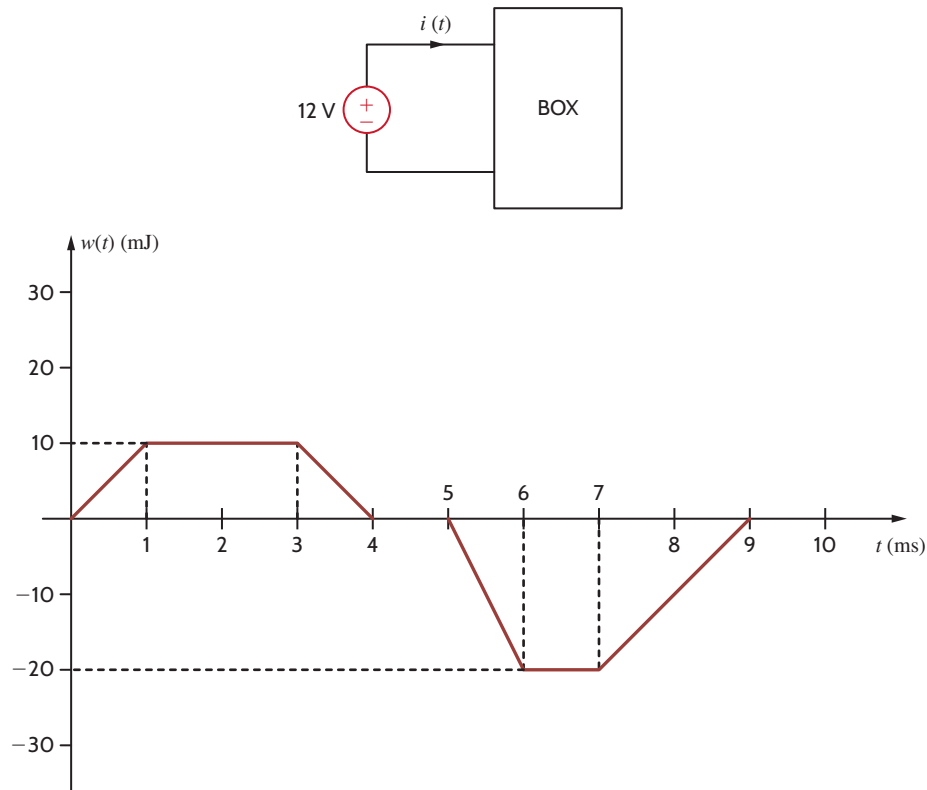
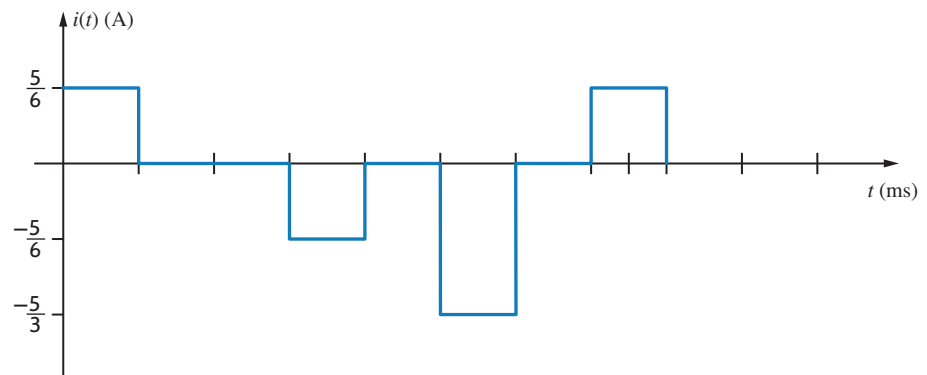


FIGURE P1.2.19

Solution:

$$P = \frac{dw}{dt}$$

$$P = V \cdot i = (12) \cdot i$$

$$0 \text{ s} \leq t \leq 1 \text{ ms}$$

$$P = \frac{10\text{m} - 0}{1\text{m} - 0} = 10 \text{ W}, \quad i = \frac{P}{V} = \frac{10}{12} = \frac{5}{6} \text{ A}$$

$$1 \text{ ms} \leq t \leq 3 \text{ ms}$$

$$P = \frac{10\text{m} - 10\text{m}}{3\text{m} - 1\text{m}} = 0 \text{ W}, \quad i = 0 \text{ A}$$

$$3 \text{ ms} \leq t \leq 4 \text{ ms}$$

$$P = \frac{0 - 10\text{m}}{4\text{m} - 3\text{m}} = -10 \text{ W}, \quad i = \frac{P}{V} = -\frac{10}{12} = -\frac{5}{6} \text{ A}$$

$$4 \text{ ms} \leq t \leq 5 \text{ ms}$$

$$P = \frac{0 - 0}{5\text{m} - 4\text{m}} = 0 \text{ W}, \quad i = 0 \text{ A}$$

$$5 \text{ ms} \leq t \leq 6 \text{ ms}$$

$$P = \frac{-20\text{m} - 0}{6\text{m} - 5\text{m}} = -20 \text{ W}, \quad i = \frac{P}{V} = -\frac{20}{12} = -\frac{5}{3} \text{ A}$$

$$6 \text{ ms} \leq t \leq 7 \text{ ms}$$

$$P = \frac{-20\text{m} - (-20\text{m})}{7\text{m} - 6\text{m}} = 0 \text{ W}, \quad i = 0 \text{ A}$$

$$7 \text{ ms} \leq t \leq 9 \text{ ms}$$

$$P = \frac{0 - (-20\text{m})}{9\text{m} - 7\text{m}} = 10 \text{ W}, \quad i = \frac{P}{V} = \frac{10}{12} = \frac{5}{6} \text{ A}$$

$$t > 9 \text{ ms}$$

$$P = 0 \text{ W}, \quad i = 0 \text{ A}$$

- 1.2.20 (a) In Fig. P1.2.20(a), $P_1 = 36$ W. Is element 2 absorbing or supplying power, and how much?
 (b) In Fig. P1.2.20(b), $P_2 = -48$ W. Is element 1 absorbing or supplying power, and how much?

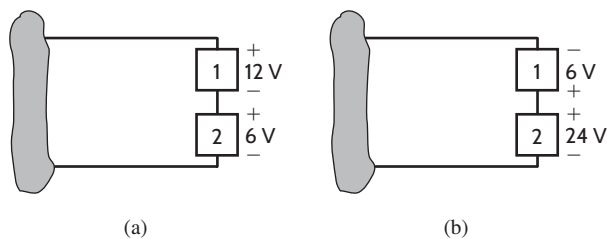
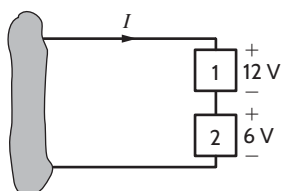


FIGURE P1.2.20

Solution:

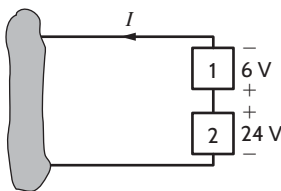


$$\text{a) } P_1 = 36 = V_1 \cdot I$$

$$I = \frac{36}{12} = 3 \text{ A}$$

$$P_2 = V_2 \cdot I = (6)(3)$$

$$P_2 = 18 \text{ W absorbed}$$



$$\text{b) } P_2 = -48 = -V_2 \cdot I$$

$$I = \frac{-48}{-24} = 2 \text{ A}$$

$$P_1 = V_1 \cdot I = (6)(2)$$

$$P_1 = 12 \text{ W absorbed}$$

1.2.21 The charge that enters the BOX in Fig. P1.2.21 is shown in the graph below. Calculate and sketch the current flowing into and the power absorbed by the BOX between 0 and 10 milliseconds.

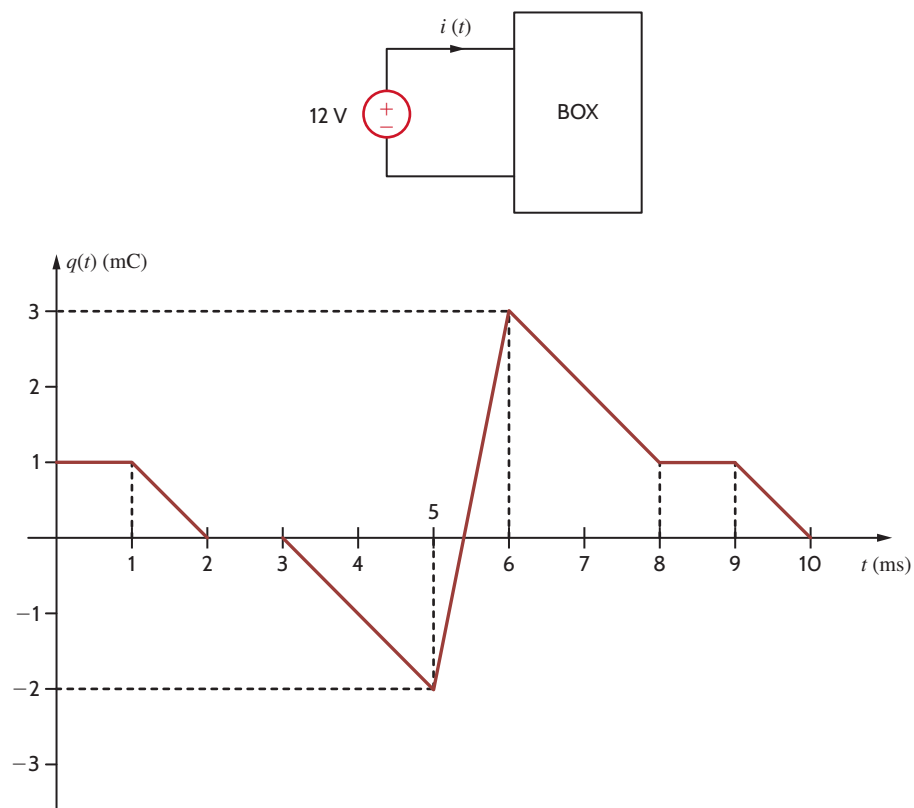


FIGURE P1.2.21

Solution:

$$i(t) = \frac{dq}{dt}$$

$$P = V \cdot i = (12) \cdot i$$

$$0 \text{ s} \leq t \leq 1 \text{ ms}$$

$$i = \frac{1\text{m} - 1\text{m}}{1\text{m} - 0} = 0 \text{ A}, \quad P = 0 \text{ W}$$

$$1 \text{ ms} \leq t \leq 2 \text{ ms}$$

$$i = \frac{0 - 1\text{m}}{2\text{m} - 1\text{m}} = -1 \text{ A}, \quad P = (12)(-1) = -12 \text{ W}$$

$$2 \text{ ms} \leq t \leq 3 \text{ ms}$$

$$i = \frac{0 - 0}{3\text{m} - 2\text{m}} = 0 \text{ A}, \quad P = 0 \text{ W}$$

$$3 \text{ ms} \leq t \leq 5 \text{ ms}$$

$$i = \frac{-2\text{m} - 0}{5\text{m} - 3\text{m}} = -1 \text{ A}, \quad P = (12)(-1) = -12 \text{ W}$$

$$5 \text{ ms} \leq t \leq 6 \text{ ms}$$

$$i = \frac{3\text{m} - (-2\text{m})}{6\text{m} - 5\text{m}} = 5 \text{ A}, \quad P = (12)(5) = 60 \text{ W}$$

$$6 \text{ ms} \leq t \leq 8 \text{ ms}$$

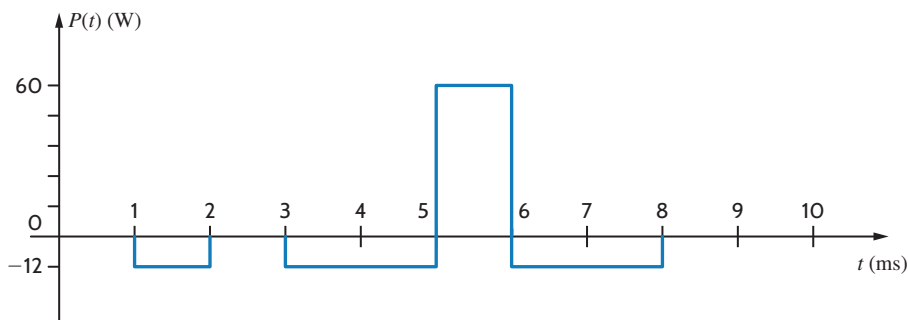
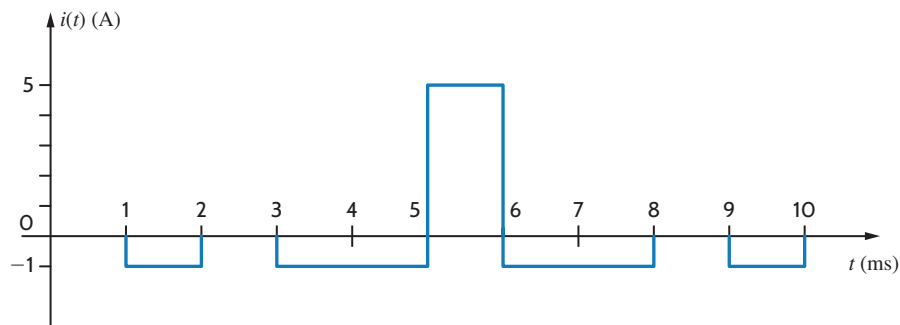
$$i = \frac{1\text{m} - 3\text{m}}{8\text{m} - 6\text{m}} = -1 \text{ A}, \quad P = (12)(-1) = -12 \text{ W}$$

$$8 \text{ ms} \leq t \leq 9 \text{ ms}$$

$$i = \frac{1\text{m} - 1\text{m}}{9\text{m} - 8\text{m}} = 0 \text{ A}, \quad P = 0 \text{ W}$$

$$9 \text{ ms} \leq t \leq 10 \text{ ms}$$

$$i = \frac{0 - 1\text{m}}{10\text{m} - 9\text{m}} = -1 \text{ A}, \quad P = (12)(-1) = -12 \text{ W}$$



Section 1.3 Solutions

1.3.1 Find V_x in the network in Fig. P1.3.1 using Tellegen's theorem.

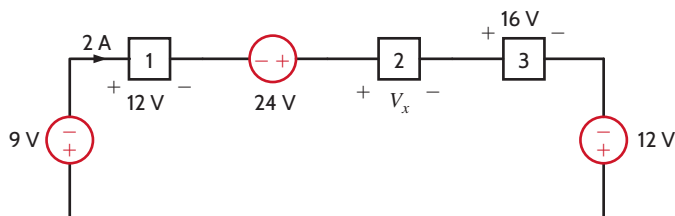


FIGURE P1.3.1

Solution:

$$P_{9V} = (9)(2) = 18 \text{ W} \rightarrow 18 \text{ W absorbed}$$

$$P_1 = (12)(2) = 24 \text{ W} \rightarrow 24 \text{ W absorbed}$$

$$P_{24V} = (-24)(2) = -48 \text{ W} \rightarrow 48 \text{ W supplied}$$

$$P_2 = V_x(2) = 2 V_x \text{ W} \rightarrow 2 V_x \text{ W absorbed}$$

$$P_3 = (16)(2) = 32 \text{ W} \rightarrow 32 \text{ W absorbed}$$

$$P_{12V} = (-12)(2) = -24 \text{ W} \rightarrow 24 \text{ W supplied}$$

$$P_{\text{sup}} = P_{\text{abs}}$$

$$48 + 24 = 18 + 24 + 2V_x + 32$$

$$V_x = -1 \text{ V}$$

1.3.2 Find the power that is absorbed or supplied by the circuit elements in Fig. P1.3.2.

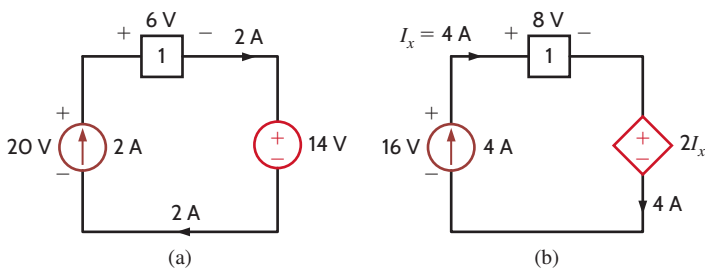


FIGURE P1.3.2

Solution:

a. $P_{2A} = (-20) \cdot (2) = -40 \text{ W}$

$$P_{2A} = 40 \text{ W supplied}$$

$$P_1 = (6) \cdot (2) = 12 \text{ W absorbed}$$

$$P_{14V} = (14) \cdot (2) = 28 \text{ W absorbed}$$

b. $P_{4A} = (-16)(4) = -64 \text{ W}$

$$P_{4A} = 64 \text{ W supplied}$$

$$P_1 = (8)(4) = 32 \text{ W absorbed}$$

$$P_{2I_x} = [2(4)] \cdot (4) = 32 \text{ W absorbed}$$

1.3.3 Find the power that is absorbed or supplied by element 2 in Fig. P1.3.3.

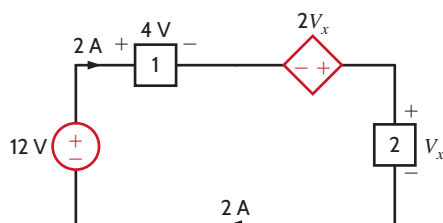


FIGURE P1.3.3

Solution:

$$P_{12\text{ V}} = (-12) \cdot (2) = -24 \text{ W} \rightarrow 24 \text{ W supplied}$$

$$P_1 = (4) \cdot (2) = 8 \text{ W} \rightarrow 8 \text{ W absorbed}$$

$$P_{2V_x} = (-2V_x) \cdot (2) = -4V_x \text{ W} \rightarrow 4V_x \text{ W supplied}$$

$$P_2 = (V_x) \cdot (2) = 2V_x \text{ W} \rightarrow 2V_x \text{ W absorbed}$$

$$P_{\text{sup}} = P_{\text{abs}}$$

$$24 + 4V_x = 8 + 2V_x$$

$$V_x = -8 \text{ V}$$

$$P_2 = (-8) \cdot (2) = -16 \text{ W}$$

$$P_2 = 16 \text{ W supplied}$$

1.3.4 Find I_x in the circuit in Fig. P1.3.4 using Tellegen's theorem.

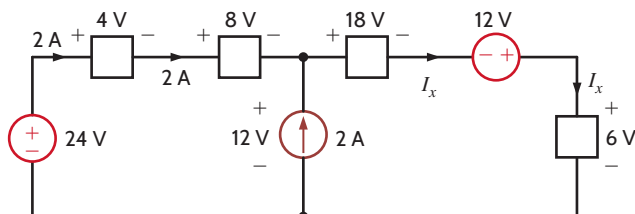


FIGURE P1.3.4

Solution:

$$P_{24\text{ V}} = (-24)(2) = -48 \text{ W} \rightarrow 48 \text{ W supplied}$$

$$P_{4\text{ V}} = (4)(2) = 8 \text{ W} \rightarrow 8 \text{ W absorbed}$$

$$P_{8\text{ V}} = (8)(2) = 16 \text{ W} \rightarrow 16 \text{ W absorbed}$$

$$P_{2\text{ A}} = (-12)(2) = -24 \text{ W} \rightarrow 24 \text{ W supplied}$$

$$P_{18\text{ V}} = (18)(I_x) = 18I_x \text{ W} \rightarrow 18I_x \text{ W absorbed}$$

$$P_{12\text{ V}} = (-12)(I_x) = -12I_x \text{ W} \rightarrow 12I_x \text{ W supplied}$$

$$P_{6\text{ V}} = (6)(I_x) = 6I_x \text{ W} \rightarrow 6I_x \text{ W absorbed}$$

$$P_{\text{sup}} = P_{\text{abs}}$$

$$48 + 24 + 12I_x = 8 + 16 + 18I_x + 6I_x$$

$$I_x = 4 \text{ A}$$

1.3.5 Is the source, V_s , in the network in Fig. P1.3.5 absorbing or supplying power, and how much?

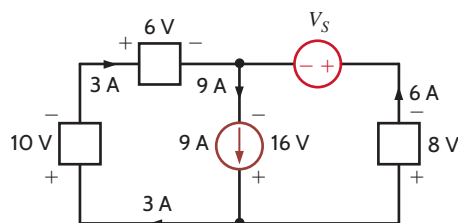


FIGURE P1.3.5

Solution:

$$P_{10V} = (10)(3) = 30 \text{ W} \rightarrow 30 \text{ W absorbed}$$

$$P_{6V} = (6)(3) = 18 \text{ W} \rightarrow 18 \text{ W absorbed}$$

$$P_{9A} = (-16)(9) = -144 \text{ W} \rightarrow 144 \text{ W supplied}$$

$$P_{V_s} = V_s(6) = 6 V_s \text{ W} \rightarrow 6 V_s \text{ W absorbed}$$

$$P_{8V} = (8)(6) = 48 \text{ W} \rightarrow 48 \text{ W absorbed}$$

$$P_{\text{sup}} = P_{\text{abs}}$$

$$144 = 30 + 18 + 6 V_s + 48$$

$$V_s = 8 \text{ V}$$

$$P_{V_s} = (8)(6) = 48 \text{ W absorbed}$$

1.3.6 Calculate the power absorbed by each element in the circuit in Fig. P1.3.6. Also, verify that Tellegen's theorem is satisfied by this circuit.

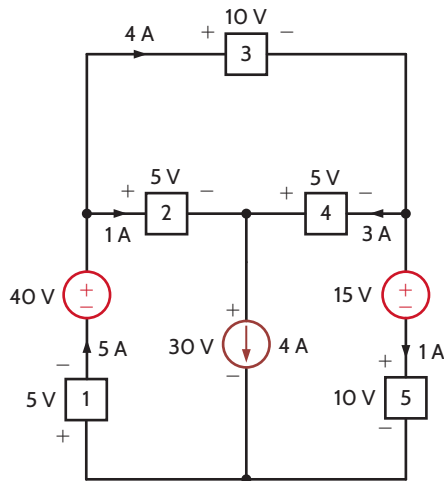


FIGURE P1.3.6

Solution:

$$P_{40\text{ V}} = (-40)(5) = -200\text{ W} \rightarrow 200\text{ W supplied}$$

$$P_{4\text{ A}} = (30)(4) = 120\text{ W} \rightarrow 120\text{ W absorbed}$$

$$P_{15\text{ V}} = (15)(1) = 15\text{ W} \rightarrow 15\text{ W absorbed}$$

$$P_1 = (5)(5) = 25\text{ W} \rightarrow 25\text{ W absorbed}$$

$$P_2 = (5)(1) = 5\text{ W} \rightarrow 5\text{ W absorbed}$$

$$P_3 = (10)(4) = 40\text{ W} \rightarrow 40\text{ W absorbed}$$

$$P_4 = (-5)(3) = -15\text{ W} \rightarrow 15\text{ W supplied}$$

$$P_5 = (10)(1) = 10\text{ W} \rightarrow 10\text{ W absorbed}$$

$$P_{\text{sup}} - P_{\text{abs}} = 0$$

$$(200 + 15) - (120 + 15 + 25 + 5 + 40 + 10) = 0$$

$$(215) - (215) = 0$$

1.3.7 Find the power that is absorbed or supplied by the network elements in Fig. P1.3.7.

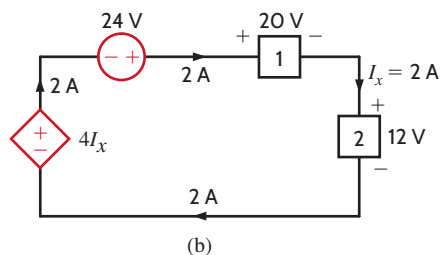
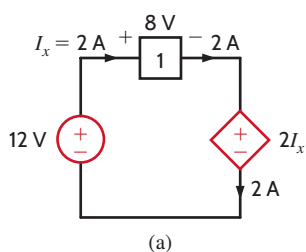


FIGURE P1.3.7

Solution:

a. $P_{12\text{ V}} = (-12)(2) = -24\text{ W}$

$$P_{12\text{ V}} = 24\text{ W supplied}$$

$$P_1 = (8)(2) = 16\text{ W absorbed}$$

$$P_{2I_x} = [2 \cdot (2)] \cdot (2) = 8\text{ W absorbed}$$

b. $P_{4I_x} = [-4(2)] \cdot (2) = -16\text{ W}$

$$P_{4I_x} = 16\text{ W supplied}$$

$$P_{24\text{ V}} = (-24)(2) = -48\text{ W}$$

$$P_{24\text{ V}} = 48\text{ W supplied}$$

$$P_1 = (20) \cdot (2) = 40\text{ W absorbed}$$

$$P_2 = (12) \cdot (2) = 24\text{ W absorbed}$$

1.3.8 Find the power absorbed or supplied by element 1 in Fig. P1.3.8.

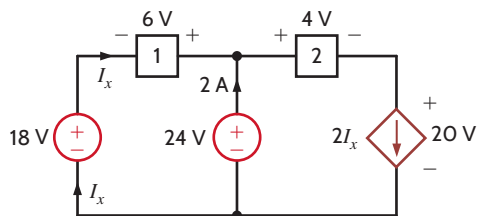


FIGURE P1.3.8

Solution:

$$P_{18V} = (-18) \cdot I_x = -18I_x \text{ W} \rightarrow 18 \cdot I_x \text{ W supplied}$$

$$P_1 = (-6) \cdot I_x = -6I_x \text{ W} \rightarrow 6 \cdot I_x \text{ W supplied}$$

$$P_{24V} = (-24) \cdot (2) = -48 \text{ W} \rightarrow 48 \text{ W supplied}$$

$$P_2 = (4) \cdot (2I_x) = 8I_x \text{ W} \rightarrow 8 \cdot I_x \text{ W absorbed}$$

$$P_{2I_x} = (20)(2I_x) = 40I_x \text{ W} \rightarrow 40I_x \text{ W absorbed}$$

$$P_{\text{sup}} = P_{\text{abs}}$$

$$18I_x + 6I_x + 48 = 8I_x + 40I_x$$

$$I_x = 2 \text{ A}$$

$$P_1 = (-6) \cdot (2) = -12 \text{ W}$$

$$P_1 = 12 \text{ W supplied}$$

1.3.9 Find I_x in the network in Fig. P1.3.9.

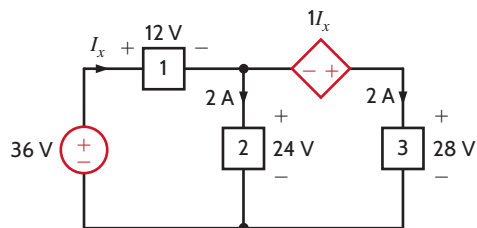


FIGURE P1.3.9

Solution:

$$P_{36V} = (-36) \cdot I_x = -36I_x \text{ W} \rightarrow 36 \cdot I_x \text{ W supplied}$$

$$P_1 = (12) \cdot I_x = 12I_x \text{ W} \rightarrow 12 \cdot I_x \text{ W absorbed}$$

$$P_2 = (24) \cdot (2) = 48 \text{ W} \rightarrow 48 \text{ W absorbed}$$

$$P_{1I_x} = [-1(I_x)] \cdot 2 = -2 \cdot I_x \text{ W} \rightarrow 2 \cdot I_x \text{ W supplied}$$

$$P_3 = (28) \cdot (2) = 56 \text{ W} \rightarrow 56 \text{ W absorbed}$$

$$P_{\text{sup}} = P_{\text{abs}}$$

$$36I_x + 2 \cdot I_x = 12I_x + 48 + 56$$

$$I_x = 4 \text{ A}$$

1.3.10 Determine the power absorbed by element 1 in Fig. P1.3.10.

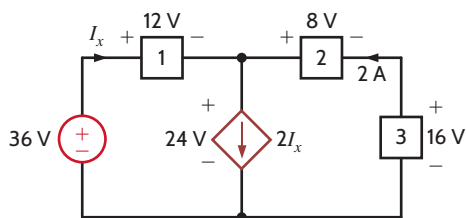


FIGURE P1.3.10

Solution:

$$P_{36V} = (-36) \cdot I_x = -36 \cdot I_x \text{ W} \rightarrow 36 \cdot I_x \text{ W supplied}$$

$$P_1 = (12) \cdot I_x = 12I_x \text{ W} \rightarrow 12 \cdot I_x \text{ W absorbed}$$

$$P_{2I_x} = (24) \cdot (2I_x) = 48 \cdot I_x \text{ W} \rightarrow 48I_x \text{ W absorbed}$$

$$P_2 = (-8)(2) = -16 \text{ W} \rightarrow 16 \text{ W supplied}$$

$$P_3 = (-16)(2) = -32 \text{ W} \rightarrow 32 \text{ W supplied}$$

$$P_{\text{sup}} = P_{\text{abs}}$$

$$36I_x + 16 + 32 = 12I_x + 48I_x$$

$$I_x = 2 \text{ A}$$

$$P_1 = (12)(2) = 24 \text{ W absorbed}$$

1.3.11 Find the power absorbed or supplied by element 1 in Fig. P1.3.11.

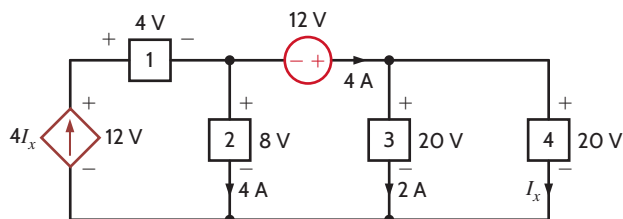


FIGURE P1.3.11

Solution:

$$P_{4I_x} = (-12) \cdot (4I_x) = -48I_x \text{ W} \rightarrow 48I_x \text{ W supplied}$$

$$P_1 = (4)(4I_x) = 16I_x \text{ W} \rightarrow 16I_x \text{ W absorbed}$$

$$P_2 = (8)(4) = 32 \text{ W} \rightarrow 32 \text{ W absorbed}$$

$$P_{12V} = (-12)(4) = -48 \text{ W} \rightarrow 48 \text{ W supplied}$$

$$P_3 = (20)(2) = 40 \text{ W} \rightarrow 40 \text{ W absorbed}$$

$$P_4 = (20) \cdot I_x = 20I_x \text{ W} \rightarrow 20I_x \text{ W absorbed}$$

$$P_{\text{sup}} = P_{\text{abs}}$$

$$48I_x + 48 = 16I_x + 32 + 40 + 20I_x$$

$$I_x = 2 \text{ A}$$

$$P_1 = 16(2) = 32 \text{ W absorbed}$$

1.3.12 Find I_o in the network in Fig. P1.3.12 using Tellegen's theorem.

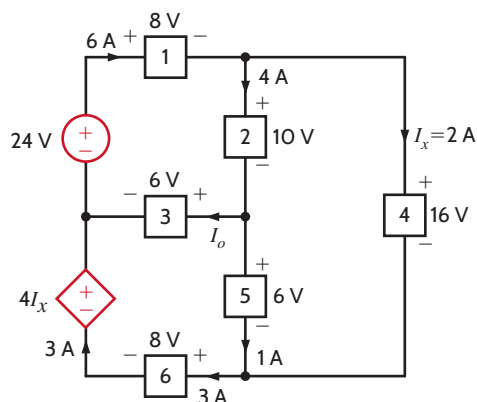


FIGURE P1.3.12

Solution:

$$P_{24V} = (-24)(6) = -144 \text{ W} \rightarrow 144 \text{ W supplied}$$

$$P_{4I_x} = [-4(2)](3) = -24 \text{ W} \rightarrow 24 \text{ W supplied}$$

$$P_1 = (8)(6) = 48 \text{ W} \rightarrow 48 \text{ W absorbed}$$

$$P_2 = (10)(4) = 40 \text{ W} \rightarrow 40 \text{ W absorbed}$$

$$P_3 = (6) \cdot I_o = 6I_o \text{ W} \rightarrow 6I_o \text{ W absorbed}$$

$$P_4 = (16)(2) = 32 \text{ W} \rightarrow 32 \text{ W absorbed}$$

$$P_5 = (6)(1) = 6 \text{ W} \rightarrow 6 \text{ W absorbed}$$

$$P_6 = (8)(3) = 24 \text{ W} \rightarrow 24 \text{ W absorbed}$$

$$P_{\text{sup}} = P_{\text{abs}}$$

$$144 + 24 = 48 + 40 + 6I_o + 32 + 6 + 24$$

$$I_o = 3 \text{ A}$$

1.3.13 Calculate the power absorbed by each element in the circuit in Fig. P1.3.13. Also, verify that Tellegen's theorem is satisfied by this circuit.

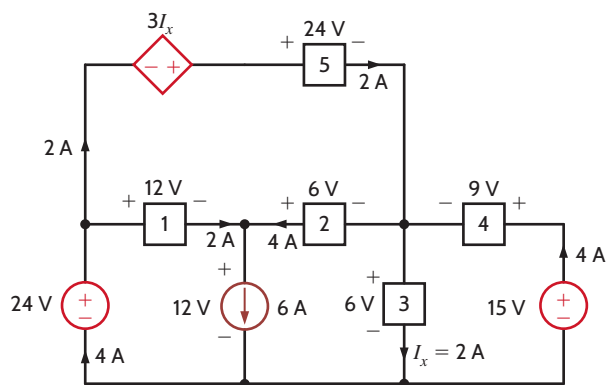


FIGURE P1.3.13

Solution:

$$P_{3I_x} = [-3(2)] \cdot (2) = -12 \text{ W} \rightarrow 12 \text{ W supplied}$$

$$P_{24V} = (-24)(4) = -96 \text{ W} \rightarrow 96 \text{ W supplied}$$

$$P_{6A} = (12)(6) = 72 \text{ W} \rightarrow 72 \text{ W absorbed}$$

$$P_{15V} = (-15)(4) = -60 \text{ W} \rightarrow 60 \text{ W supplied}$$

$$P_1 = (12)(2) = 24 \text{ W} \rightarrow 24 \text{ W absorbed}$$

$$P_2 = (-6)(4) = -24 \text{ W} \rightarrow 24 \text{ W supplied}$$

$$P_3 = (6)(2) = 12 \text{ W} \rightarrow 12 \text{ W absorbed}$$

$$P_4 = (9)(4) = 36 \text{ W} \rightarrow 36 \text{ W absorbed}$$

$$P_5 = (24)(2) = 48 \text{ W} \rightarrow 48 \text{ W absorbed}$$

$$P_{\text{sup}} - P_{\text{abs}} = 0$$

$$(12 + 96 + 60 + 24) - (72 + 24 + 12 + 36 + 48) = 0$$

$$(192) - (192) = 0$$