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:

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

a. $$\Delta Q = \frac{\Delta \text{W}}{V}$$
$$\Delta Q = 8.33\text{ C}$$

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.

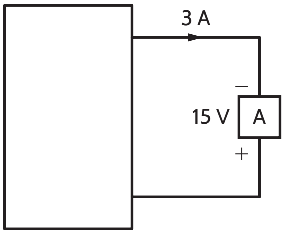
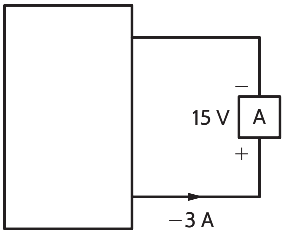


FIGURE P1.2.6

Solution:



$P_A = (15)(-3)$

$P_A = -45$ W absorbed

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

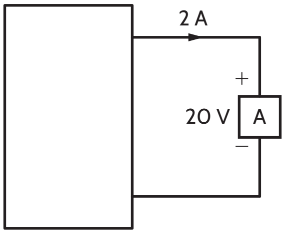
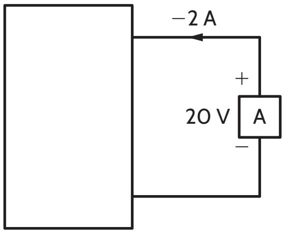


FIGURE P1.2.7

Solution:



$P_A = (20)(-2)$

$P_A = -40$ 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:

$$q(t) = -12\,e^{-2t}\ \text{mC}$$
$$P(t) = 2.4\,e^{-3t}\ \text{W}$$
$$i(t) = \frac{dq(t)}{dt} = -2 \cdot (-12\,e^{-2t})$$
$$i(t) = 24\,e^{-2t}\ \text{mA}$$
$$\text{W} = \int_{t1}^{t2} P(t)dt = \int_{0}^{100\text{m}} 2.4\,e^{-3t}\,dt$$
$$\text{W} = \left.\frac{(2.4\,e^{-3t})}{-3}\right|_{0}^{100\ \text{m}}$$
$$\text{W} = 207.35\ \text{mJ}$$
$$V(t) = \frac{P(t)}{i(t)}$$
$$V(t) = 100\,e^{-t}\ \text{V}$$

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:

$$V(t) = 12\,e^{-2t}\ \text{V}$$
$$i(t) = 2\,e^{-2t}\ \text{A}$$
$$\text{W} = \int_{t1}^{t2} V \cdot i dt = \int_{0}^{1.5} (12\,e^{-2t}) \cdot (2\,e^{-2t})dt$$
$$\text{W} = \left.\frac{(24\,e^{-4t})}{-4}\right|_{0}^{1.5}$$
$$\text{W} = 5.99\ \text{J}$$

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.

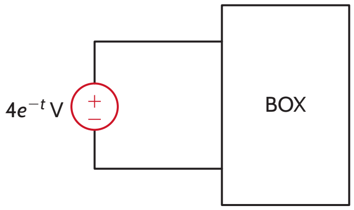


FIGURE P1.2.10

Solution:

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

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.

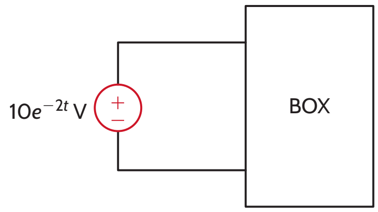


FIGURE P1.2.11

Solution:

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

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

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

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

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.

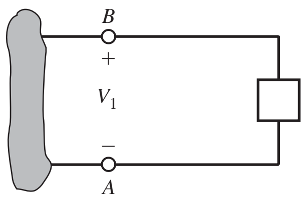


FIGURE P1.2.12

Solution:

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

$$\text{W} = -V_1 \cdot Q$$

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

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

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.

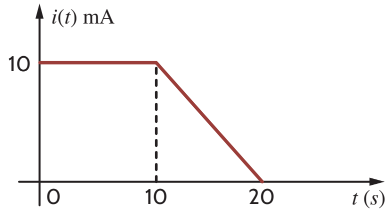


FIGURE P1.2.13

Solution:

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

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

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

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

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

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

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

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

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

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

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

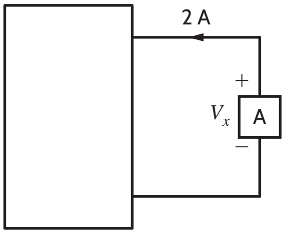
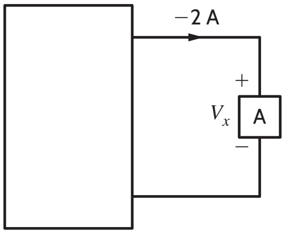


FIGURE P1.2.14

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.

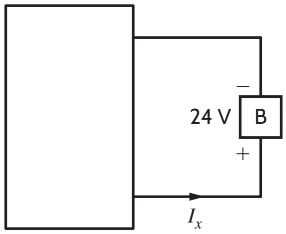
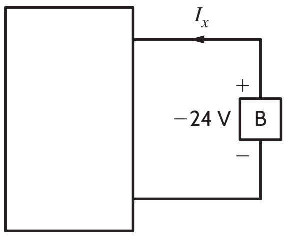


FIGURE P1.2.15

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.

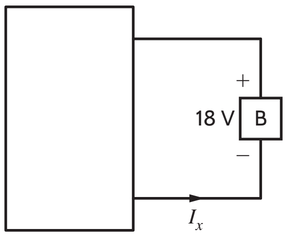


FIGURE P1.2.16

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?

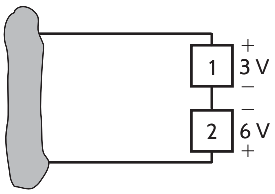
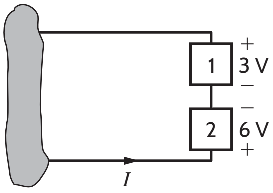


FIGURE P1.2.17

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.

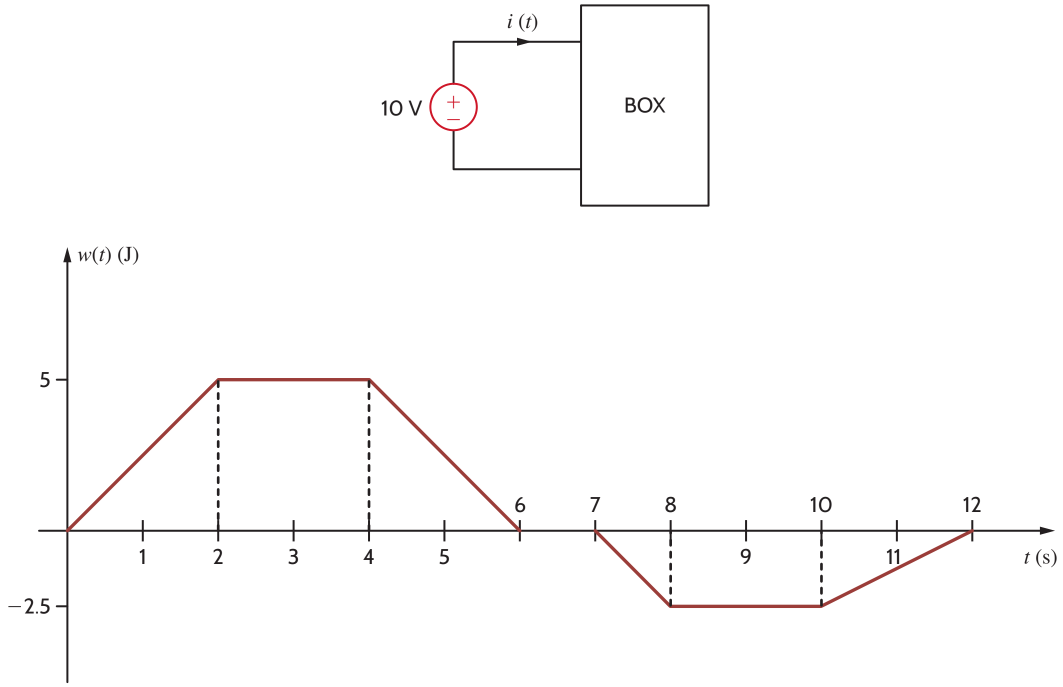
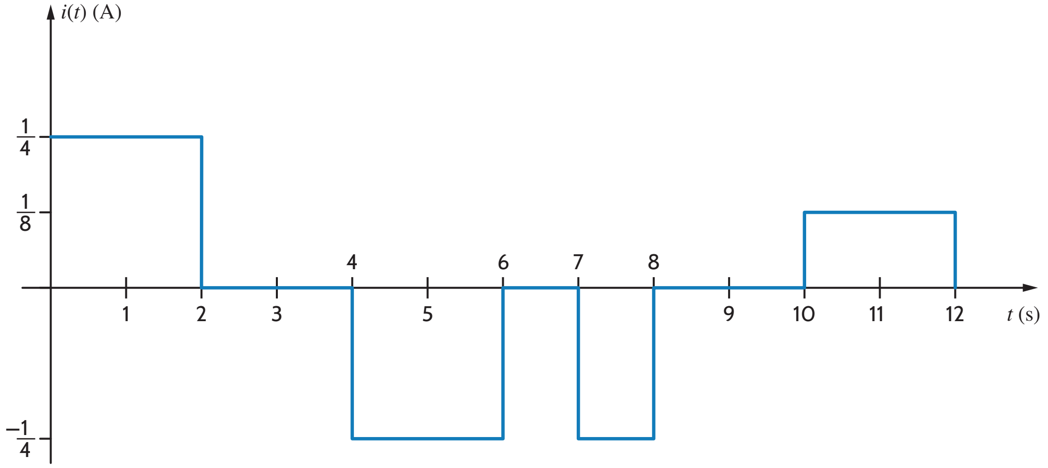


FIGURE P1.2.18

Solution:



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

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

<u>$0\text{ s} \le t \le 2\text{ s}$</u>

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

<u>$2\text{ s} \le t \le 4\text{ s}$</u>

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

<u>$4\text{ s} \le t \le 6\text{ s}$</u>

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

<u>$6\text{ s} \le t \le 7\text{ s}$</u>

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

<u>$7\text{ s} \le t \le 8\text{ s}$</u>

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

<u>$8\text{ s} \le t \le 10\text{ s}$</u>

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

<u>$10\text{ s} \le t \le 12\text{ s}$</u>

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

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

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

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

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.

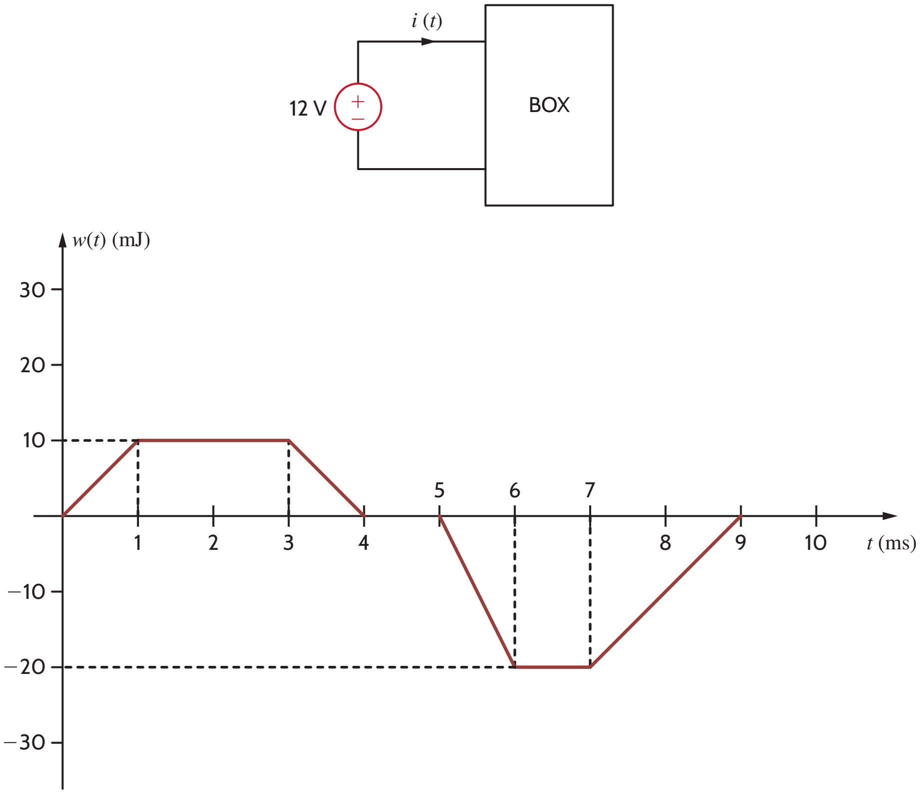
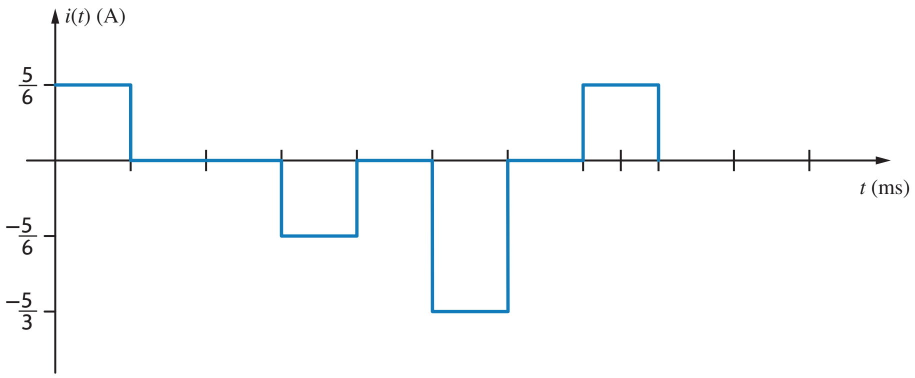


FIGURE P1.2.19

Solution:



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

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

<u>$0\text{ s} \le t \le 1\text{ ms}$</u>

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

<u>$1\text{ ms} \le t \le 3\text{ ms}$</u>

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

<u>$3\text{ ms} \le t \le 4\text{ ms}$</u>

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

<u>$4\text{ ms} \le t \le 5\text{ ms}$</u>

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

<u>$5\text{ ms} \le t \le 6\text{ ms}$</u>

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

<u>$6\text{ ms} \le t \le 7\text{ ms}$</u>

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

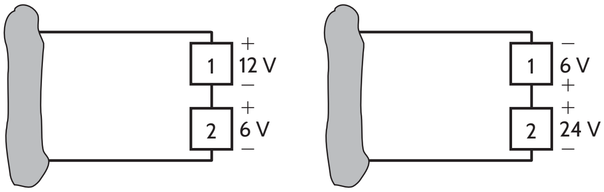
<u>$7\text{ ms} \le t \le 9\text{ ms}$</u>

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

<u>$t > 9\text{ ms}$</u>

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

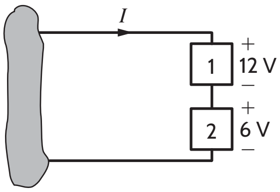
1.2.20 (a) In Fig. P1.2.20(a), $P_1 = 36$ W. Is element 2 absorbing or supplying power, and how much?
(b) In Fig. P1.2.20(b), $P_2 = -48$ W. Is element 1 absorbing or supplying power, and how much?



(a) (b)

FIGURE P1.2.20

Solution:

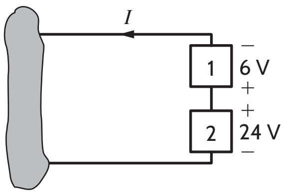


a) $P_1 = 36 = V_1 \cdot I$

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

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

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



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.

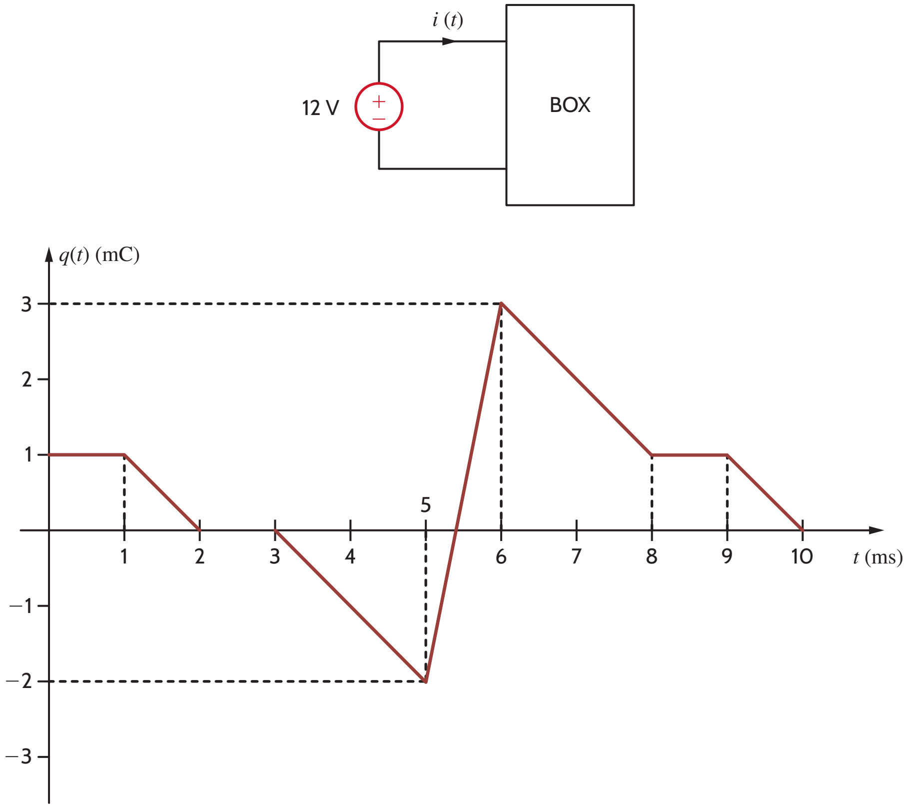


FIGURE P1.2.21

Solution:

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

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

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

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

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

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

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

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

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

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

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

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

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

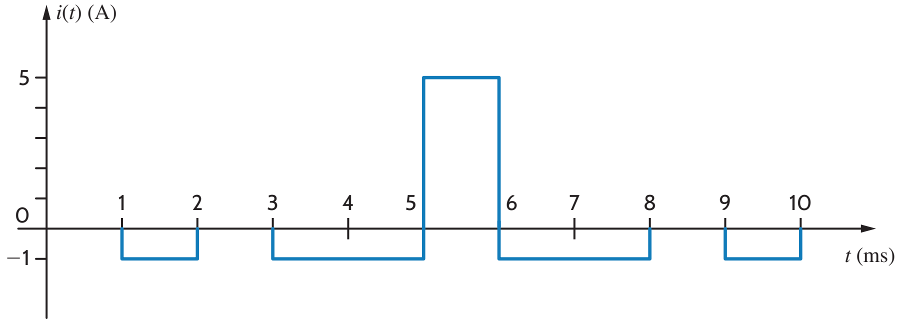
$$i = \frac{1\text{m} - 3\text{m}}{8\text{m} - 6\text{m}} = -1 \text{ A}, \quad P = (12)(-1) = -12 \text{ W}$$

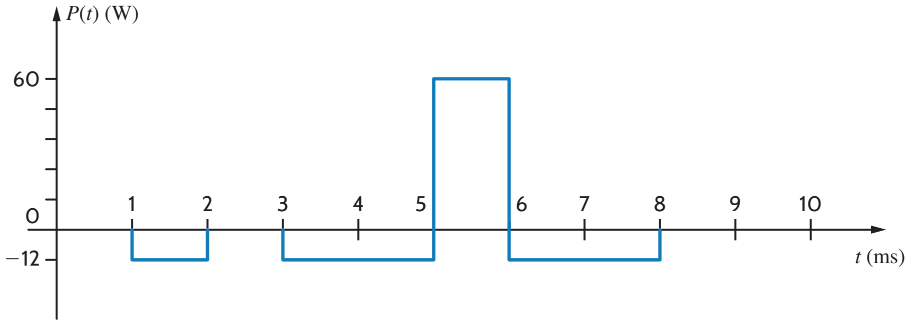
$8 \text{ ms} \leq t \leq 9 \text{ ms}$

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

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

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





Section 1.3 Solutions

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

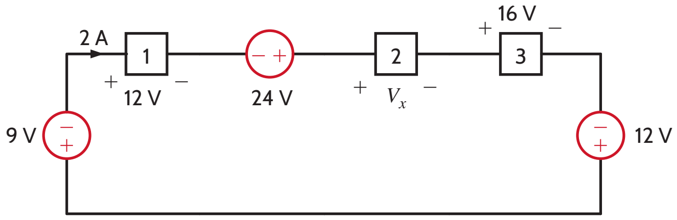


FIGURE P1.3.1

Solution:

$$P_{9\,V} = (9)(2) = 18\text{ W} \rightarrow 18\text{ W absorbed}$$
$$P_1 = (12)(2) = 24\text{ W} \rightarrow 24\text{ W absorbed}$$
$$P_{24\,V} = (-24)(2) = -48\text{ W} \rightarrow 48\text{ W supplied}$$
$$P_2 = V_x(2) = 2\,V_x\text{ W} \rightarrow 2\,V_x\text{ W absorbed}$$
$$P_3 = (16)(2) = 32\text{ W} \rightarrow 32\text{ W absorbed}$$
$$P_{12\,V} = (-12)(2) = -24\text{ W} \rightarrow 24\text{ W supplied}$$

$$P_{sup} = P_{abs}$$
$$48 + 24 = 18 + 24 + 2V_x + 32$$
$$V_x = -1\text{ V}$$

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

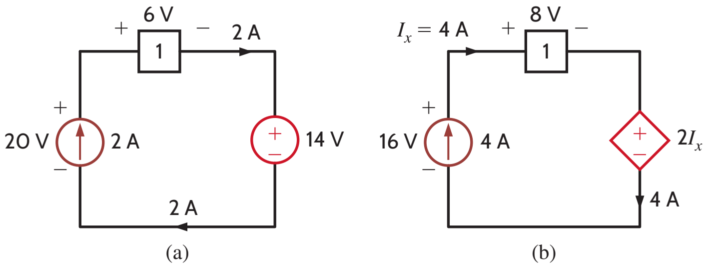


FIGURE P1.3.2

Solution:

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

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

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

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

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

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

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

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

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

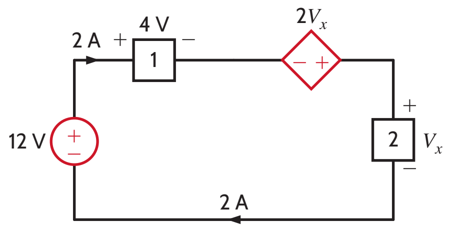


FIGURE P1.3.3

Solution:

$$P_{12\,V} = (-12)\cdot(2) = -24\text{ W} \rightarrow 24\text{ W supplied}$$
$$P_1 = (4)\cdot(2) = 8\text{ W} \rightarrow 8\text{ W absorbed}$$
$$P_{2V_x} = (-2V_x)\cdot(2) = -4V_x\text{ W} \rightarrow 4V_x\text{ W supplied}$$
$$P_2 = (V_x)\cdot(2) = 2V_x\text{ W} \rightarrow 2V_x\text{ W absorbed}$$

$$P_{sup} = P_{abs}$$
$$24 + 4\,V_x = 8 + 2\,V_x$$
$$V_x = -8\text{ V}$$

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

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

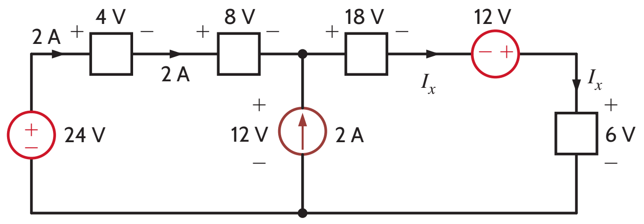


FIGURE P1.3.4

Solution:

$$P_{24\,V} = (-24)(2) = -48\text{ W} \rightarrow 48\text{ W supplied}$$
$$P_{4\,V} = (4)(2) = 8\text{ W} \rightarrow 8\text{ W absorbed}$$
$$P_{8\,V} = (8)(2) = 16\text{ W} \rightarrow 16\text{ W absorbed}$$
$$P_{2\,A} = (-12)(2) = -24\text{ W} \rightarrow 24\text{ W supplied}$$
$$P_{18\,V} = (18)(I_x) = 18I_x\text{ W} \rightarrow 18I_x\text{ W absorbed}$$
$$P_{12\,V} = (-12)(I_x) = -12I_x\text{ W} \rightarrow 12I_x\text{ W supplied}$$
$$P_{6\,V} = (6)(I_x) = 6I_x\text{ W} \rightarrow 6I_x\text{ W absorbed}$$
$$\text{P}_{sup} = \text{P}_{abs}$$
$$48 + 24 + 12I_x = 8 + 16 + 18I_x + 6I_x$$
$$I_x = 4\text{ A}$$

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

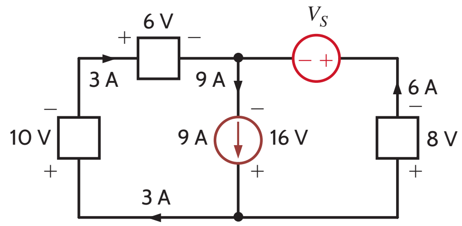


FIGURE P1.3.5

Solution:

$$P_{10\text{ V}} = (10)(3) = 30\text{ W} \rightarrow 30\text{ W absorbed}$$
$$P_{6\text{ V}} = (6)(3) = 18\text{ W} \rightarrow 18\text{ W absorbed}$$
$$P_{9\text{ A}} = (-16)(9) = -144\text{ W} \rightarrow 144\text{ W supplied}$$
$$P_{V_s} = V_s(6) = 6\,V_s\text{ W} \rightarrow 6\,V_s\text{ W absorbed}$$
$$P_{8\text{ V}} = (8)(6) = 48\text{ W} \rightarrow 48\text{ W absorbed}$$

$$P_{\text{sup}} = P_{\text{abs}}$$
$$144 = 30 + 18 + 6\,V_s + 48$$
$$V_s = 8\text{ V}$$
$$P_{V_s} = (8)(6) = 48\text{ W absorbed}$$

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.

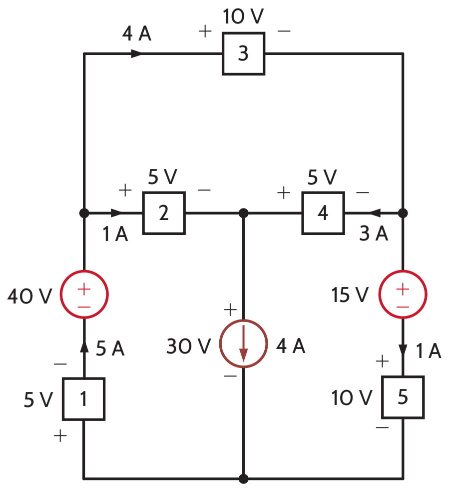


FIGURE P1.3.6

Solution:

$$P_{40\text{ V}} = (-40)(5) = -200 \text{ W} \rightarrow 200 \text{ W supplied}$$
$$P_{4\text{ A}} = (30)(4) = 120 \text{ W} \rightarrow 120 \text{ W absorbed}$$
$$P_{15\text{ V}} = (15)(1) = 15 \text{ W} \rightarrow 15 \text{ W absorbed}$$
$$P_1 = (5)(5) = 25 \text{ W} \rightarrow 25 \text{ W absorbed}$$
$$P_2 = (5)(1) = 5 \text{ W} \rightarrow 5 \text{ W absorbed}$$
$$P_3 = (10)(4) = 40 \text{ W} \rightarrow 40 \text{ W absorbed}$$
$$P_4 = (-5)(3) = -15 \text{ W} \rightarrow 15 \text{ W supplied}$$
$$P_5 = (10)(1) = 10 \text{ W} \rightarrow 10 \text{ W absorbed}$$

$$P_{sup} - P_{abs} = 0$$
$$(200 + 15) - (120 + 15 + 25 + 5 + 40 + 10) = 0$$
$$(215) - (215) = 0$$

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

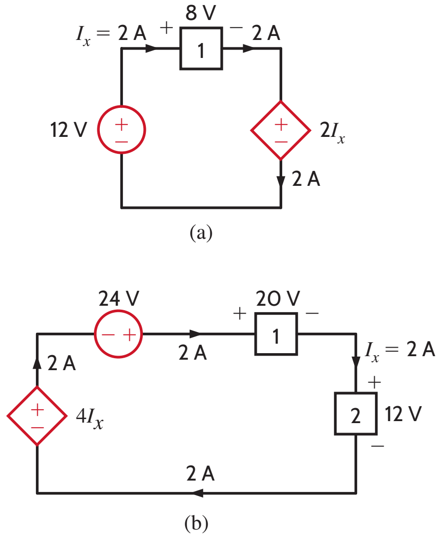


FIGURE P1.3.7

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.

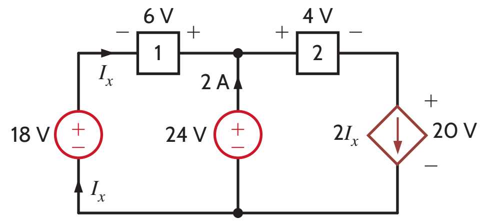


FIGURE P1.3.8

Solution:

$$P_{18\,V} = (-18)\cdot I_x = -18I_x\,W \rightarrow 18\cdot I_x\,W \text{ supplied}$$
$$P_1 = (-6)\cdot I_x = -6I_x\,W \rightarrow 6\cdot I_x\,W \text{ supplied}$$
$$P_{24\,V} = (-24)\cdot(2) = -48\,W \rightarrow 48\,W \text{ supplied}$$
$$P_2 = (4)\cdot(2I_x) = 8I_x\,W \rightarrow 8\cdot I_x\,W \text{ absorbed}$$
$$P_{2I_x} = (20)(2I_x) = 40I_x\,W \rightarrow 40I_x\,W \text{ absorbed}$$

$$P_{sup} = P_{abs}$$
$$18I_x + 6I_x + 48 = 8I_x + 40I_x$$
$$I_x = 2\text{ A}$$
$$P_1 = (-6)\cdot(2) = -12\text{ W}$$
$$P_1 = 12\text{ W supplied}$$

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

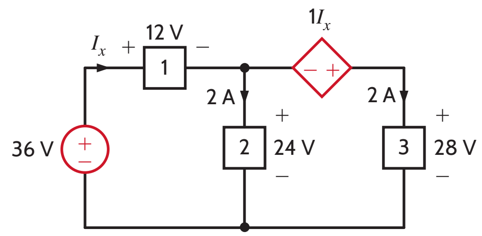


FIGURE P1.3.9

Solution:

$$P_{36\,V} = (-36)\cdot I_x = -36I_x\,W \rightarrow 36\cdot I_x\,W \text{ supplied}$$
$$P_1 = (12)\cdot I_x = 12I_x\,W \rightarrow 12\cdot I_x\,W \text{ absorbed}$$
$$P_2 = (24)\cdot(2) = 48\,W \rightarrow 48\,W \text{ absorbed}$$
$$P_1I_x = [-1(I_x)]\cdot 2 = -2\cdot I_x\,W \rightarrow 2\cdot I_x\,W \text{ supplied}$$
$$P_3 = (28)\cdot(2) = 56\,W \rightarrow 56\,W \text{ absorbed}$$

$$P_{sup} = P_{abs}$$
$$36I_x + 2\cdot I_x = 12I_x + 48 + 56$$
$$I_x = 4\text{ A}$$

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

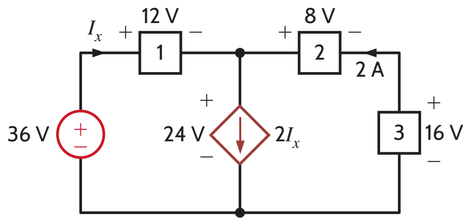


FIGURE P1.3.10

Solution:

$$P_{36\text{ V}} = (-36)\cdot I_x = -36\cdot I_x \text{ W} \rightarrow 36\cdot I_x \text{ W supplied}$$
$$P_1 = (12)\cdot I_x = 12I_x \text{ W} \rightarrow 12\cdot I_x \text{ W absorbed}$$
$$P_{2I_x} = (24)\cdot(2I_x) = 48\cdot I_x \text{ W} \rightarrow 48I_x \text{ W absorbed}$$
$$P_2 = (-8)(2) = -16 \text{ W} \rightarrow 16 \text{ W supplied}$$
$$P_3 = (-16)(2) = -32 \text{ W} \rightarrow 32 \text{ W supplied}$$

$$P_{\text{sup}} = P_{\text{abs}}$$
$$36I_x + 16 + 32 = 12I_x + 48I_x$$
$$I_x = 2 \text{ A}$$
$$P_1 = (12)(2) = 24 \text{ W absorbed}$$

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

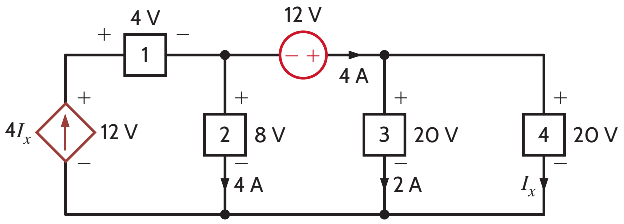


FIGURE P1.3.11

Solution:

$$P_{4I_x} = (-12)\cdot(4I_x) = -48I_x \text{ W} \rightarrow 48I_x \text{ W supplied}$$
$$P_1 = (4)(4I_x) = 16I_x \text{ W} \rightarrow 16I_x \text{ W absorbed}$$
$$P_2 = (8)(4) = 32 \text{ W} \rightarrow 32 \text{ W absorbed}$$
$$P_{12\text{ V}} = (-12)(4) = -48 \text{ W} \rightarrow 48 \text{ W supplied}$$
$$P_3 = (20)(2) = 40 \text{ W} \rightarrow 40 \text{ W absorbed}$$
$$P_4 = (20)\cdot I_x = 20I_x \text{ W} \rightarrow 20I_x \text{ W absorbed}$$

$$P_{\text{sup}} = P_{\text{abs}}$$
$$48I_x + 48 = 16I_x + 32 + 40 + 20I_x$$
$$I_x = 2 \text{ A}$$
$$P_1 = 16(2) = 32 \text{ W absorbed}$$

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

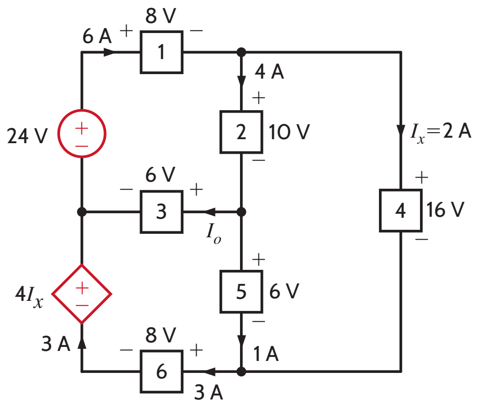


FIGURE P1.3.12

Solution:

$$P_{24\,V} = (-24)(6) = -144\text{ W} \rightarrow 144\text{ W supplied}$$
$$P_{4I_x} = [-4(2)](3) = -24\text{ W} \rightarrow 24\text{ W supplied}$$
$$P_1 = (8)(6) = 48\text{ W} \rightarrow 48\text{ W absorbed}$$
$$P_2 = (10)(4) = 40\text{ W} \rightarrow 40\text{ W absorbed}$$
$$P_3 = (6)\cdot I_o = 6I_o\text{ W} \rightarrow 6I_o\text{ W absorbed}$$
$$P_4 = (16)(2) = 32\text{ W} \rightarrow 32\text{ W absorbed}$$
$$P_5 = (6)(1) = 6\text{ W} \rightarrow 6\text{ W absorbed}$$
$$P_6 = (8)(3) = 24\text{ W} \rightarrow 24\text{ W absorbed}$$

$$P_{sup} = P_{abs}$$
$$144 + 24 = 48 + 40 + 6I_o + 32 + 6 + 24$$
$$I_o = 3\text{ A}$$

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.

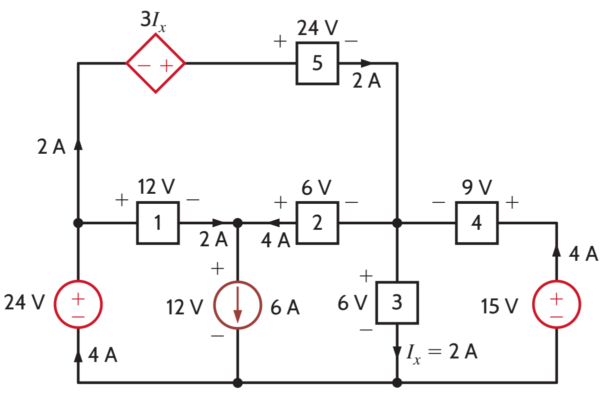


FIGURE P1.3.13

Solution:

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

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

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

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

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

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

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

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

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

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

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

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