CHAPTER 1

Basic Concepts

Section 1.2 Solutions

1.2.1 If the current in an electric conductor is 1.2 A, how many coulombs of charge pass any point in a 30-s interval?

Solution:

$$I = 1.2 \text{ A}, \Delta t = 30 \text{ s}$$

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

$$Q = 36 \text{ C}$$

1.2.2 Determine the time interval required for a 15-A battery charger to deliver 6000 C.

Solution:

$$I = 15 \text{ A}, Q = 6000 \text{ C}$$

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

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

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:

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

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 2.5 A. How many coulombs of charge pass any point in a time interval of 2.5 min?

Solution:

$$I = 2.5 \text{ A}, \Delta t = 2.5 \text{ min} = 150 \text{ s}$$

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

$$Q = 375 \text{ C}$$

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1.2.5 If 90 C of charge pass through an electric conductor in 45 s, determine the current in the conductor.

Solution:

$$Q = 90 \text{ C}, \Delta t = 45 \text{ s}$$

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

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

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

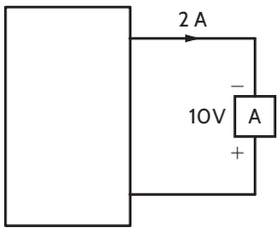
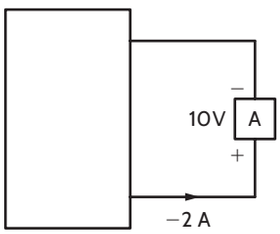


FIGURE P1.2.6

Solution:



$$P_A = (10)(-2)$$

$$P_A = -20 \text{ W absorbed}$$

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

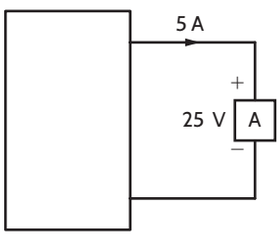
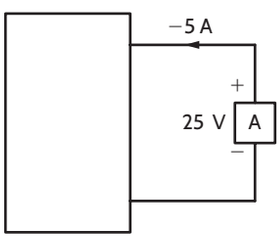


FIGURE P1.2.7

Solution:



$$P_A = (25)(-5)$$

$$P_A = -125 \text{ W supplied}$$

1.2.8 Determine the number of coulombs of charge produced by a 12-A battery charger in 1 h.

Solution:

$$I = 12 \text{ A}, \Delta t = 1 \text{ hr} = 60 \text{ min} = 3600 \text{ s}$$
$$Q = I \cdot \Delta t$$
$$Q = 43.2 \text{ kC}$$

1.2.9 The current at a given point in a certain circuit may be written as $i(t) = -3 + t$ A. Find the total charge passing the point between $t = 99$ and $t = 102$ s.

Solution: The charge passing through the circuit is

$$q = \int_{99}^{102} i(t)dt = \int_{99}^{102} (-3 + t)dt$$
$$= \left(-3 \times 102 + \frac{102^2}{2}\right) - \left(-3 \times 99 + \frac{99^2}{2}\right) = 292.5 \text{ C}$$

1.2.10 The charge entering the positive terminal of an element is given by the expression $q(t) = -10e^{-t}$ mC. The power delivered to the element is $p(t) = 2e^{-2t}$ mW. Calculate the current in the element, voltage across the element and the energy delivered to the element in the interval $0 < t < 100$ ms.

Solution:

$$I = \frac{dq}{dt} = 10e^{-t} \text{ mA}$$

Now $P = VI$, thus $V = 0.2e^{-t}$ V, is the voltage across the element.

$$E = \int p(t)dt = \int_0^2 2e^{-t}dt = 0.362 \text{ mJ}$$

1.2.11 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:

$$V(t) = 12\ e^{-2t} \text{ V}$$
$$i(t) = 2\ e^{-2t} \text{ A}$$
$$\text{W} = \int_{t1}^{t2} V \cdot idt = \int_0^{1.5} (12\ e^{-2t}) \cdot (2\ e^{-2t})dt$$
$$\text{W} = \frac{(24\ e^{-4t})}{-4}\Big|_0^{1.5}$$
$$\text{W} = 5.99 \text{ J}$$

1.2.12 The power absorbed by the BOX in Fig. P1.2.12 is $2\ e^{-2t}$ W. Calculate the amount of charge that enters the BOX between 0.1 and 0.4 seconds.

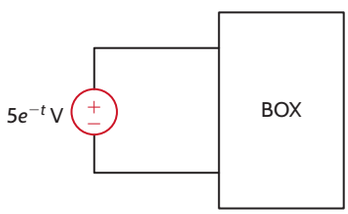


FIGURE P1.2.12

Solution:

$$P(t) = 2\,e^{-2t}\,\text{W}$$

$$V(t) = 5\,e^{-t}\,\text{V}$$

$$i(t) = \frac{P(t)}{V(t)} = 0.4\,e^{-t}\,\text{A}$$

$$\Delta q(t) = \int_{0.1}^{0.4} i(t)\,dt$$

$$= (-0.4\,e^{-t})\Big|_{0.1}^{0.4}$$

$$q(t) = 93.8\ \text{mC}, \quad 0.1\ \text{s} < t < 0.4\ \text{s}$$

1.2.13 The power absorbed by the BOX in Fig. P1.2.13 is $0.1\,e^{-4t}$ W for t ≥ 0s. Calculate the energy absorbed by the BOX during this same time interval.

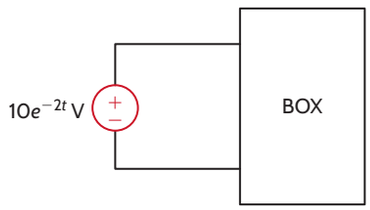


FIGURE P1.2.13

Solution:

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

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

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

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

1.2.14 Five coulombs of charge pass through element E in Fig. P1.2.14 from point A to point B. If the energy absorbed by the element is 150 J, determine the voltage across the element.

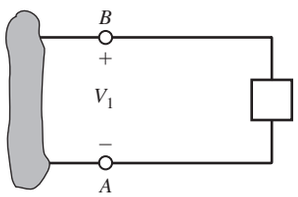


FIGURE P1.2.14

Solution:

$$\text{W} = 150\ \text{J}, Q = 5\ \text{C}$$

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

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

$$V_1 = -30\ \text{V}$$

1.2.15 The current that enters an element is shown in Fig. P1.2.15. Find the charge that enters the element in the time interval $0 < t < 20$ s.

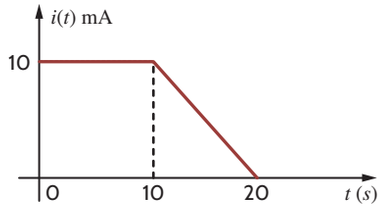


FIGURE P1.2.15

Solution:

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

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

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

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

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

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

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

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

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

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

1.2.16 Element A in the diagram in Fig. P1.2.16 absorbs 30 W of power. Calculate V_x.

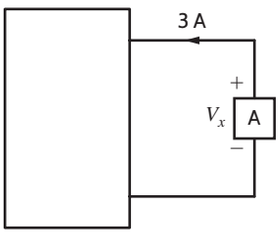
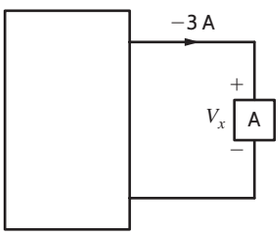


FIGURE P1.2.16

Solution:



$$30 = V_x \cdot (-3)$$

$$V_x = -10\text{ V}$$

1.2.17 Element B in the diagram in Fig. P1.2.17 supplies 84 W of power. Calculate I_x.

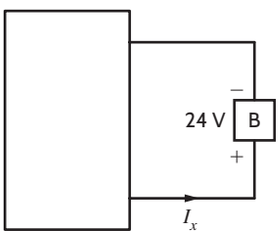
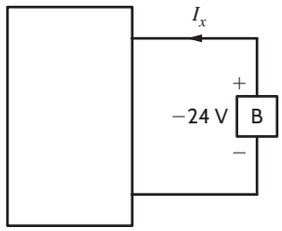


FIGURE P1.2.17

Solution:



$$84 = (-24) \cdot I_x$$

$$I_x = -3.5 \text{ A}$$

1.2.18 Element B in the diagram in Fig. P1.2.18 supplies 72 W of power. Calculate V_A.

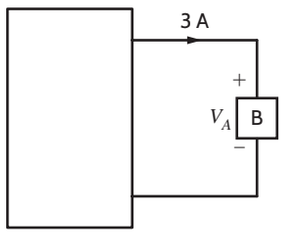
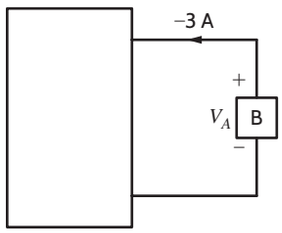


FIGURE P1.2.18

Solution:



$$72 = V_A \cdot (-3)$$

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

1.2.19 Element B in the diagram in Fig. P1.2.19 supplies 90 W of power. Calculate I_x.

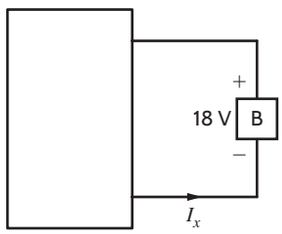


FIGURE P1.2.19

Solution:

$$90 = (18) \cdot I_x$$

$$I_x = 5 \text{ A}$$

1.2.20 Two elements are connected in series, as shown in Fig. P1.2.20. Element 1 supplies 27 W of power. Is element 2 absorbing or supplying power, and how much?

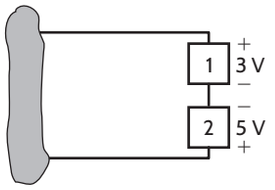
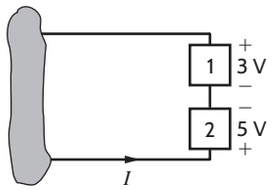


FIGURE P1.2.20

Solution:



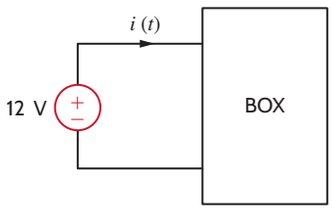
$$P_1 = 27 = V_1 \cdot I$$

$$I = \frac{27}{3} = 9 \text{ A}$$

$$P_2 = V_2 \cdot I = (5)(9)$$

$$P_2 = 45 \text{ W absorbed}$$

1.2.21 The energy absorbed by the BOX in Fig. P1.2.21 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.



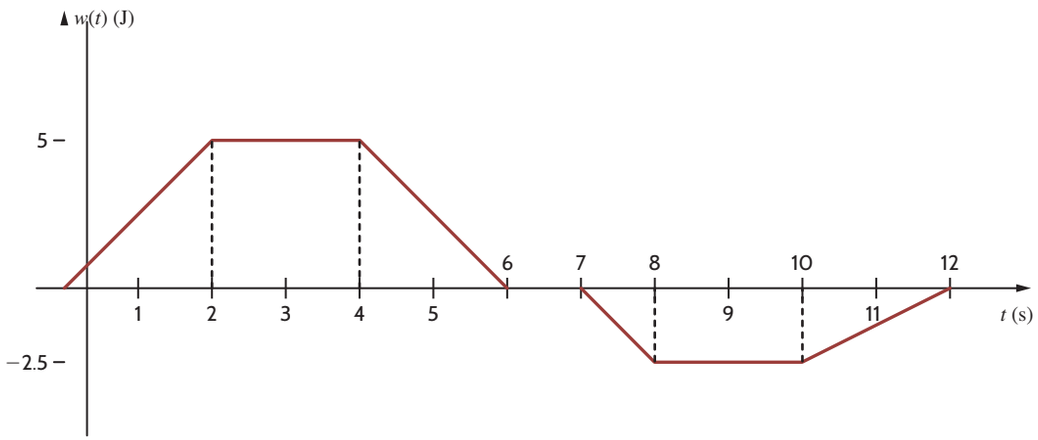
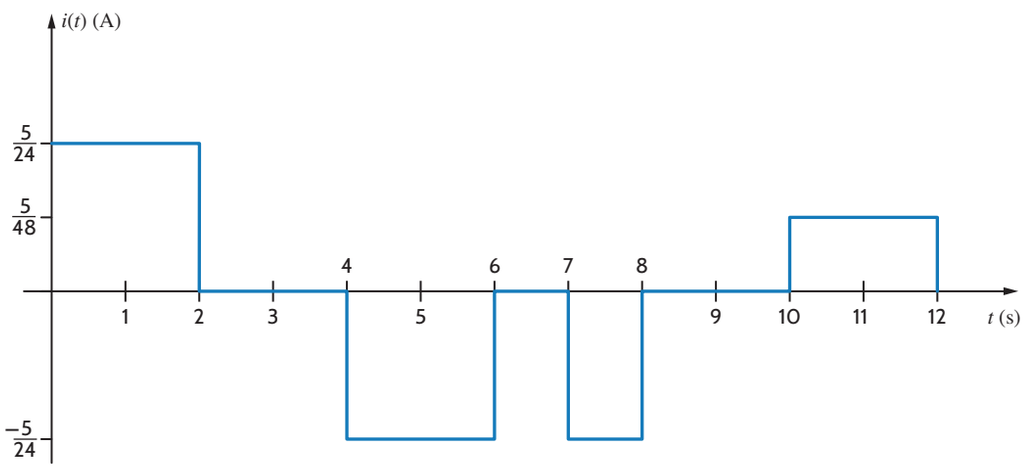


FIGURE P1.2.21

Solution:



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

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

$\underline{0\text{ s} \le t \le 2\text{ s}}$

$$P = \frac{5-0}{2-0} = 2.5\text{ W}, \quad i = \frac{P}{V} = \frac{2.5}{12} = \frac{5}{24}\text{ A}$$

$\underline{2\text{ s} \le t \le 4\text{ s}}$

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

$\underline{4\text{ s} \le t \le 6\text{ s}}$

$$P = \frac{0-5}{6-4} = -2.5\text{ W}, \quad i = \frac{P}{V} = -\frac{2.5}{12} = -\frac{5}{24}\text{ A}$$

$\underline{6\text{ s} \le t \le 7\text{ s}}$

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

$\underline{7\text{ s} \le t \le 8\text{ s}}$

$$P = \frac{-2.5-0}{8-7} = -2.5\text{ W}, \quad i = \frac{P}{V} = -\frac{2.5}{12} = -\frac{5}{24}\text{ A}$$

$\underline{8\text{ s} \le t \le 10\text{ s}}$

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

$\underline{10\text{ s} \le t \le 12\text{ s}}$

$$P = \frac{0-(-2.5)}{12-10} = 1.25\text{ W}, \quad i = \frac{P}{V} = \frac{1.25}{12} = \frac{5}{48}\text{ A}$$

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

$$q = \left(\frac{5}{24}\right) \cdot (2) + \left(-\frac{5}{24}\right) \cdot (2) + \left(-\frac{5}{24}\right) \cdot (1) + \left(\frac{5}{48}\right) \cdot (2)$$

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

1.2.22 The energy absorbed by the BOX in Fig. P1.2.22 is shown below. How much charge enters the BOX between 0 and 10 milliseconds?

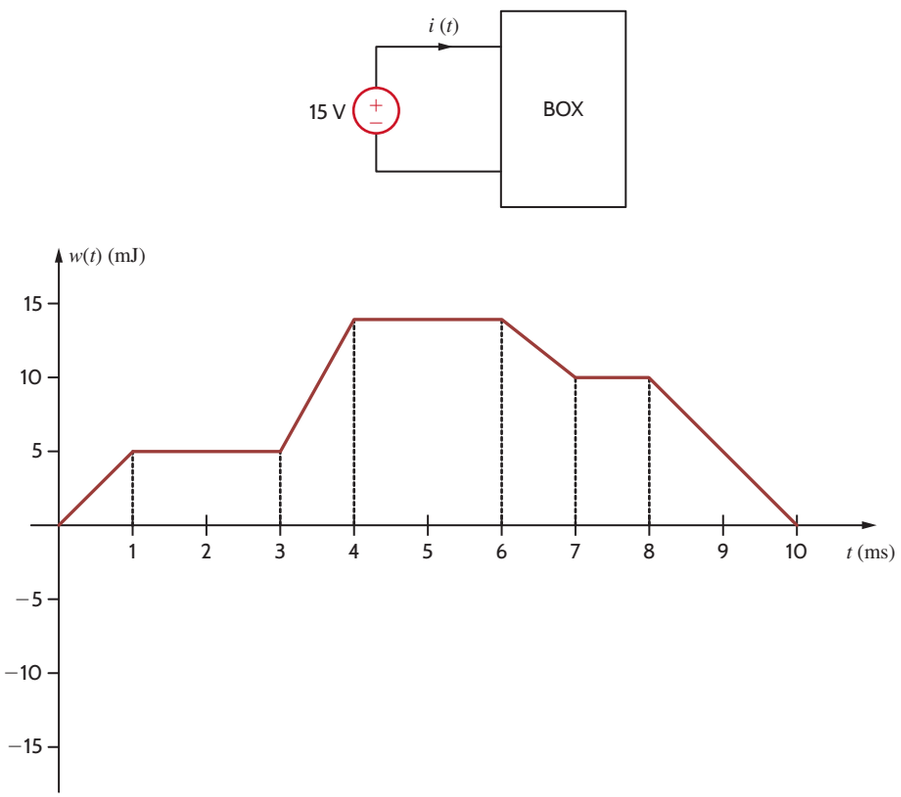


FIGURE P1.2.22

Solution:

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

$$P = V \cdot i = (15) \cdot i$$

$\underline{0\text{ s} \le t \le 1\text{ ms}}$

$$P = \frac{5\text{m} - 0}{1\text{m} - 0} = 5\text{ W}, \quad i = \frac{P}{V} = \frac{5}{15} = \frac{1}{3}\text{ A}$$

$\underline{1\text{ ms} \le t \le 3\text{ ms}}$

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

$\underline{3\text{ ms} \le t \le 4\text{ ms}}$

$$P = \frac{15\text{m} - 5\text{m}}{4\text{m} - 3\text{m}} = 10\text{ W}, \quad i = \frac{P}{V} = \frac{10}{15} = \frac{2}{3}\text{ A}$$

$\underline{4\text{ ms} \le t \le 6\text{ ms}}$

$$P = \frac{15\text{m} - 15\text{m}}{6\text{m} - 4\text{m}} = 0\text{ W}, \quad i = 0\text{ A}$$

$\underline{6\text{ ms} \le t \le 7\text{ ms}}$

$$P = \frac{10\text{m} - 15\text{m}}{7\text{m} - 6\text{m}} = -5\text{ W}, \quad i = \frac{P}{V} = -\frac{5}{15} = -\frac{1}{3}\text{ A}$$

$\underline{7\text{ ms} \le t \le 8\text{ ms}}$

$$P = \frac{10\text{m} - 10\text{m}}{8\text{m} - 7\text{m}} = 0\text{ W}, \quad i = 0\text{ A}$$

$\underline{8\text{ ms} \le t \le 10\text{ ms}}$

$$P = \frac{0 - 10\text{m}}{10\text{m} - 8\text{m}} = -5\text{ W}, \quad i = \frac{P}{V} = -\frac{5}{15} = -\frac{1}{3}\text{ A}$$

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

$$\Delta q = \left(\frac{1}{3}\right)(1\text{m}) + \left(\frac{2}{3}\right)(1\text{m}) + \left(\frac{-1}{3}\right)(1\text{m}) + \left(\frac{-1}{3}\right)(2\text{m})$$

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

1.2.23 The energy absorbed by the BOX in Fig. P1.2.23 is shown in the graph below. Calculate and sketch the current flowing into the BOX between 0 and 10 milliseconds.

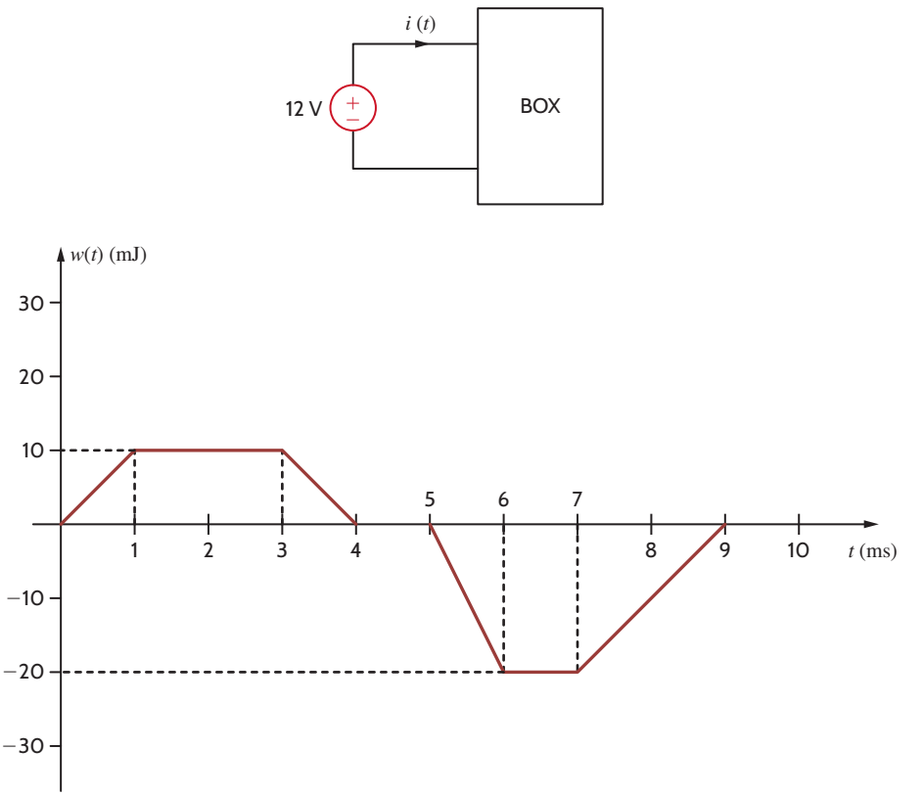
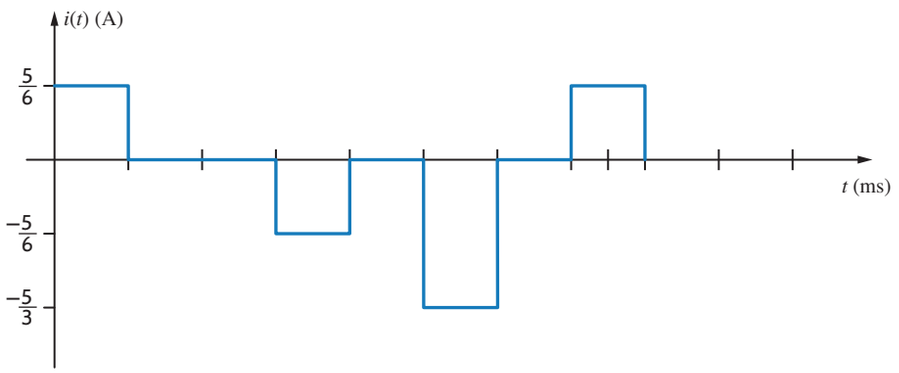


FIGURE P1.2.23

Solution:



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

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

$\underline{0\text{ s} \le t \le 1\text{ ms}}$

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

$\underline{1\text{ ms} \le t \le 3\text{ ms}}$

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

$\underline{3\text{ ms} \le t \le 4\text{ ms}}$

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

$\underline{4\text{ ms} \le t \le 5\text{ ms}}$

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

$\underline{5\text{ ms} \le t \le 6\text{ ms}}$

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

$\underline{6\text{ ms} \le t \le 7\text{ ms}}$

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

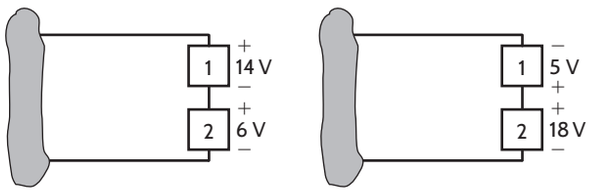
$\underline{7\text{ ms} \le t \le 9\text{ ms}}$

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

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

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

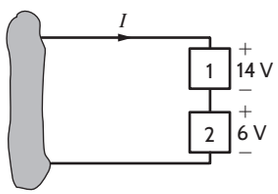
1.2.24 (a) In Fig. P1.2.24(a), $P_1 = 42$ W. Is element 2 absorbing or supplying power, and how much?
(b) In Fig. P1.2.24(b), $P_2 = -72$ W. Is element 1 absorbing or supplying power, and how much?



(a) (b)

FIGURE P1.2.24

Solution:

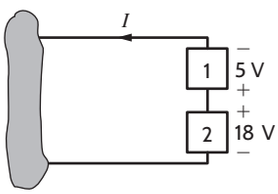


a) $P_1 = 42 = V_1 \cdot I$

$$I = \frac{42}{14} = 3\text{ A}$$

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

$P_2 = 18$ W absorbed



b) $P_2 = -72 = -V_2 \cdot I$

$$I = \frac{-72}{-18} = 4\text{ A}$$

$$P_1 = V_1 \cdot I = (5)(4)$$

$P_1 = 20$ W absorbed

1.2.25 The charge that enters the BOX in Fig. P1.2.25 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.

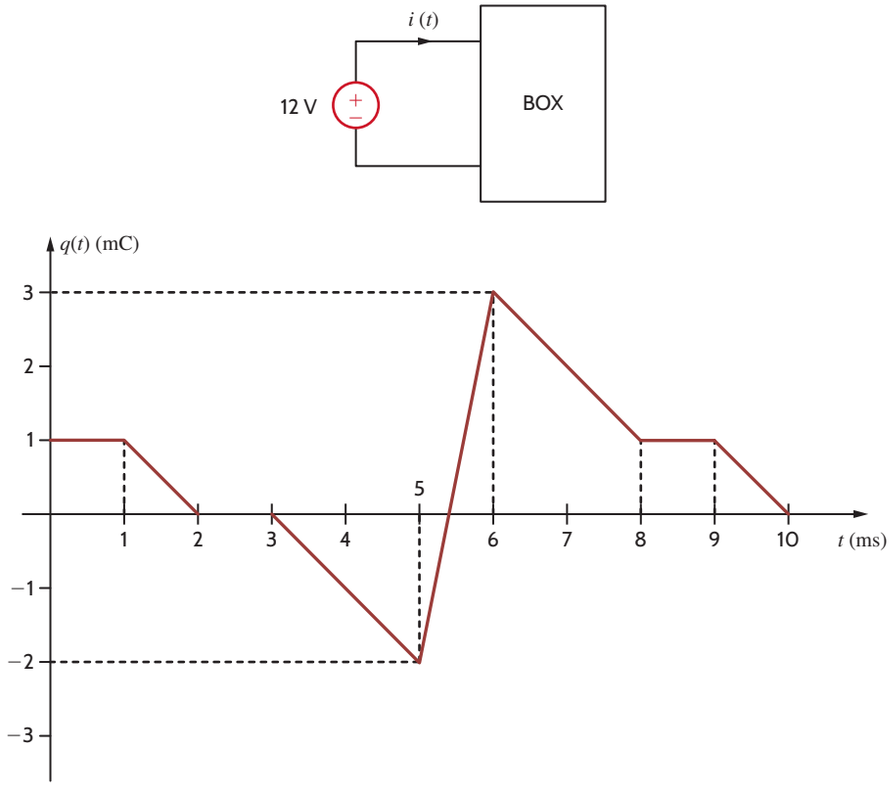


FIGURE P1.2.25

Solution:

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

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

$\underline{0\text{ s} \le t \le 1\text{ ms}}$

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

$\underline{1\text{ ms} \le t \le 2\text{ ms}}$

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

$\underline{2\text{ ms} \le t \le 3\text{ ms}}$

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

$\underline{3\text{ ms} \le t \le 5\text{ ms}}$

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

$\underline{5\text{ ms} \le t \le 6\text{ ms}}$

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

$\underline{6\text{ ms} \le t \le 8\text{ ms}}$

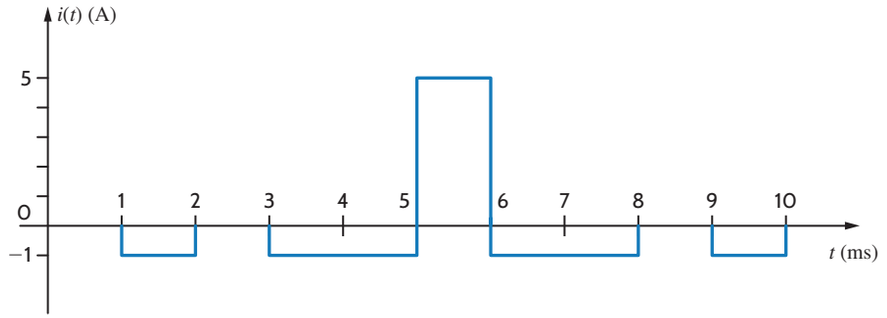
$$i = \frac{1\text{m} - 3\text{m}}{8\text{m} - 6\text{m}} = -1\text{ A}, \quad P = (12)(-1) = -12\text{ W}$$

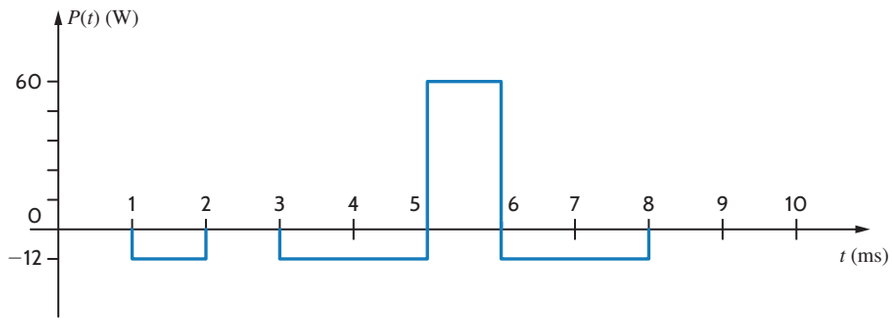
$\underline{8\text{ ms} \le t \le 9\text{ ms}}$

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

$\underline{9\text{ ms} \le t \le 10\text{ ms}}$

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





Section 1.3 Solutions

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

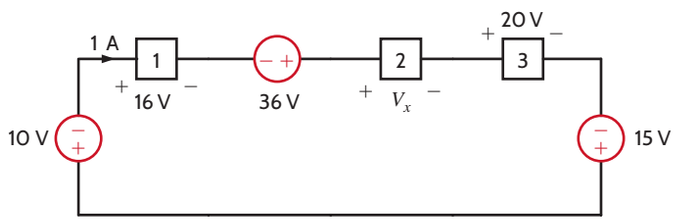


FIGURE P1.3.1

Solution:

$$P_{10\text{ V}} = (10)(1) = 10\text{ W} \rightarrow 10\text{ W absorbed}$$
$$P_1 = (16)(1) = 16\text{ W} \rightarrow 16\text{ W absorbed}$$
$$P_{36\text{ V}} = (-36)(1) = -36\text{ W} \rightarrow 36\text{ W supplied}$$
$$P_2 = V_x(1) = V_x\text{ W} \rightarrow V_x\text{ W absorbed}$$
$$P_3 = (20)(1) = 20\text{ W} \rightarrow 20\text{ W absorbed}$$
$$P_{15\text{ V}} = (-15)(1) = -15\text{ W} \rightarrow 15\text{ W supplied}$$

$$P_{\text{sup}} = P_{\text{abs}}$$
$$36 + 15 = 10 + 16 + V_x + 20$$
$$V_x = 5\text{ V}$$

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

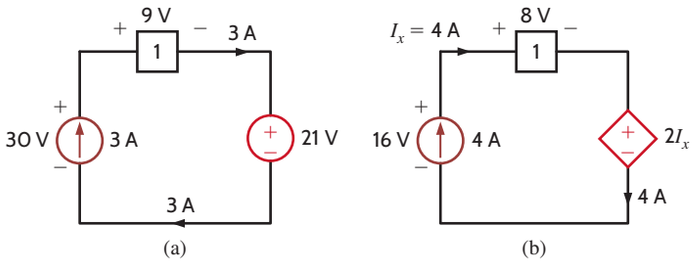


FIGURE P1.3.2

Solution:

a. $P_{3\,A} = (-30) \cdot (3) = -90$ W

$P_{3\,A} = 90$ W supplied

$P_1 = (9) \cdot (3) = 27$ W absorbed

$P_{21\,V} = (21) \cdot (3) = 63$ W absorbed

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

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

$P_1 = (8)(4) = 32$ W absorbed

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

1.3.3 Compute the power that is absorbed or supplied by the elements in the network in Fig. P1.3.3.

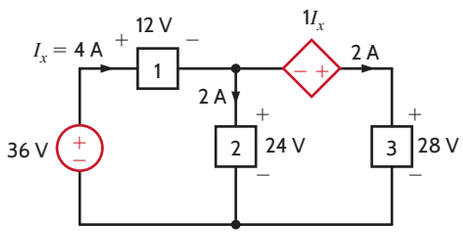


FIGURE P1.3.3

Solution:

$P_{36\,V} = (-36) \cdot I_x = (-36)(4) = -144$ W

$P_{36\,V} = 144$ W supplied

$P_1 = (12) \cdot I_x = (12) \cdot (4) = 48$ W absorbed

$P_2 = (24) \cdot (2) = 48$ W absorbed

$P_{1I_x} = [-1(4)] \cdot (2) = -8$ W

$P_{1I_x} = 8$ W supplied

$P_3 = (28) \cdot (2) = 56$ W absorbed

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

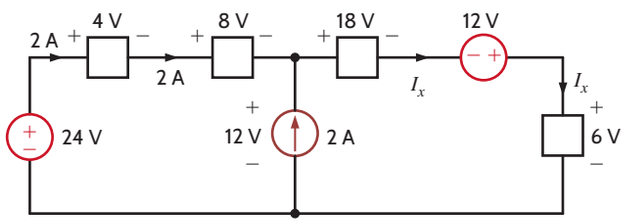


FIGURE P1.3.4

Solution:

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

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

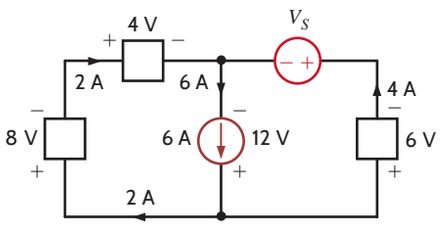


FIGURE P1.3.5

Solution:

$$P_{8\,\mathrm{V}} = (8)(2) = 16\ \mathrm{W} \rightarrow 16\ \mathrm{W\ absorbed}$$
$$P_{4\,\mathrm{V}} = (4)(2) = 8\ \mathrm{W} \rightarrow 8\ \mathrm{W\ absorbed}$$
$$P_{6\,\mathrm{A}} = (-12)(6) = -72\ \mathrm{W} \rightarrow 72\ \mathrm{W\ supplied}$$
$$P_{V_s} = V_s(4) = 4\,V_s\ \mathrm{W} \rightarrow 4\,V_s\ \mathrm{W\ absorbed}$$
$$P_{6\,\mathrm{V}} = (6)(4) = 24\ \mathrm{W} \rightarrow 24\ \mathrm{W\ absorbed}$$

$$P_{\mathrm{sup}} = P_{\mathrm{abs}}$$
$$72 = 16 + 8 + 4\,V_s + 24$$
$$V_s = 6\ \mathrm{V}$$
$$P_{V_s} = (6)(4) = 24\ \mathrm{W\ absorbed}$$

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.

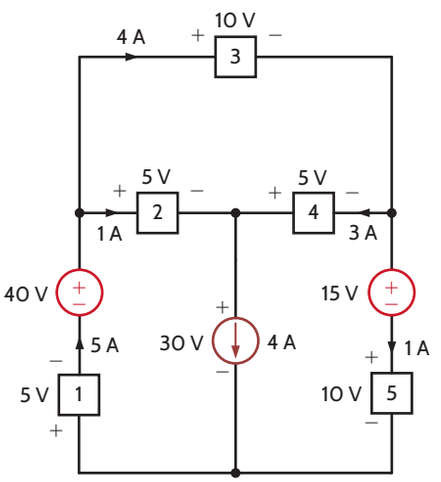


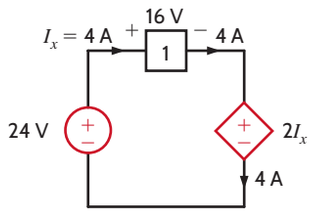
FIGURE P1.3.6

Solution:

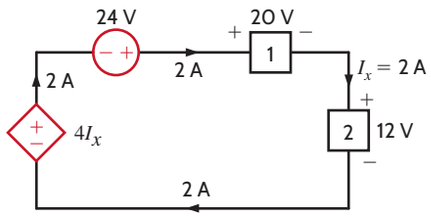
$$P_{40\,\text{V}} = (-40)(5) = -200\ \text{W} \rightarrow 200\ \text{W supplied}$$
$$P_{4\,\text{A}} = (30)(4) = 120\ \text{W} \rightarrow 120\ \text{W absorbed}$$
$$P_{15\,\text{V}} = (15)(1) = 15\ \text{W} \rightarrow 15\ \text{W absorbed}$$
$$P_1 = (5)(5) = 25\ \text{W} \rightarrow 25\ \text{W absorbed}$$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

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

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



(a)



(b)

FIGURE P1.3.7

Solution:

a. $P_{24\,\text{V}} = (-24)(4) = -96\ \text{W}$

$P_{24\,\text{V}} = 96\ \text{W supplied}$

$P_1 = (16)(4) = 64\ \text{W absorbed}$

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

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.

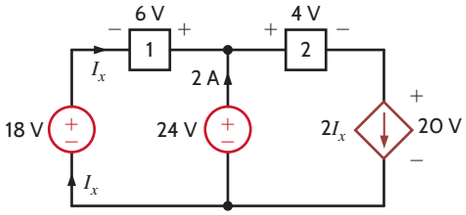


FIGURE P1.3.8

Solution:

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

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

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

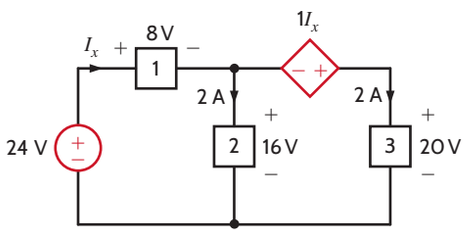


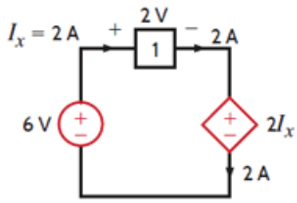
FIGURE P1.3.9

Solution:

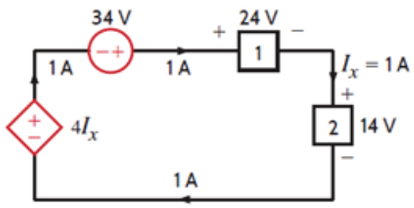
$$P_{24\,\text{V}} = (-24) \cdot I_x = -24I_x\,\text{W} \rightarrow 24 \cdot I_x\,\text{W supplied}$$
$$P_1 = (8) \cdot I_x = 8I_x\,\text{W} \rightarrow 8 \cdot I_x\,\text{W absorbed}$$
$$P_2 = (16) \cdot (2) = 32\,\text{W} \rightarrow 32\,\text{W absorbed}$$
$$P_1 I_x = [-1(I_x)] \cdot 2 = -2 \cdot I_x\,\text{W} \rightarrow 2 \cdot I_x\,\text{W supplied}$$
$$P_3 = (20) \cdot (2) = 40\,\text{W} \rightarrow 40\,\text{W absorbed}$$

$$P_{\text{sup}} = P_{\text{abs}}$$
$$24_x + 2 \cdot I_x = 8I_x + 32 + 40$$
$$I_x = 4\,\text{A}$$

1.3.10 Find the power that is absorbed or supplied by the network elements in Fig. P1.3.10.



(a)



(b)

FIGURE P1.3.10

Solution:

a. $P_1 = (2)(2) = 4$ W absorbed

$P_{2I_x} = (2.2)\,(2) = 8$ W absorbed

$P_{6v} = (-6)(2) = -12$ W

$P_{6v} = 12$ W supplied

b. $P_1 = (24)(1) = 24$ V absorbed

$P_{2v} = (14)(1) = 14$V absorbed

$P_{4I_x} = 4$ W supplied

$P_{34v} = 34$ W supplied

1.3.11 Determine the power absorbed by element 1 in Fig. P1.3.11.

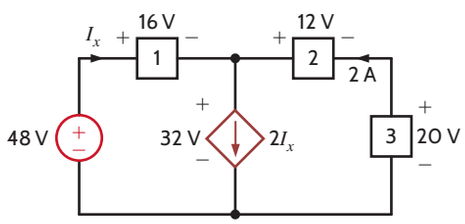


FIGURE P1.3.11

Solution:

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

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

$$P_{2I_x} = (32) \cdot (2I_x) = 64 \cdot I_x\,\text{W} \rightarrow 64\,I_x\,\text{W absorbed}$$

$$P_2 = (-12)(2) = -24\,\text{W} \rightarrow 24\,\text{W supplied}$$

$$P_3 = (-20)(2) = -40\,\text{W} \rightarrow 40\,\text{W supplied}$$

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

$$48I_x + 24 + 40 = 16I_x + 64I_x$$

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

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

1.3.12 Find the power absorbed or supplied by element 1 in Fig. P1.3.12.

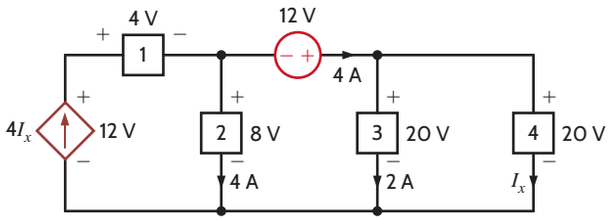


FIGURE P1.3.12

Solution:

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

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

1.3.13 Find I_o in the network in Fig. P1.3.13 using Tellegen's theorem.

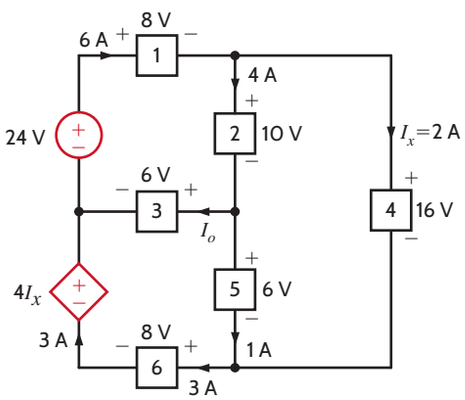


FIGURE P1.3.13

Solution:

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

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

1.3.14 Calculate the power absorbed by each element in the circuit in Fig. P1.3.14. Also, verify that Tellegen's theorem is satisfied by this circuit.

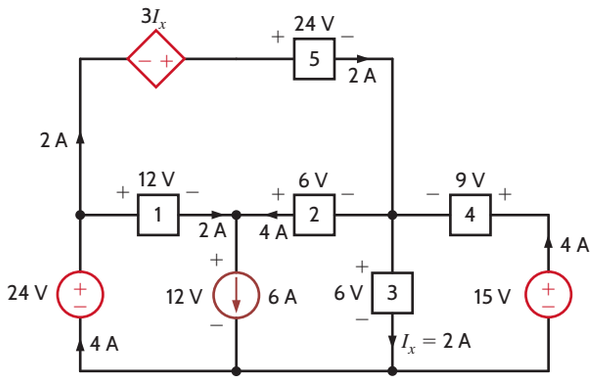


FIGURE P1.3.14

Solution:

$$P_{3I_x} = [-3(2)] \cdot (2) = -12\text{ W} \rightarrow 12\text{ W supplied}$$
$$P_{24\text{ V}} = (-24)(4) = -96\text{ W} \rightarrow 96\text{ W supplied}$$
$$P_{6\text{ A}} = (12)(6) = 72\text{ W} \rightarrow 72\text{ W absorbed}$$
$$P_{15\text{ V}} = (-15)(4) = -60\text{ W} \rightarrow 60\text{ W supplied}$$
$$P_1 = (12)(2) = 24\text{ W} \rightarrow 24\text{ W absorbed}$$
$$P_2 = (-6)(4) = -24\text{ W} \rightarrow 24\text{ W supplied}$$
$$P_3 = (6)(2) = 12\text{ W} \rightarrow 12\text{ W absorbed}$$
$$P_4 = (9)(4) = 36\text{ W} \rightarrow 36\text{ W absorbed}$$
$$P_5 = (24)(2) = 48\text{ W} \rightarrow 48\text{ W absorbed}$$

$$P_{\text{sup}} - P_{\text{abs}} = 0$$
$$(12 + 96 + 60 + 24) - (72 + 24 + 12 + 36 + 48) = 0$$
$$(192) - (192) = 0$$

1.3.15 In the circuit in Fig. P1.3.15, element 1 absorbs 40 W, element 2 supplies 50 W, element 3 supplies 25 W, and element 4 absorbs 15 W. How much power is supplied by element 5?

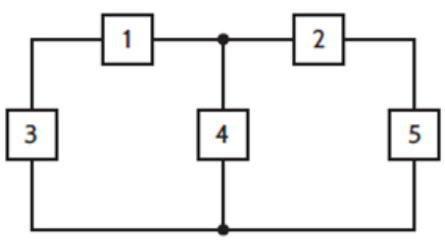


FIGURE P1.3.15

Solution:

$$P_{\text{supplied}} = P_{\text{absorbed}}$$
$$P_2 + P_3 + P_5 = P_1 + P_4$$
$$50 + 25\,P_5 = 40 + 15$$
$$P_5 = -20\text{ W supplied or } P_5 = 20\text{ W absorbed}$$

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