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

## SOLUTION:

$I = 2.4A$ , $\Delta t = 30s$

$Q = I \cdot \Delta t$

$Q = 72C$

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

## SOLUTION:

$I = 12A \quad , \quad Q = 4800C$

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

$\Delta t = 400s$

1.3 A lightning bolt carrying 30,000 A lasts for 50 micro-seconds. If the lightning strikes an airplane flying at 20,000 feet, what is the charge deposited on the plane?

## SOLUTION:

$I = 30{,}000\,A$, $\Delta t = 50\,\mu s$

$Q = I \cdot \Delta t$

$Q = 1.5\,C$

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

**SOLUTION:**

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

a) $\Delta Q = \dfrac{\Delta W}{V}$

$\Delta Q = 8.33C$

b) $I = \dfrac{\Delta Q}{\Delta t}$, $\Delta t = 5s$

$I = 1.67A$

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

## SOLUTION:

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

$Q = I \cdot \Delta t$

$Q = 135C$

**1.6** If 60 C of charge pass through an electric conductor in 30 seconds, determine the current in the conductor.

## SOLUTION:

$Q = 60C$ , $\Delta t = 30s$

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

$I = 2A$

**1.7** Determine the number of coulombs of charge produced by a 12-A battery charger in an hour.

## SOLUTION:

$I = 12A$ , $\Delta t = 1hr = 60min = 3600s$

$Q = I \cdot \Delta t$

$Q = 43.2kC$

**1.8** Five coulombs of charge pass through the element in Fig. P1.8 from point *A* to point *B*. If the energy absorbed by the element is 120 J, determine the voltage across the element.

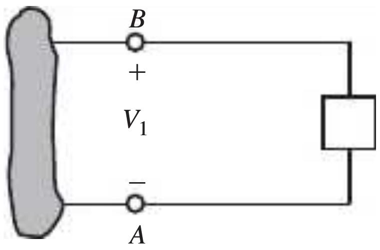


Figure P1.8

## SOLUTION:

$W = 120J, \quad Q = 5C$

$W = -V_1 \cdot Q$

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

$V_1 = -24V$

**1.9** The current that enters an element is shown in Fig. P1.9. Find the charge that enters the element in the time interval $0 < t < 20$ s.

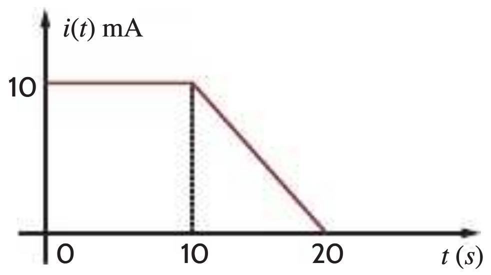


Figure P1.9

## SOLUTION:

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

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

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

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

$$b = 20m$$

$$i(t) = (-t + 20)\,mA$$

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

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

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

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

**1.10** The charge entering the positive terminal of an element is $q(t) = -30e^{-4t}$ mC. If the voltage across the element is $120e^{-2t}$ V, determine the energy delivered to the element in the time interval $0 < t < 50$ ms.

## SOLUTION:

$$q(t) = -30e^{-4t}\ \text{mC}$$

$$v(t) = 120e^{-2t}\ \text{V}$$

$$W = \int_{t1}^{t2} P\,dt = \int_{t1}^{t2} V \cdot i\,dt$$

$$i(t) = \frac{dq(t)}{dt} = -4 \cdot (-30e^{-4t}) = 120e^{-4t}\ \text{mA}$$

$$W = \int_{0}^{50m} (120e^{-2t}) \cdot (120e^{-4t} \times 10^{-3})\,dt$$

$$W = 14.4 \cdot \left( \frac{e^{-6t}}{-6} \right) \Big|_{0}^{50m}$$

$$W = 622.04\ \text{mJ}$$

1.11 The charge entering the positive terminal of an element is given by the expression $q(t) = -12e^{-2t}$ mC. The power delivered to the element is $p(t) = 2.4e^{-3t}$ 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:**

$$q(t) = -12e^{-2t} \text{ mC}$$

$$p(t) = 2.4e^{-3t} \text{ W}$$

$$i(t) = \frac{dq(t)}{dt} = -2 \cdot (-12e^{-2t})$$

$$i(t) = 24e^{-2t} \text{ mA}$$

$$W = \int_{t1}^{t2} p(t)\,dt = \int_{0}^{100m} 2.4e^{-3t}\,dt$$

$$W = \left.\frac{(2.4e^{-3t})}{-3}\right|_{0}^{100m}$$

$$W = 207.35 \text{ mJ}$$

$$v(t) = \frac{p(t)}{i(t)}$$

$$v(t) = 100e^{-t} \text{ V}$$

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

---

**SOLUTION:**

$$v(t) = 12e^{-2t}\ \text{V}$$

$$i(t) = 2e^{-2t}\ \text{A}$$

$$w = \int_{t1}^{t2} v \cdot i\, dt = \int_0^{1.5} (12e^{-2t}) \cdot (2e^{-2t})\, dt$$

$$w = \left. \frac{(24e^{-4t})}{-4} \right|_0^{1.5}$$

$$w = 5.99\ \text{J}$$

**1.13** The power absorbed by the BOX in Fig. P1.13 is $2e^{-2t}$ W. Calculate the amount of charge that enters the BOX between 0.1 and 0.4 seconds.

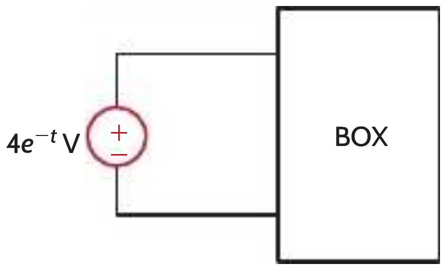


Figure P1.13

## SOLUTION:

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

$$V(t) = 4e^{-t}\ \text{V}$$

$$i(t) = \frac{P(t)}{V(t)} = 0.5e^{-t}\ \text{A}$$

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

$$= \left(-0.5e^{-t}\right)\Big|_{0.1}^{0.4}$$

$$q(t) = 117.26\ \text{mC},\quad 0.1\text{s} < t < 0.4\text{s}$$

**1.14** The power absorbed by the BOX in Fig. P1.14 is $0.1e^{-4t}$ W. Calculate the energy absorbed by the BOX during this same time interval.

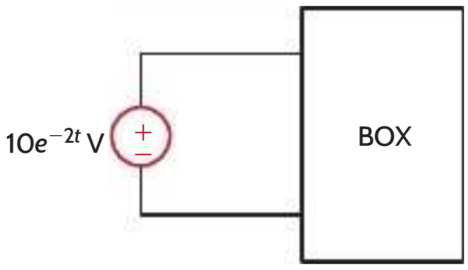


Figure P1.14

## SOLUTION:

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

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

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

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

**1.15** The energy absorbed by the BOX in Fig. P1.15 is shown below. How much charge enters the BOX between 0 and 10 milliseconds?

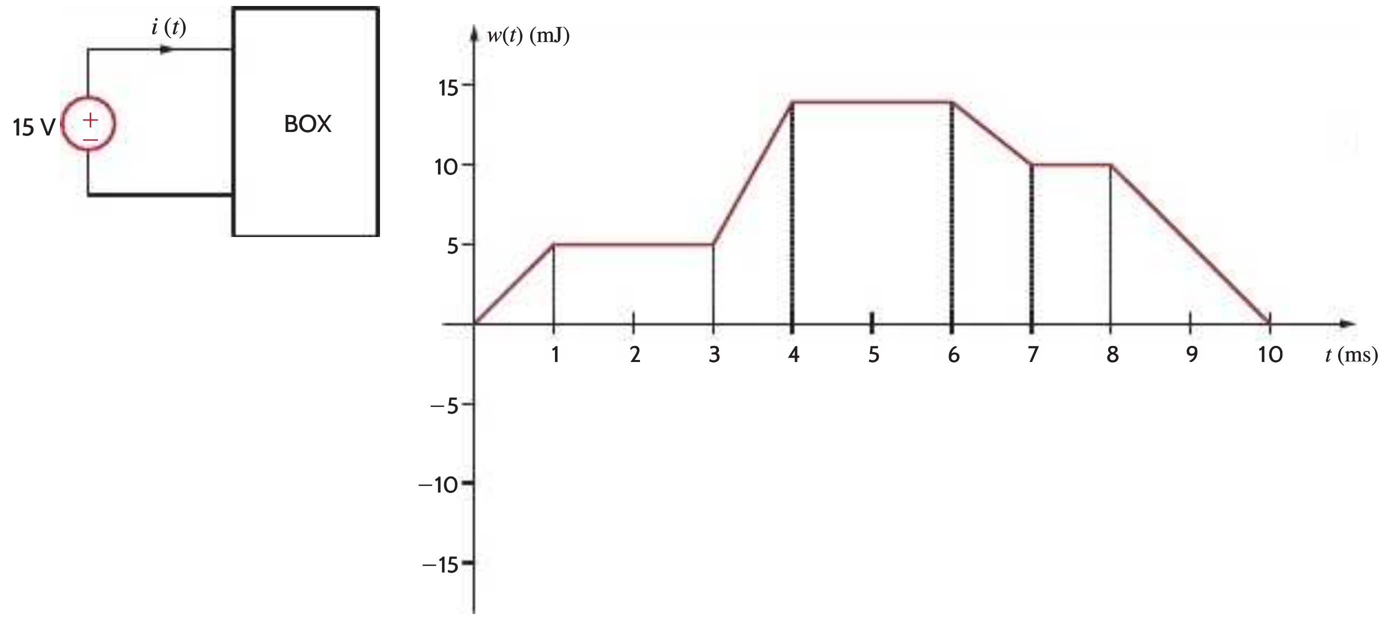


Figure P1.15

## SOLUTION:

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

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

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

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

<u>$1ms \le t \le 3ms$</u>

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

<u>$3ms \le t \le 4ms$</u>

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

<u>$4ms \le t \le 6ms$</u>

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

$6ms \le t \le 7ms$

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

$7ms \le t \le 8ms$

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

$8ms \le t \le 10ms$

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

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

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

$$\Delta q = 0C$$

**1.16** The charge that enters the BOX in Fig. P1.16 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.

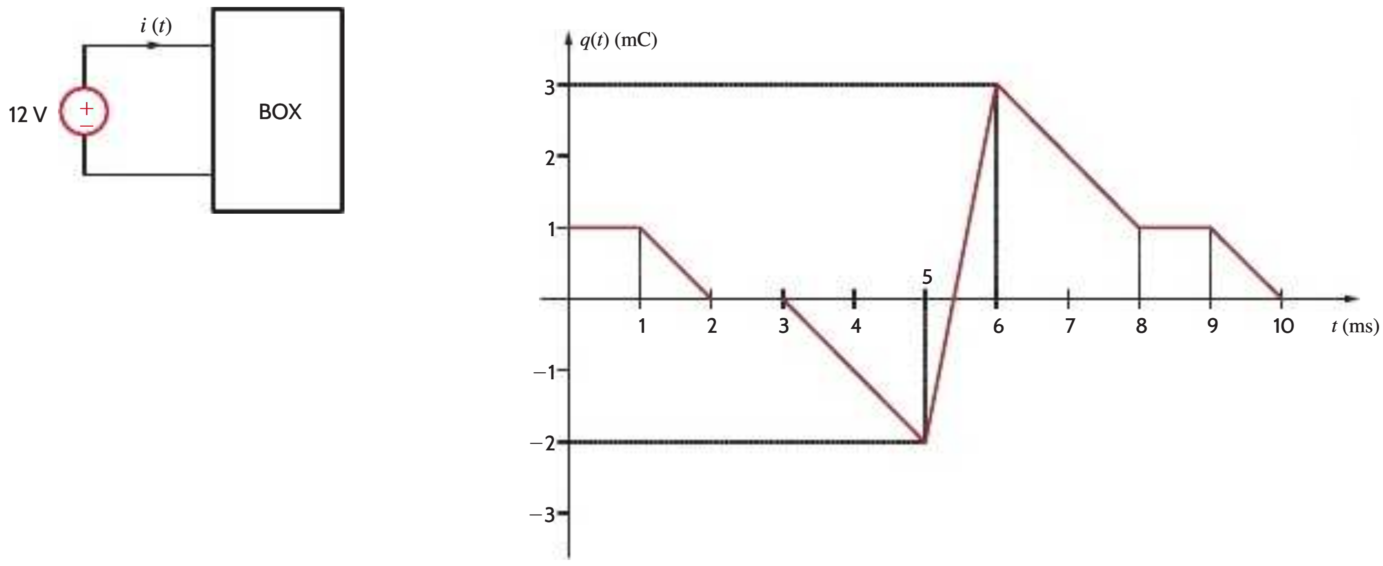


Figure P1.16

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## SOLUTION:

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

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

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

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

<u>$1ms \le t \le 2ms$</u>

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

<u>$2ms \le t \le 3ms$</u>

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

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

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

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

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

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

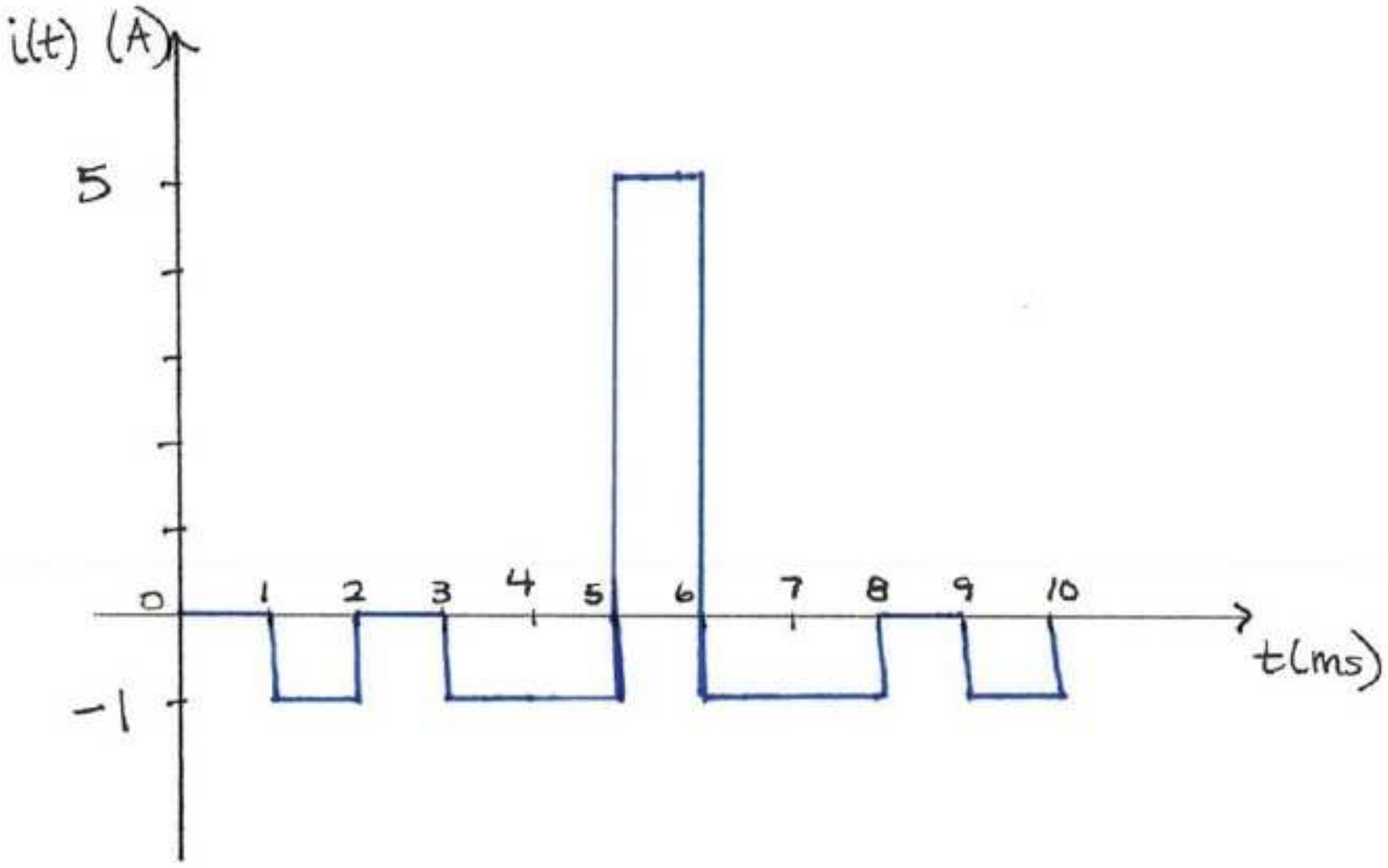
$$i = \frac{1m - 3m}{8m - 6m} = -1\,A, \quad P = (12)(-1) = -12W$$

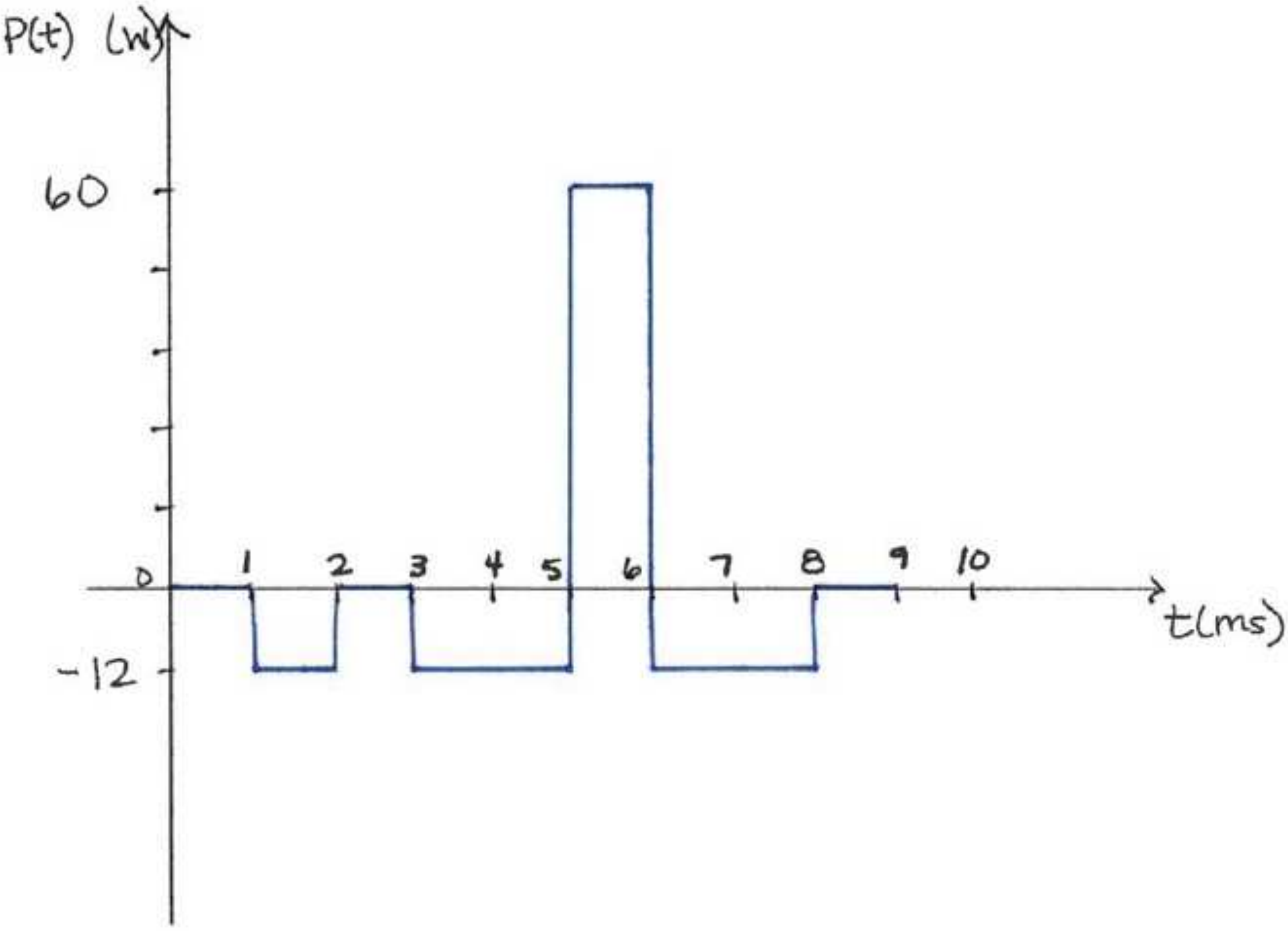
$\underline{8ms \le t \le 9ms}$

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

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

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


i(t) (A)
5
-1
0
1
2
3
4
5
6
7
8
9
10
t(ms)


P(t) (W)
60
-12
0
1
2
3
4
5
6
7
8
9
10
t(ms)

**1.17** The energy absorbed by the BOX in Fig. P1.17 is given below. Calculate and sketch the current flowing into the BOX. Also calculate the charge which enters the BOX between 0 and 12 seconds.

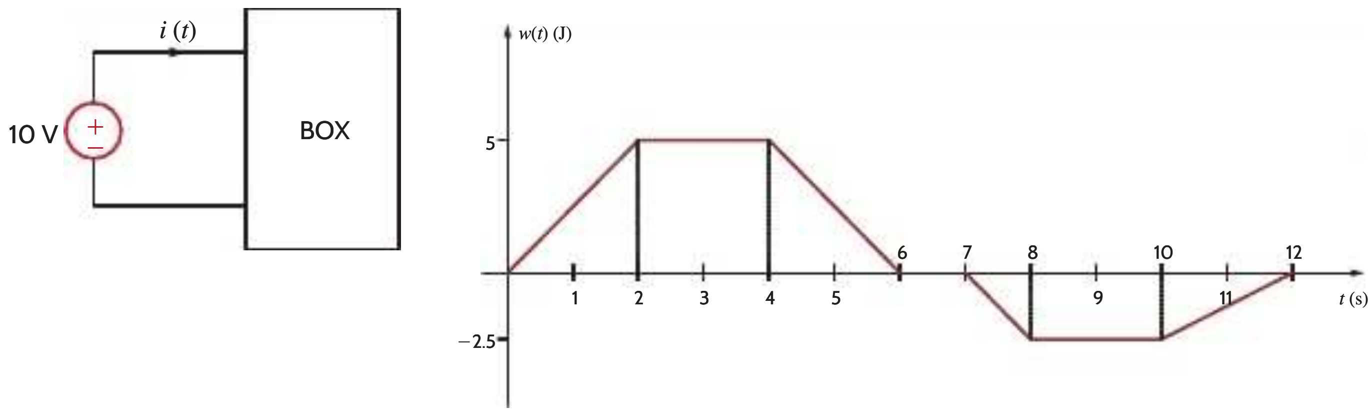



Figure P1.17

## SOLUTION:

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

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

<u>0s ≤ t ≤ 2s</u>

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

<u>2s ≤ t ≤ 4s</u>

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

<u>4s ≤ t ≤ 6s</u>

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

$6s \le t \le 7s$

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

$7s \le t \le 8s$

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

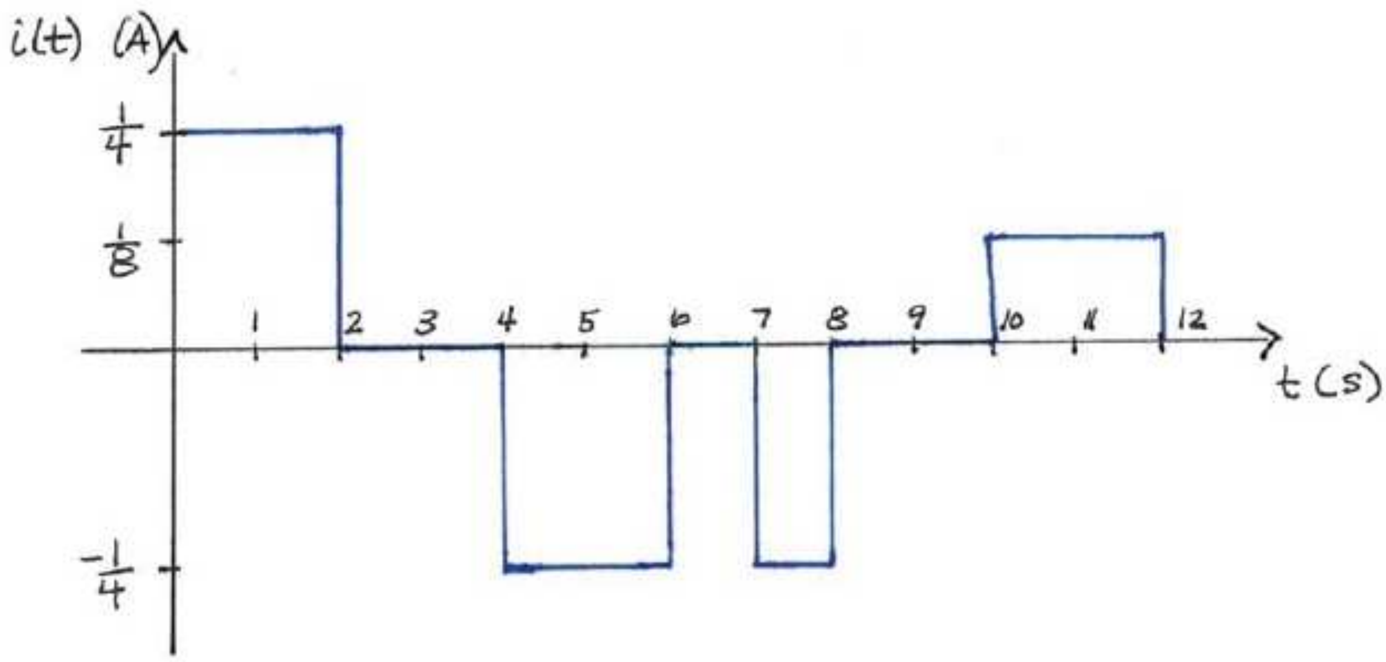
$8s \le t \le 10s$

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

$10s \le t \le 12s$

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

$$q = \int i\,dt$$
$$q = \left(\tfrac{1}{4}\right)\cdot(2) + \left(\tfrac{-1}{4}\right)(2) + \left(\tfrac{-1}{4}\right)(1) + \left(\tfrac{1}{8}\right)(2)$$
$$q = 0C$$



**1.18** The charge entering the upper terminal of the BOX in Fig. P1.18 is shown below. How much energy is absorbed by the BOX between 0 and 9 seconds?

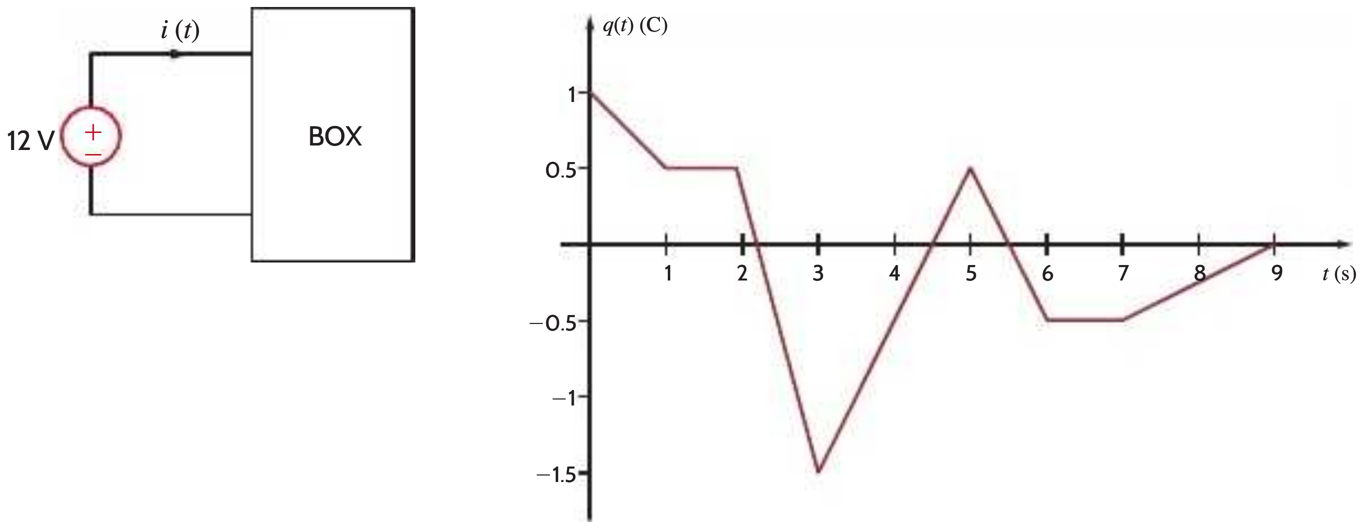



Figure P1.18

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## SOLUTION:

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

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

<u>$0s \le t \le 1s$</u>

$$i = \frac{0.5-1}{1-0} = -0.5A \ , \quad P = (12) \cdot (-0.5) = -6W$$

<u>$1s \le t \le 2s$</u>

$$i = \frac{0.5-0.5}{2-1} = 0A \ , \quad P = 0W$$

<u>$2s \le t \le 3s$</u>

$$i = \frac{-1.5-0.5}{3-2} = -2A \ , \quad P = (12)(-2) = -24W$$

$3s \le t \le 5s$

$$i = \frac{0.5-(-1.5)}{5-3} = 1A \quad , \quad P = (12)(1) = 12W$$

$5s \le t \le 6s$

$$i = \frac{-0.5-0.5}{6-5} = -1A \quad , \quad P = (12)(-1) = -12W$$

$6s \le t \le 7s$

$$i = \frac{-0.5-(-0.5)}{7-6} = 0A \quad , \quad P = 0W$$

$7s \le t \le 9s$

$$i = \frac{0-(-0.5)}{9-7} = 0.25A \quad , \quad P = (12)(0.25) = 3W$$

$$W = \int p\,dt$$

$$W = (-6)(1) + (-24)(1) + (12)(2) + (-12)(1) + (3)(2)$$

$$W = -12J$$

**1.19** The energy absorbed by the BOX in Fig. P1.19 is shown in the graph below. Calculate and sketch the current flowing into the BOX between 0 and 10 milliseconds.

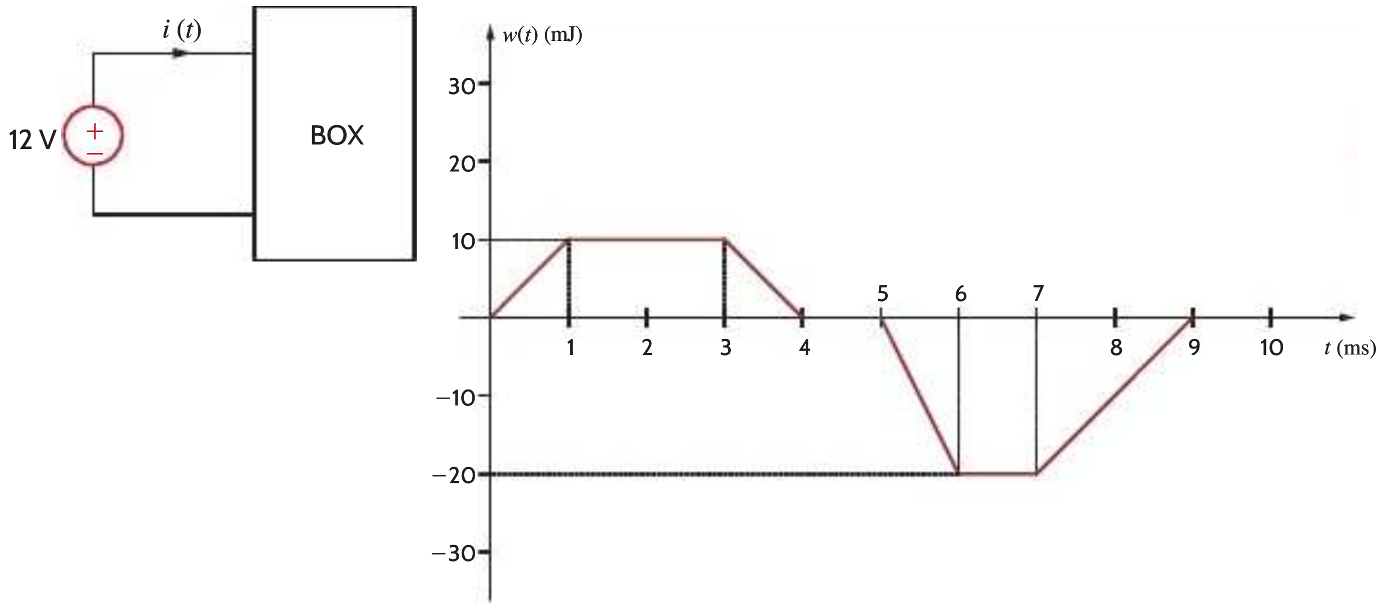



**Figure P1.19**

## SOLUTION:

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

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

$0s \le t \le 1ms$

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

$1ms \le t \le 3ms$

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

$3ms \le t \le 4ms$

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

<u>$4ms \le t \le 5ms$</u>

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

<u>$5ms \le t \le 6ms$</u>

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

<u>$6ms \le t \le 7ms$</u>

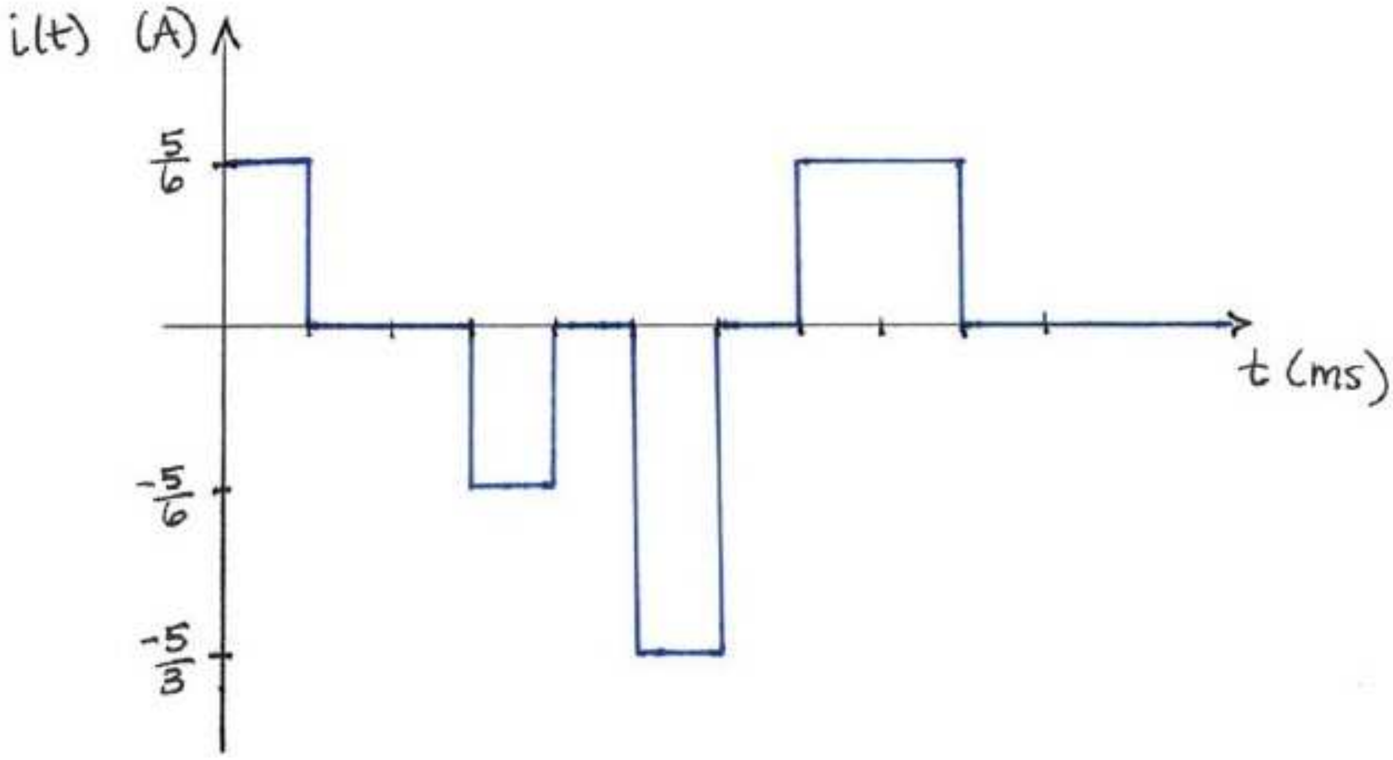
$$P = \frac{-20m-(-20m)}{7m-6m} = 0\,W\,, \quad i = 0A$$

<u>$7ms \le t \le 9ms$</u>

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

<u>$t > 9ms$</u>

$$P = 0\,W\,, \quad i = 0A$$



**1.20** Determine the amount of power absorbed or supplied by the element in Fig. P1.20 if

**(a)** $V_1 = 9$ V and $I = 2$A

**(b)** $V_1 = 9$ V and $I = -3$A

**(c)** $V_1 = -12$ V and $I = 2$A

**(d)** $V_1 = -12$ V and $I = -3$A

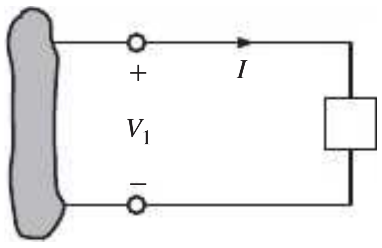



Figure P1.20

## SOLUTION:

a) $V_1 = 9V$, $I = 2A$

$P = V_1 \cdot I = 18W$ absorbed

b) $V_1 = 9V$, $I = -3A$

$P = V_1 \cdot I = -27W$

$P = 27W$ supplied

c) $V_1 = -12V$, $I = 2A$

$P = V_1 \cdot I = -24W$

$P = 24W$ supplied

d) $V_1 = -12V$, $I = -3A$

$P = V_1 \cdot I = 36W$ absorbed

**1.21** Calculate the power absorbed by element A in Fig. P1.21.

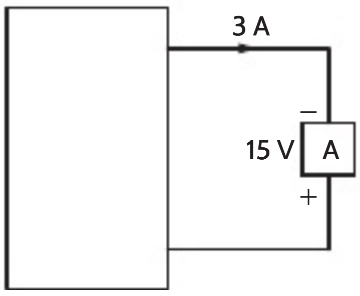
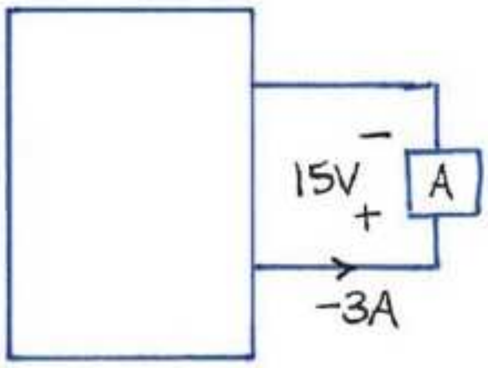



Figure P1.21

## SOLUTION:




$P_A = (15)(-3)$

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

1.22 Calculate the power supplied by element A in Fig. P1.22.

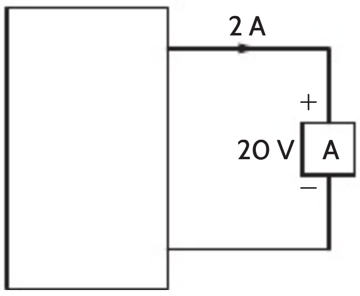
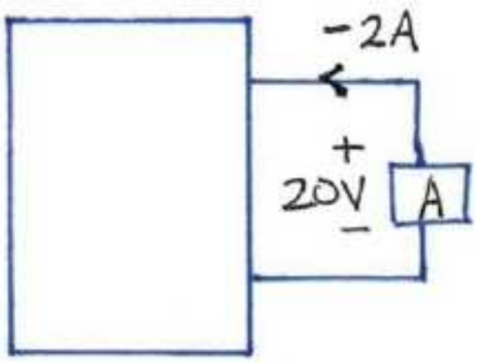



Figure P1.22

## SOLUTION:




$P_A = (20)(-2)$

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

**1.23** Element A in the diagram in Fig. P1.23 absorbs 30 W of power. Calculate $V_x$.

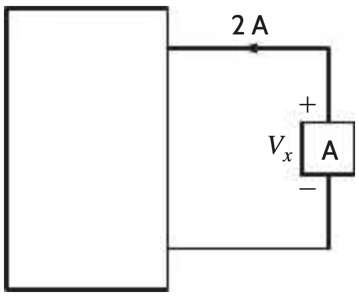
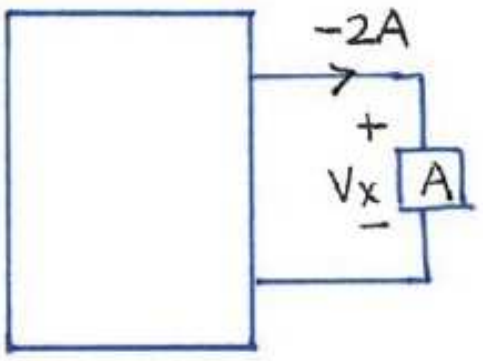



Figure P1.23

## SOLUTION:




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

$$V_x = -15\,V$$

**1.24** Element B in the diagram in Fig. P1.24 supplies 60 W of power. Calculate $I_x$.

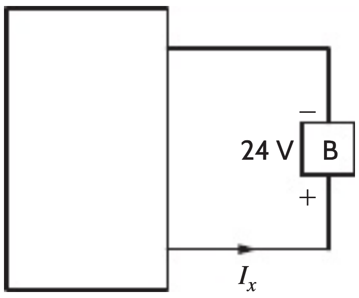



Figure P1.24

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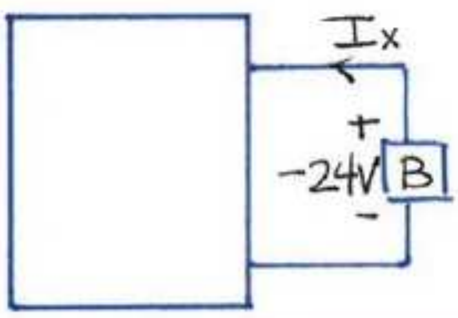
## SOLUTION:




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

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

**1.25** Element B in the diagram in Fig. P1.25 supplies 72 W of power. Calculate $V_A$.

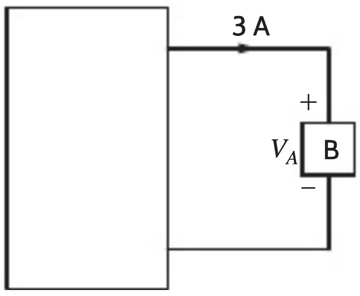
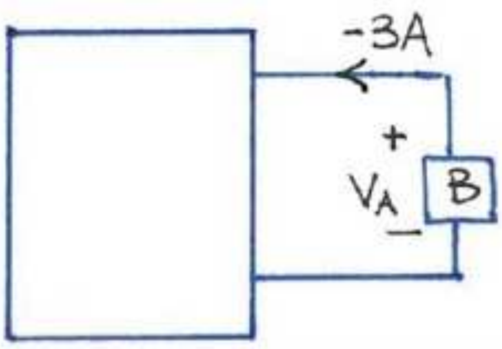



Figure P1.25

## SOLUTION:




$$72 = V_A(-3)$$

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

**1.26** Element B in the diagram in Fig. P1.26 supplies 72 W of power. Calculate $I_x$.

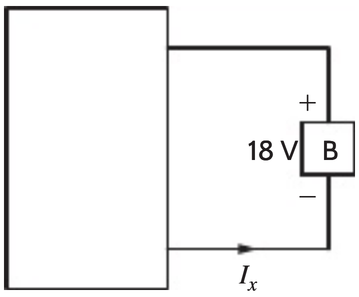



Figure P1.26

## SOLUTION:

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

$$I_x = 4A$$

**1.27** **(a)** In Fig. P1.27 (a), $P_1 = 36$ W. Is element 2 absorbing or supplying power, and how much?

**(b)** In Fig. P1.27 (b), $P_2 = -48$ W. Is element 1 absorbing or supplying power, and how much?

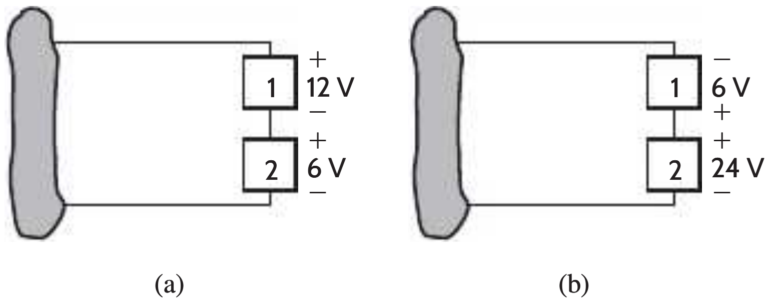
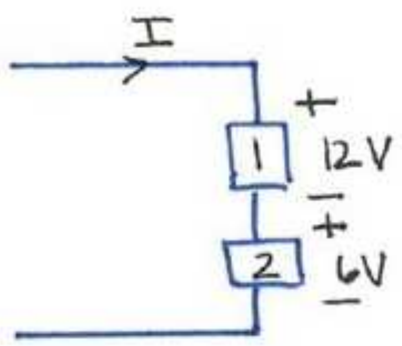



**Figure P1.27**

## SOLUTION:

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

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

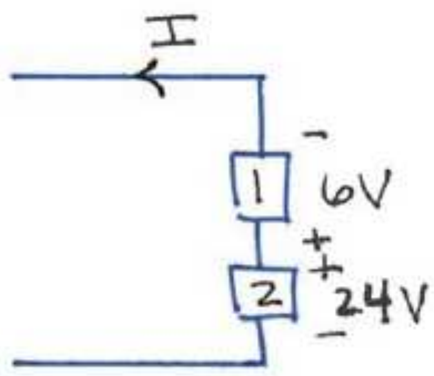



$P_2 = V_2 \cdot I = (6)(3)$

$P_2 = 18W$ absorbed

b) $P_2 = -48 = -V_2 \cdot I$

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




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

$P_1 = 12W$ absorbed

**1.28** Two elements are connected in series, as shown in Fig. P1.28. Element 1 supplies 24 W of power. Is element 2 absorbing or supplying power, and how much?

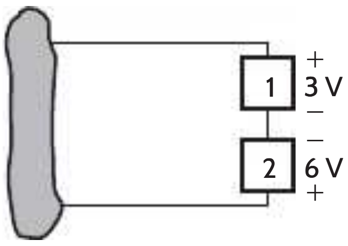
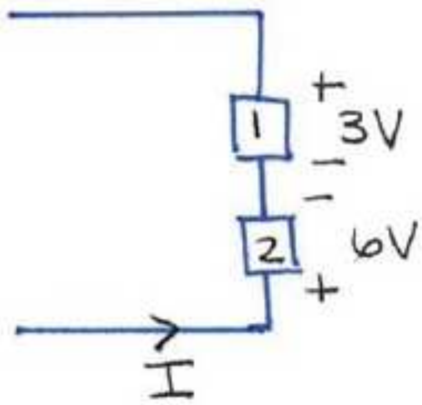



Figure P1.28

## SOLUTION:

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

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




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

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

**1.29** Element 2 in Fig. P1.29 absorbed 32 W. Find the power absorbed or supplied by elements 1 and 3.

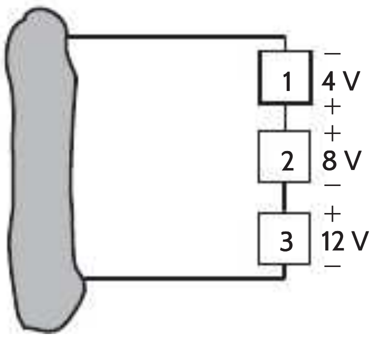
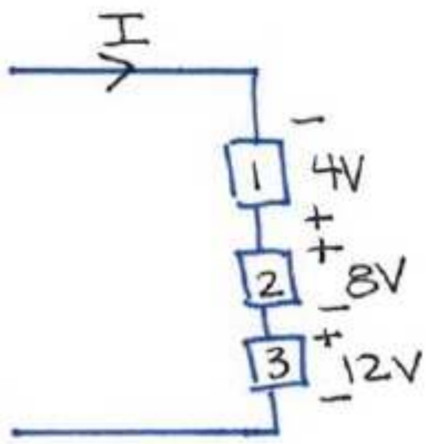



Figure P1.29

## SOLUTION:

$$P_2 = 32 = V_2 \cdot I$$

$$I = \frac{32}{8} = 4A$$




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

$P_1 = 16W$ supplied

$$P_3 = V_3 \cdot I = (12)(4)$$

$P_3 = 48 W$ absorbed

**1.30** Choose $I_s$ such that the power absorbed by element 2 in Fig. P1.30 is 7 W.

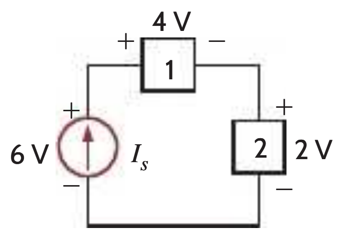



Figure P1.30

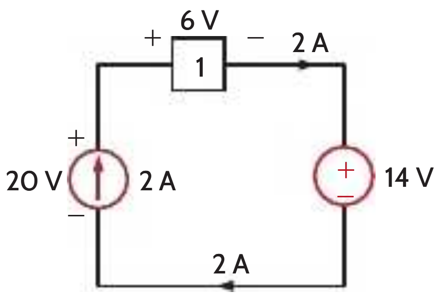
## SOLUTION:

$$P_2 = 7 = V_2 \cdot I_s$$

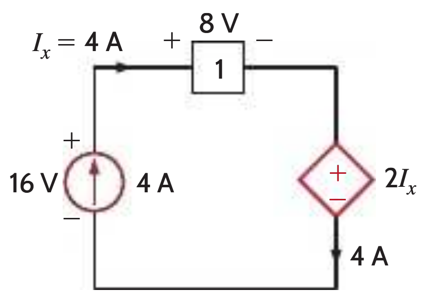
$$I_s = \frac{7}{2}$$

$$I_s = 3.5\,A$$

**1.31** Find the power that is absorbed or supplied by the circuit elements in Fig. P1.31.




(a)




(b)

Figure P1.31

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## SOLUTION:

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

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

$P_1 = (6)\cdot(2) = 12\,W$ absorbed

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

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

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

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

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

**1.32** Find the power that is absorbed or supplied by the network elements in Fig. P1.32.

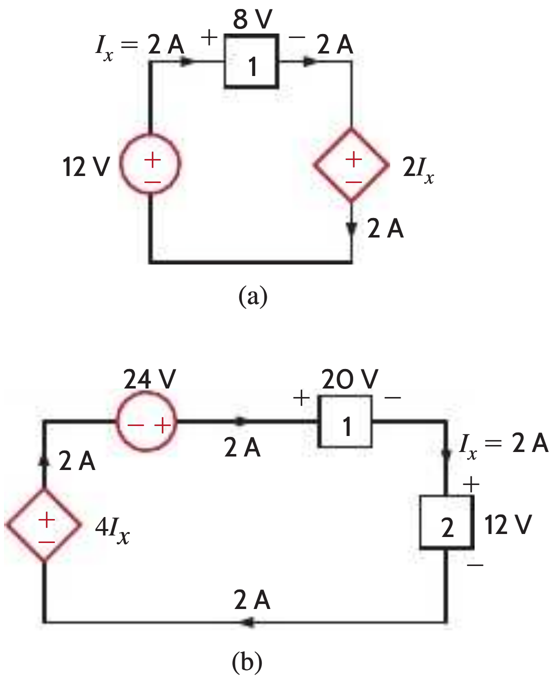


Figure P1.32

## SOLUTION:

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

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

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

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

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

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

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

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

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

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

**1.33** Compute the power that is absorbed or supplied by the elements in the network in Fig. P1.33.

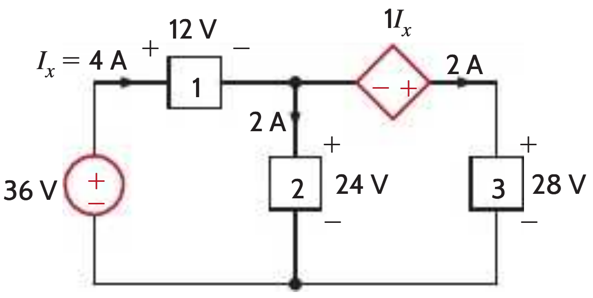


Figure P1.33

## SOLUTION:

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

$P_{36V}$ = 144 W supplied

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

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

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

$P_{1I_x}$ = 8W supplied

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

**1.34** Find the power that is absorbed or supplied by element 2 in Fig. P1.34.

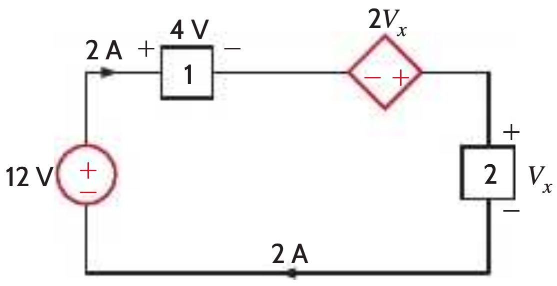


Figure P1.34

## SOLUTION:

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

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

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

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

$$P_{supplied} = P_{absorbed}$$

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

$$V_x = -8V$$

$$P_2 = (-8)\cdot(2) = -16\,W$$

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

**1.35** Find $I_x$ in the network in Fig. P1.35.

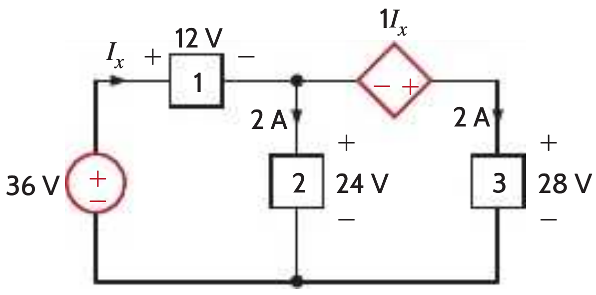


Figure P1.35

## SOLUTION:

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

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

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

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

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

$$P_{supplied} = P_{absorbed}$$

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

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

**1.36** Determine the power absorbed by element 1 in Fig. P1.36.

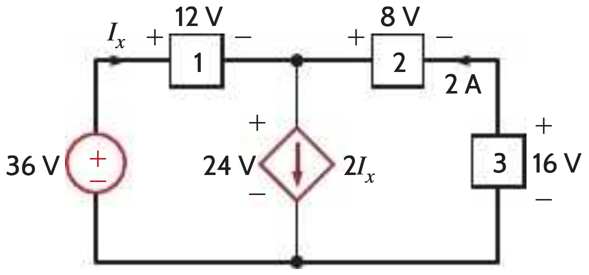


**Figure P1.36**

## SOLUTION:

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

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

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

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

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

$$P_{supplied} = P_{absorbed}$$

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

$$I_x = 2A$$

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

**1.37** Find the power absorbed or supplied by element 1 in Fig. P1.37.

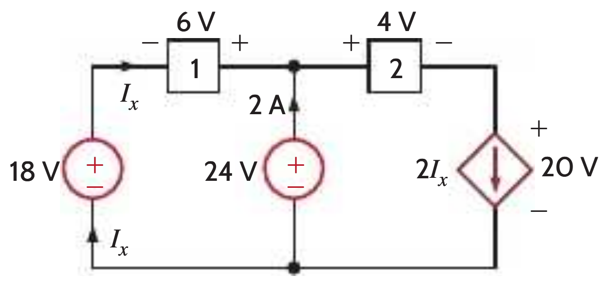


Figure P1.37

## SOLUTION:

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

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

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

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

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

$P_{supplied} = P_{absorbed}$

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

$I_x = 2A$

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

$P_1 = 12$W supplied

**1.38** Find the power absorbed or supplied by element 3 in Fig. P1.38.

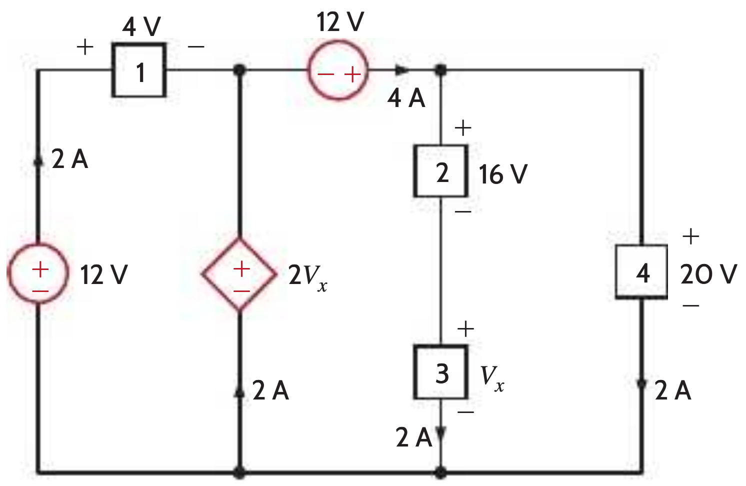


Figure P1.38

## SOLUTION:

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

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

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

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

$P_2 = (16)(2) = 32\text{ W} \rightarrow 32\text{ W absorbed}$

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

$P_4 = (20)(2) = 40\text{ W} \rightarrow 40\text{W absorbed}$

$P_{supplied} = P_{absorbed}$

$24 + 4V_x + 48 = 8 + 32 + 2V_x + 40$

$V_x = 4\text{V}$

$P_3 = (4)(2) = 8\text{W absorbed}$

**1.39** Find the power absorbed or supplied by element 1 in Fig. P1.39.

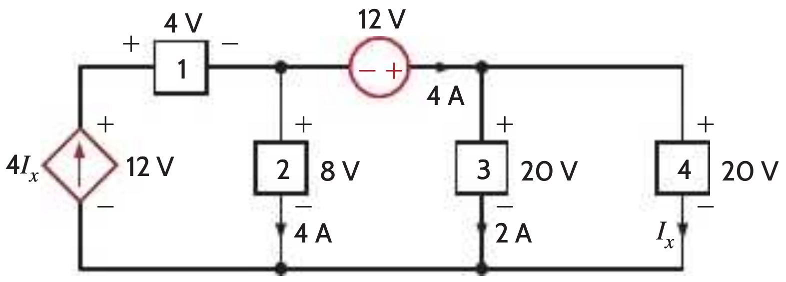


Figure P1.39

## SOLUTION:

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

$P_1 = (4)(4I_x) = 16I_x$ W → $16I_x$ W absorbed

$P_2 = (8)(4) = 32$ W → 32 W absorbed

$P_{12V} = (-12)(4) = -48$ W → 48 W supplied

$P_3 = (20)(2) = 40$ W → 40 W absorbed

$P_4 = (20)\cdot I_x = 20I_x$ W → $20I_x$ W absorbed

$P_{supplied} = P_{absorbed}$

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

$I_x = 2A$

$P_1 = 16(2) = 32$ W absorbed

**1.40** Find $V_x$ in the network in Fig. P1.40 using Tellegen's theorem.

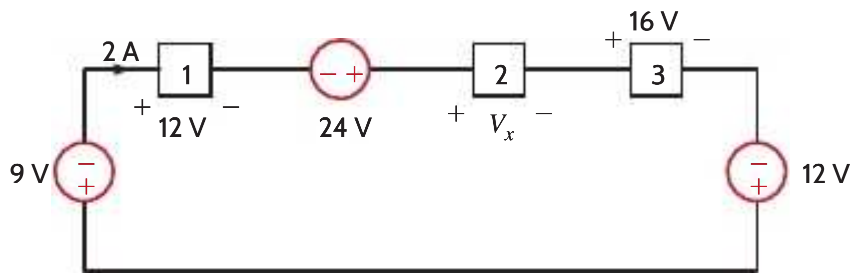


Figure P1.40

## SOLUTION:

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

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

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

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

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

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

$P_{supplied} = P_{absorbed}$

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

$V_x = -1\text{V}$

**1.41** Find $I_x$ in the circuit in Fig. P1.41 using Tellegen's theorem.

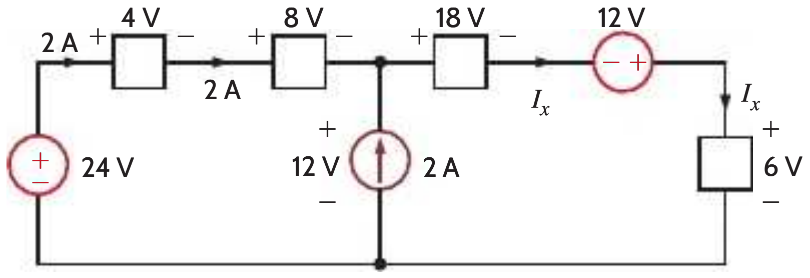


Figure P1.41

## SOLUTION:

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

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

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

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

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

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

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

$P_{supplied} = P_{absorbed}$

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

$I_x = 4A$

**1.42** Is the source $V_s$ in the network in Fig. P1.42 absorbing or supplying power, and how much?

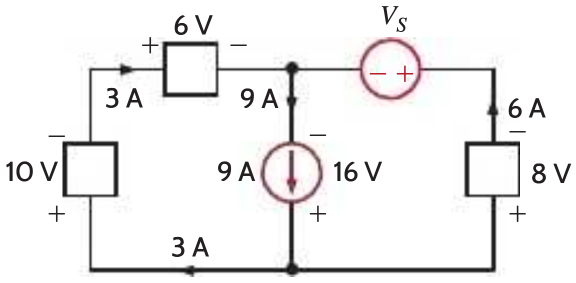


Figure P1.42

## SOLUTION:

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

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

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

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

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

$P_{supplied} = P_{absorbed}$

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

$V_s = 8V$

$P_{Vs} = (8)(6) = 48W$ absorbed

**1.43** Find $I_o$ in the network in Fig. P1.43 using Tellegen's theorem.

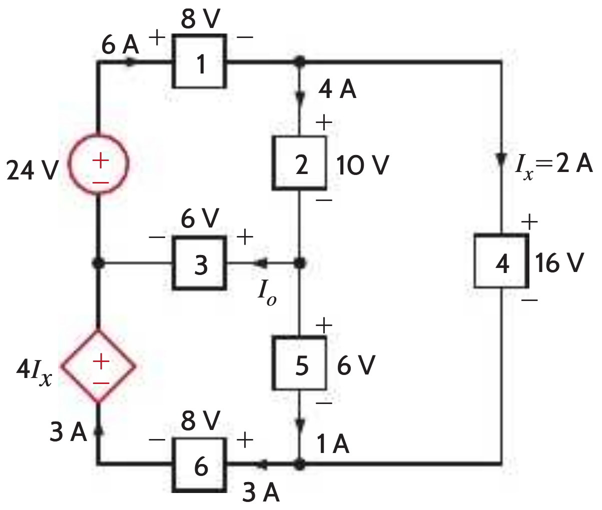


Figure P1.43

## SOLUTION:

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

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

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

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

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

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

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

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

$P_{supplied} = P_{absorbed}$

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

$I_o = 3\text{A}$

**1.44** Calculate the power absorbed by each element in the circuit in Fig. P1.44. Also, verify that Tellegen's theorem is satisfied by this circuit.

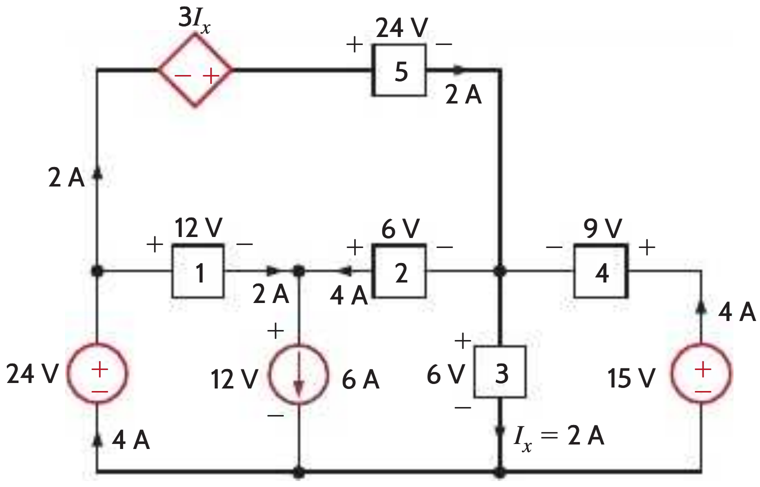


Figure P1.44

## SOLUTION:

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

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

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

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

$P_1 = (12)(2) = 24\,W \rightarrow 24\,W$ absorbed

$P_2 = (-6)(4) = -24\,W \rightarrow 24\,W$ supplied

$P_3 = (6)(2) = 12\,W \rightarrow 12\,W$ absorbed

$P_4 = (9)(4) = 36\,W \rightarrow 36\,W$ absorbed

$P_5 = (24)(2) = 48\,W \rightarrow 48\,W$ absorbed

$P_{supplied} - P_{absorbed} = 0$

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

$(192) - (192) = 0 \checkmark$

**1.45** Calculate the power absorbed by each element in the circuit in Fig. P1.45. Also, verify that Tellegen's theorem is satisfied by this circuit.

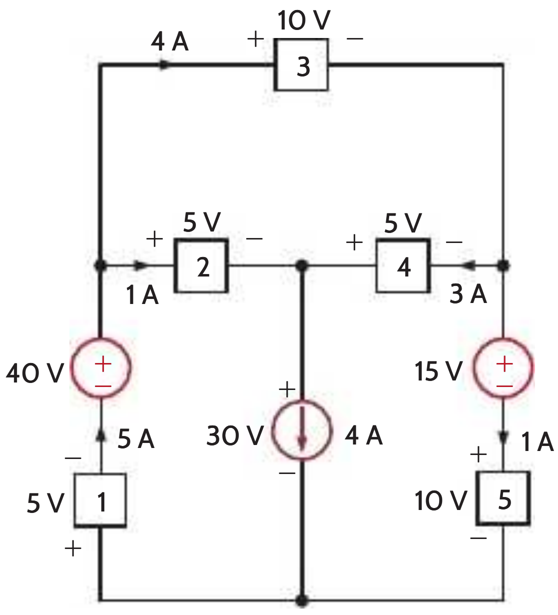


Figure P1.45

## SOLUTION:

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

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

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

$P_1 = (5)(5) = 25\,W \rightarrow 25\,W$ absorbed

$P_2 = (5)(1) = 5\,W \rightarrow 5W$ absorbed

$P_3 = (10)(4) = 40W \rightarrow 40\,W$ absorbed

$P_4 = (-5)(3) = -15\,W \rightarrow 15W$ supplied

$P_5 = (10)(1) = 10W \rightarrow 10\,W$ absorbed

$P_{supplied} - P_{absorbed} = 0$

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

$(215) - (215) = 0$ ✓

**1.46** In the circuit in Fig. P1.46, 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?

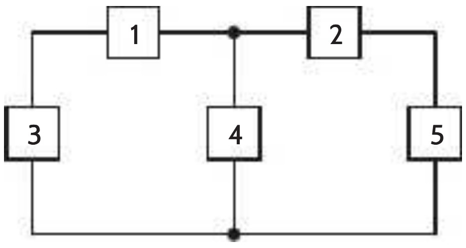


Figure P1.46

## SOLUTION:

$$P_{supplied} = P_{absorbed}$$

$$P_2 + P_3 + P_5 = P_1 + P_4$$

$$50 + 25 + P_5 = 40 + 15$$

$$P_5 = -20W \text{ supplied}$$

OR

$$P_5 = 20W \text{ absorbed}$$