Chapter 1, Problem 1

How many coulombs are represented by these amounts of electrons:

(a) 6.482×10^{17} (b) 1.24×10^{18}

(c) 2.46×10^{19} (d) 1.628×10^{20}

Chapter 1, Solution 1

(a) q = 6.482x10^{17} x [-1.602x10^{-19} C] = **<u>-0.10384 C</u>**

(b) q = 1. 24x10^{18} x [-1.602x10^{-19} C] = **<u>-0.19865 C</u>**

(c) q = 2.46x10^{19} x [-1.602x10^{-19} C] = **<u>-3.941 C</u>**

(d) q = 1.628x10^{20} x [-1.602x10^{-19} C] = **<u>-26.08 C</u>**

Chapter 1, Problem 2.

Determine the current flowing through an element if the charge flow is given by

(a) $q(t) = (3t + 8)$ mC

(b) $q(t) = (8t^2 + 4t\text{-}2)$ C

(c) $q(t) = \left(3e^{-t} - 5e^{-2t}\right)$nC

(d) $q(t) = 10\sin 120\pi$ t pC

(e) $q(t) = 20e^{-4t}\cos 50t$ μC

Chapter 1, Solution 2

(a) i = dq/dt = 3 mA

(b) i = dq/dt = (16t + 4) A

(c) i = dq/dt = (-3e^{-t} + 10e^{-2t}) nA

(d) i=dq/dt = $1200\pi \cos 120\pi t$ pA

(e) i =dq/dt = $-e^{-4t}(80\cos 50t + 1000\sin 50t)$ μ**A**

Chapter 1, Problem 3.

Find the charge $q(t)$ flowing through a device if the current is:

(a) $i(t) = 3\text{A}, q(0) = 1\text{C}$

(b) $i(t) = (2t+5)\text{mA}, q(0) = 0$

(c) $i(t) = 20\cos(10t + \pi/6)\mu\text{A}, q(0) = 2\,\mu\text{C}$

(d) $i(t) = 10e^{-30t}\sin 40t\text{A}, q(0) = 0$

Chapter 1, Solution 3

(a) $q(t) = \int i(t)dt + q(0) = \underline{(3t+1)\ \text{C}}$

(b) $q(t) = \int (2t+s)\,dt + q(v) = \underline{(t^2+5t)\ \text{mC}}$

(c) $q(t) = \int 20\cos\left(10t + \pi/6\right) + q(0) = \underline{(2\sin(10t+\pi/6)+1)\mu\text{C}}$

(d) $$q(t) = \int 10e^{-30t}\sin 40t + q(0) = \frac{10e^{-30t}}{900+1600}(-30\sin 40t - 40\cos t)$$
$$= \underline{-e^{-30t}(0.16\cos 40\ t + 0.12\ \sin 40t)\ \text{C}}$$

Chapter 1, Problem 4.

A current of 3.2 A flows through a conductor. Calculate how much charge passes through any cross-section of the conductor in 20 seconds.

Chapter 1, Solution 4

$q = it = 3.2 \text{ x } 20 = \underline{\mathbf{64\ C}}$

Chapter 1, Problem 5.

Determine the total charge transferred over the time interval of $0 \le t \le 10\text{s}$ when $i(t) = \frac{1}{2}t$ A.

Chapter 1, Solution 5

$$q = \int idt = \int_0^{10} \frac{1}{2}tdt = \left.\frac{t^2}{4}\right|_0^{10} = \underline{25\ \text{C}}$$

Chapter 1, Problem 6.

The charge entering a certain element is shown in Fig. 1.23. Find the current at:
(a) $t = 1$ ms (b) $t = 6$ ms (c) $t = 10$ ms

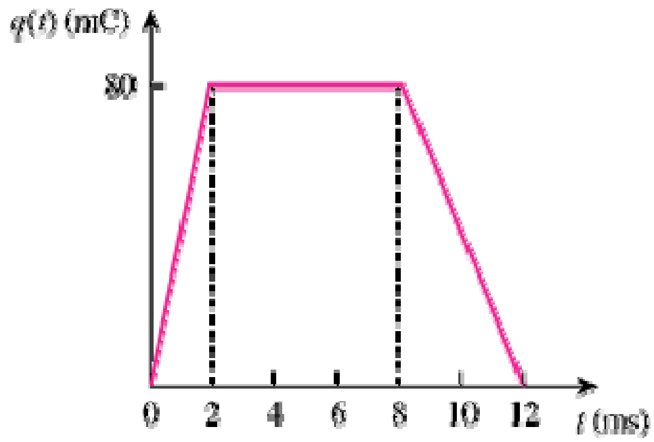


Figure 1.23

Chapter 1, Solution 6

(a) At t = 1ms, $i = \frac{dq}{dt} = \frac{80}{2} = \underline{\mathbf{40\ A}}$

(b) At t = 6ms, $i = \frac{dq}{dt} = \underline{\mathbf{0\ A}}$

(c) At t = 10ms, $i = \frac{dq}{dt} = \frac{80}{4} = \underline{\mathbf{-20\ A}}$

Chapter 1, Problem 7.

The charge flowing in a wire is plotted in Fig. 1.24. Sketch the corresponding current.

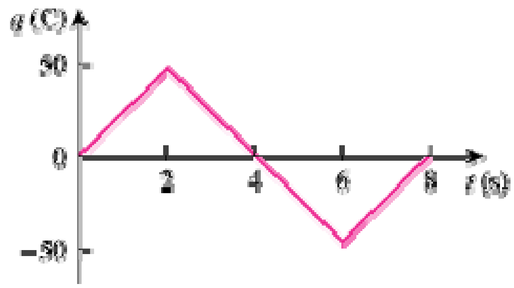
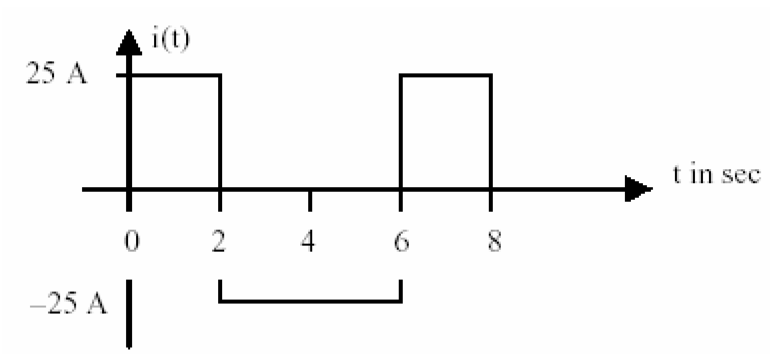


Figure 1.24

Chapter 1, Solution 7

$$i = \frac{dq}{dt} = \begin{bmatrix} 25A, & 0 < t < 2 \\ -25A, & 2 < t < 6 \\ 25A, & 6 < t < 8 \end{bmatrix}$$

which is sketched below:



Chapter 1, Problem 8.

The current flowing past a point in a device is shown in Fig. 1.25. Calculate the total charge through the point.

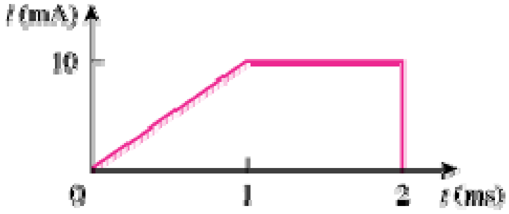


Figure 1.25

Chapter 1, Solution 8

$$q = \int i dt = \frac{10 \times 1}{2} + 10 \times 1 = \underline{15\ \mu C}$$

Chapter 1, Problem 9.

The current through an element is shown in Fig. 1.26. Determine the total charge that passed through the element at:
(a) $t = 1$ s (b) $t = 3$ s (c) $t = 5$ s

Figure 1.26

Chapter 1, Solution 9

(a) $q = \int idt = \int_0^1 10\,dt = \underline{10\ C}$

(b) $q = \int_0^3 idt = 10\times1 + \left(10 - \frac{5\times1}{2}\right) + 5\times1$

$= 15 + 7.5 + 5 = \underline{22.5C}$

(c) $q = \int_0^5 idt = 10 + 10 + 10 = \underline{30\ C}$

Chapter 1, Problem 10.

A lightning bolt with 8 kA strikes an object for 15 μs. How much charge is deposited on the object?

Chapter 1, Solution 10

$q = it = 8x10^3x15x10^{-6} =$ **<u>120 mC</u>**

Chapter 1, Problem 11.

A rechargeable flashlight battery is capable of delivering 85 mA for about 12 h. How much charge can it release at that rate? If its terminals voltage is 1.2 V, how much energy can the battery deliver?

Chapter 1, Solution 11

q= it = 85 $\times 10^{-3}$ x 12 x 60 x 60 = 3,672 C

E = pt = ivt = qv = 3672 x1.2 = 4406.4 J

Chapter 1, Problem 12.

If the current flowing through an element is given by

$$i(t) = \begin{cases} 3t\text{A}, 0 < t < 6\text{s} \\ 18\text{A}, 6 < t < 10\text{s} \\ -12\ \text{A}, 10 < t < 15\text{s} \\ 0, t > 15\text{s} \end{cases}$$

Plot the charge stored in the element over 0 < t < 20s.

Chapter 1, Solution 12

For 0 < t < 6s, assuming q(0) = 0,

$$q(t) = \int_0^t idt + q(0) = \int_0^t 3tdt + 0 = 1.5t^2$$

At t=6, q(6) = $1.5(6)^2$ = 54

For 6 < t < 10s,

$$q(t) = \int_6^t idt + q(6) = \int_6^t 18dt + 54 = 18t - 54$$

At t=10, q(10) = 180 – 54 = 126

For 10<t<15s,

$$q(t) = \int_{10}^t idt + q(10) = \int_{10}^t (-12)dt + 126 = -12t + 246$$

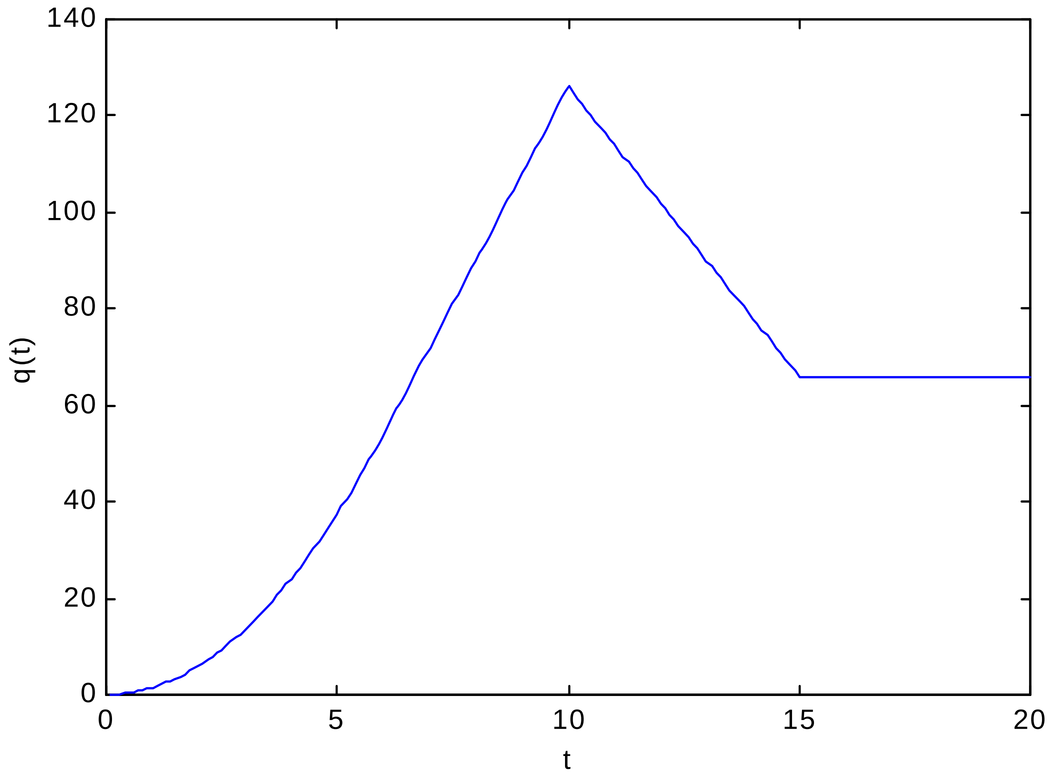
At t=15, q(15) = -12x15 + 246 = 66
For 15<t<20s,

$$q(t) = \int_{15}^{t} 0dt + q(15) = 66$$

Thus,

$$q(t) = \begin{cases} 1.5t^2 \ \mathbf{C}, & \mathbf{0 < t < 6s} \\ 18t - 54 \ \mathbf{C}, & \mathbf{6 < t < 10s} \\ -12t + 246 \ \mathbf{C}, & \mathbf{10 < t < 15s} \\ 66 \ \mathbf{C}, & \mathbf{15 < t < 20s} \end{cases}$$

The plot of the charge is shown below.



Chapter 1, Problem 13.

The charge entering the positive terminal of an element is

$$q = 10\sin 4\pi t \text{ mC}$$

while the voltage across the element (plus to minus) is

$$v = 2\cos 4\pi t \text{ V}$$

(a) Find the power delivered to the element at t = 0.3 s
(b) Calculate the energy delivered to the element between 0 and 0.6s.

Chapter 1, Solution 13

(a) $i = \dfrac{dq}{dt} = 40\pi\cos 4\pi t$ mA

$p = vi = 80\pi\cos^2 4\pi t$ mW

At t=0.3s,

$$p = 80\pi\cos^2(4\pi x 0.3) = \underline{164.5 \text{ mW}}$$

(b) $W = \int p dt = 80\pi\int_0^{0.6}\cos^2 4\pi t dt = 40\pi\int_0^{0.6}[1+\cos 8\pi t]dt$ mJ

$$W = 40\pi\left[0.6 + \frac{1}{8\pi}\sin 8\pi t\Big|_0^{0.6}\right] = \underline{78.34 \text{ mJ}}$$

Chapter 1, Problem 14.

The voltage v across a device and the current I through it are

$$v(t) = 5\cos 2t \text{ V}, \quad i(t) = 10\left(1 - e^{-0.5t}\right)\text{A}$$

Calculate:

(a) the total charge in the device at $t = 1$ s
(b) the power consumed by the device at $t = 1$ s.

Chapter 1, Solution 14

(a)
$$q = \int \text{idt} = \int_0^1 10\left(1 - e^{-0.5t}\right)dt = 10\left(t + 2e^{-0.5t}\right)\Big|_0^1$$
$$= 10\left(1 + 2e^{-0.5} - 2\right) = \underline{2.131 \text{ C}}$$

(b)
$$p(t) = v(t)i(t)$$
$$p(1) = 5\cos 2 \cdot 10(1 - e^{-0.5}) = (-2.081)(3.935)$$
$$= \underline{\mathbf{-8.188 \text{ W}}}$$

Chapter 1, Problem 15.

The current entering the positive terminal of a device is $i(t) = 3e^{-2t}$ A and the voltage across the device is $v(t) = 5\, di/dt$ V.

(a) Find the charge delivered to the device between $t = 0$ and $t = 2$ s.
(b) Calculate the power absorbed.
(c) Determine the energy absorbed in 3 s.

Chapter 1, Solution 15

(a)
$$q = \int \text{idt} = \int_0^2 3e^{-2t}dt = \frac{-3}{2}e^{2t}\Bigg|_0^2$$
$$= -1.5\left(e^{-4} - 1\right) =$$
$$\underline{\mathbf{1.4725 \text{ C}}}$$

(b)
$$v = \frac{5di}{dt} = -6e^{2t}(5) = -30e^{-2t}$$
$$p = vi = \underline{-90\, e^{-4t}\text{W}}$$

(c)
$$w = \int \text{pdt} = -90\int_0^3 e^{-4t}\, dt = \frac{-90}{-4}e^{-4t}\Bigg|_0^3 = \underline{-22.5 \text{ J}}$$

Chapter 1, Problem 16.

Figure 1.27 shows the current through and the voltage across a device. (a) Sketch the power delivered to the device for t >0. (b) Find the total energy absorbed by the device for the period of 0< t < 4s.

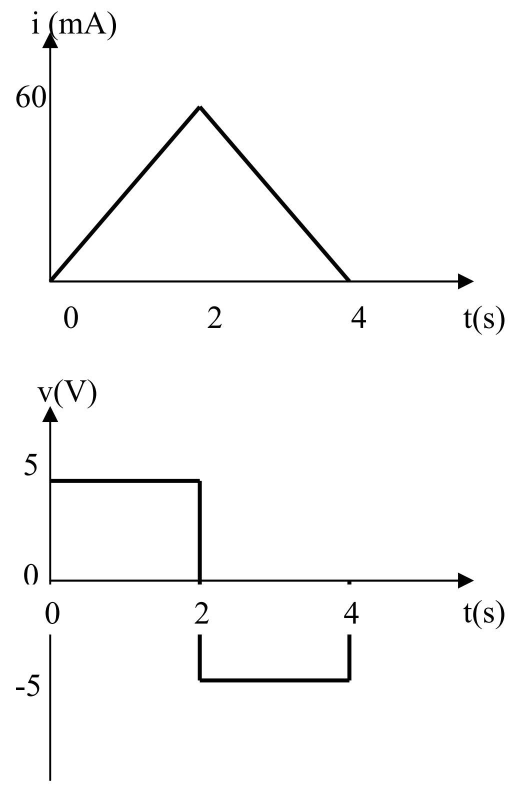


Figure 1.27 For Prob. 1.16.

Chapter 1, Solution 16

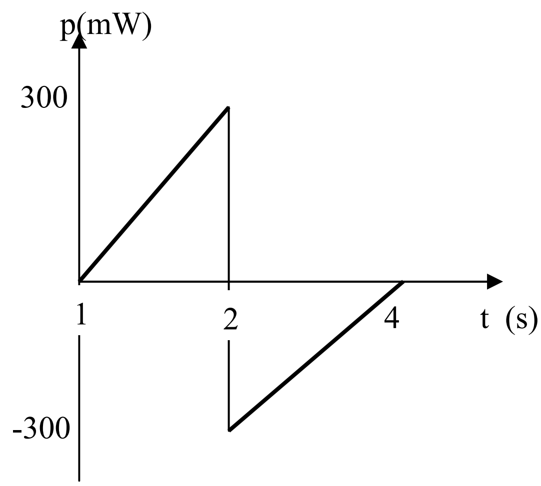
(a)

$$i(t) = \begin{cases} 30t \text{ mA}, & 0 < t < 2 \\ 120\text{-}30t \text{ mA}, & 2 < t < 4 \end{cases}$$

$$v(t) = \begin{cases} 5 \text{ V}, & 0 < t < 2 \\ -5 \text{ V}, & 2 < t < 4 \end{cases}$$

$$p(t) = \begin{cases} 150t \text{ mW}, & 0 < t < 2 \\ -600+150t \text{ mW}, & 2 < t < 4 \end{cases}$$

which is sketched below.



(b) From the graph of p,

$$W = \int_0^4 p\,dt = \underline{0 \text{ J}}$$

Chapter 1, Problem 17.

Figure 1.28 shows a circuit with five elements. If

$p_1 = -205$ W, $p_2 = 60$ W, $p_4 = 45$ W, $p_5 = 30$ W,

calculate the power p_3 received or delivered by element 3.

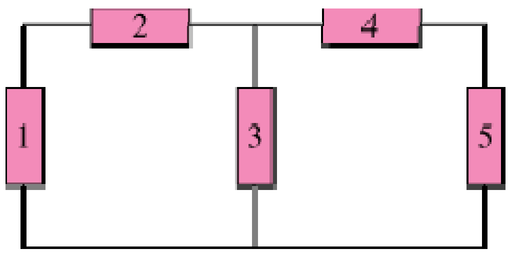


Figure 1.28

Chapter 1, Solution 17

Σ p = 0 $\rightarrow$ -205 + 60 + 45 + 30 + p_3 = 0

p_3 = 205 – 135 = 70 W

Thus element 3 receives **70 W.**

Chapter 1, Problem 18.

Find the power absorbed by each of the elements in Fig. 1.29.

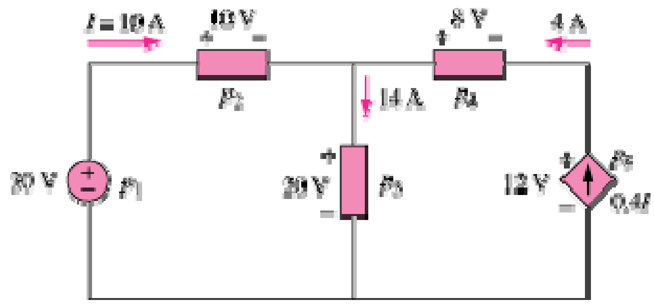


Figure 1.29

Chapter 1, Solution 18

$p_1 = 30(-10) = \underline{\mathbf{-300\ W}}$
$p_2 = 10(10) = \underline{\mathbf{100\ W}}$
$p_3 = 20(14) = \underline{\mathbf{280\ W}}$
$p_4 = 8(-4) = \underline{\mathbf{-32\ W}}$
$p_5 = 12(-4) = \underline{\mathbf{-48\ W}}$

Chapter 1, Problem 19.

Find I in the network of Fig. 1.30.

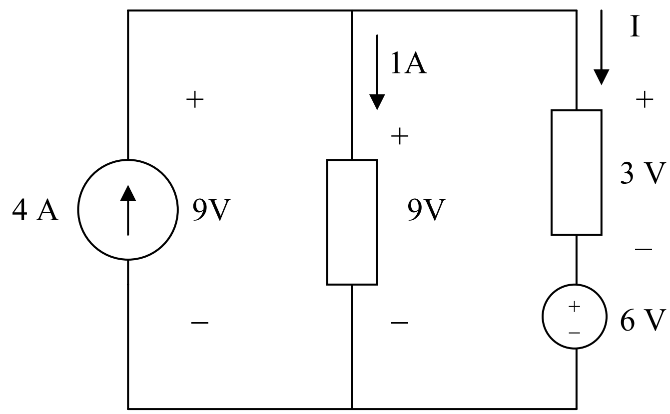


Figure 1.30 For Prob. 1.19.

Chapter 1, Solution 19

$$I = 4 - 1 = \underline{3\ \text{A}}$$

Or using power conservation,

$$9\text{x}4 = 1\text{x}9 + 3I + 6I = 9 + 9I$$

$$4 = 1 + I \quad \text{or} \quad I = \underline{\mathbf{3\ A}}$$

Chapter 1, Problem 20.

Find V_0 in the circuit of Fig. 1.31.

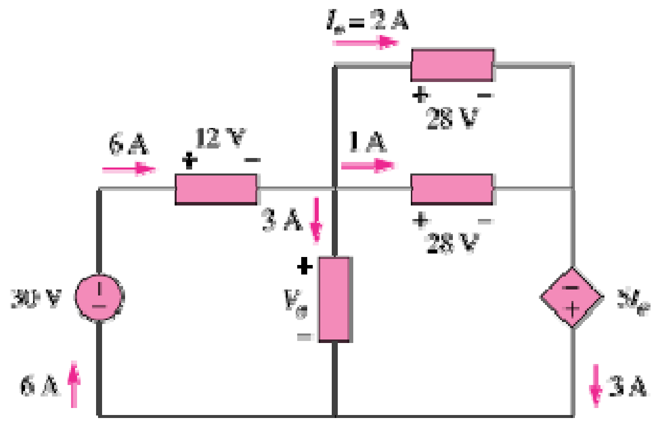


Figure 1.31

Chapter 1, Solution 20

Since Σ p = 0

$-30\times6 + 6\times12 + 3V_0 + 28 + 28\times2 - 3\times10 = 0$

$72 + 84 + 3V_0 = 210$ or $3V_0 = 54$

$V_0 = \underline{\mathbf{18\ V}}$

Chapter 1, Problem 21.

A 60-W, incandescent bulb operates at 120 V. How many electrons and coulombs flow through the bulb in one day?

Chapter 1, Solution 21

$$p = vi \qquad \longrightarrow \qquad i = \frac{p}{v} = \frac{60}{120} = 0.5\text{ A}$$

q = it = 0.5x24x60x60 = 43200 **C**

$N_e = qx6.24x10^{18} = \underline{2.696x10^{23}\text{ electrons}}$

Chapter 1, Problem 22.

A lightning bolt strikes an airplane with 30 kA for 2 ms. How many coulombs of charge are deposited on the plane?

Chapter 1, Solution 22

$q = it = 30x10^3 x2x10^{-3} = \underline{60\text{ C}}$

Chapter 1, Problem 23.

A 1.8-kW electric heater takes 15 min to boil a quantity of water. If this is done once a day and power costs 10 cents per kWh, what is the cost of its operation for 30 days?

Chapter 1, Solution 23

W = pt = 1.8x(15/60) x30 kWh = 13.5kWh
C = 10cents x13.5 = **<u>$1.35</u>**

Chapter 1, Problem 24.

A utility company charges 8.5 cents/kWh. If a consumer operates a 40-W light bulb continuously for one day, how much is the consumer charged?

Chapter 1, Solution 24

W = pt = 40 x24 Wh = 0.96 kWh
C = 8.5 cents x0.96 = **<u>8.16 cents</u>**

Chapter 1, Problem 25.

A 1.2-kW toaster takes roughly 4 minutes to heat four slices of bread. Find the cost of operating the toaster once per day for 1 month (30 days). Assume energy costs 9 cents/kWh.

Chapter 1, Solution 25

$$\text{Cost} = 1.2\text{ kW} \times \frac{4}{60}\text{hr} \times 30 \times 9\text{ cents/kWh} = \underline{21.6\text{ cents}}$$

Chapter 1, Problem 26.

A flashlight battery has a rating of 0.8 ampere-hours (Ah) and a lifetime of 10 hours.

(a) How much current can it deliver?
(b) How much power can it give if its terminal voltage is 6 V?
(c) How much energy is stored in the battery in kWh?

Chapter 1, Solution 26

(a) $i = \dfrac{0.8\text{A}\cdot\text{h}}{10\text{h}} = \underline{80\text{ mA}}$

(b) p = vi = 6 × 0.08 = **<u>0.48 W</u>**

(c) w = pt = 0.48 × 10 Wh = **<u>0.0048 kWh</u>**

Chapter 1, Problem 27.

A constant current of 3 A for 4 hours is required to charge an automotive battery. If the terminal voltage is 10 + *t*/2 V, where *t* is in hours,

(a) how much charge is transported as a result of the charging?
(b) how much energy is expended?
(c) how much does the charging cost? Assume electricity costs 9 cents/kWh.

Chapter 1, Solution 27

(a) Let $\text{T} = 4\text{h} = 4\times 3600$

$$q = \int i\,dt = \int_0^T 3\,dt = 3T = 3\times 4\times 3600 = \underline{43.2\text{ kC}}$$

(b) $$W = \int p\,dt = \int_0^T vi\,dt = \int_0^T (3)\left(10 + \frac{0.5t}{3600}\right)dt$$

$$= 3\left(10t + \frac{0.25t^2}{3600}\right)\Bigg|_0^{4\times 3600} = 3[40\times 3600 + 0.25\times 16\times 3600]$$

$$= \underline{475.2\text{ kJ}}$$

(c) $W = 475.2\text{ kWs}, \quad (\text{J} = \text{Ws})$

$$\text{Cost} = \frac{475.2}{3600}\text{kWh}\times 9\text{ cent} = \underline{1.188\text{ cents}}$$

Chapter 1, Problem 28.

A 30-W incandescent lamp is connected to a 120-V source and is left burning continuously in an otherwise dark staircase. Determine:

(a) the current through the lamp,
(b) the cost of operating the light for one non-leap year if electricity costs 12 cents per kWh.

Chapter 1, Solution 28

(a) $i = \dfrac{P}{V} = \dfrac{30}{120} = \underline{0.25 \text{ A}}$

(b) $\text{W} = \text{pt} = 30 \times 365 \times 24 \text{ Wh} = 262.8 \text{ kWh}$

$\text{Cost} = \$0.12 \times 262.8 = \underline{\$31.54}$

Chapter 1, Problem 29.

An electric stove with four burners and an oven is used in preparing a meal as follows.

Burner 1: 20 minutes
Burner 2: 40 minutes
Burner 3: 15 minutes
Burner 4: 45 minutes
Oven: 30 minutes

If each burner is rated at 1.2 kW and the oven at 1.8 kW, and electricity costs 12 cents per kWh, calculate the cost of electricity used in preparing the meal.

Chapter 1, Solution 29

$$w = pt = 1.2\text{kW}\,\frac{(20+40+15+45)}{60}\,\text{hr} + 1.8\,\text{kW}\left(\frac{30}{60}\right)\text{hr}$$

$$= 2.4 + 0.9 = 3.3\,\text{kWh}$$

$$\text{Cost} = 12 \text{ cents} \times 3.3 = \underline{39.6 \text{ cents}}$$

Chapter 1, Problem 30.

Reliant Energy (the electric company in Houston, Texas) charges customers as follows:

Monthly charge \$6
First 250 kWh @ \$0.02/kWh
All additional kWh @ \$0.07/kWh

If a customer uses 1,218 kWh in one month, how much will Reliant Energy charge?

Chapter 1, Solution 30

Monthly charge = \$6
First 250 kWh @ \$0.02/kWh = \$5
Remaining 968 kWh @ \$0.07/kWh= \$67.76
Total = **<u>\$78.76</u>**

Chapter 1, Problem 31.

In a household, a 120-W PC is run for 4 hours/day, while a 60-W bulb runs for 8 hours/day. If the utility company charges \$0.12/kWh, calculate how much the household pays per year on the PC and the bulb.

Chapter 1, Solution 31

Total energy consumed = 365(120x4 + 60x8) W
Cost = \$0.12x365x960/1000 = **<u>\$42.05</u>**

Chapter 1, Problem 32.

A telephone wire has a current of 20 μA flowing through it. How long does it take for a charge of 15 C to pass through the wire?

Chapter 1, Solution 32

$i = 20\ \mu A$

$q = 15\ C$

$t = q/i = 15/(20\times10^{-6}) = \underline{\mathbf{750\times10^{3}\ hrs}}$

Chapter 1, Problem 33.

A lightning bolt carried a current of 2 kA and lasted for 3 ms. How many coulombs of charge were contained in the lightning bolt?

Chapter 1, Solution 33

$$i = \frac{dq}{dt} \rightarrow q = \int i dt = 2000 \times 3 \times 10^{-3} = \underline{6\,C}$$

Chapter 1, Problem 34.

Figure 1.32 shows the power consumption of a certain household in one day. Calculate: (a) the total energy consumed in kWh, (b) the average power per hour.

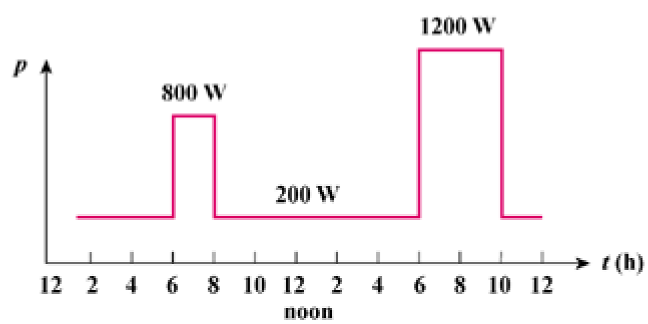


Figure 1.32

Chapter 1, Solution 34

(a) Energy = $\sum pt$ = 200 x 6 + 800 x 2 + 200 x 10 + 1200 x 4 + 200 x 2
= **<u>10 kWh</u>**

(b) Average power = 10,000/24 = **<u>416.7 W</u>**

Chapter 1, Problem 35.

The graph in Fig. 1.33 represents the power drawn by an industrial plant between 8:00 and 8:30 A.M. Calculate the total energy in MWh consumed by the plant.

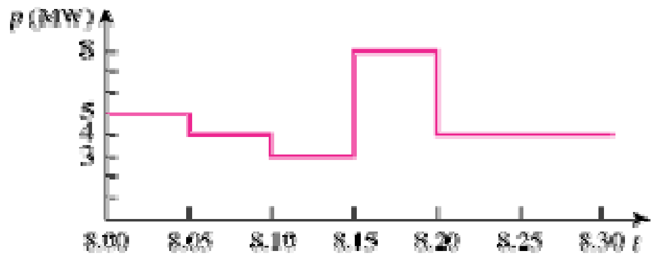


Figure 1.33

Chapter 1, Solution 35

energy = (5x5 + 4x5 + 3x5 + 8x5 + 4x10)/60 = **2.333 MWhr**

Chapter 1, Problem 36.

A battery may be rated in ampere-hours (Ah). A lead-acid battery is rated at 160 Ah.

(a) What is the maximum current it can supply for 40 h?
(b) How many days will it last if it is discharged at 1 mA?

Chapter 1, Solution 36

(a) $$i = \frac{160\text{A}\cdot\text{h}}{40} = \underline{4\ \text{A}}$$

(b) $$t = \frac{160\text{Ah}}{0.001\text{A}} = \frac{160{,}000\text{h}}{24\text{h}\,/\,\text{day}} = \underline{6{,}667\ \text{days}}$$

Chapter 1, Problem 37.

A 12-V battery requires a total charge of 40 ampere-hours during recharging. How many joules are supplied to the battery?

Chapter 1, Solution 37

W = pt = vit = 12x 40x 60x60 = **1.728 MJ**

Chapter 1, Problem 38.

How much energy does a 10-hp motor deliver in 30 minutes? Assume that 1 horsepower = 746 W.

Chapter 1, Solution 38

P = 10 hp = 7460 W

W = pt = 7460 × 30 × 60 J = $\mathbf{13.43 \times 10^6\ J}$

Chapter 1, Problem 39.

A 600-W TV receiver is turned on for 4 hours with nobody watching it. If electricity costs 10 cents/kWh, how much money is wasted?

Chapter 1, Solution 39

W = pt = 600x4 = 2.4 kWh
C = 10cents x2.4 = **24 cents**