Solution 1.1

(a) $q = 6.482x10^{17}$ x $[-1.602x10^{-19}$ C] = **–103.84 mC**

(b) $q = 1.\ 24x10^{18}$ x $[-1.602x10^{-19}$ C] = **–198.65 mC**

(c) $q = 2.46x10^{19}$ x $[-1.602x10^{-19}$ C] = **–3.941 C**

(d) $q = 1.628x10^{20}$ x $[-1.602x10^{-19}$ C] = **–26.08 C**

Solution 1.2

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

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

(b) $q(t) = (4t^2 + 20t - 4)$ C

(c) $q(t) = (15e^{-3t} - 2e^{-18t})$ nC

(d) $q(t) = 5t^2(3t^3 + 4)$ pC

(e) $q(t) = 2e^{-3t}\sin(20\pi t)$ μC

(a) $i = dq/dt = 0$ mA

(b) $i = dq/dt = (8t + 20)$ A

(c) $i = dq/dt = (-45e^{-3t} + 36e^{-18t})$ nA

(d) $i = dq/dt = (75t^4 + 40t)$ pA

(e) $i = dq/dt = \{-6e^{-3t}\sin(20\pi t) + 40\pi e^{-3t}\cos(20\pi t)\}$ μA

Solution 1.3

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

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

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

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

$= \underline{-\ e^{-30t}\,(0.16\cos 40\ t + 0.12\ \sin\ 40t)\ \ C}$

Solution 1.4

Since i is equal to $\Delta q/\Delta t$ then $i = 300/30 =$ **10 amps**.

Solution 1.5

$$q = \int i dt = \int_0^{10} \frac{1}{2} t dt = \frac{t^2}{4}\Bigg|_0^{10} = \underline{25\text{ C}}$$

Solution 1.6

(a) At t = 1ms, $i = \frac{dq}{dt} = \frac{30}{2} =$ **15 A**

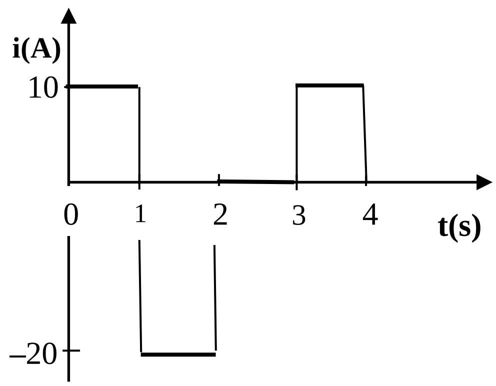
(b) At t = 6ms, $i = \frac{dq}{dt} =$ **0 A**

(c) At t = 10ms, $i = \frac{dq}{dt} = \frac{-30}{4} =$ **–7.5 A**

Solution 1.7

$$i = \frac{dq}{dt} = \begin{cases} 10A, & 0 < t < 1 \\ -20A, & 1 < t < 2 \\ 0A, & 2 < t < 3 \\ 10A, & 3 < t < 4 \end{cases}$$

which is sketched below:



Solution 1.8

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

Solution 1.9

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

(b) $q = \int_0^3 i dt = 10 \times 1 + \left(10 - \frac{5 \times 1}{2}\right) + 5 \times 1$

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

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

Solution 1.10

$q = it = 10x10^{3}x15x10^{-6}$ = **150 mC**

Solution 1.11

q= it = 90 x10^{-3} x 12 x 60 x 60 = **3.888 kC**

E = pt = ivt = qv = 3888 x1.5 = **5.832 kJ**

Solution 1.12

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

$$q(t) = \int_0^t i dt + q(0) = \int_0^t 3t dt + 0 = 1.5t^2$$

At t=6, q(6) = 1.5(6)^2 = 54
For 6 < t < 10s,

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

At t=10, q(10) = 180 – 54 = 126
For 10<t<15s,

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

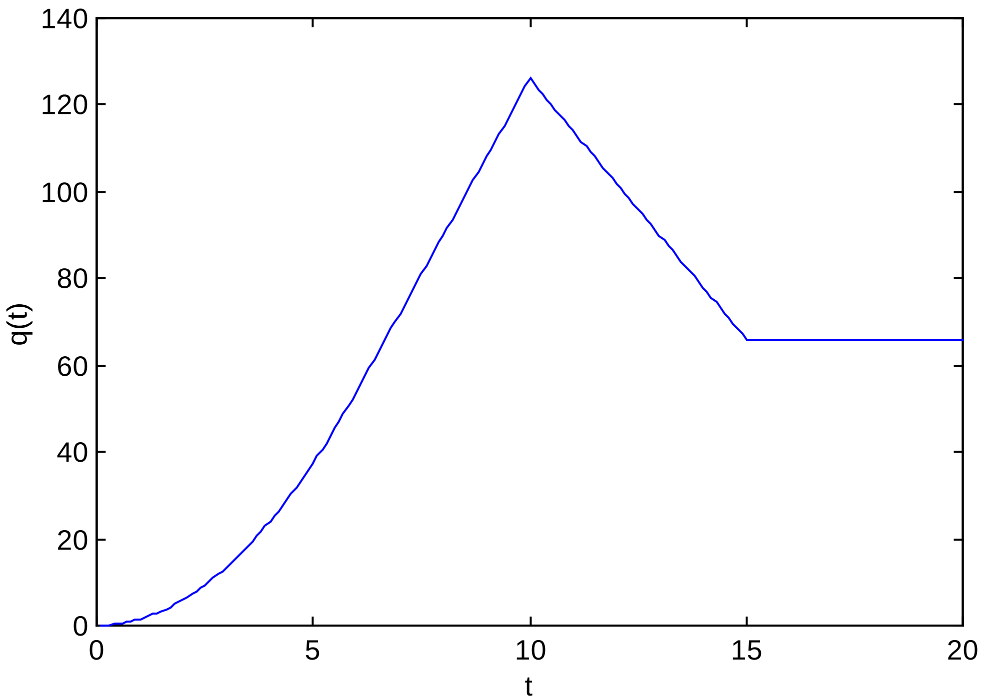
At t=15, q(15) = -12x15 + 246 = 66
For 15<t<20s,

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

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.


140
120
100
80
60
40
20
0
q(t)
0
5
10
15
20
t

Solution 1.13

(a) $i = [dq/dt] = 20\pi\cos(4\pi t)$ mA

$p = vi = 60\pi\cos^2(4\pi t)$ mW

At t=0.3s,

$$p = vi = 60\pi\cos^2(4\pi 0.3) \text{ mW} = \mathbf{123.37\ mW}$$

(b) $W =$ $\int p\,dt = 60\pi \int_0^{0.6} \cos^2(4\pi t)\,dt = 30\pi \int_0^{0.6}$

$$W = 30\pi[0.6+(1/(8\pi))[\sin(8\pi 0.6)-\sin(0)]] = \mathbf{58.76\ mJ}$$

Solution 1.14

The voltage *v(t)* across a device and the current *i(t)* through it are

$v(t) = 20\sin(4t)$ volts and $i(t) = 10(1 + e^{-2t})$ m-amps.

Calculate:

(a) the total charge in the device at $t = 1$ s, assume $q(0) = 0$.

(b) the power consumed by the device at $t = 1$ s.

(a) $q = \int i dt = \int_0^1 0.01\left(1+e^{-2t}\right)dt = 0.01\left(t-0.5e^{-2t}\right)\Big|_0^1 = 0.01\left(1-0.5e^{-2}+0.5\right)$

$= 0.01(1 - 0.135335 + 0.5) =$ **13.647 mC**.

(b) $p(t) = v(t)i(t)$; $v(1) = 20\sin(4) = 20\sin(229.18°) = –15.135$ volts;
and $i(1) = 10(1+e^{-2})(10^{-3}) = 10(1.1353)(10^{-3}) = 11.353$ m-amps
$p(1) = (–15.125)(11.353)(10^{-3}) =$ **–171.71 mW**

Solution 1.15

(a) $q = \int i dt = \int_0^2 0.006e^{-2t} dt = \frac{-0.006}{2} e^{2t} \Big|_0^2$

$= -0.003\left(e^{-4} - 1\right) =$

2.945 mC

(b) $v = \frac{10di}{dt} = -0.012e^{-2t}(10) = -0.12e^{-2t}$ V this leads to p(t) = v(t)i(t) =

$(-0.12e^{-2t})(0.006e^{-2t})$ = **$-720e^{-4t}$ μW**

(c) $w = \int p dt = -0.72\int_0^3 e^{-4t}\ dt = \frac{-720}{-4} e^{-4t} 10^{-6} \Big|_0^3$ = **–180 μJ**

Solution 1.16

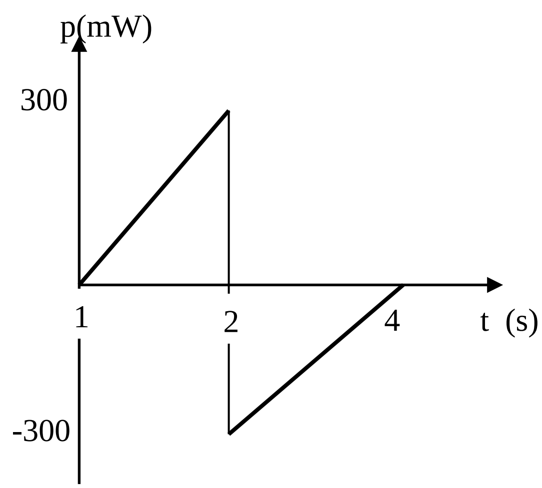
(a)

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

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

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

which is sketched below.



(b) From the graph of p,

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

Solution 1.17

Figure 1.28 shows a circuit with four elements, p_1 = 60 watts absorbed, p_3 = –145 watts absorbed, and p_4 = 75 watts absorbed. How many watts does element 2 absorb?

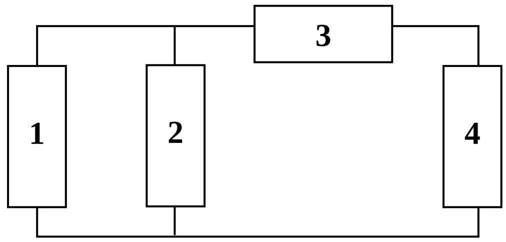


Figure 1.28
For Prob. 1.17.

Σ p = 0 = 60 + p_2 – 145 + 75 = 0 or p_2 = –60 + 145 – 75 = **10 watts absorbed**.

Solution 1.18

p_1 = 30(-10) = **-300 W**
p_2 = 10(10) = **100 W**
p_3 = 20(14) = **280 W**
p_4 = 8(-4) = **-32 W**
p_5 = 12(-4) = **-48 W**

Solution 1.19

Find I and the power absorbed by each element in the network of Fig. 1.30.

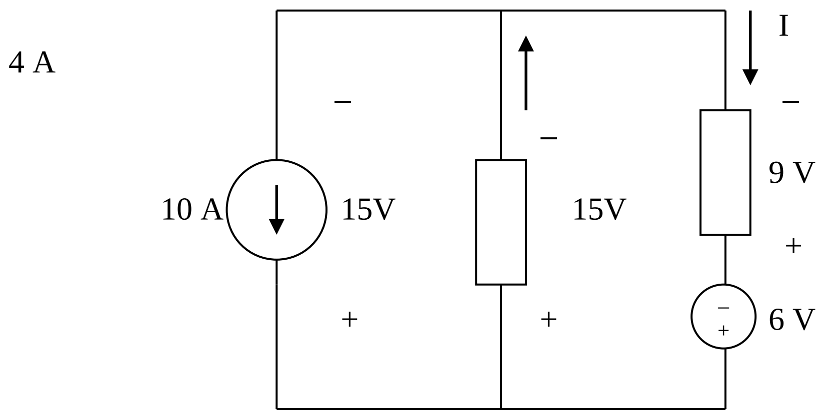


Figure 1.30
For Prob. 1.19.

I = –10 + 4 = **–6 amps**

Calculating the power absorbed by each element means we need to find vi (being careful to use the passive sign convention) for each element.

$P_{\text{10 amp source}}$ = –10x15 = **–150 W**
$p_{\text{element with 15 volts across it}}$ = 4x15 = **60 W**
$p_{\text{element with 9 volts across it}}$ = –(–6x9) = **54 W**
$p_{\text{6 volt source}}$ = –(–6x6) = **36 W**

One check we can use is that the sum of the power absorbed must equal zero which is what it does.

Solution 1.20

$p_{\text{30 volt source}}$ = 30x(–6) = **–180 W**
$p_{\text{12 volt element}}$ = 12x6 = **72 W**
$p_{\text{28 volt e.ement with 2 amps flowing through it}}$ = 28x2 = **56 W**
$p_{\text{28 volt element with 1 amp flowing through it}}$ = 28x1 = **28 W**
$p_{\text{the 5Io dependent source}}$ = 5x2x(–3) = **–30 W**

Since the total power absorbed by all the elements in the circuit must equal zero,
or 0 = –180+72+56+28–30+$p_{\text{into the element with Vo}}$ or

$p_{\text{into the element with Vo}}$ = 180–72–56–28+30 = **54 W**

Since $p_{\text{into the element with Vo}}$ = V_ox3 = 54 W or V_o = **18 V**.

Solution 1.21

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

q = it = 0.5x24x60x60 = **43.2 kC**

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

Solution 1.22

$q = it = 40x10^3x1.7x10^{-3}$ = **68 C**

Solution 1.23

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

Solution 1.24

W = pt = 60 x24 Wh = 0.96 kWh = 1.44 kWh

C = 8.2 centsx0.96 = **11.808 cents**

Solution 1.25

A 1.2–kW toaster takes roughly 4 minutes to heat four slices of bread. Find the cost of operating the toaster twice per day for 2 weeks (14 days). Assume energy costs 9 cents/kWh.

$$\text{Cost} = 1.2\ \text{kW} \times \frac{4}{60}\,\text{hr} \times 14 \times 9\ \text{cents/kWh} \ = \mathbf{10.08\ cents}$$

Solution 1.26

(a) Clearly 10.78 watt-hours = (voltage)(current)(time) = 3.85I(3) or
I = 10.78/[(3.85)(3)] = **933.3 mA**

(b) p = energy/time = 10.78/3 = **3.593 W**

(c) amp-hours = energy/voltage = 10.78/3.85 = **2.8 amp-hours**

Solution 1.27

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

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

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

$$= 3\left(10t + \frac{0.25t^2}{3600}\right)\Bigg|_0^{4\times3600} = 3[40 \times 3600 + 0.25 \times 16 \times 3600]$$

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

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

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

Solution 1.28

A 150-W incandescent outdoor lamp is connected to a 120-V source and is left burning continuously for an average of 12 hours per day. Determine:

(a) the current through the lamp when it is lit,
(b) the cost of operating the light for one non-leap year if electricity costs 9.5 cents per kWh.

(a) $i = \frac{P}{V} = \frac{150}{120}$
= **1.25 A**

(b) $\text{w} = \text{pt} = 150 \times 365 \times 12 \text{ Wh} = 657 \text{ kWh}$

$\text{Cost} = \$0.095 \times 657$
= **\$62.42**

Solution 1.29

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

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

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

Solution 1.30

Monthly charge = \$6

First 250 kWh @ \$0.02/kWh = \$5

Remaining 2,436–250 kWh = 2,186 kWh @ \$0.07/kWh= \$153.02

Total = **\$164.02**

Solution 1.31

In a household, a business is run for an average of 6 hours per day. The total power consumed by the computer and its printer is 230 watts. In addition, a 75-W light runs during the same 6 hours. If their utility charges 11.75 cents per kWhr, how much do the owners pay every 30 days?

Total energy consumed over every 30 day period = 30[(230+75)6] = 54.9 kWhr

Cost per 30 day period = $0.1175x54.9 = **$6.451**

Solution 1.32

$i = 20\ \mu A$

$q = 15\ C$

$t = q/i = 15/(20x10^{-6}) =$ **$750x10^{3}$ hrs**

Solution 1.33

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

Solution 1.34

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

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

Solution 1.35

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

Solution 1.36

A battery can be rated in ampere-hours or watt hours. The ampere hours can be obtained from the watt hours by dividing watt hours be a nominal voltage of 12 volts. If an automobile battery is rated at 20 ampere-hours,

(a) what is the maximum current that can be supplied for 15 minutes?
(b) how many days will it last if it is discharged at a rate of 2 mA?

(a) I = 20/0.25 = **80 amps**.
(b) days = (20/0.002)/24 = **416.7 days**.

Solution 1.37

A total of 2 MJ are delivered to an automobile battery (assume 12 volts) giving it an additional charge. How much is that additional charge? Express your answer in ampere-hours.

Solution

2,000,000 = w = pt = vit = 12it = 12(charge) or

charge = $2x10^6/12 = 1.666710^5$ coulomb = 1.666710^5 Coulomb x 1 hour/3,600 seconds = 46.3 ampere-hour.

charge = **46.3 ampere-hours**.

Solution 1.38

P = 10 hp = 7460 W

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

Solution 1.39

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