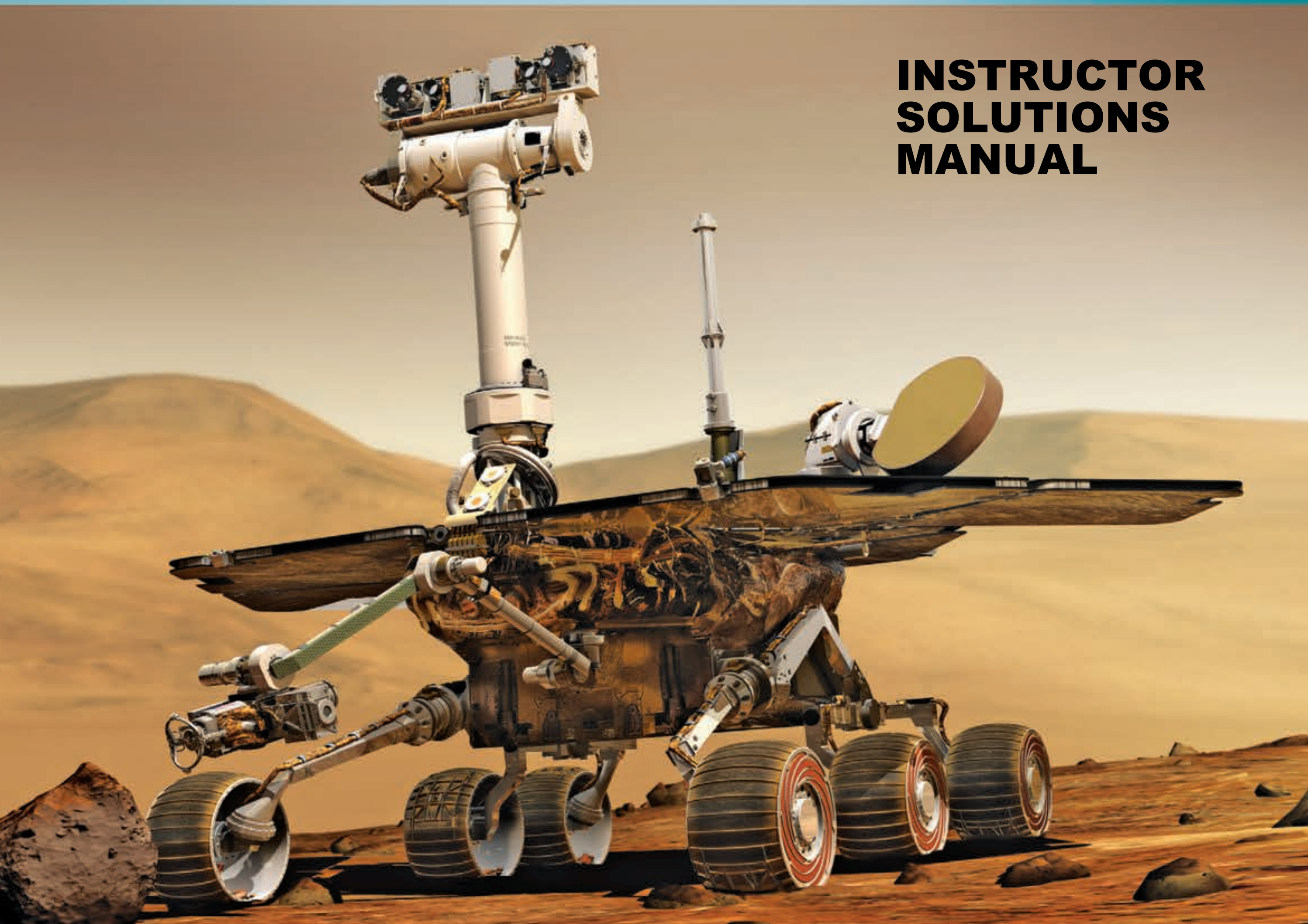
FIFTH EDITION

Fundamentals of Electric Circuits



INSTRUCTOR SOLUTIONS MANUAL

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Chapter 1, Solution 1

(a) q = $6.482\text{x}10^{17}$ x [$-1.602\text{x}10^{-19}$ C] = **–103.84 mC**

(b) q = 1. $24\text{x}10^{18}$ x [$-1.602\text{x}10^{-19}$ C] = **–198.65 mC**

(c) q = $2.46\text{x}10^{19}$ x [$-1.602\text{x}10^{-19}$ C] = **–3.941 C**

(d) q = $1.628\text{x}10^{20}$ x [$-1.602\text{x}10^{-19}$ C] = **–26.08 C**

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

Chapter 1, Solution 4

$q = it = 7.4 \times 20 = \underline{\mathbf{148\ C}}$

Chapter 1, Solution 5

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

Chapter 1, Solution 6

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

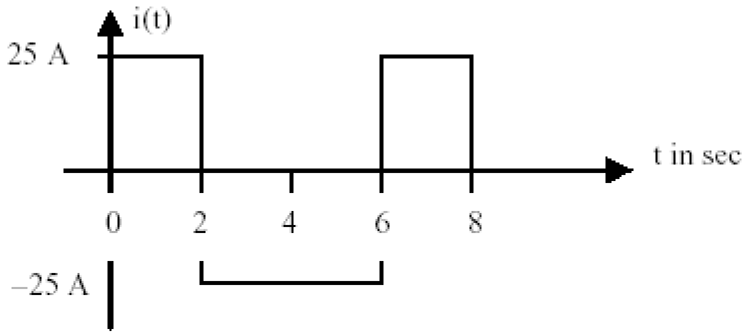
(b) At t = 6ms, $i = \frac{dq}{dt} =$ **<u>0 A</u>**

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

Chapter 1, Solution 7

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

which is sketched below:



Chapter 1, Solution 8

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

Chapter 1, Solution 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) $q = \int_0^5 i dt = 10 + 10 + 10 = \underline{30\ C}$

Chapter 1, Solution 10

$$q = it = 10x10^{3}x15x10^{-6} = \underline{\textbf{150 mC}}$$

Chapter 1, Solution 11

$q = it = 90 \times 10^{-3} \times 12 \times 60 \times 60 =$ **3.888 kC**

$E = pt = ivt = qv = 3888 \times 1.5 =$ **5.832 kJ**

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,

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

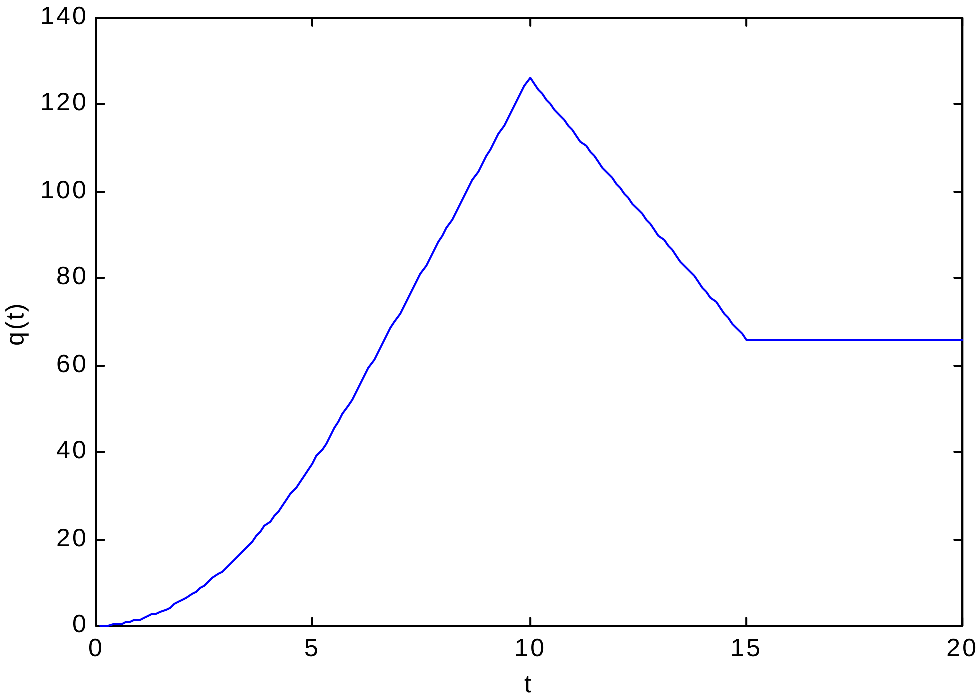
At t=15, q(15) = -12x15 + 246 = 66
For 15<t<20s,

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

Thus,

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

The plot of the charge is shown below.



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

Chapter 1, Solution 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) $W = \int p\,dt = 60\pi \int_0^{0.6} \cos^2(4\pi t)\,dt = 30\pi \int_0^{0.6} [1 + \cos(8\pi t)]\,dt$

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

Chapter 1, Solution 14

(a) $q = \int i dt = \int_0^1 0.02\left(1 - e^{-0.5t}\right)dt = 0.02\left(t + 2e^{-0.5t}\right)\Big|_0^1 = 0.02\left(1 + 2e^{-0.5} - 2\right) =$ **4.261 mC**

(b) $p(t) = v(t)i(t)$

$p(1) = 10\cos(2) \text{x} 0.02(1 - e^{-0.5}) = (-4.161)(0.007869)$

= **–32.74 mW**

Chapter 1, Solution 15

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

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

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

Chapter 1, Solution 16

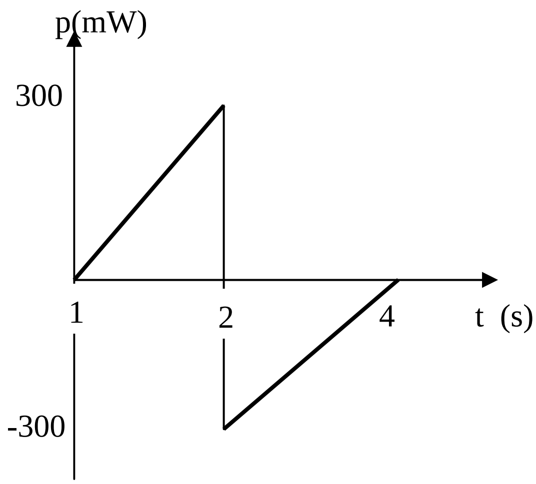
(a)

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

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

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

which is sketched below.



(b) From the graph of p,

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

Chapter 1, 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, Solution 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**

Chapter 1, Solution 19

$$I = 8 - 2 = \mathbf{6\ A}$$

Calculating the power absorbed by each element means we need to find vi for each element.

$$p_{\text{8 amp source}} = -8 \text{x} 9 = \mathbf{-72\ W}$$
$$p_{\text{element with 9 volts across it}} = 2 \text{x} 9 = \mathbf{18\ W}$$
$$p_{\text{element with 3 bolts across it}} = 3 \text{x} 6 = \mathbf{18\ W}$$
$$p_{\text{6 volt source}} = 6 \text{x} 6 = \mathbf{36\ W}$$

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

Chapter 1, Solution 20

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

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

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

Since $p_{\text{into the element with Vo}} = V_o x3 = 54$ W or V_o = **18 V**.

Chapter 1, Solution 21

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

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

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

Chapter 1, Solution 22

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

Chapter 1, Solution 23

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

Chapter 1, Solution 24

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

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

Chapter 1, Solution 25

$$\text{Cost} = 1.5\text{ kW} \times \frac{3.5}{60}\text{hr} \times 30 \times 8.2\text{ cents/kWh} = \mathbf{21.52\ cents}$$

Chapter 1, Solution 26

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

(b) p = vi = 6 × 0.08 = **0.48 W**

(c) w = pt = 0.48 × 10 Wh = **0.0048 kWh**

Chapter 1, Solution 27

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

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

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

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

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

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

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

Chapter 1, Solution 28

(a) $i = \frac{P}{V} = \frac{60}{120}$

$= \mathbf{500\ mA}$

(b) $W = pt = 60 \times 365 \times 24\ \text{Wh} = 525.6\ \text{kWh}$

$\text{Cost} = \$0.095 \times 525.6$

$= \mathbf{\$49.93}$

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, Solution 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**

Chapter 1, Solution 31

Total energy consumed = 365(120x4 + 60x8) W

Cost = $0.12x365x960/1000 = **$42.05**

Chapter 1, Solution 32

$i = 20\ \mu A$

$q = 15\ C$

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

Chapter 1, Solution 33

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

Chapter 1, Solution 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**

Chapter 1, Solution 35

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

Chapter 1, Solution 36

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

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

Chapter 1, Solution 37

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

Chapter 1, Solution 38

$P = 10 \text{ hp} = 7460 \text{ W}$

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

Chapter 1, Solution 39

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

Chapter 2, Solution 1. Design a problem, complete with a solution, to help students to better understand Ohm's Law. Use at least two resistors and one voltage source. Hint, you could use both resistors at once or one at a time, it is up to you. Be creative.

Although there is no correct way to work this problem, this is an example based on the same kind of problem asked in the third edition.

Problem

The voltage across a 5-kΩ resistor is 16 V. Find the current through the resistor.

Solution

$v = iR$ $\quad\quad$ $i = v/R = (16/5)$ mA $=$ **3.2 mA**

Chapter 2, Solution 2

$p = v^2/R \rightarrow$ **R** $= v^2/p = 14400/60 =$ **240 ohms**

Chapter 2, Solution 3

For silicon, $\rho = 6.4x10^2$ Ω-m. $A = \pi r^2$. Hence,

$$R = \frac{\rho L}{A} = \frac{\rho L}{\pi r^2} \quad \longrightarrow \quad r^2 = \frac{\rho L}{\pi R} = \frac{6.4x10^2 \, x4x10^{-2}}{\pi x240} = 0.033953$$

r = **184.3 mm**

Chapter 2, Solution 4

(a) $\mathbf{i} = 40/100 = \mathbf{400\ mA}$

(b) $\mathbf{i} = 40/250 = \mathbf{160\ mA}$

Chapter 2, Solution 5

n = **9**; l = **7**; **b** = n + l – 1 = **15**

Chapter 2, Solution 6

$n = 12$; $l = 8$; $\mathbf{b} = n + l - 1 = \underline{\mathbf{19}}$

Chapter 2, Solution 7

6 branches and 4 nodes

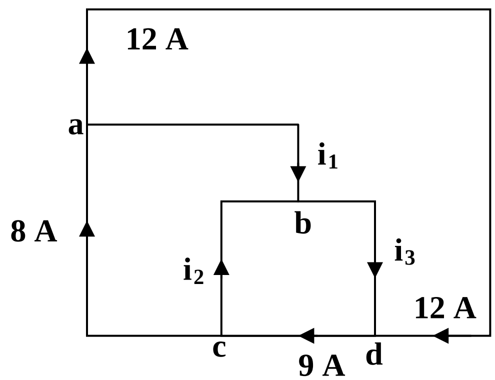
Chapter 2, Solution 8. Design a problem, complete with a solution, to help other students to better understand Kirchhoff's Current Law. Design the problem by specifying values of i_a, i_b, and i_c, shown in Fig. 2.72, and asking them to solve for values of i_1, i_2, and i_3. Be careful specify realistic currents.

Although there is no correct way to work this problem, this is an example based on the same kind of problem asked in the third edition.

Problem

Use KCL to obtain currents i_1, i_2, and i_3 in the circuit shown in Fig. 2.72.

Solution



At node a, $8 = 12 + i_1 \longrightarrow$ $\underline{\mathbf{i_1 = -4A}}$

At node c, $9 = 8 + i_2 \longrightarrow$ $\underline{\mathbf{i_2 = 1A}}$

At node d, $9 = 12 + i_3 \longrightarrow$ $\underline{\mathbf{i_3 = -3A}}$

Chapter 2, Solution 9

At A, $1+6-i_1 = 0$ or $i_1 = 1+6 =$ **7 A**

At B, $-6+i_2+7 = 0$ or $i_2 = 6-7 =$ **–1 A**

At C, $2+i_3-7 = 0$ or $i_3 = 7-2 =$ **5 A**