CHAPTER 1 SOLUTIONS

Problem 1.1

$$i(t) = \frac{dq(t)}{dt} = \begin{cases} 0.002\,A, & t \geq 0 \\ 0\,A, & t < 0 \end{cases} = \begin{cases} 2\,mA, & t \geq 0 \\ 0\,mA, & t < 0 \end{cases}$$

Problem 1.2

$$i(t) = \frac{dq(t)}{dt} = \begin{cases} -e^{-0.2t}\,A, & t \geq 0 \\ 0\,A, & t < 0 \end{cases}$$

Problem 1.3

$$i(t) = \frac{dq(t)}{dt} = \begin{cases} 0.024e^{-0.003t}\,A, & t \geq 0 \\ 0\,A, & t < 0 \end{cases} = \begin{cases} 24e^{-0.003t}\,mA, & t \geq 0 \\ 0\,mA, & t < 0 \end{cases}$$

Problem 1.4

$$i(t) = \frac{dq(t)}{dt} = \begin{cases} \left(7e^{-0.003t} - 0.021te^{-0.003t}\right)A, & t \geq 0 \\ 0\,A, & t < 0 \end{cases} = \begin{cases} \left(7 - 0.021t\right)e^{-0.003t}\,A, & t \geq 0 \\ 0\,A, & t < 0 \end{cases}$$

Problem 1.5

$$i(t) = \frac{dq(t)}{dt} = \begin{cases} 16\pi \times 10^{-3}\cos(2\pi \times 1000t)\,A, & t \geq 0 \\ 0\,A, & t < 0 \end{cases} = \begin{cases} 50.2655\cos(2\pi \times 1000t)\,mA, & t \geq 0 \\ 0\,mA, & t < 0 \end{cases}$$

Problem 1.6

The charge q(t) entering an element can be written as

$$q(t) = \begin{cases} 0.5 \times 10^{-3}t, & 0 \leq t < 2 \\ -10^{-3}t + 3 \times 10^{-3}, & 2 \leq t < 4 \\ \frac{1}{3} \times 10^{-3}t - \frac{7}{3} \times 10^{-3}, & 4 \leq t < 7 \\ 0, & elsewhere \end{cases}$$

The current through the element can be written as

$$i(t) = \frac{dq(t)}{dt} = \begin{cases} 0.5\times10^{-3}\,A, & 0 \le t < 2 \\ -10^{-3}\,A, & 2 \le t < 4 \\ \frac{1}{3}\times10^{-3}\,A, & 4 \le t < 7 \\ 0\,A, & elsewhere \end{cases} = \begin{cases} 0.5\,mA, & 0 \le t < 2 \\ -1\,mA, & 2 \le t < 4 \\ \frac{1}{3}mA, & 4 \le t < 7 \\ 0\,mA, & elsewhere \end{cases}$$

The current i(t) is shown in Figure S1.6.

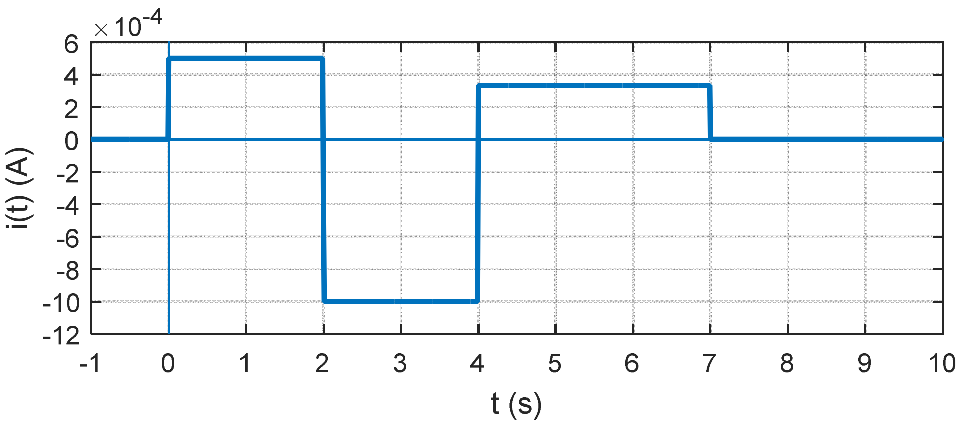

Figure S1.6

Problem 1.7

$$q(t) = \int_0^5 5\times10^{-3}\,dt = 5\times10^{-3}\times5 = 25\times10^{-3}\,C$$

Problem 1.8

$$q(t) = \int_0^5 5\times10^{-6}e^{-0.2t}dt = 5\times10^{-6}\frac{e^{-0.2t}\Big|_0^5}{-0.2} = 5\times10^{-6}\times\frac{e^{-1}-1}{-0.2} = 1.5803\times10^{-5}\,C = 15.803\,\mu C$$

Problem 1.9

$$q(t) = \int_0^5 3\left(1-e^{-0.5t}\right)dt = \int_0^5 3dt - 3\int_0^5 e^{-0.5t}dt = 3t\Big|_0^5 - 3\frac{e^{-0.5t}\Big|_0^5}{-0.5} = 3(5-0) + \frac{3\left(e^{-2.5}-1\right)}{0.5} = 9.4925\,C$$

Problem 1.10

From integral table, we have $\int te^{at}dt = \frac{e^{at}\left(at-1\right)}{a^2}$. Thus,

$$q(t)=\int_0^5 2te^{-3t}dt = 2\frac{e^{-3t}\left(-3t-1\right)\Big|_0^5}{9} = \frac{2}{9}\left[e^{-15}(-15-1)-e^{-0}(-0-1)\right] \approx \frac{2}{9} = 0.2222\,C$$

Problem 1.11

From integral table, we have $\int \sin(at)dt = -\frac{1}{a}\cos(at)$. Thus,

$$q(t)=\int_0^5 7\sin\left(\frac{\pi t}{5}\right)dt = -\frac{7}{\frac{\pi}{5}}\cos\left(\frac{\pi t}{5}\right)\Bigg|_0^5 = -\frac{35}{\pi}\left[\cos(\pi)-1\right] = \frac{70}{\pi} = 22.2817\,C$$

Problem 1.12

P = VI = 5 V × 2 A = 10 W, absorbing power

Problem 1.13

P = VI = 2 V × (-3 A) = -6 W, delivering power

Problem 1.14

P = VI = (-5 V) × 4 mA = -20 mW, delivering power

Problem 1.15

P = VI = (-12 V) × (-10 mA) = 120 mW, absorbing power

Problem 1.16

p(t) = v(t) i(t) = (5 V) × (2 mA) = 10 mW

Problem 1.17

p(t) = v(t) i(t) = [5 sin(2π1000t) V] × [25 cos(2π1000t) mA]
= 125 sin(2π1000t) cos(2π1000t) mW = 62.5 sin(2π2000t) mW

Problem 1.18

p(t) = v(t) i(t) = 420 $e^{-0.15t}$ u(t) mW

Problem 1.19

p(t) = v(t) i(t) = [3 cos(2π100t) V] × [8 cos(2π100t) mA]
= 24 $\cos^2$(2π100t) mW = [12 + 12 cos(2π200t)] mW

Problem 1.20

$p(t) = v(t)\,i(t) = [2 \sin(2\pi 100t)\ \text{V}] \times [6 \sin(2\pi 100t)\ \text{mA}]$
$= 12 \sin^2(2\pi 100t)\ \text{mW} = [6 - 6 \cos(2\pi 200t)]\ \text{mW}$

Problem 1.21

The circuit with one current source and one voltage source is shown in Figure S1.21.

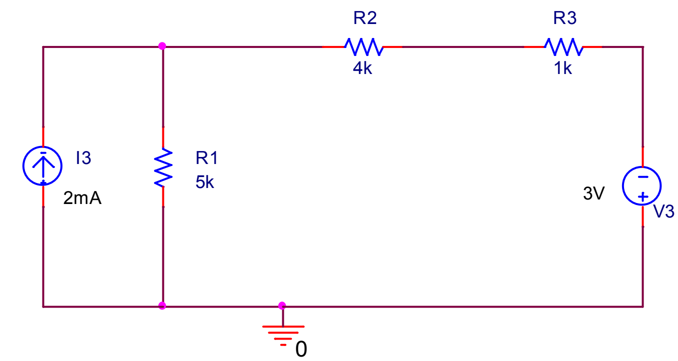

Figure S1.21 Circuit with one current source and one voltage source.

Problem 1.22

The circuit with one current source and one voltage source is shown in Figure S1.22.

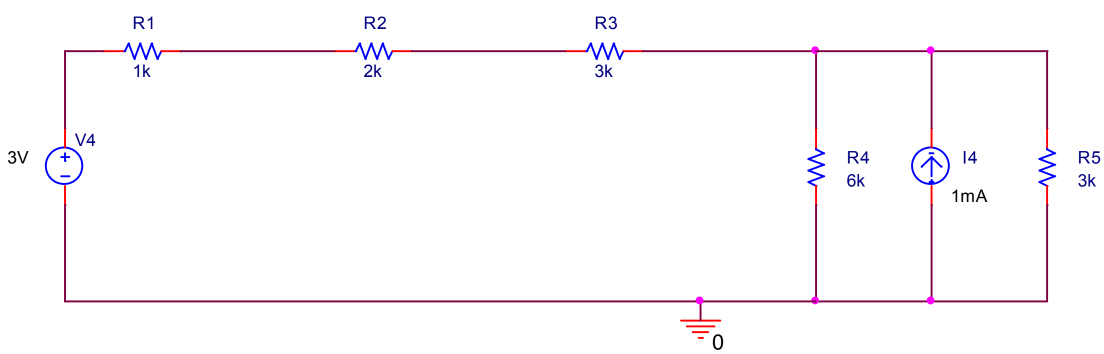

Figure S1.22 Circuit with one current source and one voltage source.

Problem 1.23

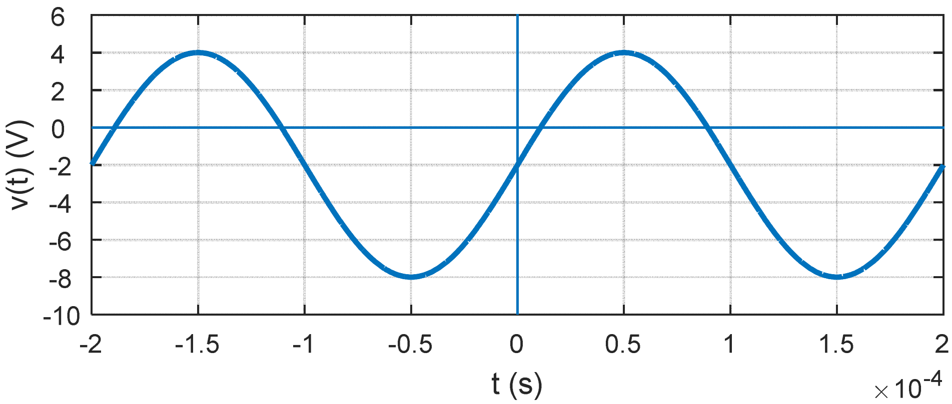

Figure S1.23

Problem 1.24

$v(t) = -2 + 8\cos(2\pi 10^6 t - 135^o)$ V

Problem 1.25

The voltage across the VCVS from positive to negative is given by

$0.5\ v_a = 0.5 \times 1.2908$ V = 0.6454 V

The current through the VCCS in the direction indicated in Figure P1.25 (↓) is

$0.001\ v_a = 0.001$ (A/V) ×1.2908 V = 0.0012908 A = 1.2908 mA

Problem 1.26

The voltage across the CCVS from positive to negative is given by

$500\ i_a = 500 \times 0.8714$ mA = 0.4357 V

The current through the CCCS in the direction indicated in Figure P1.26 (←) is

$0.6\ i_a = 0.6$ (A/V) × 0.8714 mA = 0.52284 mA

Problem 1.27

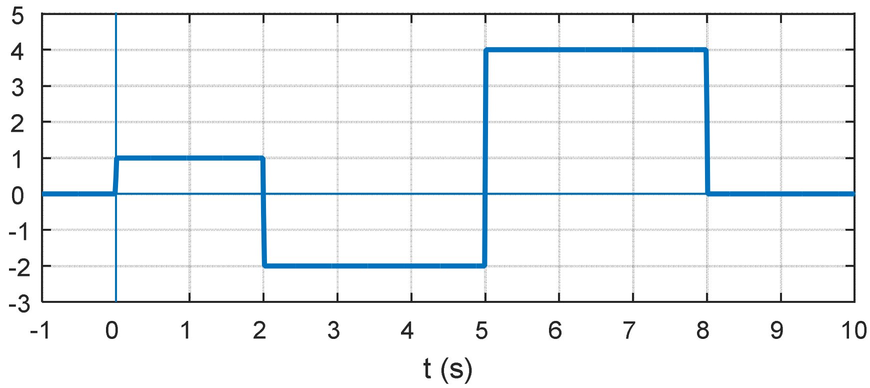

Figure S1.27

Problem 1.28

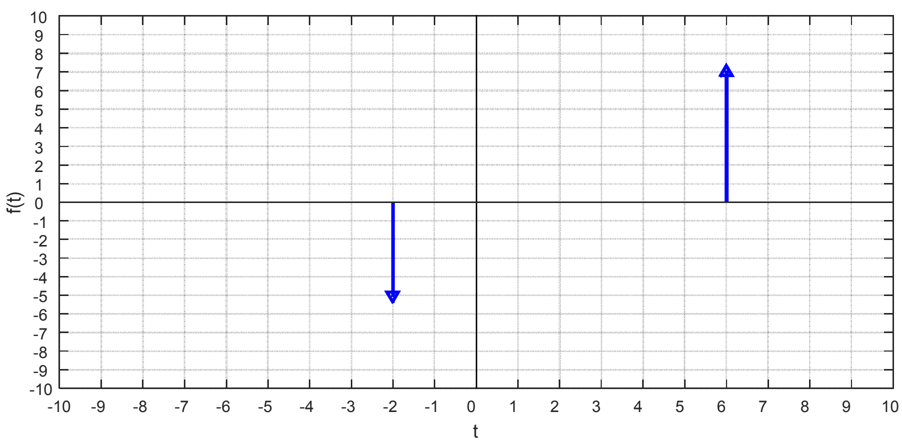

Figure S1.28

Problem 1.29

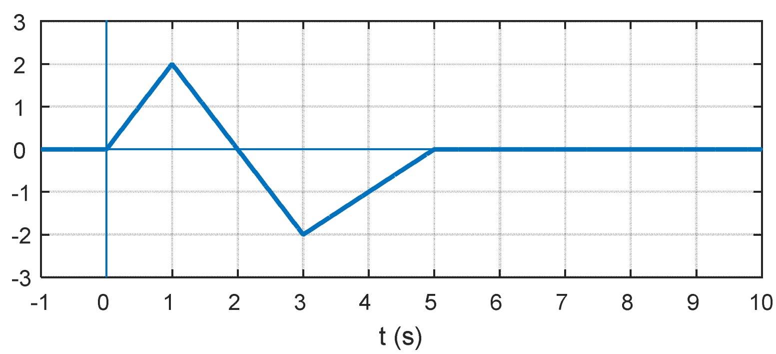

Figure S1.29

Problem 1.30

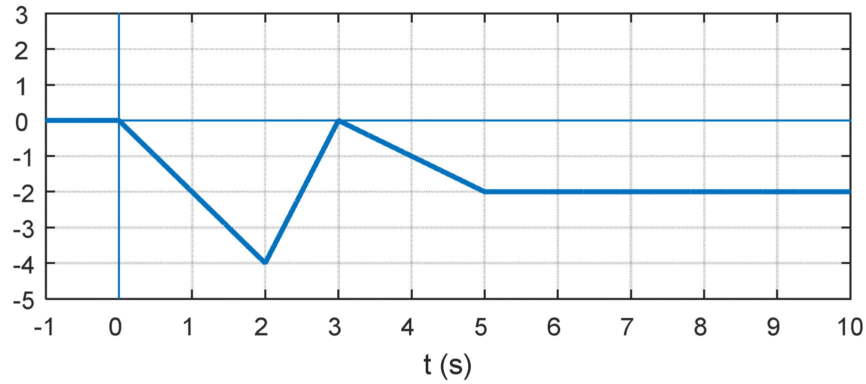

Figure S1.30

Problem 1.31

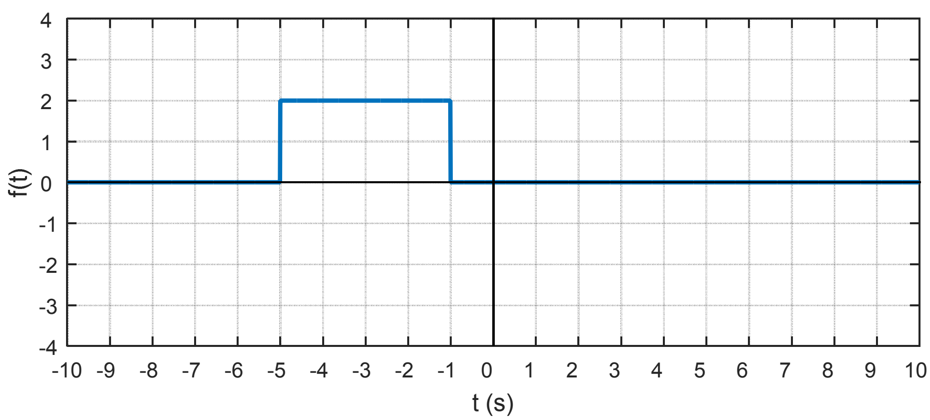

Figure S1.31

Problem 1.32

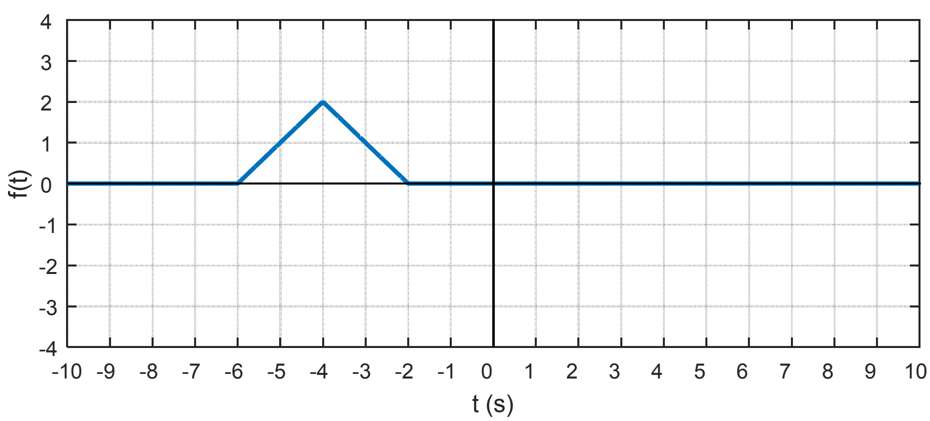

Figure S1.32

CHAPTER 2 SOLUTIONS

Problem 2.1

From Ohm's law, the current I_1 through R_1 is given by

$$I_1 = \frac{V}{R_1} = \frac{6V}{3k\Omega} = \frac{6V}{3000\Omega} = 0.002A = 2\,mA$$

Notice that 1 V/1 kΩ = 1 mA.
From Ohm's law, the current I_2 through R_2 is given by

$$I_2 = \frac{V}{R_2} = \frac{6V}{6k\Omega} = \frac{6V}{6000\Omega} = 0.001A = 1\,mA$$

Problem 2.2

From Ohm's law, the current I_1 through R_1 is given by

$$I_1 = \frac{V_1}{R_1} = \frac{2.4V}{800\Omega} = 0.003A = 3\,mA$$

From Ohm's law, the current I_2 through R_2 is given by

$$I_2 = \frac{V_2}{R_2} = \frac{3.6V}{2k\Omega} = 1.8\,mA$$

From Ohm's law, the current I_3 through R_3 is given by

$$I_3 = \frac{V_2}{R_3} = \frac{3.6V}{3k\Omega} = 1.2\,mA$$

Problem 2.3

From Ohm's law, the current I_1 through R_1 is given by

$$I_1 = \frac{V_1}{R_1} = \frac{2.4V}{4k\Omega} = 0.6\,mA = 600\,\mu A$$

From Ohm's law, the current I_2 through R_2 is given by

$$I_2 = \frac{V_1}{R_2} = \frac{2.4V}{6k\Omega} = 0.4\,mA = 400\,\mu A$$

From Ohm's law, the current I_3 through R_3 is given by

$$I_3 = \frac{V_2}{R_2} = \frac{1.2V}{1.8k\Omega} = \frac{2}{3}mA = 0.6667\,mA = 666.5557\,\mu A$$

From Ohm's law, the current I_4 through R_4 is given by

$$I_4 = \frac{V_2}{R_4} = \frac{1.2V}{6k\Omega} = 0.2\,mA = 200\,\mu A$$

From Ohm's law, the current I_5 through R_5 is given by

$$I_5 = \frac{V_2}{R_5} = \frac{1.2V}{9k\Omega} = \frac{2}{15}mA = 0.1333\,mA = 133.3333\,\mu A$$

Problem 2.4

From Ohm's law, the voltage across R_2 is given by

$V_o = R_2I_2 = 6$ kΩ × 1.2 mA = 6000 × 0.0012 = 7.2 V

Notice that 1 kΩ × 1 mA = 1 V.
From Ohm's law, the current I_1 through R_1 is given by

$$I_1 = \frac{V_1}{R_1} = \frac{2.8V}{1.4k\Omega} = 2\,mA$$

From Ohm's law, the voltage across R_2 is given by

$V_o = R_2I_2 = 6$ kΩ × 1.2 mA = 6000 × 0.0012 = 7.2 V

From Ohm's law, the current I_3 through R_3 is given by

$$I_3 = \frac{V_o}{R_3} = \frac{7.2V}{9k\Omega} = 0.8\,mA = 800\,\mu A$$

Problem 2.5

From Ohm's law, the voltage across R_4 is given by

$V_o = R_4I_4 = 18$ kΩ × 0.2 mA = 18000 × 0.0002 = 3.6 V

From Ohm's law, the current I_3 through R_3 is given by

$$I_3 = \frac{V_o}{R_3} = \frac{3.6V}{6k\Omega} = 0.6\,mA = 600\,\mu A$$

Problem 2.6

From Ohm's law, the voltage across R_4 is given by

$V_o = R_4 I_4 = 8$ kΩ × 0.4 mA = 8000 × 0.0004 = 3.2 V

From Ohm's law, the current I_2 through R_2 is given by

$$I_2 = \frac{V_o}{R_2} = \frac{3.2V}{3k\Omega} = \frac{16}{15}mA = 1.06667\,mA$$

From Ohm's law, the current I_3 through R_3 is given by

$$I_3 = \frac{V_o}{R_3} = \frac{3.2V}{6k\Omega} = \frac{16}{30}mA = 0.53333\,mA = 533.3333\,\mu A$$

Problem 2.7

From Ohm's law, the voltage across R_3 is given by

$V_o = R_3 I_3 = 42$ kΩ × (1/12) mA = 42/12 V= 3.5 V

From Ohm's law, the resistance value R_2 is given by

$$R_2 = \frac{V_o}{I_2} = \frac{3.5V}{\frac{7}{60}mA} = 30\,k\Omega$$

1 V/1 mA = 1 kΩ

Problem 2.8

The power on R_1 is

$P_{R_1} = I^2 R_1 = (2\times10^{-3})^2 \times 2000 = 4\times10^{-6}\times2\times10^3 = 8\times10^{-3}W = 8\,mW$ (absorbed)

The power on R_2 is

$P_{R_2} = I^2 R_1 = (2\times10^{-3})^2 \times 3000 = 4\times10^{-6}\times3\times10^3 = 12\times10^{-3}W = 12\,mW$ (absorbed)

The power on V_s is

$$P_{V_s} = -IV_s = -2\times10^{-3}\times10 = -20\times10^{-3}W = -20\,mW \text{ (released)}$$

Total power absorbed = 20 mW = total power released

Problem 2.9

The power on R_1 is

$$P_{R_1} = \frac{V_o^2}{R_1} = \frac{4.8^2}{8000} = 2.88\times10^{-3}W = 2.88\,mW \text{ (absorbed)}$$

The power on R_2 is

$$P_{R_2} = \frac{V_o^2}{R_2} = \frac{4.8^2}{12000} = 1.92\times10^{-3}W = 1.92\,mW \text{ (absorbed)}$$

The power on V_s is

$$P_{I_s} = -I_sV_o = -1\times10^{-3}\times4.8 = -4.8\times10^{-3}W = -4.8\,mW \text{ (released)}$$

Problem 2.10

From Ohm's law, current I_1 is given by

$$I_1 = \frac{20V - 15V}{R_1} = \frac{5V}{0.5\,k\Omega} = 10\,mA$$

From Ohm's law, current I_2 is given by

$$I_2 = \frac{20V - 10V}{R_2} = \frac{10V}{2\,k\Omega} = 5\,mA$$

From Ohm's law, current I_3 is given by

$$I_3 = \frac{10V - 0V}{R_3} = \frac{10V}{1\,k\Omega} = 10\,mA$$

From Ohm's law, current I_4 is given by

$$I_4 = \frac{10V - 15V}{R_4} = \frac{-5V}{1k\Omega} = -5\,mA$$

Problem 2.11

From Ohm's law, current *i* is given by

$$i = \frac{10V - 8V}{R_3} = \frac{2V}{2k\Omega} = 1\,mA$$

From Ohm's law, current I_1 is given by

$$I_1 = \frac{12V - 10V}{R_1} = \frac{2V}{1k\Omega} = 2\,mA$$

From Ohm's law, current I_2 is given by

$$I_2 = \frac{10V - 5V}{R_2} = \frac{5V}{5k\Omega} = 1\,mA$$

From Ohm's law, current I_3 is given by

$$I_3 = \frac{12V - 8V}{R_4} = \frac{4V}{2k\Omega} = 2\,mA$$

From Ohm's law, current I_4 is given by

$$I_4 = \frac{8V - 5V}{R_5} = \frac{3V}{3k\Omega} = 1\,mA$$

From Ohm's law, current I_5 is given by

$$I_5 = \frac{8V}{R_6} = \frac{8V}{4k\Omega} = 2\,mA$$

Problem 2.12

Application of Ohm's law results in

$$I_1 = \frac{34V - 24V}{R_1} = \frac{10V}{2k\Omega} = 5\,mA$$

$$I_2 = \frac{24V - 10V}{R_2} = \frac{14V}{2k\Omega} = 7\,mA$$

$$I_3 = \frac{24V - 28V}{R_3} = \frac{-4V}{2k\Omega} = -2\,mA$$

$$I_4 = \frac{34V - 28V}{R_4} = \frac{6V}{0.6k\Omega} = 10\,mA$$

$$I_5 = \frac{28V - 10V}{R_5} = \frac{18V}{6k\Omega} = 3\,mA$$

$$I_6 = \frac{28V}{R_6} = \frac{28V}{5.6k\Omega} = 5\,mA$$

$$I_7 = \frac{10V}{R_7} = \frac{10V}{1k\Omega} = 10\,mA$$

Problem 2.13

The total voltage from the four voltage sources is

$V = V_{s1} + V_{s2} + V_{s3} + V_{s4} = 9\ V + 2\ V - 3\ V + 2\ V = 10V$

The total resistance from the five resistors is

$R = R_1 + R_2 + R_3 + R_4 + R_5 = 3\ k\Omega + 5\ k\Omega + 4\ k\Omega + 2\ k\Omega + 4\ k\Omega = 18\ k\Omega$

The current through the mesh is

$$I = \frac{V}{R} = \frac{10V}{18000\Omega} = \frac{5}{9}mA = 0.5556\,mA$$

From Ohm's law, the voltages across the five resistors are given respectively

$V_1 = R_1 I = 3\times5/9\ V = 15/9\ V = 5/3\ V = 1.6667\ V$

$V_2 = R_2 I = 5\times5/9\ V = 25/9\ V = 2.7778\ V$

$V_3 = R_3 I = 4\times5/9\ V = 20/9\ V = 2.2222\ V$

$V_4 = R_4 I = 2\times5/9\ V = 10/9\ V = 1.1111\ V$

$V_5 = R_5 I = 4 \times 5/9$ V = 20/9 V = 2.2222 V

Problem 2.14

Radius is r = d/2 = 0.2025 mm = 0.2025×10^{-3} m
$A = \pi r^2 = 1.28825 \times 10^{-7}$ m^2

(a)
$$R = \frac{\ell}{\sigma A} = \frac{20}{5.69 \times 10^7 \times \pi \times (0.2025 \times 10^{-3})^2} = 2.7285\,\Omega$$
(b)
$$R = \frac{\ell}{\sigma A} = \frac{200}{5.69 \times 10^7 \times \pi \times (0.2025 \times 10^{-3})^2} = 27.2846\,\Omega$$
(c)
$$R = \frac{\ell}{\sigma A} = \frac{2000}{5.69 \times 10^7 \times \pi \times (0.2025 \times 10^{-3})^2} = 272.8461\,\Omega$$
(d)
$$R = \frac{\ell}{\sigma A} = \frac{20000}{5.69 \times 10^7 \times \pi \times (0.2025 \times 10^{-3})^2} = 2728.4613\,\Omega$$

Problem 2.15

From Ohm's law, the voltage across R_2 is given by

$V_2 = I_2 R_2 = 3$ mA × 2 kΩ = 6 V

From Ohm's law, the current through R_3 is given by

$$I_3 = \frac{V_2}{R_3} = \frac{6V}{3k\Omega} = 2\,mA$$

According to KCL, current I_1 is the sum of I_2 and I_3. Thus, we have

$I_1 = I_2 + I_3 = 3$ mA + 2 mA = 5 mA

The voltage across R_1 is given by

$V_1 = R_1 I_1 = 1$ kΩ × 5 mA = 5 V

Problem 2.16

From Ohm's law, the currents I_2, I_3, and I_4 are given respectively by