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

$v = iR \qquad i = v/R = (16/5)\text{ mA} = \mathbf{3.2\text{ mA}}$

Chapter 2, Solution 2

$p = v^2/R \rightarrow \mathbf{R} = v^2/p = 14400/60 =$ **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) $\quad \mathbf{i} = 40/100 = \mathbf{400\ mA}$

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

Chapter 2, Solution 5

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

Chapter 2, Solution 6

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

Chapter 2, Solution 7

6 branches and 4 nodes

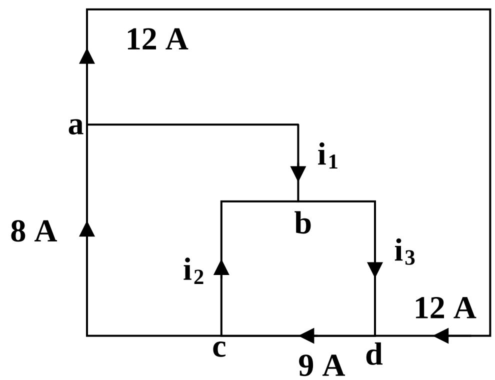
Chapter 2, Solution 8. Design a problem, complete with a solution, to help other students to better understand Kirchhoff's Current Law. Design the problem by specifying values of i_a, i_b, and i_c, shown in Fig. 2.72, and asking them to solve for values of i_1, i_2, and i_3. Be careful specify realistic 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,	$9 = 12 + i_3 \longrightarrow$	$\underline{\mathbf{i_3 = -3A}}$

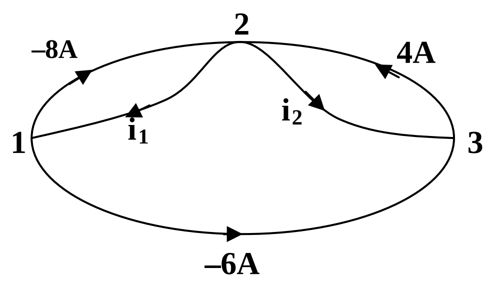
Chapter 2, Solution 9

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**

Chapter 2, Solution 10



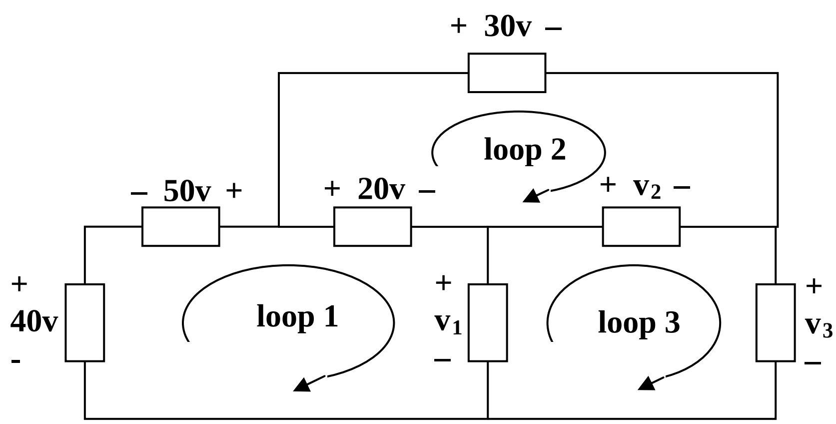
At node 1, $-8-i_1-6 = 0$ or $i_1 = -8-6 =$ **-14 A**

At node 2, $-(-8)+i_1+i_2-4 = 0$ or $i_2 = -8-i_1+4 = -8+14+4 =$ **10 A**

Chapter 2, Solution 11

$$-V_1 + 1 + 5 = 0 \quad \longrightarrow \quad V_1 = \underline{6\text{ V}}$$
$$-5 + 2 + V_2 = 0 \quad \longrightarrow \quad V_2 = \underline{3\text{ V}}$$

Chapter 2, Solution 12

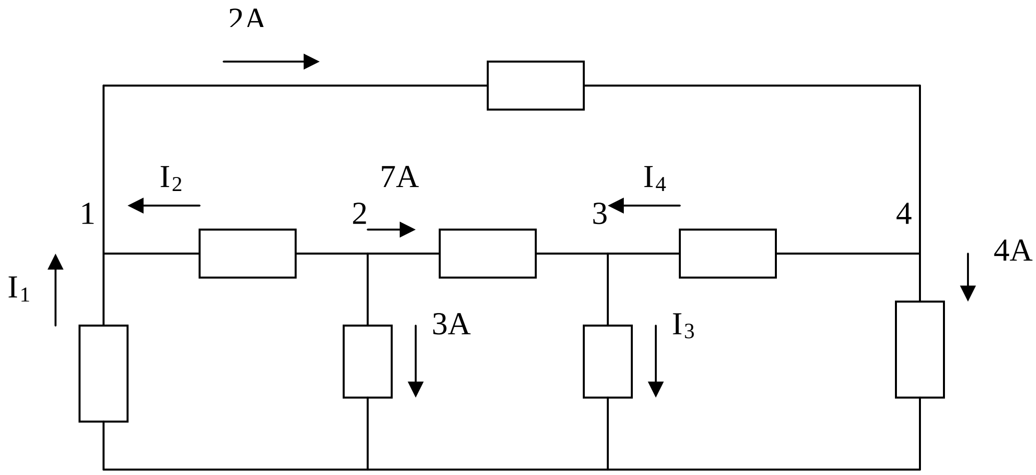


For loop 1, $-40 - 50 + 20 + v_1 = 0$ or $v_1 = 40 + 50 - 20 =$ **70 V**

For loop 2, $-20 + 30 - v_2 = 0$ or $v_2 = 30 - 20 =$ **10 V**

For loop 3, $-v_1 + v_2 + v_3 = 0$ or $v_3 = 70 - 10 =$ **60 V**

Chapter 2, Solution 13



At node 2,

$$3+7+I_2=0 \quad \longrightarrow \quad I_2=-10A$$

At node 1,

$$I_1+I_2=2 \quad \longrightarrow \quad I_1=2-I_2=12A$$

At node 4,

$$2=I_4+4 \quad \longrightarrow \quad I_4=2-4=-2A$$

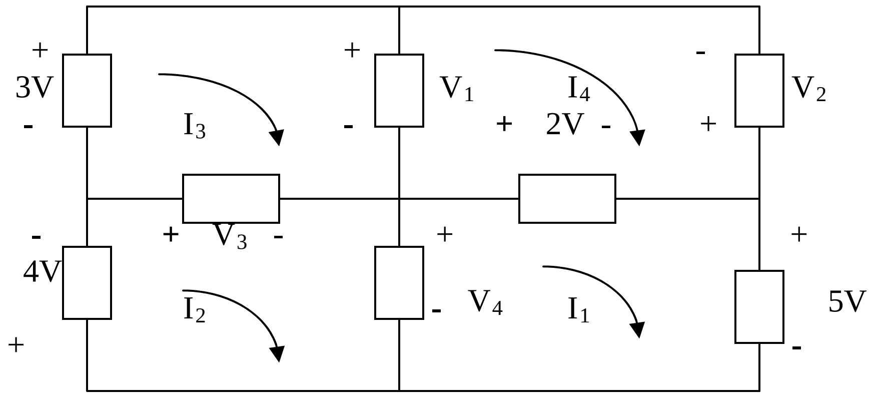
At node 3,

$$7+I_4=I_3 \quad \longrightarrow \quad I_3=7-2=5A$$

Hence,

$$\underline{I_1=12A, \quad I_2=-10A, \quad I_3=5A, \quad I_4=-2A}$$

Chapter 2, Solution 14



For mesh 1,

$-V_4 + 2 + 5 = 0 \longrightarrow V_4 = 7V$

For mesh 2,

$+4 + V_3 + V_4 = 0 \longrightarrow V_3 = -4 - 7 = -11V$

For mesh 3,

$-3 + V_1 - V_3 = 0 \longrightarrow V_1 = V_3 + 3 = -8V$

For mesh 4,

$-V_1 - V_2 - 2 = 0 \longrightarrow V_2 = -V_1 - 2 = 6V$

Thus,

$\underline{V_1 = -8V, \quad V_2 = 6V, \quad V_3 = -11V, \quad V_4 = 7V}$

Chapter 2, Solution 15

Calculate v and i_x in the circuit of Fig. 2.79.

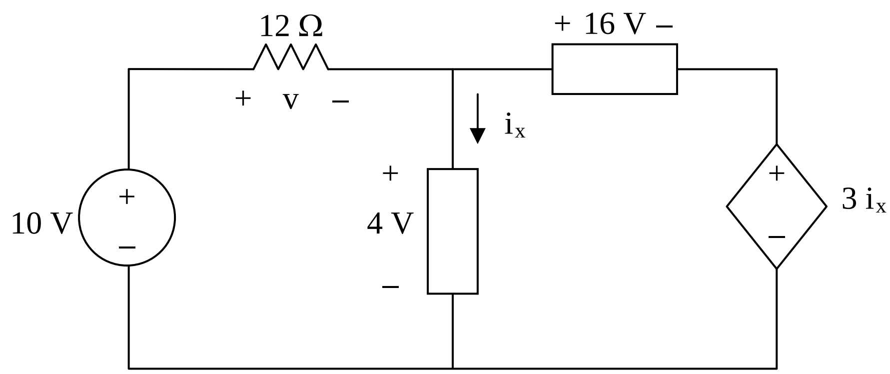


Figure 2.79
For Prob. 2.15.

Solution

For loop 1, $-10 + v + 4 = 0$, $v =$ **6 V**

For loop 2, $-4 + 16 + 3i_x = 0$, $i_x =$ **–4 A**

Chapter 2, Solution 16

Determine $\boldsymbol{V_o}$ in the circuit in Fig. 2.80.

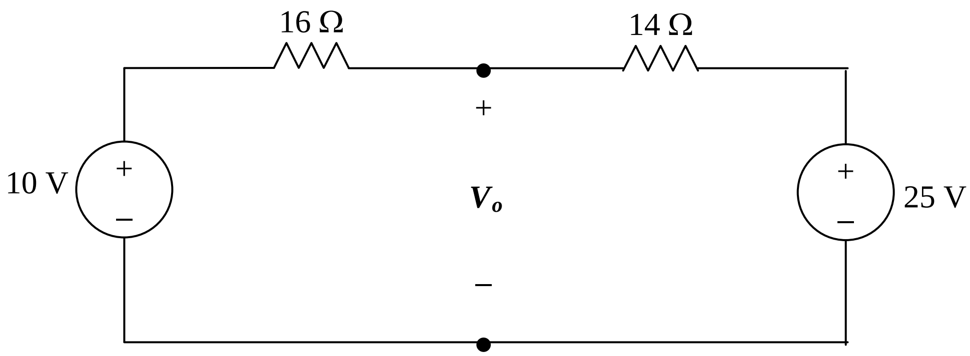


Figure 2.80
For Prob. 2.16.

Solution

Apply KVL,

$$-10 + (16+14)I + 25 = 0 \text{ or } 30I = 10-25 = - \text{ or } I = -15/30 = -500 \text{ mA}$$

Also,

$$-10 + 16I + \boldsymbol{V_o} = 0 \text{ or } \boldsymbol{V_o} = 10 - 16(-0.5) = 10+8 = \mathbf{18\ V}$$

Chapter 2, Solution 17

Applying KVL around the entire outside loop we get,

$-24 + v_1 + 10 + 12 = 0$ or $v_1 =$ **2V**

Applying KVL around the loop containing v_2, the 10-volt source, and the 12-volt source we get,

$v_2 + 10 + 12 = 0$ or $v_2 =$ **–22V**

Applying KVL around the loop containing v_3 and the 10-volt source we get,

$-v_3 + 10 = 0$ or $v_3 =$ **10V**

Chapter 2, Solution 18

Applying KVL,

$$-30 - 10 + 8 + I(3+5) = 0$$

$$8I = 32 \longrightarrow I = \underline{\mathbf{4A}}$$

$$-V_{ab} + 5I + 8 = 0 \longrightarrow V_{ab} = \underline{\mathbf{28V}}$$

Chapter 2, Solution 19

Applying KVL around the loop, we obtain

$$-(-8) - 12 + 10 + 3i = 0 \longrightarrow \mathbf{i = -2A}$$

Power dissipated by the resistor:

$$p_{3\Omega} = i^2R = 4(3) = \mathbf{12W}$$

Power supplied by the sources:

$$p_{12V} = 12\,((-2)) = \mathbf{-24W}$$

$$p_{10V} = 10\,(-(-2)) = \mathbf{20W}$$

$$p_{8V} = (-8)(-2) = \mathbf{16W}$$

Chapter 2, Solution 20

Determine i_o in the circuit of Fig. 2.84.

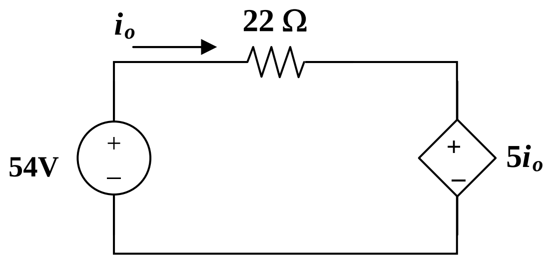


Figure 2.84
For Prob. 2.20

Solution

Applying KVL around the loop,

$$-54 + 22\boldsymbol{i_o} + 5\boldsymbol{i_o} = 0 \longrightarrow \quad \boldsymbol{i_o = 4A}$$

Chapter 2, Solution 21

Applying KVL,

$$-15 + (1+5+2)I + 2V_x = 0$$

But $V_x = 5I$,

$$-15 + 8I + 10I = 0, \qquad I = 5/6$$

$$V_x = 5I = 25/6 = \mathbf{4.167\ V}$$

Chapter 2, Solution 22

Find $\boldsymbol{V_o}$ in the circuit in Fig. 2.86 and the power absorbed by the dependent source.

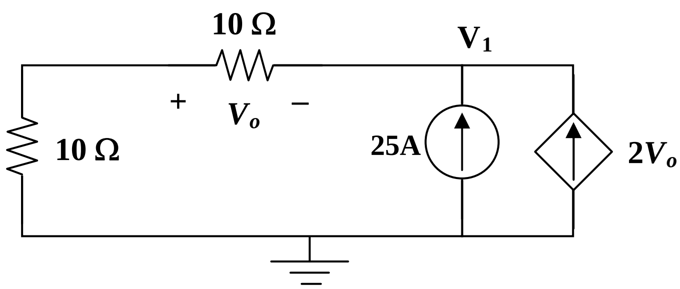


Figure 2.86
For Prob. 2.22

Solution

At the node, KCL requires that $[-V_o/10]+[-25]+[-2V_o] = 0$ or $2.1V_o = -25$

or $V_o =$ **-11.905 V**

The current through the controlled source is $i = 2V_0 = -23.81$ A
and the voltage across it is $V_1 = (10+10)\, i_0$ (where $i_0 = -V_0/10) = 20(11.905/10)$
$= 23.81$ V.

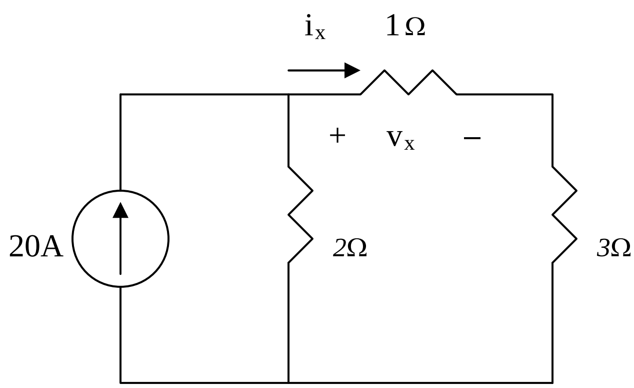
Hence,

$p_{\text{dependent source}} = V_1(-i) = 23.81x(-(-23.81)) =$ **566.9 W**

Checking, $(25-23.81)^2(10+10) + (23.81)(-25) + 566.9 = 28.322 - 595.2 + 566.9$
$= 0.022$ which is equal zero since we are using four places of accuracy!

Chapter 2, Solution 23

8//12 = 4.8, 3//6 = 2, (4 + 2)//(1.2 + 4.8) = 6//6 = 3
The circuit is reduced to that shown below.



Applying current division,

i_x = [2/(2+1+3)]20 = 6.667 and v_x = 1x6.667 = 6.667 V

$$i_x = \frac{2}{2+1+3}(6\,A) = 2\,A, \qquad v_x = 1i_x = \underline{2V}$$

The current through the 1.2-Ω resistor is 0.5i_x = 3.333 A. The voltage across the 12-Ω resistor is 3.333 x 4.8 = 16V. Hence the power absorbed by the 12-ohm resistor is equal to

$$(16)^2/12 = \mathbf{21.33\ W}$$

Chapter 2, Solution 24

(a) $I_0 = \dfrac{V_s}{R_1 + R_2}$

$$V_0 = -\alpha I_0 \left(R_3 \| R_4\right) = -\frac{\alpha V_s}{R_1 + R_2} \cdot \frac{R_3 R_4}{R_3 + R_4}$$

$$\boldsymbol{\frac{V_0}{Vs} = \frac{-\alpha R_3 R_4}{(R_1 + R_2)(R_3 + R_4)}}$$

(b) If $R_1 = R_2 = R_3 = R_4 = R$,

$$\left|\frac{V_0}{V_S}\right| = \frac{\alpha}{2R} \cdot \frac{R}{2} = \frac{\alpha}{4} = 10 \longrightarrow \boldsymbol{\alpha = 40}$$

Chapter 2, Solution 25

$$V_0 = 5 \text{ x } 10^{-3} \text{ x } 10 \text{ x } 10^3 = 50V$$

Using current division,

$$I_{20} = \frac{5}{5+20}(0.01x50) = \mathbf{0.1\ A}$$

$$V_{20} = 20 \text{ x } 0.1 \text{ kV} = \mathbf{2\ kV}$$

$$p_{20} = I_{20}\, V_{20} = \mathbf{0.2\ kW}$$

Chapter 2, Problem 26.

For the circuit in Fig. 2.90, $\boldsymbol{i_o}$ = 3 A. Calculate $\boldsymbol{i_x}$ and the total power absorbed by the entire circuit.

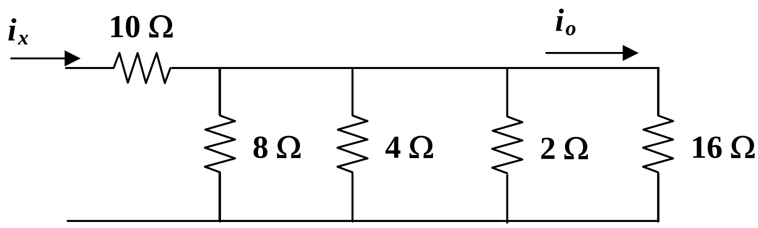


Figure 2.90
For Prob. 2.26.

Solution

If $i_{16} = \boldsymbol{i_o} = 3$A, then v = 16x3 = 48 V and $i_8 = 48/8 = 6$A; $i_4 = 48/4 = 12$A; and $i_2 = 48/2 = 24$A.

Thus,

$$\boldsymbol{i_x} = i_8 + i_4 + i_2 + i_{16} = 6 + 12 + 24 + 3 = \mathbf{45\ A}$$

$$p = (45)^2 10 + (6)^2 8 + (12)^2 4 + (24)^2 2 + (3)^2 16 = 20{,}250 + 288 + 576 + 1152 + 144$$

$$= 20250 + 2106 = \mathbf{22.356\ kW}.$$

Chapter 2, Problem 27.

Calculate $\boldsymbol{I_o}$ in the circuit of Fig. 2.91.

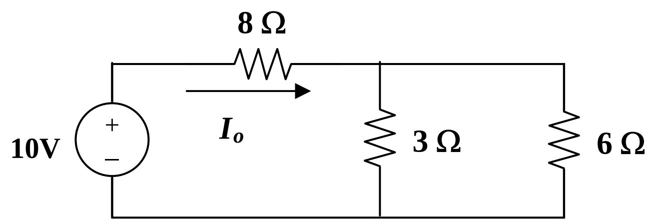


Figure 2.91
For Prob. 2.27.

Solution

The 3-ohm resistor is in parallel with the c-ohm resistor and can be replaced by a [(3x6)/(3+6)] = 2-ohm resistor. Therefore,

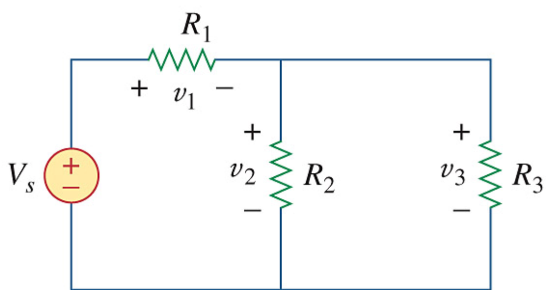
$$\boldsymbol{I_o} = 10/(8+2) = \mathbf{1\ A}.$$

Chapter 2, Solution 28 Design a problem, using Fig. 2.92, to help other students better understand series and parallel circuits.

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

Find v_1, v_2, and v_3 in the circuit in Fig. 2.92.



Solution

We first combine the two resistors in parallel

$$15 \| 10 = 6\ \Omega$$

We now apply voltage division,

$$v_1 = \frac{14}{14+6}(40) = \underline{\textbf{28 V}}$$

$$v_2 = v_3 = \frac{6}{14+6}(40) = 12\text{ V}$$

Hence, v_1 = **28 V**, v_2 = **12 V,** v_s = **12 V**

Chapter 2, Solution 29

All resistors in Fig. 2.93 are 5 Ω each. Find R_{eq}.

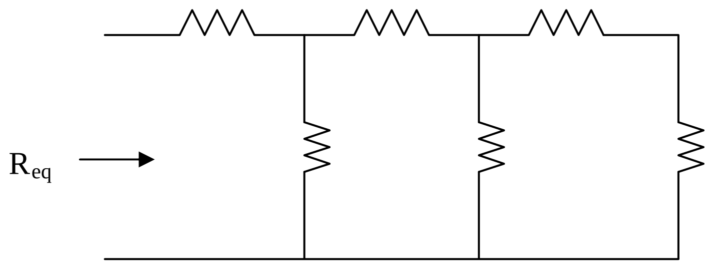


Figure 2.93
For Prob. 2.29.

Solution

R_{eq} = 5 + 5||[5+5||(5+5)] = 5 + 5||[5+(5x10/(5+10))] = 5+5||(5+3.333) = 5 + 41.66/13.333

= **8.125 Ω**

Chapter 2, Problem 30.

Find $\boldsymbol{R_{eq}}$ for the circuit in Fig. 2.94.

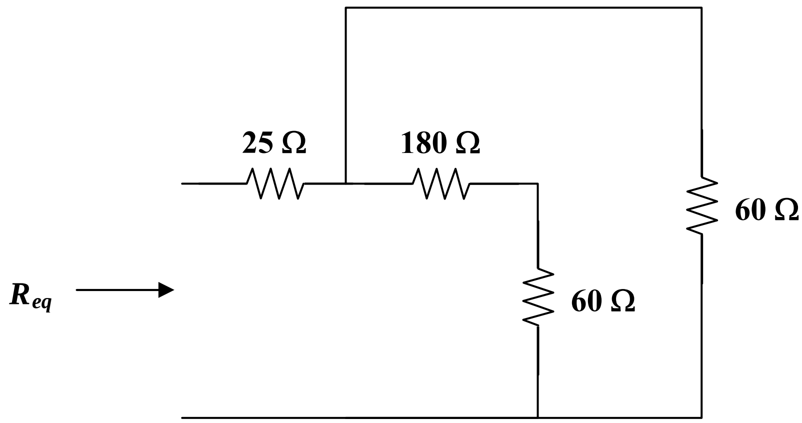


Figure 2.94
For Prob. 2.30.

Solution

We start by combining the 180-ohm resistor with the 60-ohm resistor which in turn is in parallel with the 60-ohm resistor or = [60(180+60)/(60+180+60)] = 48.

Thus,

$$R_{eq} = 25+48 = \mathbf{73\ \Omega}.$$

Chapter 2, Solution 31

$$R_{eq} = 3 + 2 // 4 // 1 = 3 + \frac{1}{1/2 + 1/4 + 1} = 3.5714$$

i_1 = 200/3.5714 = **56 A**

$v_1 = 0.5714 x i_1$ = 32 V and i_2 = 32/4 = **8 A**

i_4 = 32/1 = **32 A**; i_5 = 32/2 = **16 A**; and i_3 = 32+16 = **48 A**

Chapter 2, Solution 32

Find i_1 through i_4 in the circuit in Fig. 2.96.

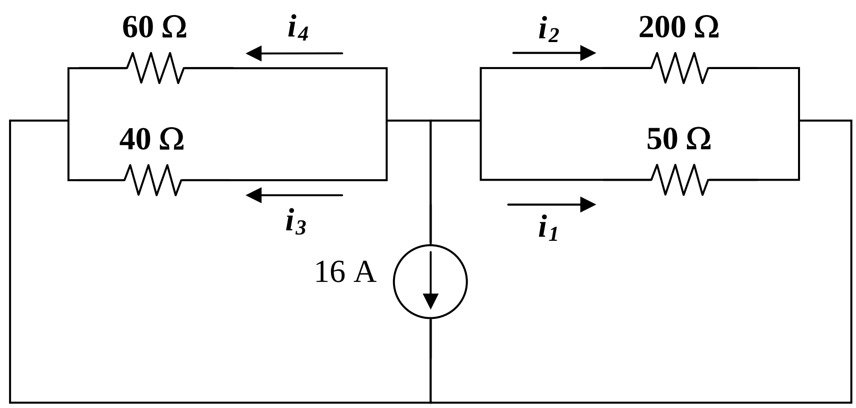


Figure 2.96
For Prob. 2.32.

Solution

We first combine resistors in parallel.

$$40\|60 = \frac{40\text{x}60}{100} = 24\ \Omega \text{ and } \quad 50\|200 = \frac{50\text{x}200}{250} = 40\ \Omega$$

Using current division principle,

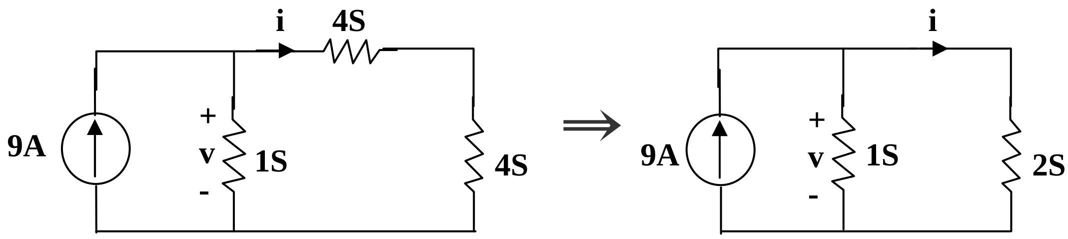
$$i_1 + i_2 = \frac{24}{24+40}(-16) = -6\text{A}, i_3 + i_4 = \frac{40}{64}(-16) = -10\text{A}$$

$$i_1 = \frac{200}{250}(6) = \mathbf{-4.8\ A} \text{ and } i_2 = \frac{50}{250}(-6) = \mathbf{-1.2\ A}$$

$$i_3 = \frac{60}{100}(-10) = \mathbf{-6\ A} \text{ and } i_4 = \frac{40}{100}(-10) = \mathbf{-4\ A}$$

Chapter 2, Solution 33

Combining the conductance leads to the equivalent circuit below



$$6S \| 3S = \frac{6x3}{9} = 2S \text{ and } 2S + 2S = 4S$$

Using current division,

$$i = \frac{1}{1+\frac{1}{2}}(9) = \mathbf{6\ A}, \; v = 3(1) = \mathbf{3\ V}$$

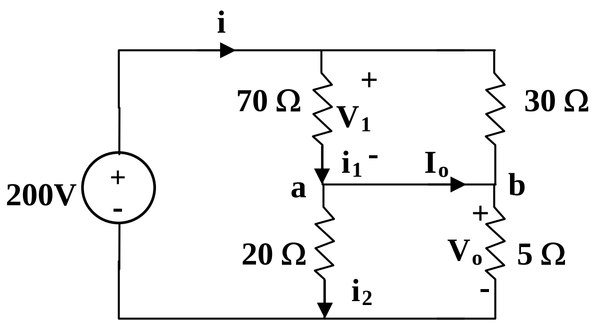
Chapter 2, Solution 34

160//(60 + 80 + 20)= 80 Ω,
160//(28+80 + 52) = 80 Ω

$\boldsymbol{R_{eq}}$ = 20+80 = **100 Ω**

I = 200/100 = 2 A or p = VI = 200x2 = **400 W**.

Chapter 2, Solution 35



Combining the resistors that are in parallel,

$$70\|30 = \frac{70x30}{100} = 21\Omega\ , \qquad 20\|5 = \frac{20x5}{25} = 4\ \Omega$$

$$i = \frac{200}{21+4} = 8\ A$$

v_1 = 21i = 168 V, v_o = 4i = 32 V

$i_1 = \frac{v_1}{70} =$ 2.4 A, $i_2 = \frac{v_o}{20} =$ 1.6 A

At node a, KCL must be satisfied

$$i_1 = i_2 + I_o \longrightarrow 2.4 = 1.6 + I_o \longrightarrow I_o = 0.8\ A$$

Hence,

v_o = **32 V** and I_o = **800 mA**

Chapter 2, Solution 36

$20//(30+50) = 16$, $24 + 16 = 40$, $60//20 = 15$
$R_{eq} = 80+(15+25)40 = 80+20 = 100\ \Omega$

$i = 20/100 = 0.2$ A

If i_1 is the current through the 24-Ω resistor and i_o is the current through the 50-Ω resistor, using current division gives

$i_1 = [40/(40+40)]0.2 = 0.1$ and $i_o = [20/(20+80)]0.1 = 0.02$ A or

$$v_o = 30i_o = 30x0.02 = \mathbf{600\ mV}.$$

Chapter 2, Solution 37

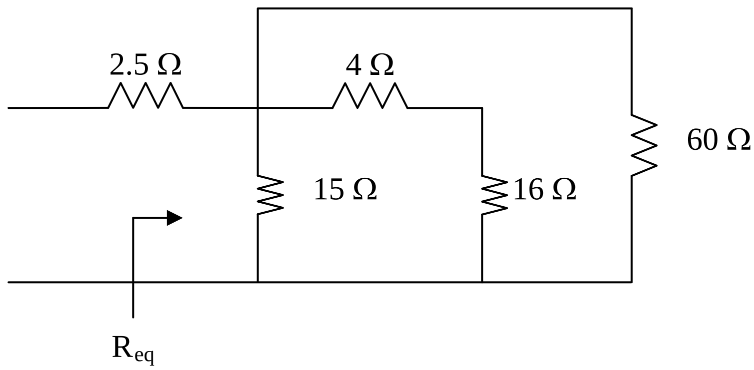
Applying KVL,

$$-20 + 10 + 10I - 30 = 0, \quad I = 4$$

$$10 = RI \quad \longrightarrow \quad R = \frac{10}{I} = \underline{2.5\ \Omega}$$

Chapter 2, Solution 38

20//80 = 80x20/100 = 16, 6//12 = 6x12/18 = 4
The circuit is reduced to that shown below.



(4 + 16)//60 = 20x60/80 = 15

R_{eq} = 2.5+15||15 = 2.5+7.5 = **10 Ω** and

i_o = 35/10 = **3.5 A**.

Chapter 2, Solution 39

(a) We note that the top 2k-ohm resistor is actually in parallel with the first 1k-ohm resistor. This can be replaced (2/3)k-ohm resistor. This is now in series with the second 2k-ohm resistor which produces a 2.667k-ohm resistor which is now in parallel with the second 1k-ohm resistor. This now leads to,

$$R_{eq} = [(1x2.667)/3.667]k = \mathbf{727.3\ \Omega}.$$

(b) We note that the two 12k-ohm resistors are in parallel producing a 6k-ohm resistor. This is in series with the 6k-ohm resistor which results in a 12k-ohm resistor which is in parallel with the 4k-ohm resistor producing,

$$R_{eq} = [(4x12)/16]k = \mathbf{3\ k\Omega}.$$

Chapter 2, Solution 40

$$\text{Req} = 8 + 4 \| (2 + 6 \| 3) = 8 + 2 = \mathbf{10\ \Omega}$$

$$\text{I} = \frac{15}{R_{eq}} = \frac{15}{10} = \mathbf{1.5\ A}$$

Chapter 2, Solution 41

Let R_0 = combination of three 12Ω resistors in parallel

$$\frac{1}{R_o} = \frac{1}{12} + \frac{1}{12} + \frac{1}{12} \longrightarrow \quad R_o = 4$$

$$R_{eq} = 30 + 60 \| (10 + R_0 + R) = 30 + 60 \| (14 + R)$$

$$50 = 30 + \frac{60(14 + R)}{74 + R} \longrightarrow 74 + R = 42 + 3R$$

or R = **16 Ω**

Chapter 2, Solution 42

(a) $R_{ab} = 5 \| (8 + 20 \| 30) = 5 \| (8 + 12) = \dfrac{5x20}{25} =$ **4 Ω**

(b) $R_{ab} = 2 + 4 \| (5 + 3) \| 8 + 5 \| 10 \| 4 = 2 + 4 \| 4 + 5 \| 2.857 = 2 + 2 + 1.8181 =$ **5.818 Ω**

Chapter 2, Solution 43

(a) $R_{ab} = 5 \| 20 + 10 \| 40 = \frac{5x20}{25} + \frac{400}{50} = 4 + 8 =$ **12 Ω**

(b) $60 \| 20 \| 30 = \left(\frac{1}{60} + \frac{1}{20} + \frac{1}{30}\right)^{-1} = \frac{60}{6} = 10\Omega$

$R_{ab} = 80 \| (10 + 10) = \frac{80 + 20}{100} =$ **16 Ω**

Chapter 2, Solution 44

For the circuits in Fig. 2.108, obtain the equivalent resistance at terminals *a*-*b*.

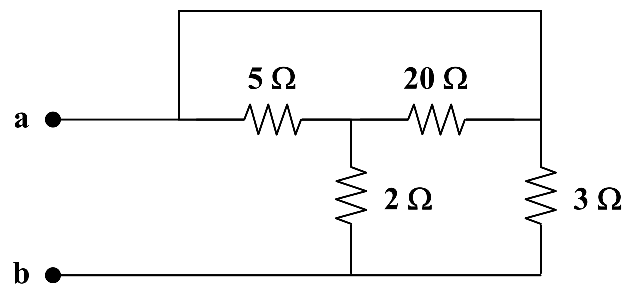


Figure 2.108
For Prob. 2.44

Solution

First we note that the 5 Ω and 20 Ω resistors are in parallel and can be replaced by a 4 Ω [(5x20)/(5+20)] resistor which in now in series with the 2 Ω resistor and can be replaced by a 6 Ω resistor in parallel with the 3 Ω resistor thus,

$$R_{ab} = [(6x3)/(6+3)] = \mathbf{2\ \Omega}.$$

Chapter 2, Solution 45

(a) 10//40 = 8, 20//30 = 12, 8//12 = 4.8

$$R_{ab} = 5 + 50 + 4.8 = \underline{59.8\Omega}$$

(b) 12 and 60 ohm resistors are in parallel. Hence, 12//60 = 10 ohm. This 10 ohm and 20 ohm are in series to give 30 ohm. This is in parallel with 30 ohm to give 30//30 = 15 ohm. And 25//(15+10) = 12.5. Thus,

$$R_{ab} = 5 + 12.8 + 15 = \underline{32.5\Omega}$$

Chapter 2, Solution 46

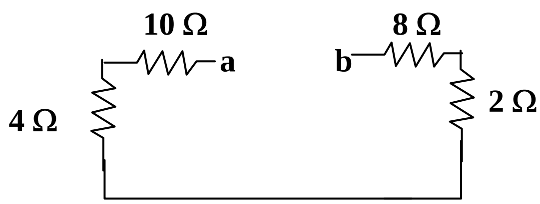
$R_{eq} = 12 + 5||20 + [1/((1/15)+(1/15)+(1/15))] + 5 + 24||8$
$= 12 + 4 + 5 + 5 + 6 = 32\ \Omega$

$$I = 80/32 = \mathbf{2.5\ A}$$

Chapter 2, Solution 47

$$5 \| 20 = \frac{5x20}{25} = 4\Omega$$

$$6 \| 3 = \frac{6x3}{9} = 2\Omega$$



$R_{ab} = 10 + 4 + 2 + 8 = \mathbf{24\ \Omega}$

Chapter 2, Solution 48

(a) $$R_a = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_3} = \frac{100+100+100}{10} = 30$$

$R_a = R_b = R_c =$ **30 Ω**

(b) $$R_a = \frac{30x20 + 30x50 + 20x50}{30} = \frac{3100}{30} = 103.3\Omega$$

$$R_b = \frac{3100}{20} = 155\Omega, \quad R_c = \frac{3100}{50} = 62\Omega$$

$R_a =$ **103.3 Ω**, $R_b =$ **155 Ω**, $R_c =$ **62 Ω**

Chapter 2, Solution 49

(a) $$R_1 = \frac{R_a R_c}{R_a + R_b + R_c} = \frac{12*12}{36} = 4\Omega$$

$$R_1 = R_2 = R_3 = \mathbf{4\ \Omega}$$

(b) $$R_1 = \frac{60x30}{60+30+10} = 18\Omega$$

$$R_2 = \frac{60x10}{100} = 6\Omega$$

$$R_3 = \frac{30x10}{100} = 3\Omega$$

$$\mathbf{R_1 = 18\Omega,\ R_2 = 6\Omega,\ R_3 = 3\Omega}$$

2.50 Design a problem to help other students better understand wye-delta transformations using Fig. 2.114.

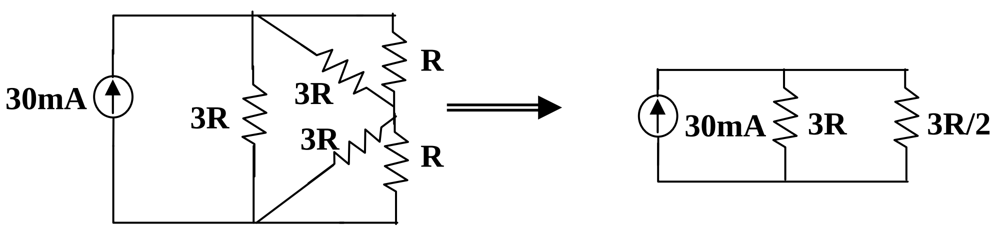
Although there is no correct way to work this problem, this is an example based on the same kind of problem asked in the third edition.

Problem

What value of *R* in the circuit of Fig. 2.114 would cause the current source to deliver 800 mW to the resistors.

Solution

Using $R_\Delta = 3R_Y = 3R$, we obtain the equivalent circuit shown below:



$$3R \| R = \frac{3RxR}{4R} = \frac{3}{4}R$$

$$3R \| \left(\frac{3}{4}R + \frac{3}{4}R\right) = 3R \| \frac{3}{2}R = \frac{3Rx\frac{3}{2}R}{3R + \frac{3}{2}R} = R$$

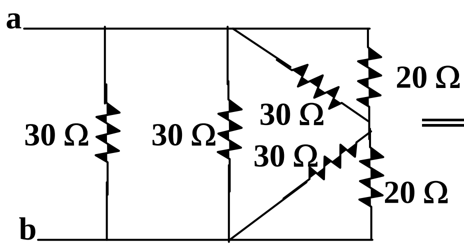
$$P = I^2R \longrightarrow 800 \text{ x } 10^{-3} = (30 \text{ x } 10^{-3})^2 R$$

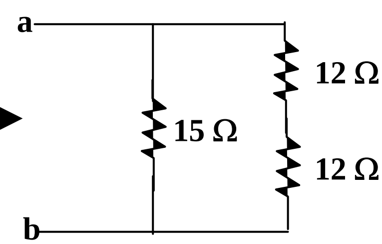
R = **<u>889 Ω</u>**

Chapter 2, Solution 51

(a) $30\|30 = 15\Omega$ and $30\|20 = 30x20/(50) = 12\Omega$

$R_{ab} = 15\|(12+12) = 15x24/(39) = \mathbf{9.231\ \Omega}$





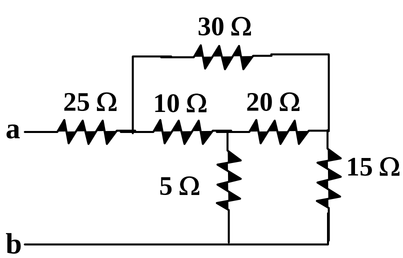
(b) Converting the T-subnetwork into its equivalent Δ network gives

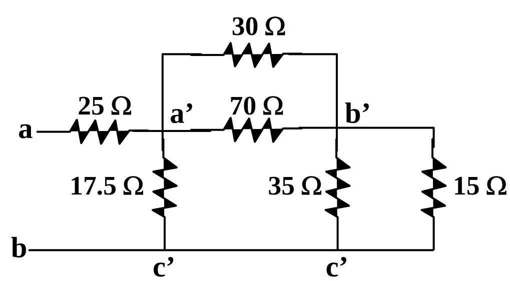
$R_{a'b'}$ = 10x20 + 20x5 + 5x10/(5) = 350/(5) = 70 Ω
$R_{b'c'}$ = 350/(10) = 35Ω, Ra'c' = 350/(20) = 17.5 Ω

Also $30\|70 = 30x70/(100) = 21\Omega$ and 35/(15) = 35x15/(50) = 10.5

$R_{ab} = 25 + 17.5\|(21+10.5) = 25+17.5\|31.5$

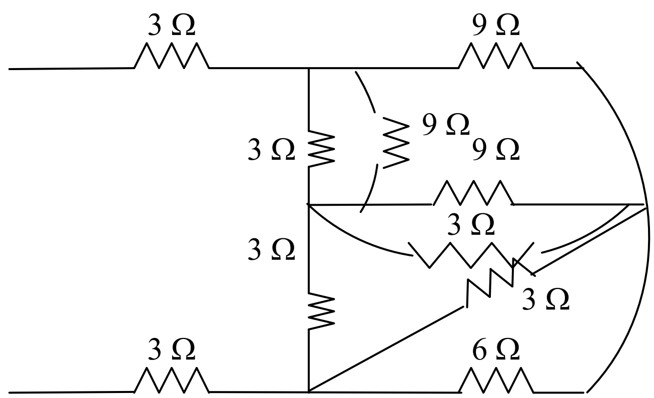
R_{ab} = **36.25 Ω**



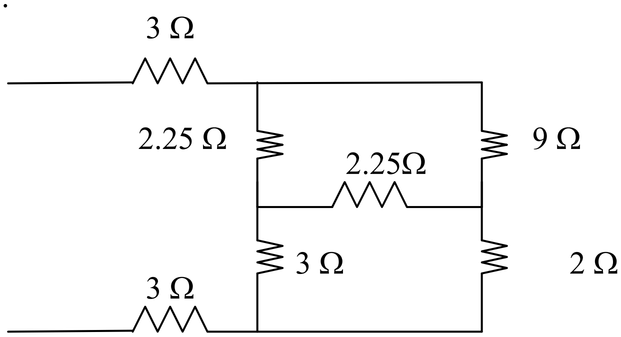


Chapter 2, Solution 52

Converting the wye-subnetwork to delta-subnetwork, we obtain the circuit below.



3//1 = 3x1/4 = 0.75, 2//1 =2x1/3 = 0.6667. Combining these resistances leads to the circuit below.

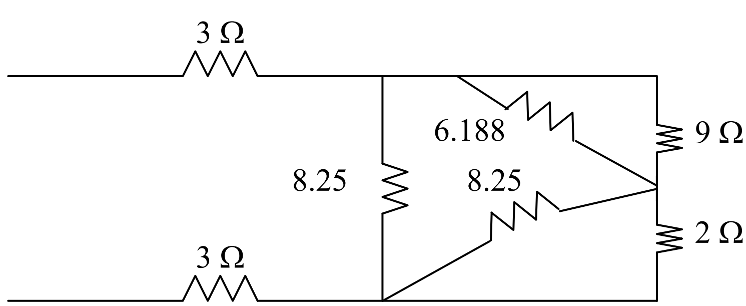


We now convert the wye-subnetwork to the delta-subnetwork.

$R_a = [(2.25x3+2.25x3+2.25x2.25)/3] = 6.188\ \Omega$

$R_b = R_c = 18.562/2.25 = 8.25\ \Omega$

This leads to the circuit below.

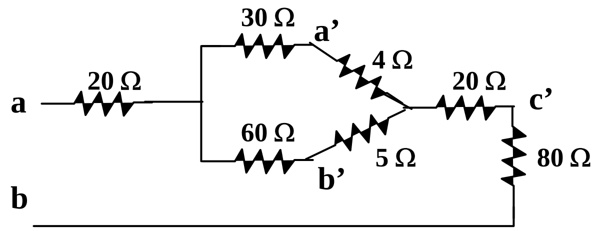


$R = 9||6.188+8.25||2 = 3.667+1.6098 = 5.277$

$R_{eq} = 3+3+8.25||5.277 = \mathbf{9.218\ \Omega}$.

Chapter 2, Solution 53

(a) Converting one Δ to T yields the equivalent circuit below:



$$R_{a'n} = \frac{40x10}{40+10+50} = 4\Omega,\ \ R_{b'n} = \frac{10x50}{100} = 5\Omega,\ \ R_{c'n} = \frac{40x50}{100} = 20\Omega$$

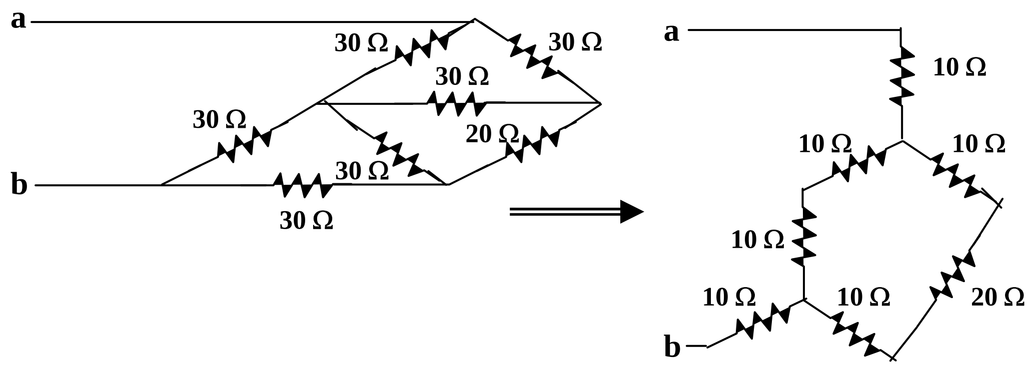
R_{ab} = 20 + 80 + 20 + $(30+4)\|(60+5) = 120+34\|65$

R_{ab} = **142.32 Ω**

(b) We combine the resistor in series and in parallel.

$$30\|(30+30) = \frac{30x60}{90} = 20\Omega$$

We convert the balanced Δs to Ts as shown below:



R_{ab} = 10 + $(10+10)\|(10+20+10)+10 = 20+20\|40$

$\mathbf{R_{ab}}$ **= 33.33 Ω**

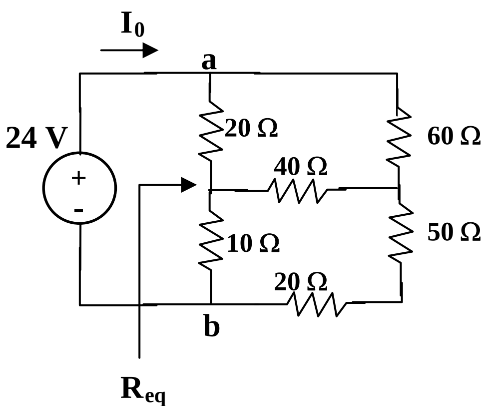
Chapter 2, Solution 54

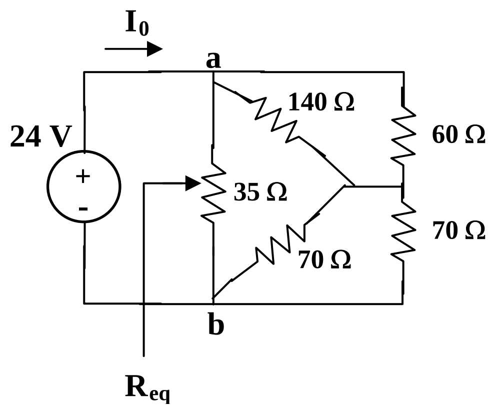
(a) $R_{ab} = 50 + 100 // (150 + 100 + 150) = 50 + 100 // 400 = \underline{130\Omega}$

(b) $R_{ab} = 60 + 100 // (150 + 100 + 150) = 60 + 100 // 400 = \underline{140\Omega}$

Chapter 2, Solution 55

We convert the T to Δ.





$$R_{ab} = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_3} = \frac{20x40 + 40x10 + 10x20}{40} = \frac{1400}{40} = 35\Omega$$

R_{ac} = 1400/(10) = 140Ω, R_{bc} = 1400/(20) = 70Ω

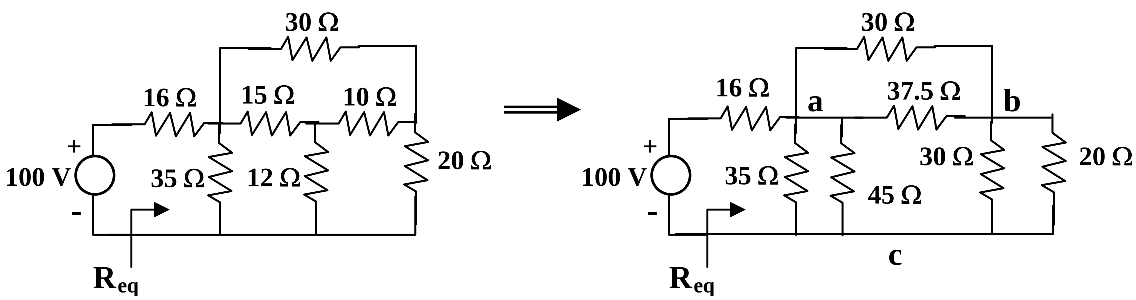
$70\|70 = 35$ and $140\|160 =$ 140x60/(200) = 42

$R_{eq} = 35\|(35 + 42) = 24.0625\Omega$

I_0 = 24/(R_{ab}) = **997.4mA**

Chapter 2, Solution 56

We need to find R_{eq} and apply voltage division. We first tranform the Y network to Δ.



$$R_{ab} = \frac{15x10 + 10x12 + 12x15}{12} = \frac{450}{12} = 37.5\Omega$$

$R_{ac} =$ 450/(10) = 45Ω, R_{bc} = 450/(15) = 30Ω

Combining the resistors in parallel,

$$30||20 = (600/50) = 12\ \Omega,$$

$$37.5||30 = (37.5x30/67.5) = 16.667\ \Omega$$

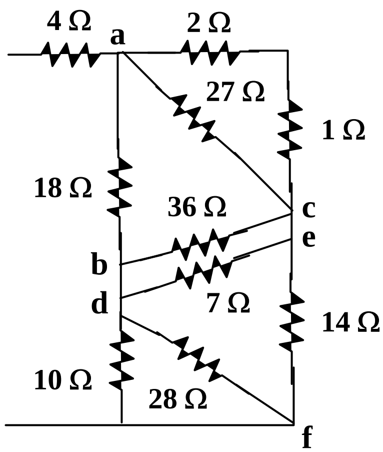
$$35||45 = (35x45/80) = 19.688\ \Omega$$

$$R_{eq} = 19.688||(12 + 16.667) = 11.672\Omega$$

By voltage division,

$$v = \frac{11.672}{11.672 + 16}100 = \underline{\mathbf{42.18\ V}}$$

Chapter 2, Solution 57



$$R_{ab} = \frac{6x12 + 12x8 + 8x6}{12} = \frac{216}{12} = 18\ \Omega$$

R_{ac} = 216/(8) = 27Ω, R_{bc} = 36 Ω

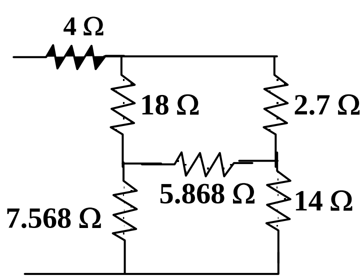
$$R_{de} = \frac{4x2 + 2x8 + 8x4}{8} = \frac{56}{8} 7\ \Omega$$

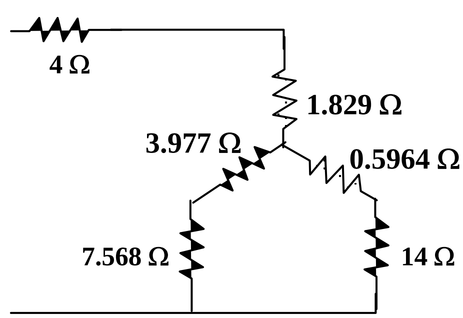
R_{ef} = 56/(4) = 14Ω, R_{df} = 56/(2) = 28 Ω

Combining resistors in parallel,

$$10\|28 = \frac{280}{38} = 7.368\Omega,\ \ 36\|7 = \frac{36x7}{43} = 5.868\Omega$$

$$27\|3 = \frac{27x3}{30} = 2.7\Omega$$





$$R_{an} = \frac{18x2.7}{18 + 2.7 + 5.867} = \frac{18x2.7}{26.567} = 1.829\ \Omega$$

$$R_{bn} = \frac{18x5.868}{26.567} = 3.977\ \Omega$$

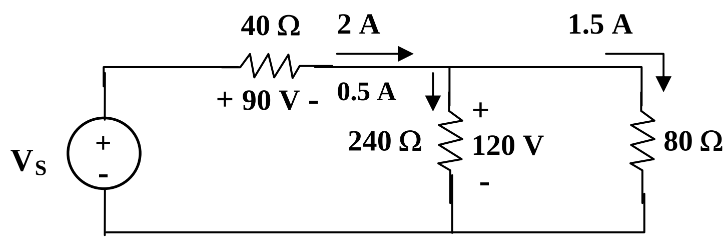
$$R_{cn} = \frac{5.868x2.7}{26.567} = 0.5904\ \Omega$$

$$R_{eq} = 4 + 1.829 + (3.977 + 7.368) \| (0.5964 + 14)$$
$$= 5.829 + 11.346 \| 14.5964 = \mathbf{12.21\ \Omega}$$

$i = 20/(R_{eq})$ = **1.64 A**

Chapter 2, Solution 58

The resistance of the bulb is $(120)^2/60 = 240\Omega$



Once the 160Ω and 80Ω resistors are in parallel, they have the same voltage 120V. Hence the current through the 40Ω resistor is equal to 2 amps.

$$40(0.5 + 1.5) = 80 \text{ volts.}$$

Thus

$$v_s = 80 + 120 = \mathbf{200\ V}.$$

Chapter 2, Solution 59

Three light bulbs are connected in series to a 120-V source as shown in Fig. 2.123. Find the current *I* through each of the bulbs. Each bulb is rated at 120 volts. How much power is each bulb absorbing? Do they generate much light?

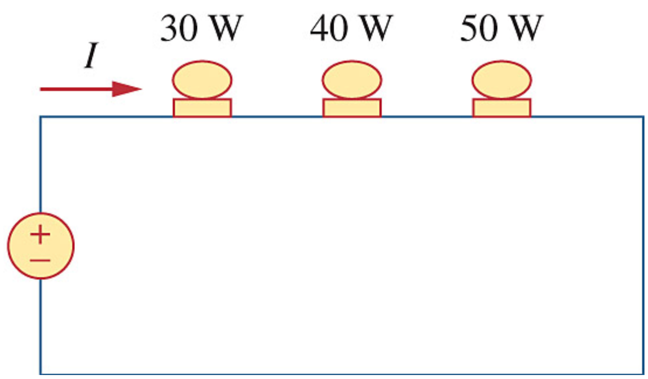


Figure 2.123
For Prob. 2.59.

Solution

Using $p = v^2/R$, we can calculate the resistance of each bulb.

$R_{30W} = (120)^2/30 = 14{,}400/30 = 480\ \Omega$

$R_{40W} = (120)^2/40 = 14{,}400/40 = 360\ \Omega$

$R_{50W} = (120)^2/50 = 14{,}400/50 = 288\ \Omega$

The total resistance of the three bulbs in series is $480+360+288 = 1128\ \Omega$.

The current flowing through each bulb is $120/1128 = 0.10638$ A.

$p_{30} = (0.10638)^2 480 = 0.011317\text{x}480 =$ **5.432 W**.

$p_{40} = (0.10638)^2 360 = 0.011317\text{x}360 =$ **4.074 W**.

$p_{50} = (0.10638)^2 288 = 0.011317\text{x}288 =$ **3.259 W**.

Clearly these values are well below the rated powers of each light bulb so we would not expect very much light from any of them. To work properly, they need to be connected in parallel.

Chapter 2, Solution 60

If the three bulbs of Prob. 2.59 are connected in parallel to the 120-V source, calculate the current through each bulb.

Solution

Using $p = v^2/R$, we can calculate the resistance of each bulb.

$R_{30W} = (120)^2/30 = 14{,}400/30 = 480\ \Omega$

$R_{40W} = (120)^2/40 = 14{,}400/40 = 360\ \Omega$

$R_{50W} = (120)^2/50 = 14{,}400/50 = 288\ \Omega$

The current flowing through each bulb is 120/R.

$i_{30} = 120/480 =$ **250 mA**.

$i_{40} = 120/360 =$ **333.3 mA**.

$i_{30} = 120/288 =$ **416.7 mA**.

Unlike the light bulbs in 2.59, the lights will glow brightly!

Chapter 2, Solution 61

There are three possibilities, but they must also satisfy the current range of 1.2 + 0.06 = 1.26 and 1.2 – 0.06 = 1.14.

(a) Use R_1 and R_2:
$R = R_1 \| R_2 = 80 \| 90 = 42.35\Omega$
$p = i^2R = 70W$
$i^2 = 70/42.35 = 1.6529$ or $i = 1.2857$ (which is outside our range)
cost = \$0.60 + \$0.90 = \$1.50

(b) Use R_1 and R_3:
$R = R_1 \| R_3 = 80 \| 100 = 44.44\ \Omega$
$i^2 = 70/44.44 = 1.5752$ or $i = 1.2551$ (which is within our range),
cost = \$1.35

(c) Use R_2 and R_3:
$R = R_2 \| R_3 = 90 \| 100 = 47.37\Omega$
$i^2 = 70/47.37 = 1.4777$ or $i = 1.2156$ (which is within our range),
cost = \$1.65

Note that cases (b) and (c) satisfy the current range criteria and (b) is the cheaper of the two, hence the correct choice is:

R_1 and R_3

Chapter 2, Solution 62

$p_A = 110x8 = 880$ W, $p_B = 110x2 = 220$ W

Energy cost = \$0.06 x 365 x10 x (880 + 220)/1000 = **\$240.90**

Chapter 2, Solution 63

Use eq. (2.61),

$$R_n = \frac{I_m}{I - I_m} R_m = \frac{2x10^{-3} x100}{5 - 2x10^{-3}} = 0.04\Omega$$

$I_n = I - I_m = 4.998$ A

$p = I_n^2 R = (4.998)^2 (0.04) = 0.9992 \cong \mathbf{1\ W}$

Chapter 2, Solution 64

When $R_x = 0$, $i_x = 10A$ $\quad R = \frac{110}{10} = 11\ \Omega$

When R_x is maximum, $i_x = 1A \longrightarrow R + R_x = \frac{110}{1} = 110\ \Omega$

i.e., $R_x = 110 - R = 99\ \Omega$

Thus, $R =$ **11 Ω**, $\quad R_x =$ **99 Ω**

Chapter 2, Solution 65

$$R_n = \frac{V_{fs}}{I_{fs}} - R_m = \frac{50}{10mA} - 1\ k\Omega = \mathbf{4\ k\Omega}$$

Chapter 2, Solution 66

$$20\ \mathrm{k}\Omega/\mathrm{V} = \text{sensitivity} = \frac{1}{I_{fs}}$$

$$\text{i.e., } I_{fs} = \frac{1}{20}\ \mathrm{k}\Omega/\mathrm{V} = 50\ \mu\mathrm{A}$$

The intended resistance $R_m = \frac{V_{fs}}{I_{fs}} = 10(20\mathrm{k}\Omega/\mathrm{V}) = 200\mathrm{k}\Omega$

(a) $R_n = \frac{V_{fs}}{i_{fs}} - R_m = \frac{50\ \mathrm{V}}{50\,\mu\mathrm{A}} - 200\ \mathrm{k}\Omega = \mathbf{800\ k\Omega}$

(b) $p = I_{fs}^2 R_n = (50\ \mu\mathrm{A})^2 (800\ \mathrm{k}\Omega) = \mathbf{2\ mW}$

Chapter 2, Solution 67

(a) By current division,

$i_0 = 5/(5 + 5)$ (2 mA) = 1 mA
$V_0 = (4\ k\Omega)\ i_0 = 4 \times 10^3 \times 10^{-3} =$ **4 V**

(b) $4k \| 6k = 2.4k\Omega$. By current division,

$$i_0^{'} = \frac{5}{1 + 2.4 + 5}(2mA) = 1.19\ mA$$

$v_0^{'} = (2.4\ k\Omega)(1.19\ mA) =$ **2.857 V**

(c) % error = $\left|\frac{v_0 - v_0^{'}}{v_0}\right|$ x 100% = $\frac{1.143}{4} x100 =$ **28.57%**

(d) $4k \| 36\ k\Omega = 3.6\ k\Omega$. By current division,

$$i_0^{'} = \frac{5}{1 + 3.6 + 5}(2mA) = 1.042mA$$

$v_0^{'}(3.6\,k\Omega)(1.042\,mA) = 3.75V$

% error = $\left|\frac{v - v_0^{'}}{v_0}\right| x100\% = \frac{0.25x100}{4} =$ **6.25%**

Chapter 2, Solution 68

(a) $40 = 24 \| 60\Omega$

$i = \dfrac{4}{16 + 24} = \mathbf{100\ mA}$

(b) $i' = \dfrac{4}{16 + 1 + 24} = \mathbf{97.56\ mA}$

(c) $\%\ \text{error} = \dfrac{0.1 - 0.09756}{0.1} \text{x}100\% = \mathbf{2.44\%}$

Chapter 2, Solution 69

With the voltmeter in place,

$$V_0 = \frac{R_2 \| R_m}{R_1 + R_S + R_2 \| R_m} V_S$$

where R_m = 100 kΩ without the voltmeter,

$$V_0 = \frac{R_2}{R_1 + R_2 + R_S} V_S$$

(a) When R_2 = 1 kΩ, $R_m \| R_2 = \frac{100}{101}$ kΩ

$$V_0 = \frac{\frac{100}{101}}{\frac{100}{101} + 30}(40) = \textbf{1.278 V (with)}$$

$$V_0 = \frac{1}{1+30}(40) = \textbf{1.29 V (without)}$$

(b) When R_2 = 10 kΩ, $R_2 \| R_m = \frac{1000}{110} = 9.091\text{k}\Omega$

$$V_0 = \frac{9.091}{9.091+30}(40) = \textbf{9.30 V (with)}$$

$$V_0 = \frac{10}{10+30}(40) = \textbf{10 V (without)}$$

(c) When R_2 = 100 kΩ, $R_2 \| R_m = 50\text{k}\Omega$

$$V_0 = \frac{50}{50+30}(40) = \textbf{25 V (with)}$$

$$V_0 = \frac{100}{100+30}(40) = \textbf{30.77 V (without)}$$

Chapter 2, Solution 70

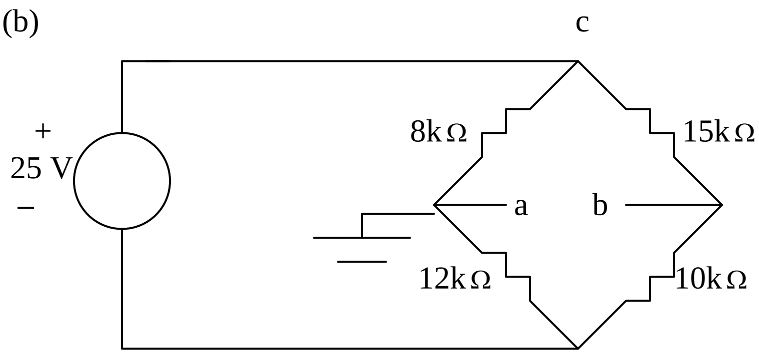
(a) Using voltage division,

$$v_a = \frac{12}{12+8}(25) = \underline{15V}$$

$$v_b = \frac{10}{10+15}(25) = \underline{10V}$$

$$v_{ab} = v_a - v_b = 15 - 10 = \underline{5V}$$

(b)

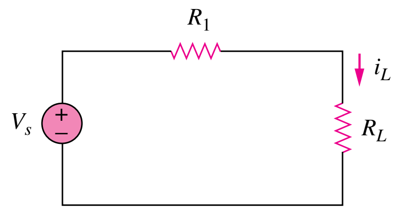


$v_a = \underline{\mathbf{0}}$; $v_{ac} = -(8/(8+12))25 = -10V$; $v_{cb} = (15/(15+10))25 = 15V$.

$v_{ab} = v_{ac} + v_{cb} = -10 + 15 = \underline{\mathbf{5V}}$.

$v_b = -v_{ab} = \underline{\mathbf{-5V}}$.

Chapter 2, Solution 71

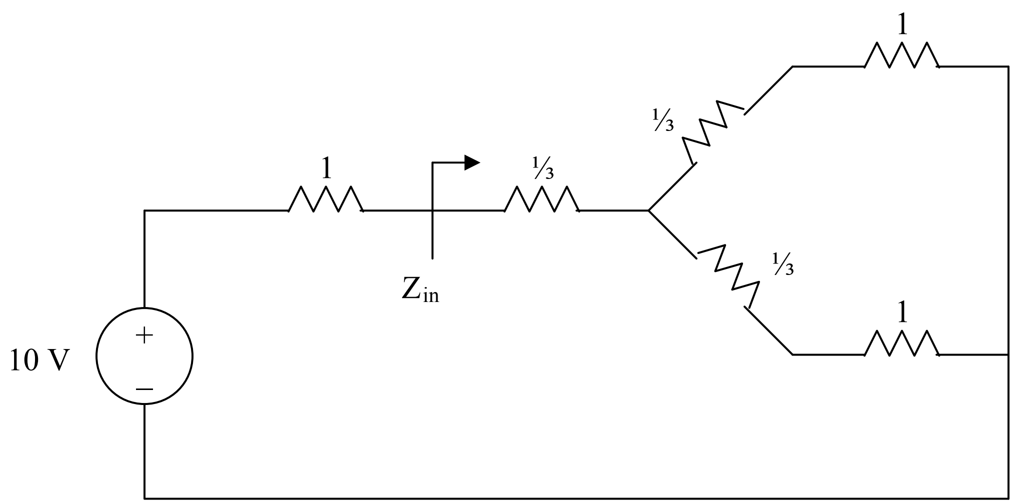


Given that $v_s = 30$ **V**, $R_1 = 20\ \Omega$, $I_L = 1$ **A**, find R_L.

$$v_s = i_L(R_1 + R_L) \quad \longrightarrow \quad R_L = \frac{v_s}{i_L} - R_1 = \frac{30}{1} - 20 = \underline{10\Omega}$$

Chapter 2, Solution 72

Converting the delta subnetwork into wye gives the circuit below.



$$Z_{in} = \frac{1}{3} + (1 + \frac{1}{3}) // (1 + \frac{1}{3}) = \frac{1}{3} + \frac{1}{2}(\frac{4}{3}) = 1\ \Omega$$

$$V_o = \frac{Z_{in}}{1 + Z_{in}}(10) = \frac{1}{1+1}(10) = \underline{5\ \text{V}}$$

Chapter 2, Solution 73

By the current division principle, the current through the ammeter will be one-half its previous value when

$R = 20 + R_x$
$65 = 20 + R_x \longrightarrow R_x = \mathbf{45\ \Omega}$

Chapter 2, Solution 74

With the switch in high position,

$6 = (0.01 + R_3 + 0.02) \times 5 \longrightarrow R_3 =$ **$1.17\ \Omega$**

At the medium position,

$6 = (0.01 + R_2 + R_3 + 0.02) \times 3 \longrightarrow R_2 + R_3 = 1.97$

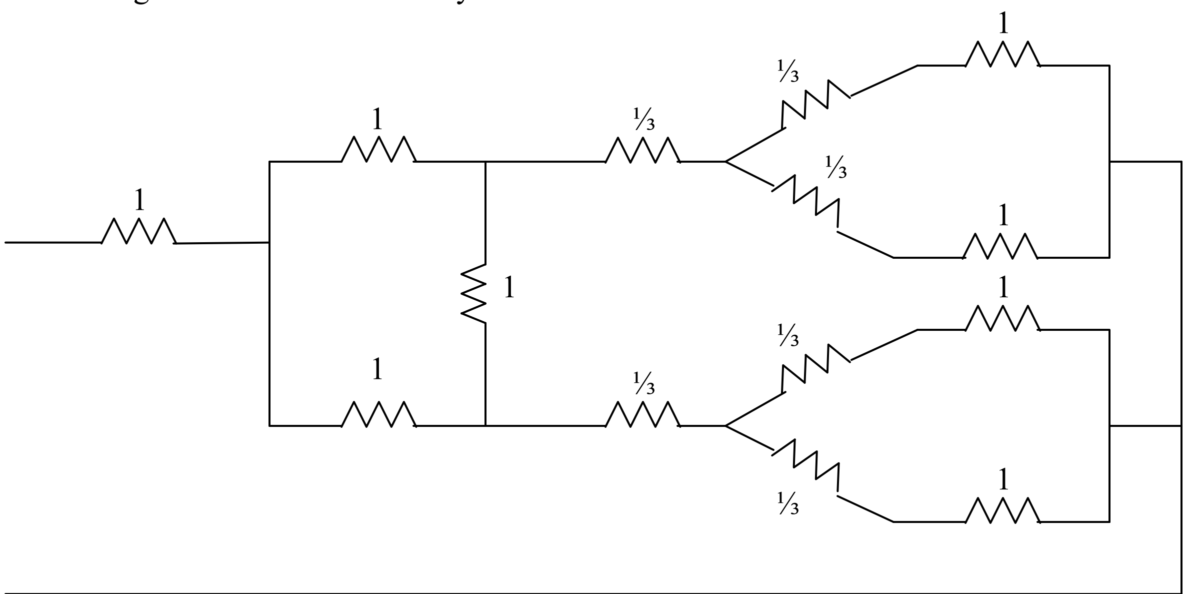
or $R_2 = 1.97 - 1.17 =$ **$0.8\ \Omega$**

At the low position,

$6 = (0.01 + R_1 + R_2 + R_3 + 0.02) \times 1 \longrightarrow R_1 + R_2 + R_3 = 5.97$
$R_1 = 5.97 - 1.97 =$ **$4\ \Omega$**

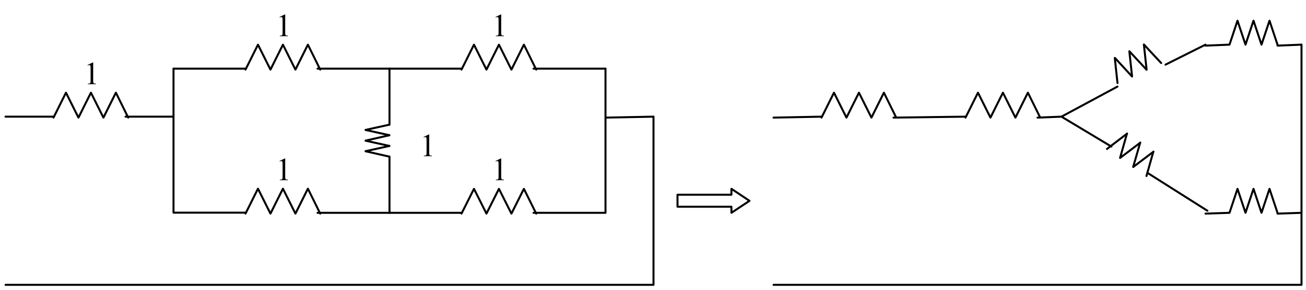
Chapter 2, Solution 75

Converting delta-subnetworks to wye-subnetworks leads to the circuit below.



$$\frac{1}{3}+(1+\frac{1}{3})//(1+\frac{1}{3})=\frac{1}{3}+\frac{1}{2}(\frac{4}{3})=1$$

With this combination, the circuit is further reduced to that shown below.



$$Z_{ab}=1+\frac{1}{3}+(1+\frac{1}{3})//(1+\frac{1}{3})=1+1=\underline{2\ \Omega}$$

Chapter 2, Solution 76

$Z_{ab} = 1 + 1 = \mathbf{2\ \Omega}$

Chapter 2, Solution 77

(a) $5\ \Omega = 10\|10 = 20\|20\|20\|20$

i.e., **four 20 Ω resistors in parallel.**

(b) $311.8 = 300 + 10 + 1.8 = 300 + 20\|20 + 1.8$

i.e., **one 300Ω resistor in series with 1.8Ω resistor and a parallel combination of two 20Ω resistors.**

(c) $40\text{k}\Omega = 12\text{k}\Omega + 28\text{k}\Omega = (24\|24k) + (56k\|56k)$

i.e., **Two 24kΩ resistors in parallel connected in series with two 56kΩ resistors in parallel.**

(a) $42.32\text{k}\Omega = 42l + 320$

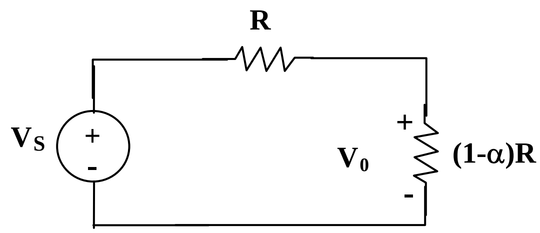
$= 24\text{k} + 28\text{k} = 320$

$= 24\text{k} = 56\text{k}\|56\text{k} + 300 + 20$

i.e., **A series combination of a 20Ω resistor, 300Ω resistor, 24kΩ resistor, and a parallel combination of two 56kΩ resistors.**

Chapter 2, Solution 78

The equivalent circuit is shown below:



$$V_0 = \frac{(1-\alpha)R}{R+(1-\alpha)R} V_S = \frac{1-\alpha}{2-\alpha} V_S$$

$$\frac{V_0}{V_S} = \frac{1-\alpha}{2-\alpha}$$

Chapter 2, Solution 79

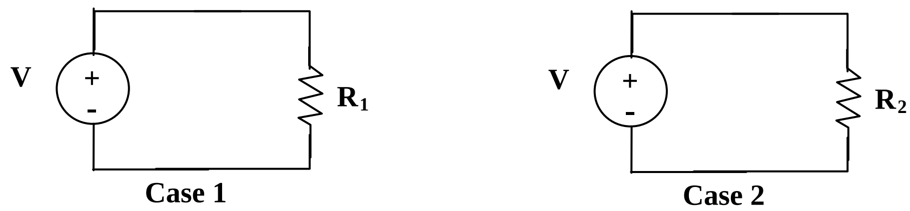
Since $p = v^2/R$, the resistance of the sharpener is
$R = v^2/(p) = 6^2/(240 \text{ x } 10^{-3}) = 150\Omega$
$I = p/(v) = 240 \text{ mW}/(6\text{V}) = 40 \text{ mA}$

Since R and R_x are in series, I flows through both.

$IR_x = V_x = 9 - 6 = 3 \text{ V}$
$R_x = 3/(I) = 3/(40 \text{ mA}) = 3000/(40) =$ **75 Ω**

Chapter 2, Solution 80

The amplifier can be modeled as a voltage source and the loudspeaker as a resistor:



Hence $p = \dfrac{V^2}{R}, \quad \dfrac{p_2}{p_1} = \dfrac{R_1}{R_2} \longrightarrow p_2 = \dfrac{R_1}{R_2} p_1 = \dfrac{10}{4}(12) = \mathbf{30\ W}$

Chapter 2, Solution 81

Let R_1 and R_2 be in kΩ.

$$R_{eq} = R_1 + R_2 \| 5 \qquad (1)$$

$$\frac{V_0}{V_S} = \frac{5\|R_2}{5\|R_2 + R_1} \qquad (2)$$

From (1) and (2), $0.05 = \frac{5\|R_1}{40} \longrightarrow \quad 2 = 5\|R_2 = \frac{5R_2}{5 + R_2}$ or $R_2 = 3.333$ kΩ

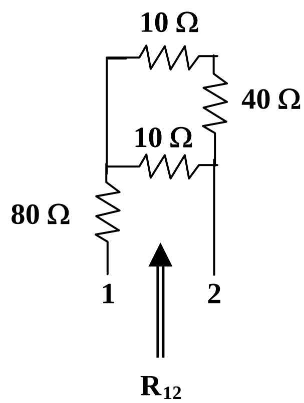
From (1), $40 = R_1 + 2 \longrightarrow \quad R_1 = 38$ kΩ

Thus,

$$\mathbf{R_1 = 38\ k\Omega,\ R_2 = 3.333\ k\Omega}$$

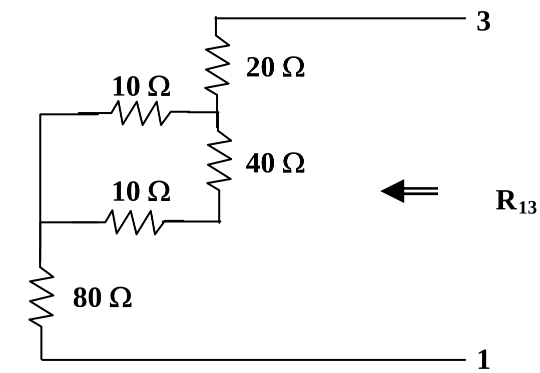
Chapter 2, Solution 82

(a)



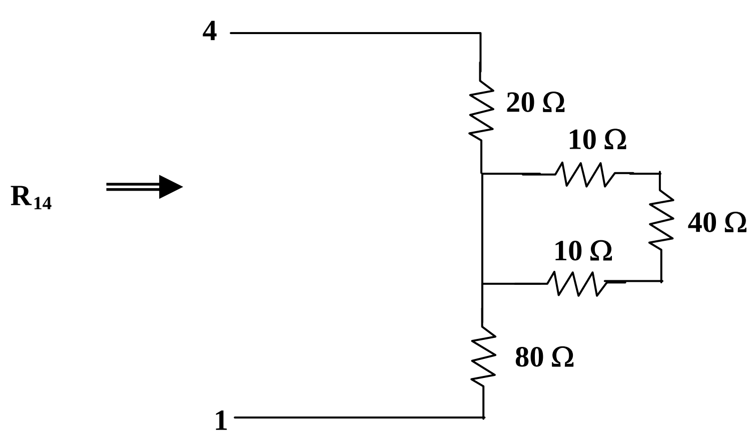
$$R_{12} = 80 + 10\|(10+40) = 80 + \frac{50}{6} = \mathbf{88.33\ \Omega}$$

(b)



$$R_{13} = 80 + 10\|(10+40) + 20 = 100 + 10\|50 = \mathbf{108.33\ \Omega}$$

(c)



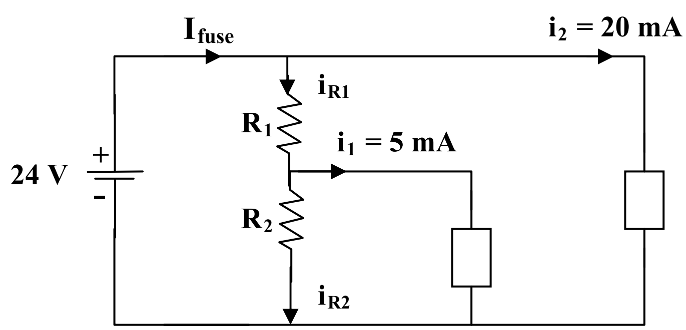
$$R_{14} = 80 + 0\|(10+40+10) + 20 = 80 + 0 + 20 = \mathbf{100\ \Omega}$$

Chapter 2, Solution 83

The voltage across the fuse should be negligible when compared with 24 V (this can be checked later when we check to see if the fuse rating is exceeded in the final circuit). We can calculate the current through the devices.

$$I_1 = \frac{p_1}{V_1} = \frac{45mW}{9V} = 5mA$$

$$I_2 = \frac{p_2}{V_2} = \frac{480mW}{24} = 20mA$$



Let R_3 represent the resistance of the first device, we can solve for its value from knowing the voltage across it and the current through it.

$$R_3 = 9/0.005 = 1{,}800\ \Omega$$

This is an interesting problem in that it essentially has two unknowns, R_1 and R_2 but only one condition that need to be met and that the voltage across R_3 must equal 9 volts. Since the circuit is powered by a battery we could choose the value of R_2 which draws the least current, $R_2 = \infty$. Thus we can calculate the value of R_1 that give 9 volts across R_3.

$$9 = (24/(R_1 + 1800))1800 \text{ or } R_1 = (24/9)1800 - 1800 = \mathbf{3\ k\Omega}$$

This value of R_1 means that we only have a total of 25 mA flowing out of the battery through the fuse which means it will not open and produces a voltage drop across it of 0.05V. This is indeed negligible when compared with the 24-volt source.